Perseus Review

Dallas Lankford, 2/2/08, rev. 12/22/08

The Perseus hardware and Version 1.1C software are without a doubt the best SDR package currently available with respect to spurious responses, intermodulation distortion, recording and playback bandwidths and other characteristics provided your computer has an appropriate operating system and hardware for external hard drives. An excellent in depth review by Bjarne Mjelde has covered many aspects of the Perseus which I will try not to duplicate here. Another excellent source of information about Perseus is Guy Atkins' Five Below blog.

Version 1.1C has two minor defects, namely (1) inability to jump to the latter part of some 800 kHz BW WAV files during playback (this according to some, I haven't actually checked it myself), and (2) "holes" or missing parts of the playback at each transition from one WAV file to the next with 1600 kHz BW recordings. As it has turned out, no parts of the recordings are missing, they just cannot be played back completely (without holes) with 1.1C. However, 2.1A solved that problem nicely and even plays 1.1C recordings with no "holes." As if to remind us of the past 2.1A does turn on the red ADC CLIP light when playing back 1600 kHz BW recordings made with 1.1C, but with no audible evidence of distortion.

When playing back 1600 kHz BW recordings with 500 GB or 1TB hard drives, you may experience stuttering, especially with external hard drives used with laptops. I found that the E-SATA version of the BlacX HD caddy was virtually stutter free during playback of 1600 kHz BW recordings, but that the USB version of the BlacX HD caddy was not. Remaining stuttering was eliminated by using an IOGear eSATA 3 Gbps ExpressCard/34 adapter with the eSATA output of the BlacX (be aware that some BlacX caddys do not have an eSATA output!). Whether you experience stuttering or not during playback while performing other tasks may also depend on the CPU if you use a laptop. The T2xx series of CPU's seems more or less immune to stuttering while performing other tasks during playback, while later laptop CPU's may stutter. This can sometimes be alleviated to some extent by using software like Notebook Hardware Control to set the CPU for maximum performance.

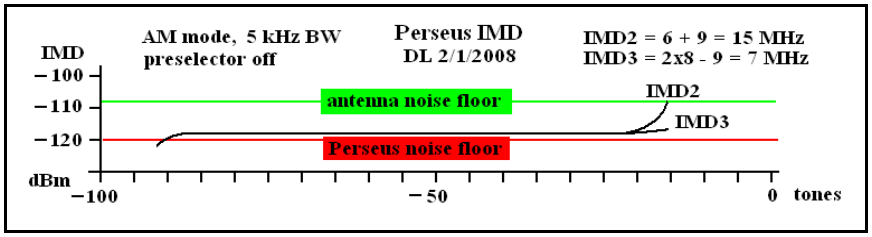
I took my Perseus with Version 1.1C software to Quoddy Head, Maine for a DXpedition from 10/19/08 to 10/26/08 and the results have been outstanding, both at QH and since I have returned to Louisiana. I recorded the entire MW band using a 250 meter BOG, sometimes phased, and occasionally using a phased loop and active whip, typically from about 1930 to 0700 UTC many nights, and have enjoyed over seven weeks of "DXing," some while was there, but most since I returned. Almost every night since I returned I have heard one or more new TA's. It is like going to Quoddy Head without actually going there. There is no way I could be doing this with any other receiver. The Perseus receiver is truly in a class by itself.

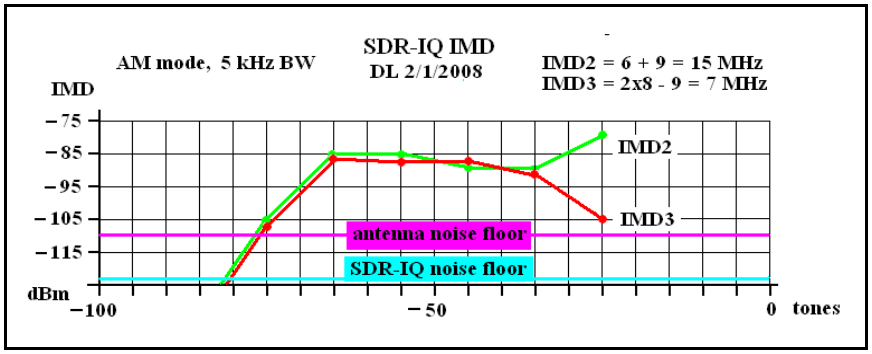
Things I Like

Perseus is virtually spur free free in contrast to, for example, SDR-IQ which has numerous obvious spurs above 15 MHz when signal levels are sufficiently high. Perseus does have very weak garden variety spurs at almost every multiple of 500 kHz which are observable and detectable at the Perseus noise floor with no antenna attached, but I do not believe that any of these will ever be heard when using an antenna because they will almost certainly be well below the antenna man made noise floor.

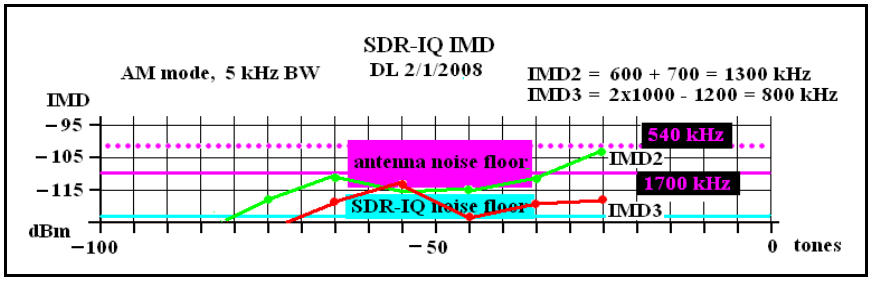
Perseus intercepts are typically more than 15 dB greater than SDR-IQ. Perseus 2nd order intercepts are typically greater than +75 dBm, and Perseus 3rd order intercepts are generally greater than +30 dBm in the SW bands when its preselector is turned off, but in some cases are as low as +24 dBm in the SW bands when its preselector is turned on. So it seems that the preselector should only be turned on at SW frequencies when the ADC is overloaded due to out of band signals. Below 1700 kHz there is no difference in Perseus 3rd order intercepts with the preselector on or off. MW and LW 3rd order intercepts for tones in the lower part of the MW band are as low as +21 dBm. Overall the Perseus 2nd order intercepts are outstanding, and the 3rd order intercepts are very good to excellent. The tones used for Perseus measurements above were -16 dBm at the Perseus antenna input. The tones used for SDR-IQ measurements above were -25 dBm at the SDR-IQ antenna input.

However, it is well known that intercepts for a DDC SDR do not obey the usual slope 2 (IMD2) and slope 3 (IMD3) laws. The intercepts, if we call them that, are dependent on the tones levels, The Perseus IMD graph below right is based on measurements of my Perseus. If we calculate the intercepts based on -15 dBm tones we get IIP2 = +78 dBm and IIP3 = +36 dBm. But for other tones levels we can get vastly different intercepts. For example, with -50 dBm tones, the IMD2 ands IMD3 intermod are about -118 dBm in both cases, so IIP2 = -17 dBm and IIP3 = -16.5 dBm. But like I said, a DDC SDR does not obey the usual slope 2 and slope 3 intermod laws. Except for tones near the clipping level, the Perseus IMD is only slightly, ever so slightly, above the Perseus noise floor, at least for a 5 kHz bandwidth and AM mode, which is what I used. The intermod line between about -80 and -25 dBm tones, which we might call ***the SDR intermod floor***, actually varies up and down a few dB, but it was easier for me to draw it as a horizontal line.

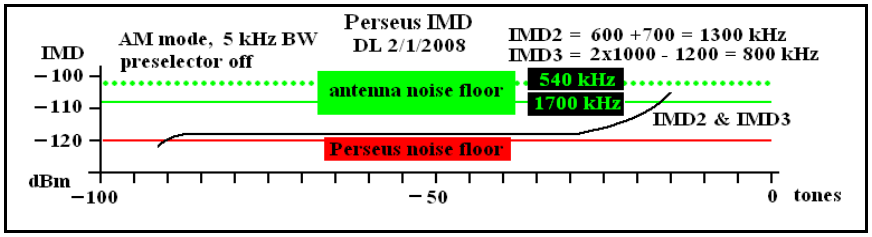




My antenna noise floor at the frequencies where the intermod was measured is typically about -108 dBm at the Perseus antenna input, so all of the intermod noise floor is safely about 10 dB below my antenna noise, and has never been heard. On the other hand, the SDR-IQ presents ample opportunities for intermod to be heard at SW frequencies as shown by the graph above. But then surprisingly the IQ has excellent low intermod levels in the MW band as shown in the graph below right. The 2nd order performance shown in the MW graph is about 15 dB better than that a stock SDR-IQ because of the preamp modification I have done to my SDR-IQ which is described in an article in The Dallas Files.



The graph below right shows typical Perseus intermod performance in the MW band. As can be seen, while it is somewhat better than a modified SDR-IQ, both should produce little, if any, observable intermod in the MW band due to MW signals. Both are also excellent performers in the NDB band.



The Perseus AM mode is excellent, and produces produces much less AM fading distortion than an analog receiver AM mode, especially if the signal carrier is tuned to one side or the other of the passband ("AM SSB"). Perseus AM mode is so good that at first I thought it produced no distortion during fades, but eventually some AM mode fading distortion was observed on very deep fades.

The Perseus SAM mode is even better than the AM mode, better than most other SAM's I have used; it locks fast (almost instantaneously), the received signal can be detuned to achieve USB AMS, LSB AMS, or anything in

between, it has never lost lock when I was listening, and it produces no audible AM fading distortion, even in the deepest fades. Others have reported the Perseus SAM mode is not so great for MW splits or multiple co-channel signals, but I have not observed this myself.

The narrow bandwidth noise blanker of Version 1.1B (not previously available on earlier versions) when using the 12 kHz BW is (1) as good as any noise blanker I have ever used, and (2) better than most. One can even "detune" the 12 kHz BW narrow noise blanker "window" by dragging the demodulating BW "window" to one side or the other, a feature which no other receiver has, and which can enhance the narrow noise blanker performance. The narrow bandwidth noise blanker is generally not effective with wider or narrower bandwidth noise blanker windows. This is not a defect of Perseus but rather a defect of noise blankers in general.

Perseus SSB phase noise at close offsets (out to, say, 30 or 40 kHz) is better than any other receiver that I am aware of. At 455 kHz and 1400 kHz, for example, I measured the Perseus 5 kHz offset SSB phase noise as -147 dBc/Hz. To the best of my knowledge, no other receiver even comes close. However, this probably does not make Perseus a better MW DX receiver than other receivers with merely good SSB phase noise because MW transmitters put out so much slop at such high levels in such a broad spectrum.

Griffin PowerMate Setup And Use

After installing the software (from the PowerMate CD) and plugging the PowerMate into a vacant USB port, left click on the PowerMate icon in the Control Panel. That brought up a window which allowed selection and application of various options. I selected Rotate Right for the user action and Scroll Down for the associated computer action and clicked left on the Apply Now button, then I selected Rotate Left for the user action and Scroll Up for the associated computer action and clicked left on the Apply Now button. That's it. Naturally I guessed wrong the first time as to whether Scroll Down increased or decreased frequency. Now when the pointer tip is over the units, or tens, or hundreds, etc. Hertz digits, the frequency changes by that step size when the PowerMate is rotated clockwise (for frequency increase) or counter clockwise (for frequency decrease).

The Griffin PowerMate tuning knob can also be customized to move the pointer tip left or right to whatever digit (units, tens, hundreds, etc. Hz) you want. The User Action to accomplish this is Click & Rotate Right (respectively Left) and the associated Computer Action is Cursor Right (respectively Left). "Click & Rotate" means "Hold Down The Knob While Rotating" and "Cursor Right" means "The Cursor Moves Right." In other words, with the PowerMate knob alone you can tune Perseus in whatever steps you desire (assuming the pointer tip is already in the frequency display). You will probably find that if you rotate the knob while in the process of pressing the knob down, you can change the frequency in undesired ways. So it may take you a few tries to adjust your hand coordination appropriately.

How to tune the notch with the PowerMate was not entirely clear to me at first. Fortunately Bjarne provided me with several useful hints. Left clicking on the Notch button below the filter window activate the notch was, of course, a no brainer. Placing the tip of the mouse inside the filter window produced a red vertical line. And double left clicking produced a yellow vertical line with two small yellow "feet" at the bottom of the yellow line. Rotating the PowerMate CW or CCW, which is equivalent to scrolling left or right with my PowerMate setup (see above), increased or decreased the notch depth. Because the notch width is dependent on the notch depth, rotating CW or CCW also varies the notch width. For notch depths greater than about 50 dB the notch width becomes so wide as to be unacceptable. This is another aspect of the Perseus which could be improved. To tune the notch, hold the left click button down and rotate the PowerMate knob while pressing down on the knob. This amounts to holding the left click button down while scrolling left or right with my PowerMate setup (see above). To turn off the notch, click right. Again, a notch filter is generally superfluous for a receiver with a filters which have steep skirts, such as the Perseus or SDR-IQ. But occasionally I have to eat my words. A few evenings ago while I was playing the the Perseus notch filter I noticed a het on 530 kHz. As it turned out a new (to me) beacon LYQ has recently appeared on 529 kHz, said to be Morristown, TN. With steep filter skirts I can usually eliminate such a het merely by off tuning. But in this case some residual het seemed to remain... very curious. Activating the notch and placing it on 530 kHz did not improve matters... even more curious.

Eventually I found that there were two hets, one due to the 530 kHz carrier, and a second one due to a carrier on 528 kHz. Tuning the Perseus notch to eliminate the 528 kHz carrier left 529 LYQ in the clear, except for too much static to ID. Oh well, sometimes we can't have everything.

As stated previously, PowerMate is not entirely stable on my T61. Frequently it does not "turn on" when my T61 boots. Recently I found a work around for this. Right click on the PowerMate icon on the Taskbar, and uncheck "Run on Startup" on the pop up menu. Go to the PowerMate folder (C: > Program Files > Griffin Technology > PowerMate and drag shortcut of PowerMate(.exe) to the desktop. With the PowerMate shortcut on the desktop, unplug the PowerMate USB cable each time before booting Windows, double left click on the PowerMate shortcut after booting, and plug in the PowerMate USB cable. The PowerMate blue LED should turn on and the PowerMate will be operational. Sometimes it is necessary to left click with the mouse pointer (once) in the frequency display before PowerMate will tune any of the frequency display digits. And sometimes I have to leave the PowerMate USB cable unplugged until after PowerMate(.exe) is initialized. Flakey? Yes. All of this could be avoided if better Perseus tuning would be implemented, like for the SDR-IQ.

Additional Observations

Here is a way to calibrate the displayed frequency of a Perseus with an accuracy of 0.5 Hz or less at all frequencies. Tune to 5.000000, 10.000000, or 15.000000 MHz, whichever is strongest. Select the USB or LSB mode and adjust the filter so that the lower cutoff frequency of the filter is sufficiently below (or above) the carrier that subaudible hetrodynes can be heard clearly. Left click the CalClr button. A het will be heard. Tune the Perseus to the frequency you think is zero beat. Then tune 3 Hz each side of the frequency you think is zero beat. The SAH's on each side of zero beat should sound identical, or nearly so. If not, one SAH will be faster (higher in frequency) than the other. Guess again where you think zero beat is, and again tune 3 Hz each side of your new guess. The SAH's should be more nearly identical. Do this guessing and tuning 3 Hz each side of your guess as many times as necessary to arrive at your best guess for zero beat, which should be within 0.5 Hz of zero beat. Left click the Cal button, the Perseus frequency display will change from the displayed frequency of your best zero beat guess to 5.000000 MHz (or to whatever WWV frequency you started at), and the Perseus should be calibrated to within 0.5 Hz or less at all frequencies.

Perseus comes close to implementing bandwidths the way I would like to see them implemented because there are multiple bandwidths of 0.8, 1.6, 3, 6, 12, and 25 kHz, each bandwidth is displayed in the (small) filter window, the user can adjust each (well, almost) of the bandwidths, and the customized bandwidths are remembered, even when Perseus is exited and rebooted. However, after customizing, the actual bandwidths of the filters are no longer the bandwidths displayed on the filter buttons. It would be nice if (1) the actual bandwidths were displayed on the filter buttons, or if not then perhaps the filter buttons could be relabeled as, say, Narrower, Narrow, Medium, Wide, Wider, and Widest, or some such, and (2) each of the bandwidths could be customized for each mode (except, perhaps, leaving the USB and LSB bandwidths the same for each button).

Things I Would Change

Tuning a Perseus is difficult if you have a laptop without an external mouse or if our mouse does not have a scroll wheel. It should be easy to implement frequency changing by left and right clicking like the SDR-IQ, but that has not been done.

Rather than buy an external mouse with a scroll wheel for my laptop, I decided to try a Griffin PowerMate. This turned out to be an excellent choice, and even if the Perseus frequency could be changed by left and right clicking like the SDR-IQ, I would use the PowerMate. A description of how to set up and use the PowerMate is given above.

Unfortunately, the PowerMate when used with Perseus is not completely stable and sometimes malfunctions in various ways; in the worst case you may have to uninstall the PowerMate driver – Control Panel > System > Hardware (tab) > Device Manager (button) > left click on + of Human Interface Devices > right click on USB Human Interface Device (this is the Griffin PowerMate driver) > left click on Uninstall in the pop up window –

and then reinstall with the PowerMate CD and reconfigure. Also, PowerMate regularly does not "turn on" when my T61 boots, and it is necessary to unplug and re-plug (sometimes several times) the PowerMate USB cable. A work around for this problem is above below where setup and use of the PowerMate is discussed.

Adjusting the notch depth cannot be done without a mouse with scroll wheel or PowerMate, see the discussion in Griffin PowerMate Setup And Use above. The notch can be tuned by holding down the left click button and dragging the notch frequency indicator. It would be easy enough to implement notch depth adjustment by left and right clicking, except that right clicking turns the notch off. The correct way to turn the notch off would have been to left click (again) on the notch button.

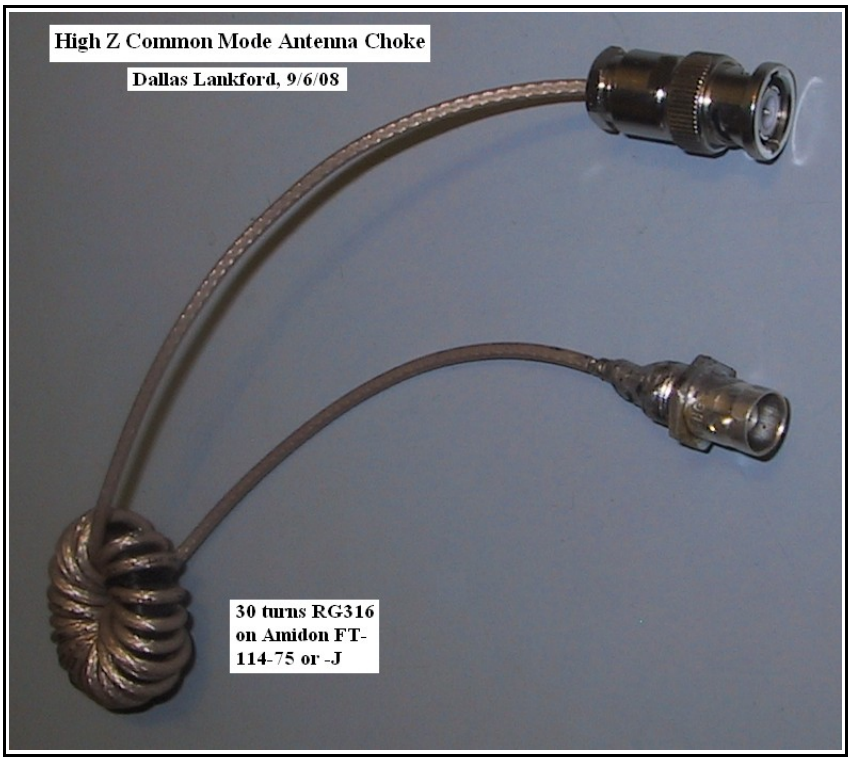
It would be nice if the AGC release times were selectable by the user, as is the case for the SDR-IQ.

The Perseus clock oscillator long term stability is not as good as it should be for a premium grade receiver.

The stated Perseus calibration procedure is not ideal. It consists of tuning to WWV (say, 10.000000 or 15.000000 MHz), left clicking the CalClr button, selecting AM mode, selecting 0.8 kHz BW, placing the mouse pointer inside the (small) filter display and aligning the vertical red line with the WWV carrier, double left clicking, and left clicking the Cal button. However, this seldom calibrates Perseus more accurately than 2 Hz. The SDR-IQ can be calibrated to within a fraction of a Hz, although not exactly as described in the SDR-IQ Calibration documentation. Surely a software change could be found to calibrate the Perseus as accurately.

The Perseus preselector does reduce out of band signal levels, which improves clipping caused by out of band signals, but generally does not improve intermod performance caused by out of band signals. In some cases SW 3rd order intercepts are reduced when the preselector is turned on. The latter may be due to the use of tiny inductors, perhaps with insufficiently large ferrite cross sections. Also, Perseus harmonic distortion with the preselector turned on is not as good as it has been said to be. Use of larger preselector inductor would probably improve the Perseus out of band intermodulation and harmonic distortion performance.

Common Mode Antenna Chokes

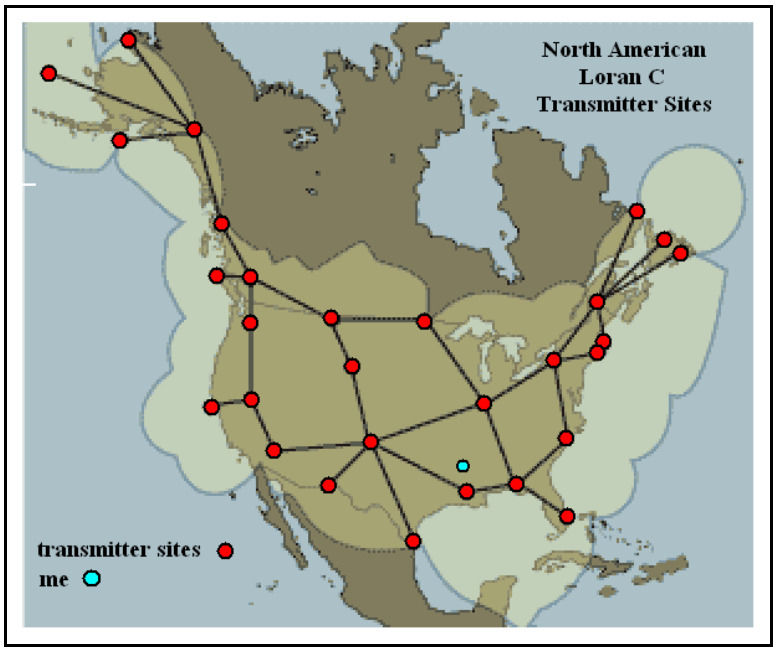


Perseus and other SDR radios may produce RFI which limits weak signal performance. Or the computers they are used with may cause the RFI. With conventional radios which contain microprocessors, such RFI generally occurs at higher frequencies, above 15 MHz or so. But SDR's like Perseus and SDR-IQ can produce RFI just about anywhere in the RF spectrum. On days with low man made noise when using a splitter I have observed Perseus and SDR-IQ common mode RFI at several places in the MW band. I use common mode antenna chokes shown in the figure at right to eliminate this kind of RFI.

These common mode antenna chokes are variations of common mode chokes described here by Chuck Counselman in his article "Common-Mode Chokes."

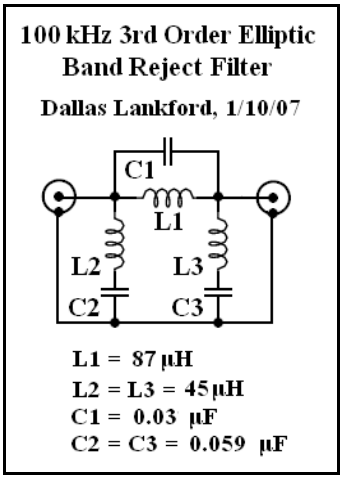
Overloading Due To Loran C

Depending on the proximity of the nearest Loran C transmitter and the signal levels delivered by your antenna, and SDR like Perseus or SDR-IQ can have overload and clipping problems due to the Loran C transmitter. The North American Loran C Transmitter Sites are shown on the map at right.

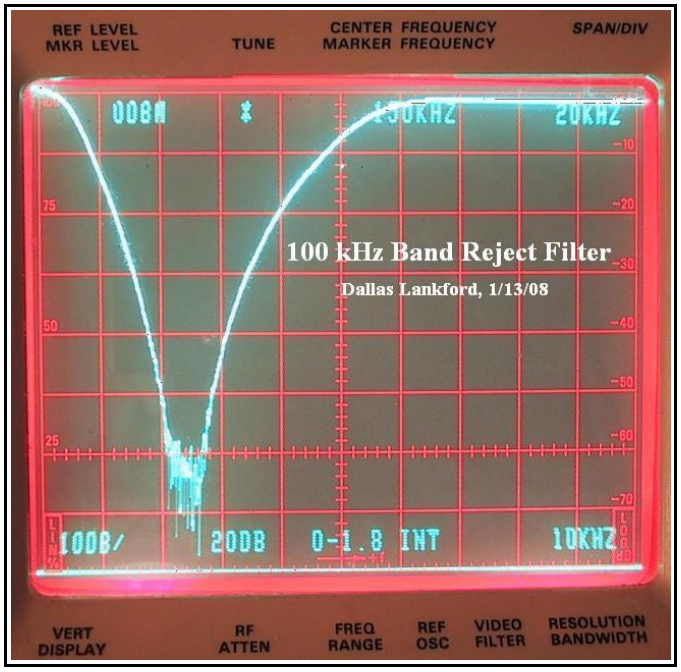


At my location, which is not all that far from the nearest Loran C transmitting antenna, a simplified 3rd order 100 kHz elliptic band reject filter has been sufficient for eliminating Perseus overloading due to Loran C.

A schematic and sweep of the filter are given below. The inductors were inexpensive off the shelf inductors available from Mouser. The capacitors were made by paralleling disc ceramic capacitors which I had on hand, some purchased in the past from Mouser, and others bought at hamfests over the years. L1 was marked as a 100 µH inductor, and L2 and L3 were marked as 47 µH, but they measured 87 µH and 45 µH respectively using an AADE digital inductance meter. The capacitor values may be calculated from the formula for LC resonance, namely $f = 1/2\pi SQRT(LC)$. Both sides of the LC resonant frequency formula are squared from which it is found that $C = 1/4\pi^2 f^2 L$ where f is in Hertz and L is in Henrys. For example, taking L1 = 87 µH we have $C = 1/4\pi^2 100{,}000^2 0.000087 = 0.000000029$ F = 0.029 µF.

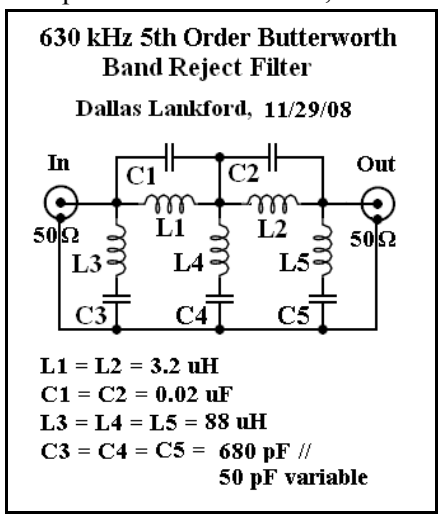


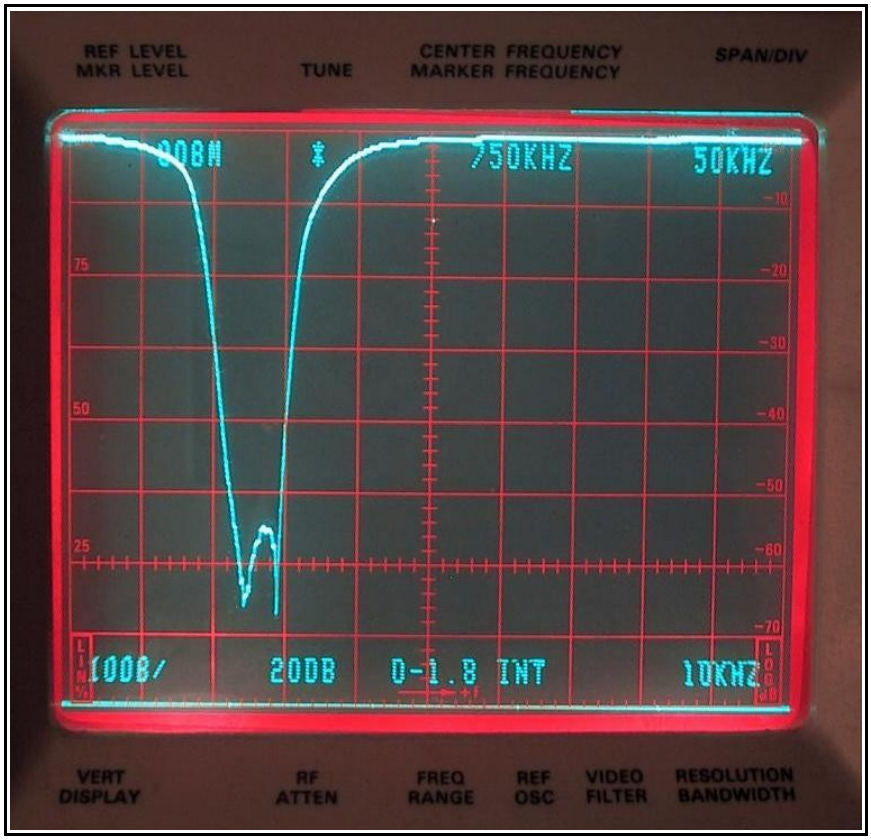
The AADE inductance meter also measures capacitance, so it was used to make a 0.029 µF capacitor by paralleling capacitors of lower value. The 100 kHz elliptic band reject filter obtained in this manner was not perfectly symmetric about 100 kHz, but it was more than satisfactory with greater than 70 dB attenuation at100 kHz While examining the filter shape with a signal generator and spectrum analyzer I found that 0.03 µF gave a slightly better shape, so that is what I specified in the schematic figure at left. However, the improvement was probably due to error in my digital capacitance meter (with a meter indication of 0.03 µF the capacitance was actually, say, 0.0293 µF). The other values were arrived at similarly.



A 630 kHz 5th Order Butterworth Band Reject Filter

One of the defects of current software defined radios is that their AD converters overload when there are one or more sufficiently strong transmitters nearby, and this often occurs at signal levels considerably less than the rated input ADC clipping level. This is not uncommon for Dxers relatively near high power European MW transmitters, for urban DXers in the USA near 50 kW transmitters, and for DXers near Loran C transmitters.





A suitable band reject filter, such as a 5th order Butterworth band reject filter, will typically eliminate ADC clipping caused by only one strong signal. The inductor and capacitor values were first approximated with the excellent free filter software available here from Almost All Digital Electronics, and then adjusted for best filter shape while sweeping a preliminary version with a Tektronix 495P spectrum analyzed and matching Tektronix TR 503 tracking generator. The a prototype was built with soldered connections and used 50 pF variable capacitors in parallel with 680 pF for C3, C4, and C5 to adjust the final filter shape shown in the photograph above. It might be difficult to make such a filter without a spectrum analyzer and tracking generator.

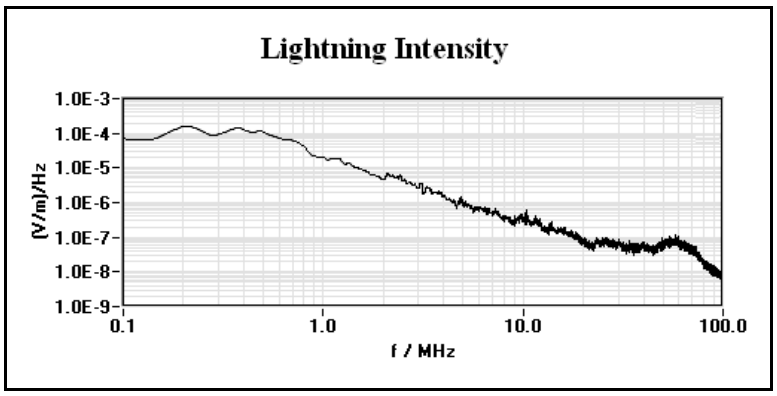
The filter above was designed to attenuate the 100 kW Vigra, Norway signal at Smola about 82 miles away where 30 dB attenuation must be used between Perseus and a 400 meter beverage pointed 300 degrees azimuth with respect to true North to prevent Perseus ADC clipping. With the filter inserted no attenuation is needed even with 10 dB amplification for winter daytime DXing of North American signals. Of course, the filter causes some undesirable attenuation of one or two adjacent channels.

It may be possible through careful design and selection of component values to fabricate a band reject filter which has a narrower top while still attenuating the undesired carrier and its sidebands by a sufficient amount (probably 40 dB or more) to prevent overloading Perseus. That remains to be seen.

Overloading Due To Lightning

Static causes overload? Not in an analog receiver or DSP receiver with analog front end to the best of my knowledge. But much to my surprise it can for SDR receivers like Perseus and SDR-IQ depending on the frequency to which the SDR-IQ is tuned or whether front end filtering is used in the case of Perseus. Listening in and around the MW band as a thunderstorm passed by I observed the red LED clipping indicator flashing on

(and off) followed by a slightly delayed audible static burst. When there were multiple static bursts, they were preceded by multiple red LED flashes. As in the case of Loran C, whether a lightning storm will cause your SDR to clip will depend on the proximity of the storm and the signal levels delivered by your antenna. It has been said that the field strength of lightning tends to approach a maximum about 5 kHz, decreases approximately as 1/f as the frequency approaches 100 MHz, and then presumably decreases slowly for higher frequencies. The figure at right and others do not exactly agree with that statement, but then such results are approximations. If we accept the figure at right as typical, then as the frequency increases from 100 kHz to 1 MHz, the intensity of received static tends to decrease by 20 dB, and from 1 MHz to 10 MHz it decreases by another 20 dB, assuming that the antenna response is flat. For MW overloading due to lightning can be improved by using a 500 kHz high pass filter, and for SW by using a 2 MHz high pass filter.



1 TB Hard Drives

When I bought a 1 TB Western Digital My Book for use with Version 1.1B and 800 kHz recording, to my dismay it was terrible because it exhibited continuous "stuttering" when recording, and occasional "stuttering" during playback. When I mentioned this sad state of affairs to Guy Atkins he said he had read SP3 was needed for big hard drives on computers with XP. I downloaded SP3 from a Microsoft web site, installed it, reformatted the 1 TB HD, and it recorded and played back perfectly.

Unfortunately, perfection is often only temporary. With Version 1.1C and 1600 kHz recordings, stuttering was experienced again playing back from external hard drives. The new stuttering was eliminated by using an IOGear eSATA 3 Gbps ExpressCard/34 adapter with the eSATA output of a BlacX hard drive caddy (be aware that some BlacX caddys do not have an eSATA output!). Of course, this required (destructively!) removing the 1TB HD from its case so that it can be inserted into the BlacX HD caddy.