METEOR & Es DETECTION NOTES & TESTS
Updated 5/9/2014 by K1SIX

FT857D/ DEMI TRANSVERTER Frequency Calibration:

Using the WG2XPN GPS disciplined beacon on 70.005.00 Mhz, to produce a 700 Hz tone (the default) in the FT857D, required a frequency setting of 70.005.02. This indicated an initial radio dial calibration error of -20 Hz on 12/18/13. The optional TCXO in use within the FT857D is 0.5 ppm (+/- 35 Hz)/hr at 25°C after warm up. The standard DEMI 4M transverter frequency tolerance is not specified by the manufacturer. The antenna used is a 6 Element VINE yagi mounted 45' AGL at a hilltop location ~ 1,275' ASL at location FN43ad87. ***Note: the FT857D vfo has a tuning resolution of 10 Hz <u>without</u> the use of the clarifier.***

<u>TV4 (Still Analog until Sept. 2015) LPTV & Translator Tests</u>

Predominant sig in RED, 2nd in BLUE. Underlined values indicate an often weak and continuous residual background trace using Spectrum Lab. All tests are in CW mode with a narrow 300 Hz IF filter using Spectrum Lab. Doppler and slight frequency drift must be expected. ***700 Hz is estimated to be very close to the assigned offset frequency based upon the initial calibration shown in the preceding section*** :

67.240 (- offset) CW Test Results (Dial at 67.240.02 to produce 700 Hz= 67.240, 500 Hz Span). Values marked with an "*" show correlation with a nearby 6m beacon):

Careful monitoring for meteor pings at all bearings during the morning random diurnal maximum revealed <u>few regular MS bursts detected</u>. However, a weak continuous trace was noted at 677 Hz peaking to the southwest with no pings. This offset may still be useful for Es and Au events. ***706 Hz was detected <u>only</u> during 50 MHz Es to WSW.***

Likely Stations within 1,500 miles (RED is confirmed):

???: WLCU-CA Campbellsville, KY (EM77hi @ 813 mi. 245°) 70 W ERP
???: WJPS-LP Evansville, IN (EM67ex @ 894 mi. 252°) 100 W ERP
???: CFCLTV4 Hearst, ON (EN89fp @ 709 mi. 313°) **402 W ERP**

67.250 (0 offset) CW Test Results (Dial at 67.250.02 to produce 700 Hz= 67.250, 500 Hz Span). Values marked with an "*" show correlation with a nearby 6m beacon :

Bearing 055°- <u>631, 667 & 823 Hz</u> with Pings at 651, 656. 660, **<u>667</u>**, 671 & **750** Hz.
Bearing 215°- <u>638 & 828 Hz</u> with Pings at 638, 656, **660**, 668, 696, 706, **750** & 779 Hz.
Bearing 235°- <u>638 & 828 Hz</u> with Pings at 656, 660, 668, 675, 696, **750**, **756** & 767 Hz.
Bearing 260°- <u>638 Hz</u> with Pings at 638, 660, **664,** 677, 665, 695 & **752** Hz.
Bearing 280°- Pings at 624, 638, 642, 650, 656, **660**, **666**, 740 & 755 Hz.
Bearing 315°- Pings at 638, 647, 660 & **666** Hz.
Bearing 360°- Pings at **660**, **666**, 676, 734 & 750 Hz.

Likely Stations within 1,500 miles (RED is confirmed):

667?: CJCN-TV Grand Falls, NFLD (GN29ib @ 893 mi. **57°**) **100 kW** ERP
667?: CJCB-TV Sydney, NS (FN96vc @ 612 mi. **66°**) **180 kW ERP**
???: W04CI Appomattox, VA (FM07xg @ 554 mi. **225°**) 62 W ERP
750: WUVM-LP Atlanta, GA (EM73tt @ 929 mi. **230°**) **2.5 kW** ERP
???: W04DE Laurel, MS (EM51lq @ 1,225 mi. **235°**) 100 W ERP

660?: WKXE-LP Knoxville, TN (EM86aa @ 807 mi. **236°**) 30 W ERP
???: WBXF De Moines, IA (EN31eo @ 1,109 mi. **272°**) 15 W ERP
CORRELATIONS (# of times in ( )):
660 (2), 745 (2): W4CBX/B EM86wk 233°
667 (1): Good correlation during VO1VCE (GN37ol) opening
745 (100+!): N4LR/B EM73gn 232°

67.260 (+ offset) CW Test Results (Dial at 67.260.02 to produce 700 Hz= 67.260, 500 Hz Span). Values marked with an "*" show correlation with a nearby 6m beacon):
Bearing 055°- No pings detected
Bearing 215°- No pings detected
Bearing 235°- No pings detected
Bearing 260°- Infrequent weak pings at 702 Hz, 706 & 713 Hz
Bearing 270°- Pings at **702**, 706 (EN61?), 717, **720**, 805 and > **830 Hz**.
Bearing 283°- Infrequent weak pings at **710** & 718 Hz (67.260.018)
Bearing 315°- Unproductive with weak continuous trace at 692 Hz (67.259.992).
Bearing 360°- No pings detected, no residual background signals.
Likely Stations within 1,500 miles (RED is confirmed):
???: WLWP-LP Millsboro, DE (FM28jn @ 361 mi. 210°) 60 W ERP
???: WKPZ-CA Pennington Gap, VA (EM86ls @ 734 mi. 237°) 43 W ERP
???: W04CW Tigerton, WI (EN54nq @ 849 mi. 283°) 251 W ERP
???: CIIITV4 Owen Sound, ON (EN94mk @ 461 mi. 284°) **37 kW ERP**

SPECTRUM LAB NOTES

- PC Speaker Audio can be muted by clicking the FILTER RESPONSE GRAPHIC within the X-Axis frequency ruler then selecting "Mute Output of this Filter" option. There is a noticeable delay between when the MS pings are detected on both the spectrum analyzer and waterfall and when the actual ping becomes audible from the PC Speakers. Muting Spectrum Lab audio and running Spectran in the background just to produce a more real-time PC speaker audio response may be a better alternative for certain applications.
- The double "\\" for the DIR in the script is correct and used as escapes. ***However, the directory must be created first.*** ***In my case, the directory is "d:\\spectrum\\meteorlog\\" as I prefer to keep my data files on a drive separate from programs.***
- **K1SIX.USR** is the normal saved user file.
- Turned off generation of a 600k+ .jpg file for each detected meteor with a REM statement near the bottom of the script. Remove REM for jpg generation!
- Atlanta (929 mi. @ 230°) detection 740 – 760 Hz, THRESHOLD of 15
  Conditional Actions File: **Atlanta_2014-01-05.TXT**
  User File: **Atlanta_MS.USR**
- Removed secondary tests: "& (Test_A & B) " per author recommendations to greatly improve sensitivity for meteor detection. New Conditional Actions File: **Atlanta_2014-01-07.TXT**

- Recalibrated 1/8/2014 @ 13Z: 700 Hz tone on 70.005.000. Set receiver to 67.250.010 and adjusted **Atlanta_2014-01-07.TXT** Conditional Actions File Script to a detection range of 745 – 770 Hz to account for equipment ambient temperature frequency drift, an expected problem with very narrow BW settings.
- The new settings are centered around a 25 Hz BW with a center frequency of 757.5 Hz. For Atlanta meteor counting runs, the receiver vfo was be adjusted so that most pings fall near 757.5 Hz or slightly higher and maintain this center frequency during the duration of any runs. This will ensure minimal false counts from the Doppler shifted 60 Hz sidebands of a nearby "interferer" 90 Hz lower in frequency and compensate for any equipment drift due to ambient temperature. 25 Hz detection BW ***for this environment*** is the maximum recommended. However, 20 Hz BW may offer slightly improved protection from the interferer. The initial goal is to accurately detect radio meteors from only a single known source (Atlanta).
- Due to interference from a birdie, a new file **Atlanta_2014-01-10.TXT** was created with a 20 dB trigger. This is the only change to the file **Atlanta_2014-01-07.TXT.** A test run began on 1/10/2014. The main "interferer" may be centered near 660 Hz in the waterfall and another TV carrier marker at ~ 813 Hz for reference are very obvious.

SUMMARY OF ATLANTA RADIO METEOR TESTS

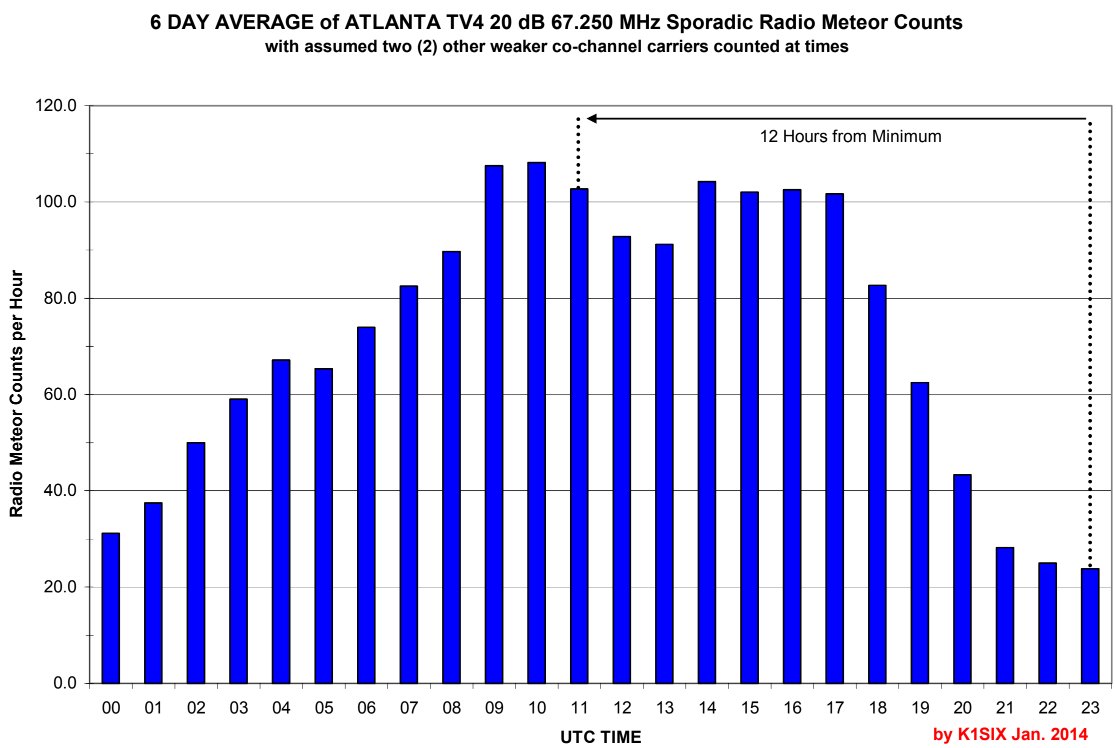
Atlanta is an excellent choice for meteor scatter tests as it is located at a perfect distance of 929 miles for reception on an antenna that is pointed on the horizon. Initial tests revealed successful results in detecting a statistical minimum of ~ 30% of meteors from Atlanta only due to an occasional severe Doppler shifted 60 Hz sideband from a strong over the horizon interferer 90 Hz lower in frequency (approx. < 1% of the time) and up to two other weaker and significantly lower ERP TV stations sharing the same narrow detection bandwidth likely resulting in false counts. Sometimes one or both of these two nearby carriers are enhanced at the same time as Atlanta but not always. Thus, it would take careful analysis of each individual "ping" to more accurately estimate the overall percent of meteors detected from only Atlanta using a 20 dB threshold. It is possible that a higher threshold and/or adjusting the presently disabled Test A and Test B parameters may improve accuracy and further experimentation is required.

During these tests the receiver had to be step adjusted, at intervals based upon the rate of ambient temperature change, +/- 10 Hz from a center frequency to ensure detection in a very narrow 25 Hz bandwidth, centered to produce a 757.5 Hz tone, to compensate for both receiver and transverter oscillator drift. A clarifier was never used. The human intervention factor requirement indicates that a completely automated detection system ***may not be possible*** unless the ambient temperature is more tightly controlled. The equipment room has the thermostat turned down to 13 C° and is not air conditioned. In winter, this room can experience an ambient temperature swing from 17 – 28 °C if the door is left open as it was during these tests. It is believed that increasing the detection bandwidth beyond 25 Hz in this interference environment as compensation is not an option and would only result in more false counts.

The averaged diurnal ratio of minimum to maximum sporadic meteor counts for the above six tests was 4.54 which meets or exceeds expectations. The results are plotted as ***Figure 1*** below. Some points of interest:

- Minimum counts average during the 23:00 UTC hour period which should imply a peak hour of 11:00 UTC hour.
- There is subtle evidence of a double peak either side of the 11:00 UTC hour. The first being during the 10:00 UTC hour with a secondary peak during the 14:00 UTC hour. Reduced counts in between these times could be due to a high elevation angle of the most influential radiant(s) for the primary path and path midpoint of interest.

Figure 1. Plot of 67.250 Atlanta Reflections



OBSERVATION

There is very strong correlation between the Atlanta 67.250 MHz meteor scatter signal and the meteor scatter signal received from the N4LR 50.068 MHz beacon located within 65 miles of the TV 4 site. Almost always, when a "ping" is received from the N4LR beacon, a "ping" will be received from the Atlanta TV 4 station. Sometimes there is a delay of up to ~ 2 seconds. Very often after the 67.250 MHz signal fades, the 50.068 MHz beacon is still received for a few seconds longer. For meteor scatter, the MUF rises very rapidly. This would unlikely be the case for Es. So, it would seem that for those interested in early Es detection, the use of a second "anti-coincidence receiver", significantly higher in frequency than the main receiver, may assist in weeding out MS propagation from Es propagation very quickly. In the above case, the two receivers are separated by 17.182 MHz.

CLICK HERE FOR A WEB PAGE with the ATLANTA TEST RESULTS

WG2XPN 70.005 MHz BEACON TESTS

The experimental WG2XPN CW beacon on 70.005 MHz is a 3 kW ERP GPS disciplined base station with a 3 element yagi, pointed on the horizon at a heading of 60° true. It is located along the Blue Hills area of Virginia, near Buchanan, at locator FM07fm at a bearing of 228° true which is only 2° deviation from Atlanta and a less than optimum distance of only 558 miles. However, there are no presently known interferers near this frequency except an infrequent rise in the background noise floor during strong Es when existing digital TV4 stations become enhanced. Therefore it may be possible to increase the detection bandwidth to compensate for receiver drift and reduce the threshold to 15 dB or lower in an effort to detect radio meteors from a single known source to near 100% accuracy. It is also possible that there could be strong correlation to the diurnal variation experienced for the Atlanta tests due to the similarity of bearings from the receiving site. However, with a short distance of only 558 miles, it is also possible that there is an elevated risk of aircraft reflections causing elevated counts. The direct path midpoint was calculated to be grid FN20bj, above Reading, PA.

Initial Setup:
LOW= 600 Hz, High= 800 Hz for desired center frequency of 700 Hz, 200 Hz BW
THRESHOLD= 15 dB
Conditional Actions File: WG2XPN_2014-01-17.TXT
User File: **WG2XPN_MS.USR (with noise sample displayed on unused button)**

RESULTS AND OBSERVATIONS FOR TESTS WITH WG2XPN BEACON

The equipment room temperature range during the test period was 62.9 – 85.1 °F and the goal was to ensure that accurate detection was maintained across a 200 Hz bandwidth with as little human intervention as possible. Based upon past experience, the receiver VFO was set to a frequency of 70.005.010 (10 Hz high- a "sweet spot" for the ambient temperature range experienced in the equipment area during winter) and left running there for as long as possible until such time that combined receiver and transverter oscillator drift indicated a risk of lost detection. Tuning never had to be retouched during the entire duration of the tests. However, with no air conditioning in the equipment room, it is possible that a new "sweet spot" will be required for summer temperatures.

On 1/18/14 starting around 2200 UTC, infrequent and sometimes pulsing noise bursts were noted that caused some false counts and blocked some detection. Some of this is believed to be from other TV4 ***Digital*** TV stations enhanced by MS propagation which would show up as noise. Further evaluation indicated that this should be expected to occur at any time and if truly random and evenly distributed; should have minimal impact on overall radio meteor counting results. However, raising the detection threshold above the very sensitive 15 dB to mitigate as much impact as possible may provide higher quality overall results. The Spectrum Lab counting script application already includes effective ***smoothed*** noise averaging (NOI) and it is exceeding a threshold value (THRESHOLD) above the background noise that will trigger a count or at least the first step in determining if it really is a meteor (IF SIG > NOI + THRESHOLD then…).

Starting on 1/21/14 and during very cold (0 °F and below) the 70 MHz noise floor was elevated by approximately 10 dB. This is likely due to power line noise. Only the stronger meteor bursts were counted. On 1/23/14 and 1/24/14 pulsing noise was noted that was causing many false counts. It is extremely difficult to resolve meteor bursts when the background noise floor changes abruptly. RMOB files were manually edited to delete the defective data that was being uploaded to RMOB.ORG. This continued until the counts for sporadics returned to what was believed to be a normal pattern. However, during periods of extreme cold, system sensitivity will likely suffer dramatically due to what is believed due to elevated power line noise. Detection of the diurnal variation of sporadics is always considered a benchmark for quality of data.

On 1/27/14 under warmer temperatures and a near normal noise floor, a weak trace (birdie?) was noted at 624 Hz which is within the 600 - 800 Hz detection window. Its level would sometimes rise to just slightly over the 15 dB counting threshold. This combined with a concern of false counting pulsing noise, aircraft scatter and double/triple counts sometimes during overdense bursts indicates that a 15 dB threshold is too sensitive in this environment.

The overall ***average*** of 7 days of testing with a 15 dB threshold was a daily count of 2,039. The ***average*** for daily minimums was 42 with ***averaged*** daily maximums of 128. These averages were placed in the Average for 15 dB Column of a test spreadsheet for comparison purposes for the next series of tests. Please refer to ***Figure 2*** below.

18 dB THRESHOLD TESTS

The WG2XPN_2014-01-17 Conditional Actions file was modified by only changing the threshold value from 15 dB to 18 dB and saved as **WG2XPN_2014-02-01**. The overall ***average*** of 6 days of testing with an 18 dB threshold was a daily count of 1,040 with a diurnal ratio of 5.27. The ***average*** for daily minimums was 16 with ***averaged*** daily maximums of 79. The 3 dB increase in threshold value eliminated most if not all false counting from pulsing external noise, some double counting and some counting of weaker aircraft scatter returns but both still occurred. The results of both 15 and 18 dB tests are plotted as ***Figure 2*** below. 15 dB threshold averages are shown in **PLUM** and 18 dB threshold averages in **DARK BLUE** ***for a direct heading***.

COLORGRAMME RMOB LAB

On the afternoon of 1/18/14, Colorgramme RMOB Lab v. 2.8 was installed and tested. As of that date, automatic hourly meteor counts were being sent to the RMOB.ORG server at 5 minutes past each hour. Spot checks to ensure proper frequency netting are accomplished regularly. RMOB.ORG is an excellent source of information, tools and references that can assist others in providing high quality radio meteor data that could be of great value. On 1/23/14 RMOB Lab was upgraded to version 2.9.

AZIMUTH OFFSET

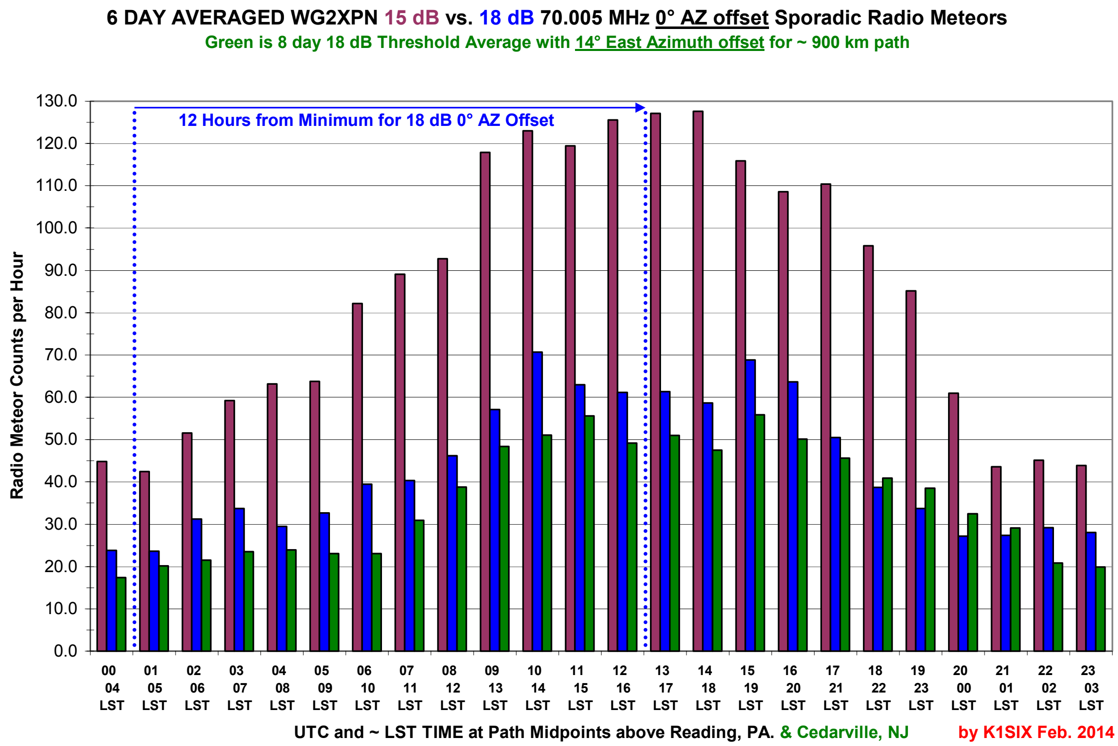
The WG2XPN beacon 3 element yagi antenna is set at an azimuth of 60° true which is 17° south of my true reverse bearing of 43°. Based upon theory for a 900 km path and a common reflection altitude of 95 km, an azimuth offset of 14° is recommended. Beginning on 9 February at exactly 1200 UTC, near the estimated peak for this link, the 6 element yagi antenna azimuth at this end was moved 14° south to a new bearing of 214° true in an attempt to capture more candidate sporadic meteor trails while reducing potential aircraft scatter returns. This moved the new common reflection midpoint from above Reading, PA in Grid FN20bj to above Cedarville, NJ in Grid FM29ji, 80 miles to the southeast. Any variation in counts was evaluated in the Colorgramme RMOB Lab data by comparison against readings during previous February dates. The total count for eight 24 hour periods prior to the bearing change was ***7,968*** (***Noise Average -59.3 dB***) and for the eight 24 hour periods immediately as possible following the change was ***6,865*** (***Noise Average –62.2 dB***) representing a 13.8% reduction in counts with a lowered noise floor of ~ 2.9 dB. However, the averaged diurnal ratio improved to 5.99:1 at the offset bearing. Aircraft scatter reflections from the direct bearing versus the offset bearing were not evaluated but both midpoints have significant large aircraft traffic at altitudes greater than 25,000 feet based upon Flightradar24.com data. Periods of high noise degradation, shown in red, at ***<u>any time</u>*** were discarded:

Feb. 11, 2014 (Low Temperature 3.5 °F.) Average noise -54.8 (12.1 dB)
Feb. 12, 2014 (Low Temperature -0.2 °F.) Average noise -54.2 (12.7 dB)
Feb. 13, 2014 (00 – 03 UTC Low Temperature 12.3 °F.) Average noise -54.3 (12.6 dB)
Feb. 21, 2014 Ice storm and high VSWR with noise floor of only -77 dB

The lowest hourly noise floor experienced during the entire testing period was –66.9 dB and the highest was –49.2 dB representing potential noise degradation spread of up to 17.7 dB! The estimated impact of noise degradation to assumed stable count values is shown in ***Figure 4*** below and the averaged results of 8 days of testing at the offset bearing are plotted against the other tests, in color **GREEN**, in ***Figure 2*** below.

Figure 2 also shows evidence of a double maximum, believed to be due to high elevation angles (> 55°) of the most influential radiant(s) for the primary path and path midpoint of interest combined with vertical antenna patterns. That evidence is strongest for the direct (**BLUE**) path and more subtle and shifted in time for the offset path.

Figure 2. Comparison of WG2XPN/B Averaged Test Results



NOISE DEGRADATION ESTIMATES

As the background noise degradation has a profound impact on the meteor counts for any given hour and on the diurnal distribution as a whole if it varies from hour to hour, I decided to analyze the impact as accurately as possible. Each observer will likely realize a unique result depending upon the fade margin and ERP of the source signal(s) being received. The measurements were conducted when the majority of detected meteors were "sporadics" and any influencing meteor showers were at a minimum.

To accomplish this task, I utilized a spreadsheet to determine the lowest noise floor ever experienced on an hour by hour basis versus the highest counts ever achieved on an hour by hour basis, across the entire dataset to develop a baseline assumption that the lowest noise degradation would result in the maximum possible counts. The maximum counts ever experienced during these tests are shown in ***Figure 3***.

Next, I created an array for plotting that assumed that 0 dB degradation would result in maximum counts with the actual sampled noise floor in dBm versus the lowest recorded hourly noise floor in dBm resulting in the actual value of degradation in dB.

Finally, an Excel "stock chart" was created as ***Figure 4*** showing the minimum, maximum measured "spreads" and median value of counts ***as a percentage of maximum expectation*** versus dB of noise degradation rounded to 1 dB resolution.

Although far from perfect, this plot gives me a pretty good idea as to what to expect for sporadic meteor count "distortion" under varying noise floor conditions which at this particular location can be particularly troublesome at times, depending upon the weather condition influence upon rural power line hardware. It's not a pretty picture and this is certainly not an observatory by any means!

Figure 3. MAXIMUM Counts Experienced during Noise Testing

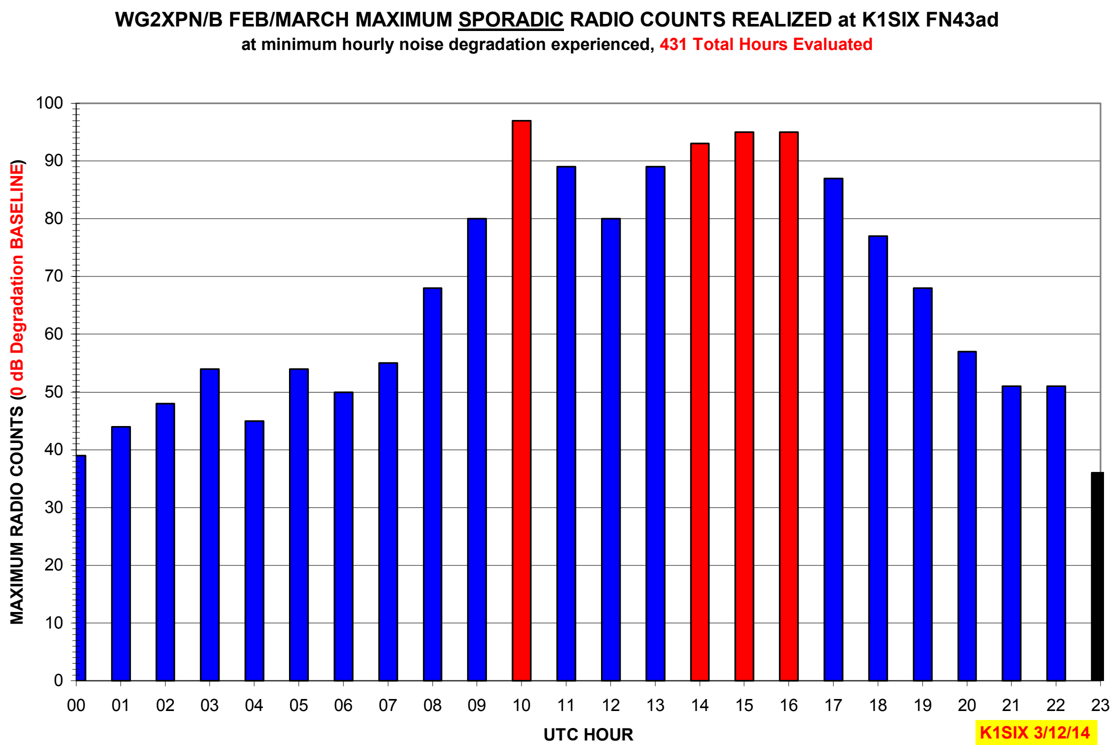
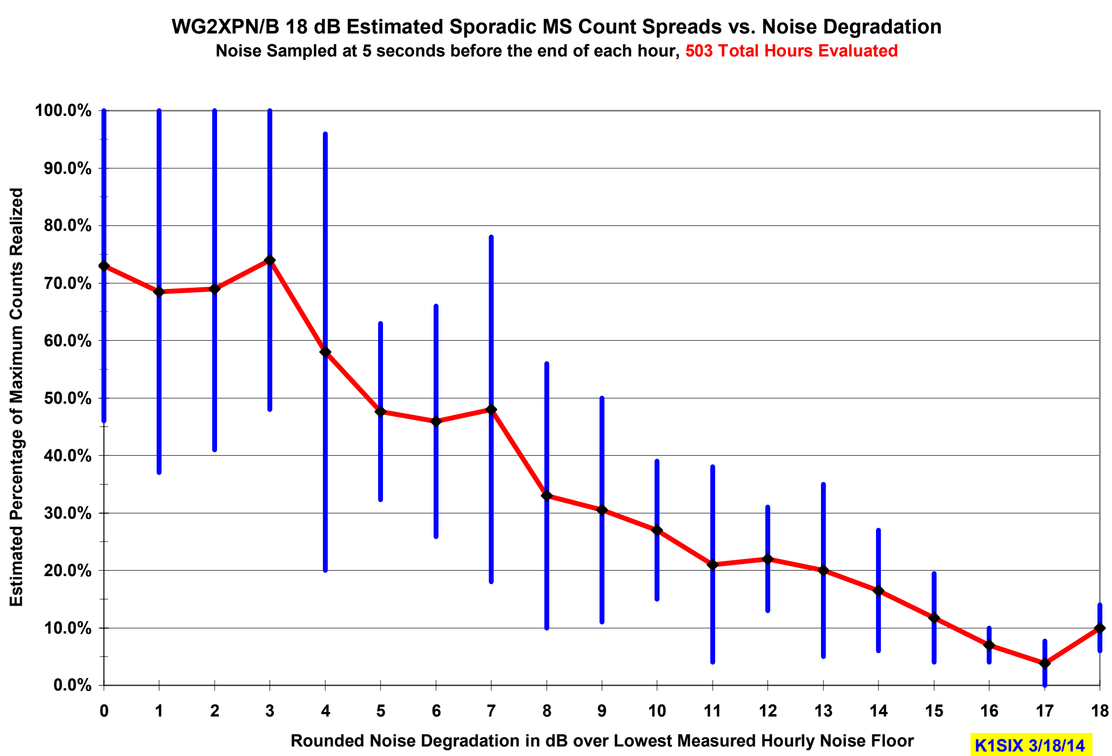


Figure 4.Estimated Noise Impact on Counts



CLICK HERE FOR A WEB PAGE with WG2XPN/B INITIAL TEST RESULTS

ATTEMPT AT DETECTION OF THE APRIL LYRIDS

The counting system was left running and automatically uploading data to RMOB.ORG at 5 minutes past each hour during the Lyrids maximum, using the single source 70 MHz WG2XPN beacon as a target for detection. Although there was some indication of elevated counts during the 1100 UTC hour, the evidence of detection of this minor shower is unconvincing. This is primarily due to a constantly changing background noise floor during the test period combined with the fact that this is a minor shower combined with the fact that even background sporadics can show some variation day-to-day.

ATTEMPT AT DETECTION OF THE MAY ETA AQUARIDS

This shower was predicted to show peak radio activity near the same time of peak activity from sporadics with a secondary peak from 1700 – 1830 UTC for the path tested. For a few days in early May, significant elevated activity was noted only during the 1700 – 1900 UTC that may or may not have been associated with this shower. Counts were expected to be low as the radiant for this shower has a southern declination. As usual, the noise floor varied between 0 to 15 dB above quiet during the 7 day testing period making any real evaluation impossible without more extensive research.

NEXT: An attempt at detection of the May (24) 2014 Camelopardids

TAKE AWAY NOTES

- External noise floor fluctuations will greatly contribute to count fluctuations and destroy any chances of providing high quality data. A carefully optimized external attenuator may help to mitigate this problem.
- Although many multiple counts have been eliminated, there are still some double and triple counts depending upon the timing of fading intervals.
- A threshold of 20 dB vs. 18 dB should be evaluated in the future.
- For this particular system, a detection bandwidth of +/- 100 Hz works well and requires no retuning or operator intervention for long duration automated counting periods.
- ***The A&B meteor tests need to be evaluated and optimized. They were disabled for these tests.***
- At present, this system WILL count lightning strikes. Perhaps sampling well outside the primary detection bandwidth, as part of a test, could red flag these events and prevent counting them.
- A properly optimized system should never experience zero counts for sporadics during any one hour period. However, more is not necessarily better. A major shower could saturate a system that counts many hundreds of background sporadics per hour. Careful adjustment of threshold values and external attenuation values to ensure worst case single or low double digit counts should greatly improve the quality of data.
- Even though initial tests indicate reduced counts from the WG2XPN beacon using the recommended 14° offset bearing, I must assume that known science is correct

and that my tests simply did not take in a sufficient sample period. As the sporadic minimum counts are adequate, the diurnal variation appears to be “cleaner” and the bearing is along the east coast rather than more inland which could attenuate more potential interferers, I have chosen to utilize the offset as the bearing of choice.

- Aircraft reflections need to be evaluated in the future.

These technical notes are not designed to be a “White Paper”. These are my own personal notes for future reference. Hopefully some of this information may be of value to others. There are many resources available on the Internet to assist in further research.

Best regards,
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