SUN NOISE

SOLAR FLUX

MEASUREMENTS

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SUN NOISE and Measurements

Aim

This paper discusses the application of use of Solar Flux values to provide evaluation of a Receive Systems performance and to make improvements where found to be deficient. Various methods of measurement are provided for most Amateur applications.

Sun Electromagnetic Noise

The Sun generates considerable Electromagnetic noise and this noise can be used for the calibration of receive equipment by the application of Y factor measurements. In this case the Y factor measurement is the difference between two known noise sources, the Sun and a Cold Sky or some other known reference source.

Frequencies used for Noise Measurements

Eight receive frequencies have been chosen to provide specific levels of noise and these are used to further derive the corrected sfu values by inter and extrapolation.

The Sun is what is called a broadband emitter, that is, it gives off radiation over a very wide frequency range. The Learmonth[1] solar radio telescopes monitor both the quiet and active Sun, at 245, 410, 610, 1415, 2695, 4995, 8800, and 15400 MHz.
The origin of the Solar noise can be related to 245 MHz the Lower Corona, 410, 610 and 1415 MHz the Upper Chromo sphere , 2695 and 4995 MHz the Middle Chromo sphere, 8800 and 15400 MHz the Lower Chromo sphere.

Y Factor

Given that you know the Solar Flux you then are able to derive a Y-Factor. This is achieved by pointing your antennae at a Quiet Source (Aquarius) and then at a Noise Source (the Sun). The difference, as a ratio, in noise output is the Y-Factor. If Noise Temperatures are used for both sources (degrees Kelvin) then the receiver noise temperature (Te) can be calculated using the Y factor (Thot – Tcold ratio) by using the following formulae: Te = (Thot-YTcold) / (Y-1)

VK3UM EME and Receiver Performance Calculator.

It is not necessary to perform these calculations as they are provided in my EME Calculator and Receiver performance Calculator[2] where the measurements you make can be compared with the theoretical figures derived by the software and the parameters of your receiving system. All you need to measure is the Y-Factor.

Additional Help.

In this paper I do not intend to delve into the program however an extensive Help file is integral to the software and provides all the detail required to input your own data and interpret the results you obtain. You may thus reverse Engineer your data to locate possible areas needing attention to improve your receive system performance.

Solar Flux. (sfu). The reference Solar Flux is measured at 10.7cms and is given in solar flux units. One solar flux unit = 10^{-22} watt per square meter-hertz. 1 sfu = 10,000 Jansky.

The current Solar Flux value may be obtained from **Learmonth Solar Observatory** in Western Australia. This installation is part of Ionospheric Prediction Service (IPS), and is a unit of the Bureau of Meteorology. It is jointly operated by the Radio and Space Services and by the US Air Force. The Learmonth observatory is the site of one of six solar velocity imagers in the world-wide GONG (Global Oscillation Network Group) network operated by NOAO (U.S. National Optical Astronomy Observatories). Observatory sites are located at Learmonth, Australia 22.13S 114.60E 0500 San Vito, Italy 40.40N 17.43E 1200 Sagamore Hill, North America 42.38N 70.49W 1700 Palehua, Hawaii

Learmonth provides the data in the following format and can be downloaded from http://www.ips.gov.au/Solar/3/4/2

Quiet Solar (IFLUX)

```
Last updated 10 Jun 2008 07:30 UT


IFLUX : Background Solar Radio Flux
-----------------------------------

Station     Date      Time     Status     Freq    QS flux    Quality
Learmonth   10/06/8   03:37    final       245       10        good
                                           410       25         ?
                                           610       34        good
                                          1415       47        good
                                          2695       63        good
                                          4995      127        good
                                          8800      219        good
                                         15400      520        good



================================================================================

Interpolated value for 1300MHz: 45.5
Interpolated value for 1540MHz: 48.8
Interpolated value for 1707MHz: 51.2
Interpolated value for 2300MHz: 58.6
Interpolated value for 2401MHz: 59.8
Interpolated value for 2790MHz: 65.5
Interpolated value for 5625MHz: 142.4
Interpolated value for 6000MHz: 151.5
Interpolated value for 8000MHz: 199.8
Interpolated value for 8200MHz: 204.6
Interpolated value for 9410MHz: 242.9
Interpolated value for 10400MHz: 283.5
```

Deriving of sfu values.
With the assistance of the Australian Government IPS Service and John (VK5DJ)[3] we
have been able to derive from actual sfu measurements, a method commensurate with
the IPS, which now provide, by interpolation and extrapolation, sfu figures based on
actual daily measurements.

 This has been a significant break through as previous calculations were only accurate
over a small sfu range. The ability to perform this calculation with complete accuracy
has been the "Holy Grail" I had been trying (unsuccessfully) to achieve for many
years.

When you click on the 'Get latest IPS figure' the following screen will be displayed.
This screen displays the last IPS data file stored.

The above data is automatically downloaded and processed by the VK3UM EME and
Receiver performance Calculator.

In the above example the sfu is 63 (2695MHz). You can see that the value for 410
MHz has a suffix (?) which indicates that the values have not been confirmed. In
practical terms the values are of sufficient accuracy for our purposes however the
software also highlights (in red) all the extra/interpolated derived values may not be
absolutely correct.

Accuracy of Interpolated and extrapolated values.
Interpolation values will provide a good level of accuracy from 245MHz to 15.4GHz.
Extrapolation values may not provide sufficient accuracy below 245MHz or above
15.4GHz. Accordingly
    -   At 144 MHz the accuracy may be compromised at low sfu values.
    -   It is not a practical (accurate) method of measurement at 50MHz.

The following is an example from the **NOAA** site[4] :-

http://www.swpc.noaa.gov/ftpdir/lists/radio/rad.txt

```
:Product: Solar Radio Data              2day_rad.txt
:Issued: 2332 UTC 04 Jun 2008
#
# Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center
# Please send comments and suggestions to SWPC.Webmaster@noaa.gov
#   Units: 10^-22 W/m^2/Hz
#   Missing Data:  -1
#
#     Daily local noon solar radio flux values - Updated once an hour
#
  Freq  Learmonth  San Vito  Sag Hill  Penticton  Penticton  Palehua  Penticton
   MHZ   0500 UTC  1200 UTC  1700 UTC   1700 UTC   2000 UTC  2300 UTC  2300 UTC


2008 Jun 3
    245        10        15        10         -1         -1       11         -1
    410        27        -1        23         -1         -1       23         -1
    610        36        -1        30         -1         -1       35         -1
   1415        51        53        53         -1         -1       53         -1
   2695        63        60        62         -1         -1       63         -1
   2800        -1        -1        -1         66         66       -1         66
   4995       126       121       125         -1         -1      116         -1
   8800       218       211       224         -1         -1      210         -1
  15400       530       476       451         -1         -1      479         -1


2008 Jun 4
    245        11        16         4         -1         -1       11         -1
    410        37        -1        22         -1         -1       16         -1
    610        36        -1        30         -1         -1       35         -1
   1415        54        52        52         -1         -1       53         -1
   2695        62        58        63         -1         -1       64         -1
   2800        -1        -1        -1         66         65       -1         -1
   4995       127       121       115         -1         -1      116         -1
   8800       217       218       194         -1         -1      211         -1
  15400       530       473       229         -1         -1      478         -1
```

Note the missing data is shown as a -1. This can be due to fact that there is no Sun visible at the measuring Centre, given the time of year and Latitude of the site in question. Your author has considered the possibility of using the available valid data from all sites and providing a composite average. It could be of use to those outside Australia who may not have coincident Sun at the time of the Learmonth measurement. We still require real time measurement data and I am currently negotiating a possible solution.

Sun Spot Numbers

For those more familiar with Sun Spots the relationship between sfu and Sun Spot numbers can be derived from the following equation where the 10 cm.

flux =F ….   Sun Spot number = R ….. FD = F - 67.0.

The equation is valid on a statistical (average) basis.

$F = 67.0 + 0.572\ R + (0.0575\ R)^2 - (0.0209\ R)^3$
$R = 1.61\ FD - (0.0733\ FD)^2 + (0.0240\ FD)^3$

This may be seen in the following graph.
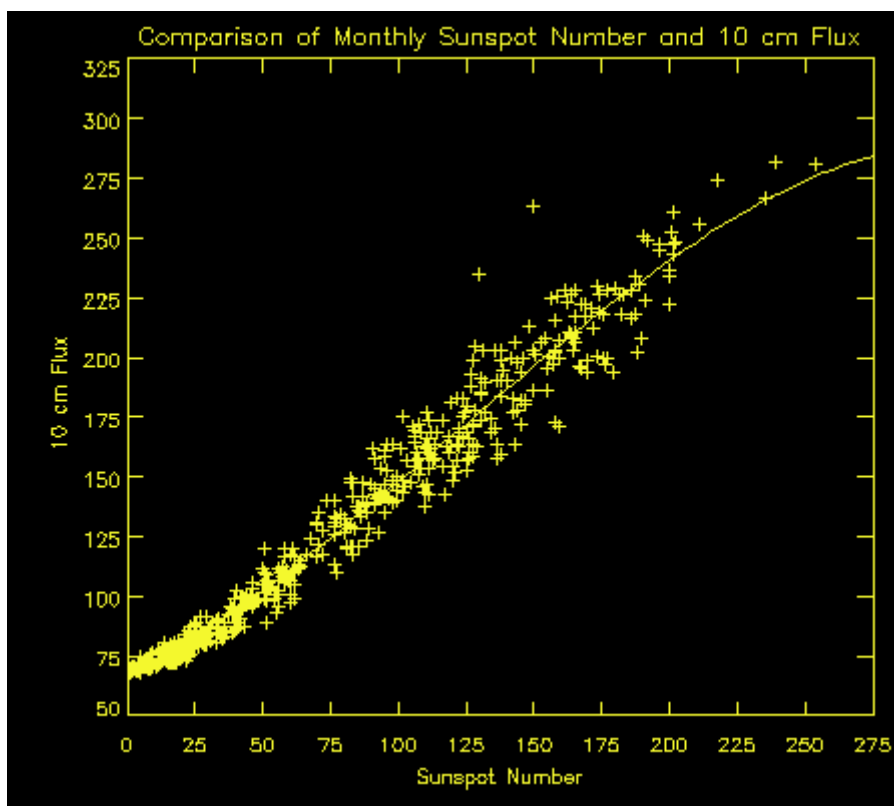
Hourly IPS sfu Plot

You may have noticed that the Solar Flux value is presented as IFLUX and is background Solar Radio Flux averaged over that day.

It is generally of sufficient an accuracy to provide accurate interpretation of the Y-Factor measured.

However during periods of active Sun, instantaneous values of sfu will greatly effect your measurements. In the following example of Friday 7th December 2007, it can be seen that there has been a significant increase of noise measured at 410 MHz whilst the other receiver frequencies remain relatively constant. On major flares all frequencies will most likely exhibit simultaneous peaks of noise.

Care should be exercised if you measure Y-Factors abnormally greater than those predicted. It is likely they may be caused by a flare.
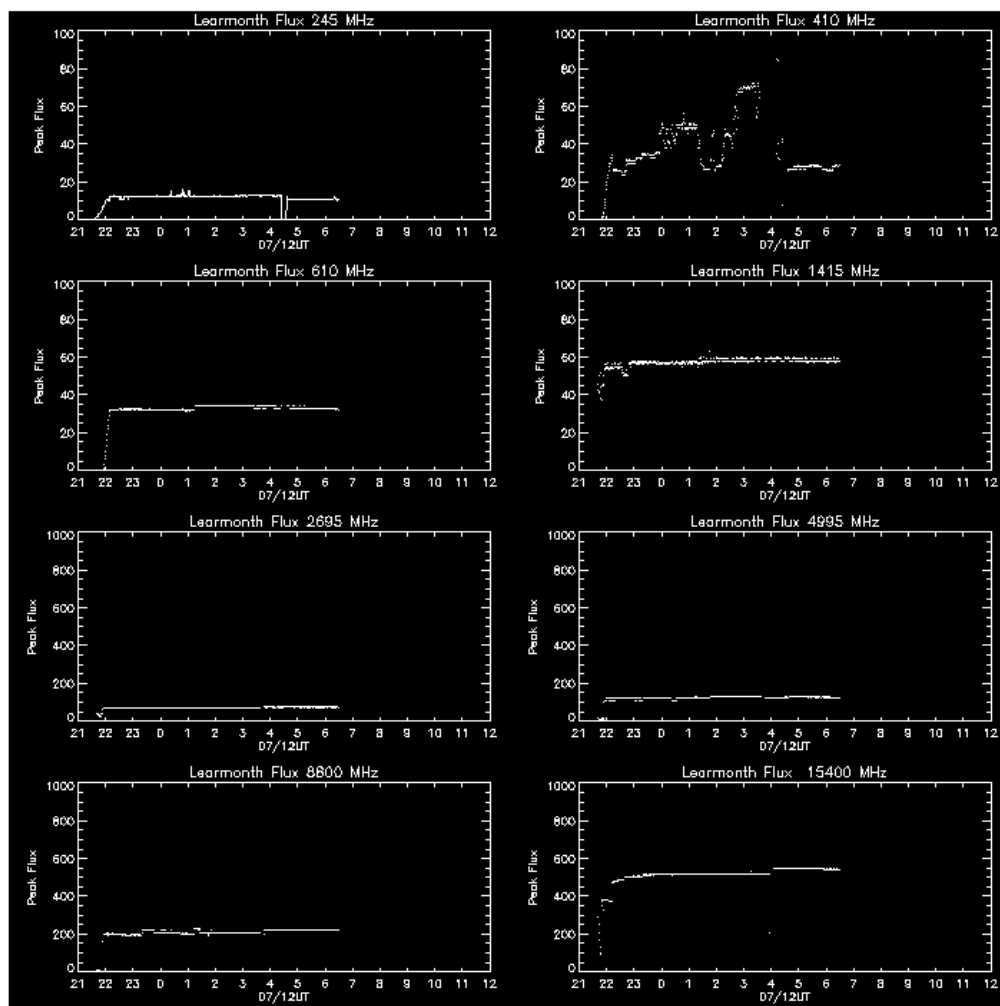
Solar Flare Event.
The following is an event I recorded on 432 MHz during 28th and 29th October 2003.

It was interesting to note that the IPS did not give a confirmed IFLUX value (estimated 235 sfu) on this date.

From my recordings I estimated that the sfu actually peaked well in excess of 500 sfu.

It is my belief that there appears to be some degree of uncertainty of values in excess of IFLUX values of 250 sfu.

Sun Flare 28/29 Oct 2003
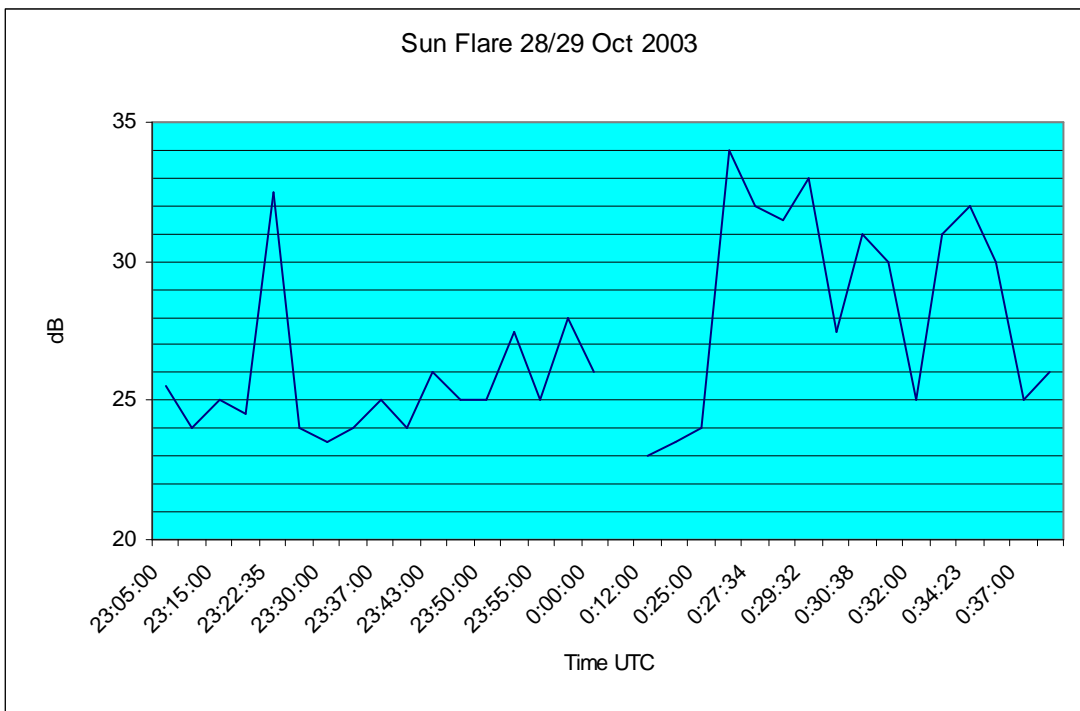
Expected values of Sun Noise (Y-Factor)

The following Table and Graph provides the relationship between antennae Gain in dB for 23 and 70 cms as well as 2 meters for a sfu of 62. This can be considered as the minimum values, given that the sfu is the lowest sfu of the cycle.

SFU 62

SunNoise dB	23cm C/S = 8°K Ant Gain dBD	Dish Size	70cm C/S =20°K Ant Gain dBD	Dish Size	144MHz Ant Gain dBD	C/S = 195°K Dish Size	Yagi
0							
1	10.9		4.3		9.0		
2	14.6		7.9		12.5		
3	16.8		10.2		14.7		
4	18.6		12.1		16.5		
5	20.1	1.3	13.5	1.8	18.1	9.1	2x16dBD
6	21.6		15.1		19.4		
7	23.0		16.3		20.7		
8	24.2		17.5		22.0		
9	25.3		18.7		23.1		
10	26.4	2.7	20.0	3.8	24.3	18.7	8x16dBD
11	27.5		20.9		25.3		
12	28.6		22.0		26.4		
13	29.7		23.1		27.5		
14	30.7		24.1		28.5		
15	31.7	4.9	25.2	6.9	30.2	34.5	32x16dBD
16	32.8		26.2		30.6		
17	33.8		27.2		31.6		
18	34.9		28.3		32.6		
19	35.9		29.2		33.7		
20	36.9	7.6	30.2	12.4	34.5	62.4	96x16dBD
21	38.0		31.3				
22	39.1		32.3				
23	40.1		33.3				
24	41.2		34.3				
25	42.4	16.8	35.4	22.5			

SUN NOISE v ANTENNAE GAIN
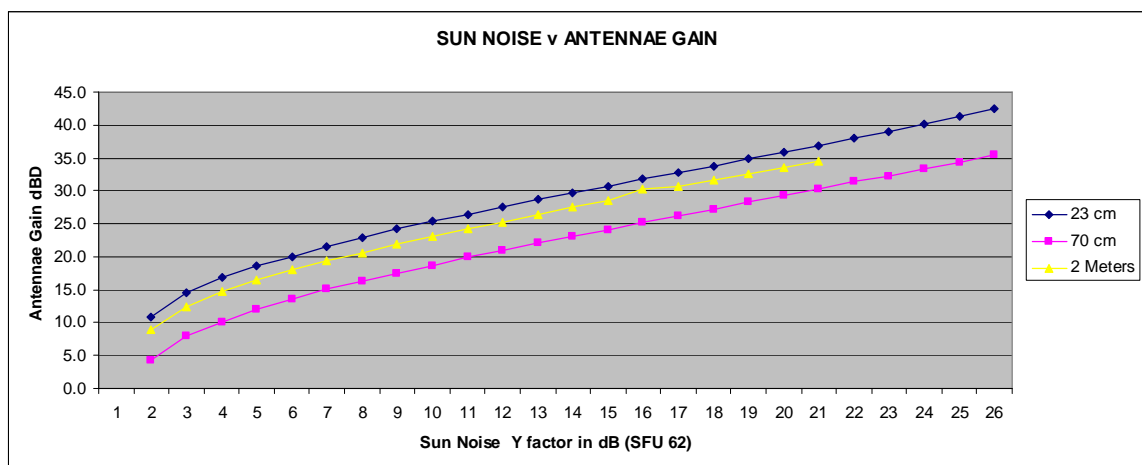
Determining Cold Sky
One of the most important measurements is the calibration of the Cold Sky reference necessary in establishing the low point of your Y-Factor calculation.

- This will pose the greatest problem for most Amateurs.
- The unknown value of Man made noise as well as trees buildings can effect the accuracy of your measurement.
- Knowing the characteristics of your antennae is paramount. (F/B side lobes etc …. i.e. its G/T)

It is essential to know the characteristics of your antennae. Knowledge of the actual gain, side and rear lobes are paramount. Side and rear lobes will add additional noise to the Quiet Sky figure. Software or manufacturers specifications can provide you with this information but it is best confirmed by actually plotting the characteristics of the antennae. This can be done by using the Sun as a source or that of a beacon.

The Sun is especially useful as you can use its drift to measure amplitude/angle. Knowing these parameters you can calculate the gain by :-

gain (dBi) = 10 log (32,027)/(°E*°H)

where E (plane) and H (plane) are the 3dB beam width points in degrees.

The VK3UM EME Calculator can also be used by varying antennae gain and noting beam width figures.

The **VK3UM Planner**[5] will provide you with the real time position of Cold Sky (Aquarius) as well as the Sun. It is best to choose a time when the Sun and Aquarius are well separated and of the greatest elevation in the Sky. The Planner will also allow you to step forward in time to ascertain the most appropriate time.

Those with large gain antennae will not be limited to the same extent as those with smaller antennae operating on lower frequencies.

Be aware however to avoid periods when the Sun is close to the Milky Way as the added background noise is additive and will provide inaccurate (greater Y-Factor) results. This occurs between November and February when the Sun transits the Milky Way.

It can be seen from the following example from the VK3UM Planner the Moon is positioned in front of Aquarius on 5th July whilst the Sun is shown at a similar position on the 6th August 2008. When the Moon is positioned in front of Aquarius it is an excellent time to perform Moon noise measurements. When the Sun is similarly placed then it is best to use Pictor as a Quiet Source.

Background Sky Noise Examples

VK3UM EME PLANNER .. Sat 5th July 2008

VK3UM EME PLANNER DECEMBER 13 .. Note where Sun is with respect to the Milky Way.
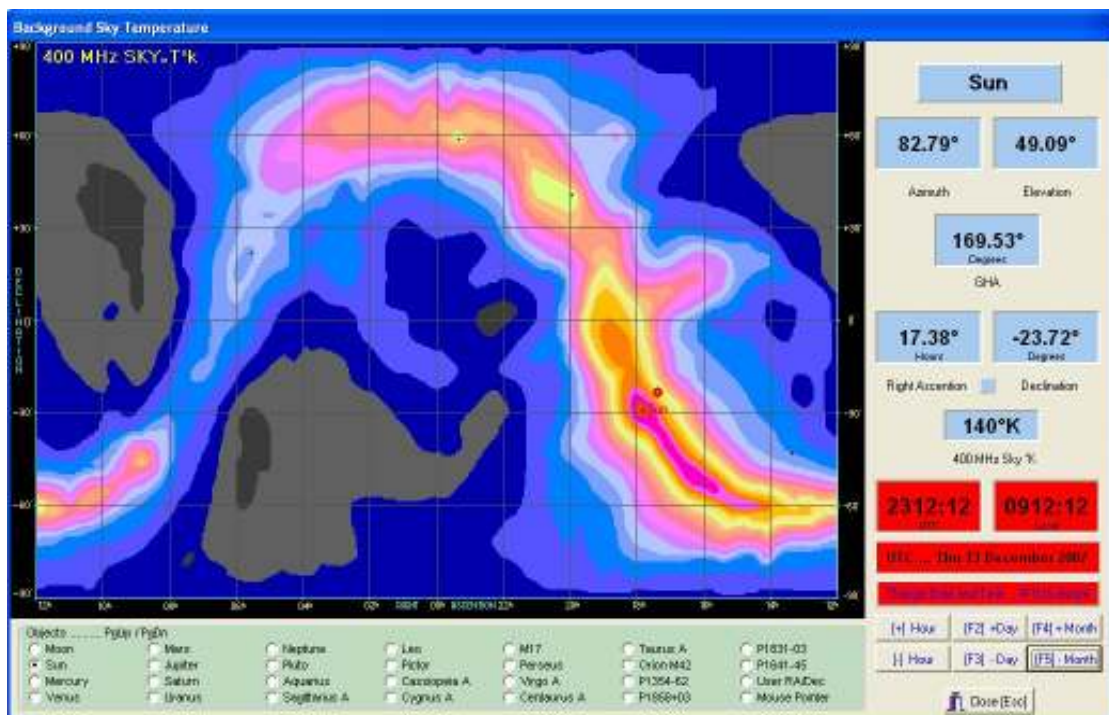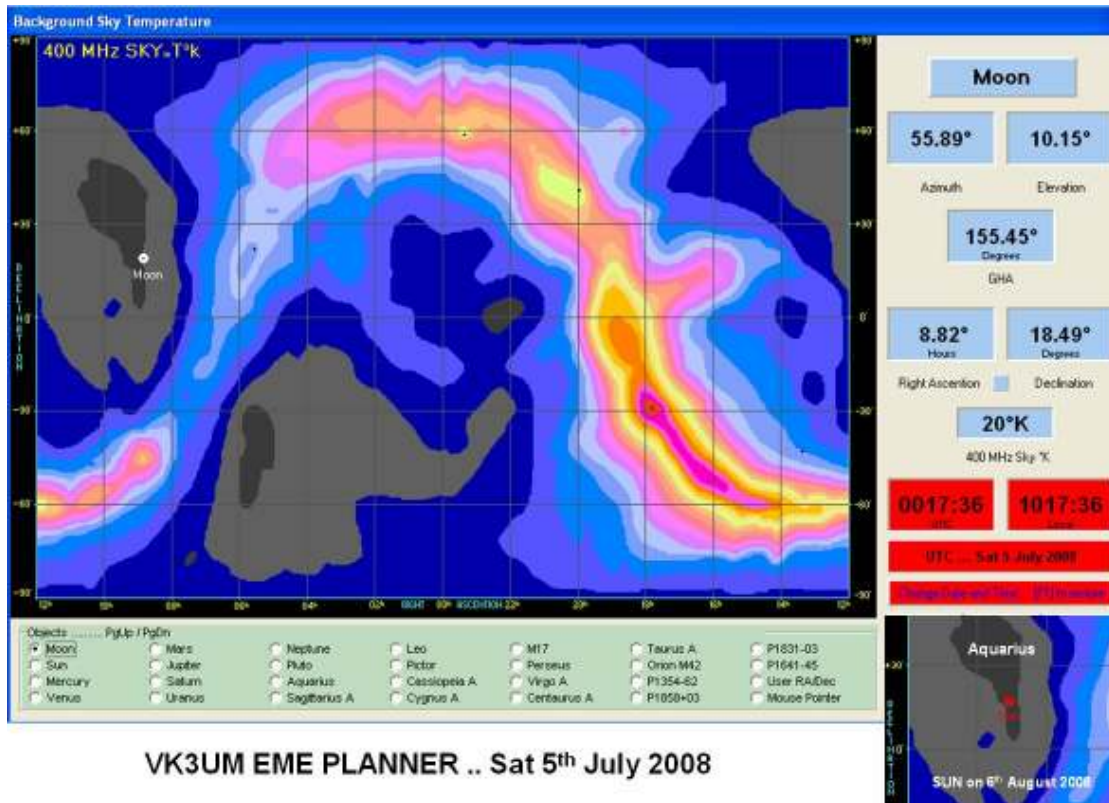
Methods of Measurement

What ever method you choose you will require absolute linearity over the expected range you are attempting to measure.

Band MHz	Antenna Gain dBD	Expected Sun Noise in dB
144	16.5	4.0
432	17.5	8.0
1296	26.5	10.0

The above table provides an indication of what overall receiver linearity is necessary. If you have a 2.7 meter dish on 23 cm you will expect to see ~10dB of Sun Noise and your receive system must be linear (at least) over that range.

Notes Measurement. Hints

- The pass band filter or Inter-digital Filter (IDF) is most desirable to reduce adjacent channel signals and IF images. A suitable design for such a filter is provided by the VK3UM Interdigital Filter[6].

- Measurements should be conducted in the widest practical bandwidth where possible. SSB or AM bandwidth should be chosen for multimode transceivers or receivers. Preferably conduct all measurements when Sun is near the zenith and check for possible additional background noise (Celestial).

- Overall receive linearity is essential to the end result accuracy of the measurement. Cross check your linearity by using switched attenuators and a known signal generator.

- It is possible to achieve 25dB linearity with most transceivers when measured at AF by careful setting of RF Gain (normally minimum required) and AF gain to maximum.

- Check the accuracy and linearity of your switched attenuator. It may well be unsuitable at 23 or 70 cm but accurate at your HF intermediate frequency.

- The use of 2 stage LNA's is desirable (>28dB gain) over single stage versions for better overall system linearity.

- Down converters can be a linearity problem and the level fed to them should be appropriate to the mixer conversion characteristic of the unit.

METHOD # 1
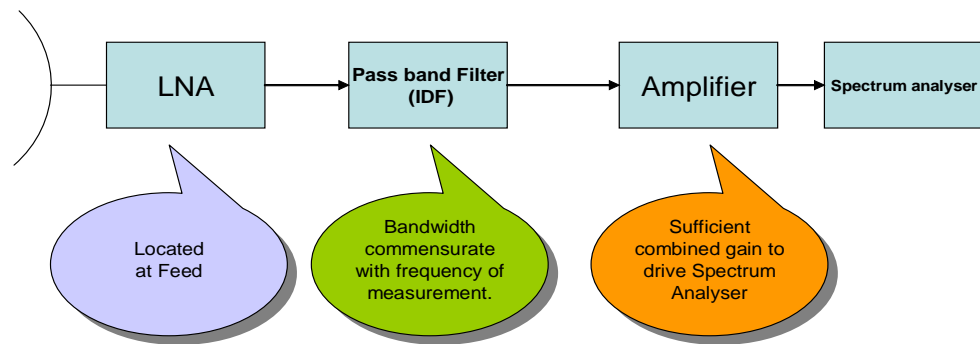
Use of a Spectrum Analyser

This example demonstrates what would be the 'ideal' measuring setup. Not all shacks are fortunate to include a Spectrum Analyser!

- Point the Antennae at the cold source and adjust the amplifier/ input attenuator on the Spectrum analyser to form a calibrate level. Ensure that there are not adjacent high level signals (off measuring frequency) that could impact on measurement.

- Point antennae at the Sun and the difference in level is the Y-Factor. The measurement should be taken at the widest bandwidth commensurate to the LNA bandwidth and filter used.

METHOD # 2

```
LNA  →  Pass band Filter (IDF)  →  Shack LNA Amplifier  →  Down Converter
                                                                    ↓
         W&G Peglemesser (precision selective voltmeter)  ←  Precision Stepped Attenuator
```

LNA	**Pass band Filter (IDF)**	**Shack LNA Amplifier**
Located at feed	Bandwidth commensurate with frequency of measurement.	Sufficient combined gain to drive the Voltmeter

Depending upon the quality of the precision stepped attenuator the position of the Down Converter may be reversed.

Use of a Selective Voltmeter and Stepped Attenuator
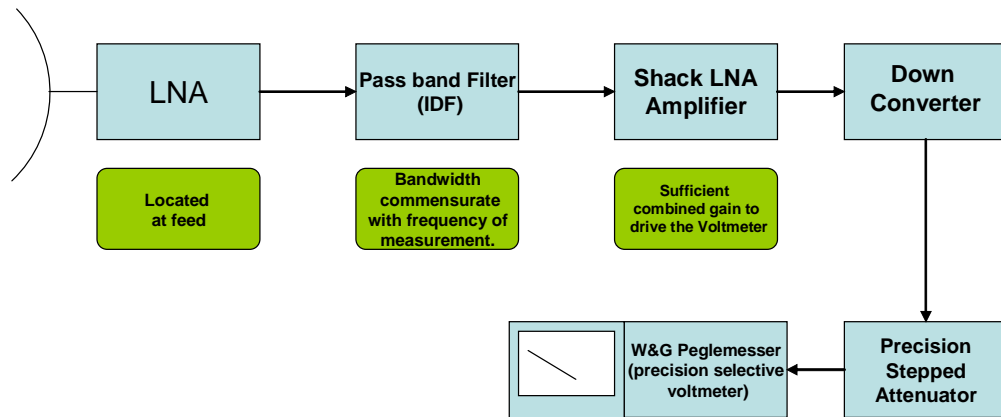
This example demonstrates what would be the 'almost ideal' measuring setup. Not all shacks are fortunate to include a Precision Selective Voltmeter!

- Point the Antennae at the cold noise source.
- Set the precision attenuator to a value such that you may add additional attenuation as expected by the increase of Sun noise.
- Calibrate the precision selective voltmeter.
- Point antennae at the Sun.
- Increase the attenuation to obtain the calibrate level as set earlier.
- the amount of added attenuation is the Y-Factor

METHOD # 3
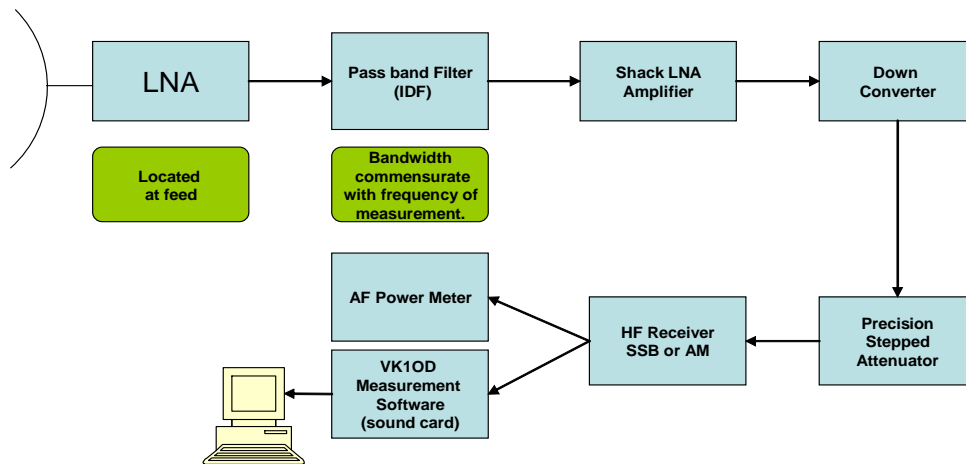
Use of a Down Converter HF Receiver and AF Power Meter

This example approaches what would be to expected in most 'advanced VHF/UHF Amateur installations and will provide excellent and reproducible results.

- Turn the Receiver AGC off and reduce the RF Gain to a satisfactorily level where overload will not occur with the system gain.
- Point the Antennae at the cold noise source.
- Set the precision attenuator to a value such that you may add additional attenuation as expected by the increase of Sun noise.
- Calibrate the AF power meter or record the value with the VK1OD Software[7].
- Point antennae at the Sun.
- Increase the attenuation to obtain the calibrate level as set earlier.
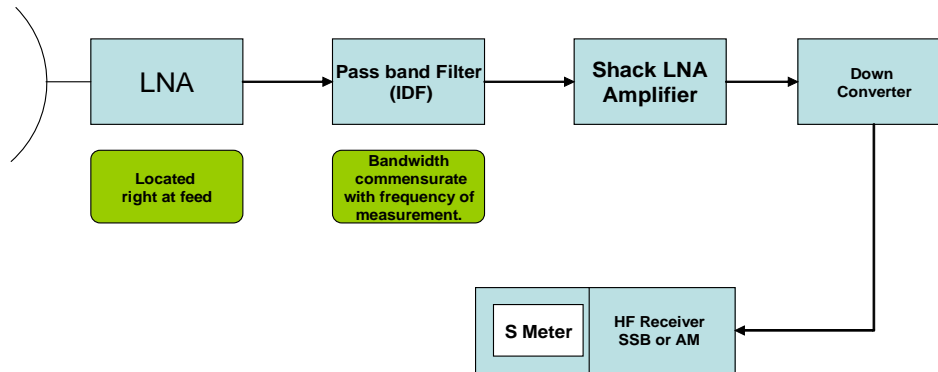- the amount of added attenuation is the Y-Factor

METHOD # 4

```
( LNA ───► Pass band Filter ───► Shack LNA ───► Down
          (IDF)                  Amplifier      Converter

  Located   Bandwidth                              │
  right at  commensurate                           │
  feed      with frequency of                      │
            measurement.                           ▼
                        ┌────────┬─────────────┐
                        │ S Meter│ HF Receiver │◄──
                        │        │ SSB or AM   │
                        └────────┴─────────────┘
```

Use of a Down Converter and HF Receiver with S Meter

This example is considered to be 'not ideal' It will however, with care, it can provide satisfactory results.

- Point the Antennae at the cold noise source.
- Adjust the RF Gain to a known S meter point (e.g. S1).
- Point antennae at the Sun.
- Read the increase in the S meter
- the increase of the S Meter in dB is the Y-Factor

This accuracy of this method is determined by the receivers' linearity and the exact value of S meter units. It is advisable to check the linearity of the S Meter with a calibrated signal generator.

METHOD # 5

```
         ┌──────────┐         ┌──────────────┐         ┌─────────────────┬──────────┐
  )──────│   LNA    │────────▶│  Shack LNA   │────────▶│ UHF Transceiver │ S Meter  │
  )      │          │         │  Amplifier   │         │   SSB or AM     │          │
  )      └──────────┘         └──────────────┘         └─────────────────┴──────────┘
         ┌──────────┐
         │ Located  │
         │ at feed  │
         └──────────┘
```
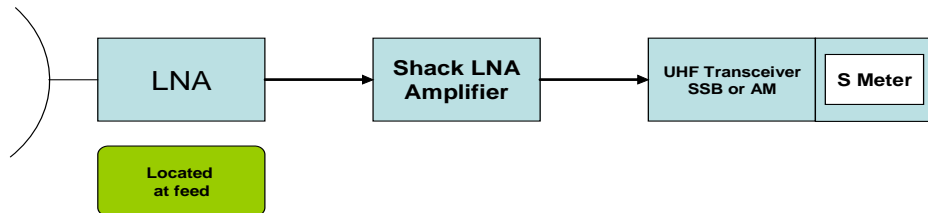
Use of a UHF Transceiver

This example is considered to be 'the bare bones'! It may provide a degree of measurement as a starting point for further improvement.

- Point the Antennae at the cold noise source.
- Adjust the RF Gain to a known S meter point (e.g. S1).
- Point antennae at the Sun.
- Read the increase in the S meter
- the increase of the S Meter in dB is the Y-Factor

The system gain may not be adequate. Image and adjacent signals will impact on the measurement. The accuracy of this method is questionable. It will be determined by the receivers' linearity and the exact value of S meter units. It is advisable to check the linearity of the S Meter with a calibrated signal generator.
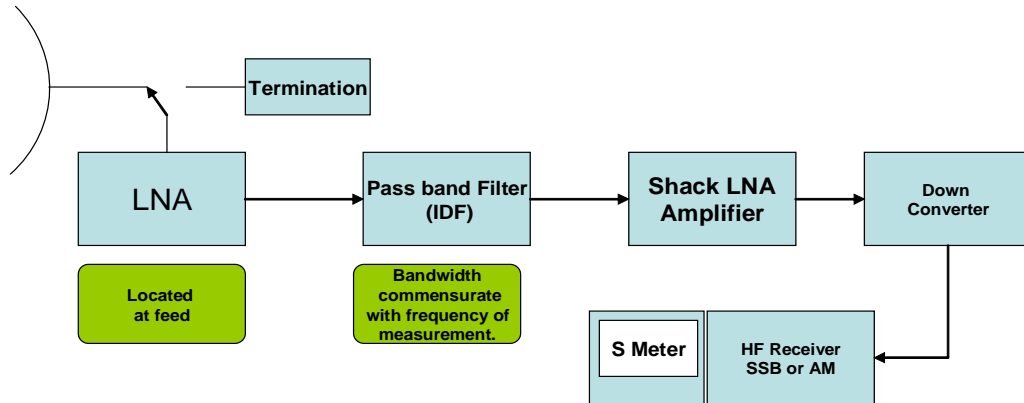
It will most likely be your first opportunity to see Sun noise and prove it exists!

AN ALTERNATIVE METHOD

```
              Termination

   LNA  →  Pass band Filter  →  Shack LNA  →  Down
           (IDF)                 Amplifier     Converter

  Located   Bandwidth                        S Meter   HF Receiver
  at feed   commensurate                                SSB or AM
            with frequency of
            measurement.
```

Alternative Method using a Termination

This method can be used for all previously described configurations.

- Point at Sun, note S Meter reading. (or other previously given methods)
- Terminate the LNA, note S Meter reading. It will be + or - depending on the band as given in the chart below.

The difference in dB value* is the Y Factor of <u>Sun to termination</u>. Use the VK3UM EMECalc software to evaluate your system.

* as explained previously it is essential that you know the calibration and linearity of the S meter etc.

Cold Sky to Termination

0.4dB Nf	Cold Sky °K (Te)	Term at 20c
50	2700.0	-9.3dB
144	530.0	-2.5dB
432	55.0	5.7dB
1296	21.0	7.5DB
2304	17.0	7.6dB

-
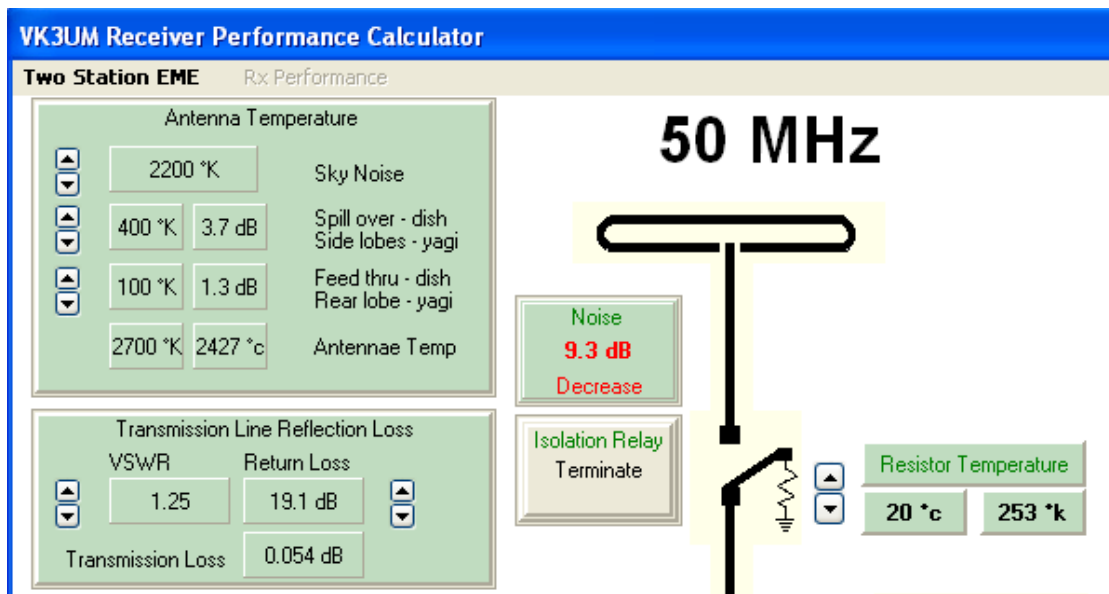
Quiet Sky Noise on 50MHz with a typical 10dBD Yagi is ~ 2700k and when a termination replaces the Antennae the noise will <u>decrease</u> by ~9.3dB.
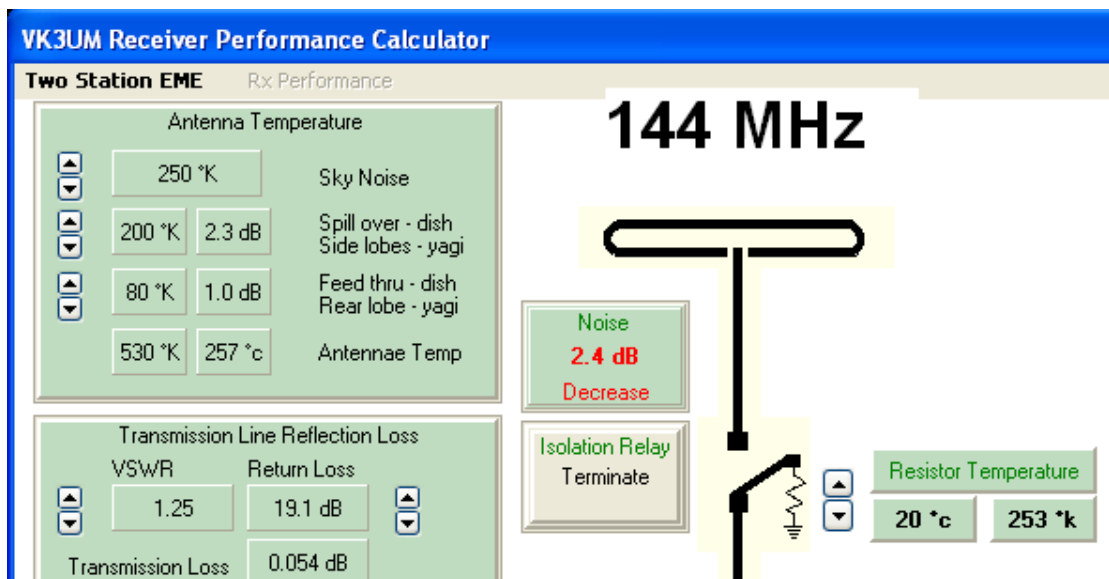
Quiet Sky Noise on 144 MHz with a typical 14dBD Yagi is ~ 530k and when a termination replaces the Antennae the noise will <u>decrease</u> by ~2.4dB.

VK3UM Receiver Performance Calculator

Two Station EME   Rx Performance

Antenna Temperature

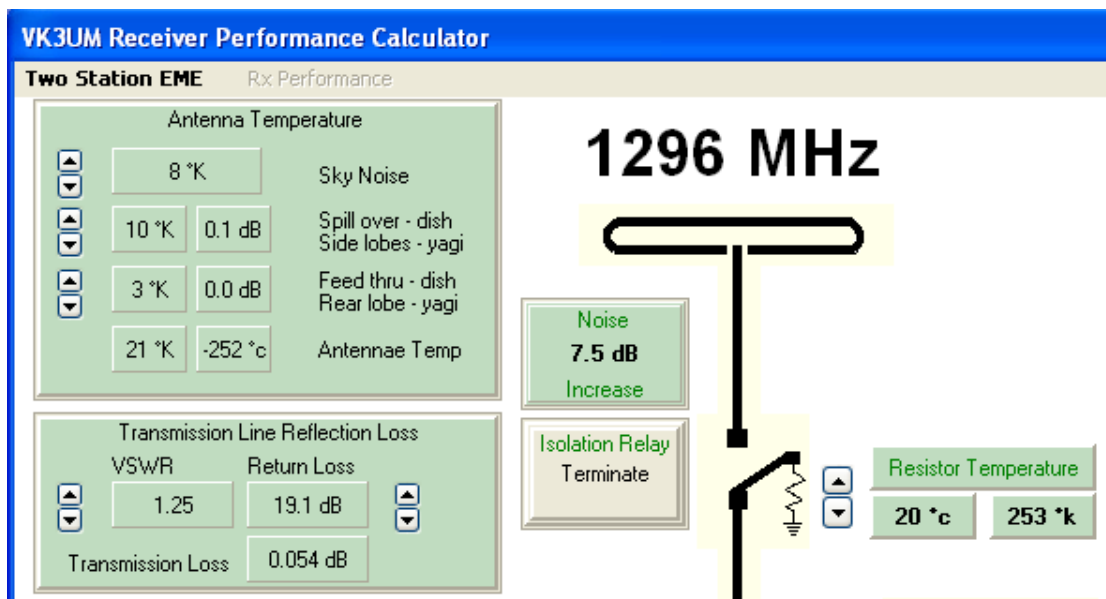|		
20 °K		Sky Noise
30 °K	0.4 dB	Spill over - dish / Side lobes - yagi
5 °K	0.1 dB	Feed thru - dish / Rear lobe - yagi
55 °K	-218 °c	Antennae Temp

432 MHz

Noise 5.7 dB Increase

Isolation Relay Terminate

Resistor Temperature   20 °c   253 °k

Transmission Line Reflection Loss

VSWR 1.25   Return Loss 19.1 dB

Transmission Loss 0.054 dB

Quiet Sky Noise on 432 MHz with a typical 16dBD Yagi is ~ 55k and when a termination replaces the Antennae the noise will increase by ~5.7dB.

VK3UM Receiver Performance Calculator

Two Station EME   Rx Performance

Antenna Temperature

8 °K		Sky Noise
10 °K	0.1 dB	Spill over - dish / Side lobes - yagi
3 °K	0.0 dB	Feed thru - dish / Rear lobe - yagi
21 °K	-252 °c	Antennae Temp

1296 MHz

Noise 7.5 dB Increase

Isolation Relay Terminate

Resistor Temperature   20 °c   253 °k

Transmission Line Reflection Loss

VSWR 1.25   Return Loss 19.1 dB

Transmission Loss 0.054 dB

Quiet Sky Noise on 1296 MHz with a typical 4 meter Dish is ~ 55k and when a termination replaces the Antennae the noise will increase by ~7.5dB.

What does it all mean?
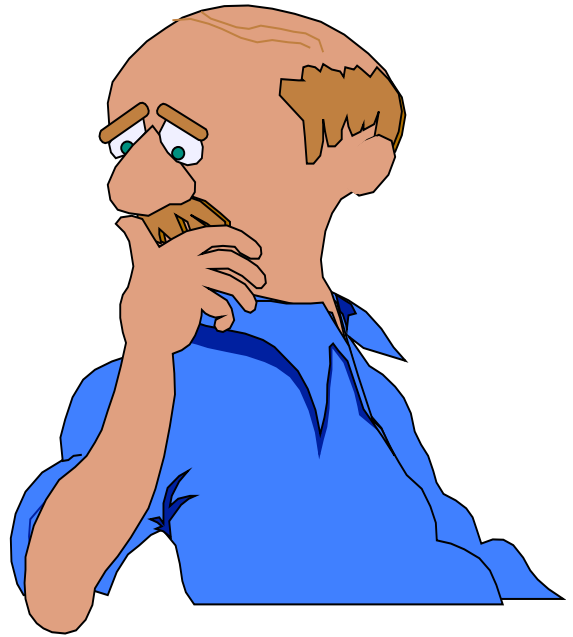
- The figures calculated by the software are "first principles" and if you do not get close to those predicted then it is _your system_ and not the software that is the problem!

- And you can now improve your systems' performance with sometimes spectacular results!!

- It's not always "_conditions_" or your QTH as you may wish to believe!

Where to look for a problem.

- First Check to see that the Dish feed focus position is optimum. W2IMU, VE4MA and Septum feeds all have different launch positions. A 50 mm error on 1296 MHz will lower the Sun Noise by ~ 3 dB and your gain!

- If you are using a commercial Dish check the manufacturers' specification. Note. This is NOT the F/D and a 0.55 value for efficiency may be conservative.

- Obtain the latest sfu.

- Check the Feedthru
  If you build your own Dish then enter the Mesh Diameter and Spacing.
  The feed thru value will be calculated for the frequency selected.
  For a Yagi array it is the rear lobe.

- Check the Spillover
  The spillover is determined by the radiation pattern of feed and how it illuminates the dish. A -9dB taper at the rim of the dish provides <u>optimum gain</u> but less (-15dB) will provide a <u>better noise temperature</u>.
  For Yagi arrays it is the combination of all side lobes.

- Check the LNA Loss
  This is the loss between the radiating element(s) and the LNA input.
  Relay(s) insertion loss, cable length, connectors etc. **All of these losses add to the Noise Figure.**

- Check the LNA Noise figure (Nf)
  LNA Noise figures are sometimes exaggerated to what can be achieved in practice. A Nf of ~ 0.4 is a conservative starting point.

- LNA Gain. It is preferable to use a two stage LNA (>25dB gain) to overcome losses and improve the cascaded noise figure.

- Coax Loss. This is the loss between the LNA and the next stage. It is not too important providing the LNA gain significantly exceeds the coax loss.

- The Receiver or Down converter Nf.

- The Overall Rx Nf is primarily dependant on LNA Nf.

Still no Joy !

- Re-check the overall linearity of the measuring system you are using.

- Re- check your Quiet source calibration. It may not be what you think it is. Side lobes, front to back and adjacent objects all will reduce the Y factor.

- For additional information please refer to my paper *Determinants of Receiver Sensitivity* GippsTech Proceedings July 2003.

- It's NOT the software!
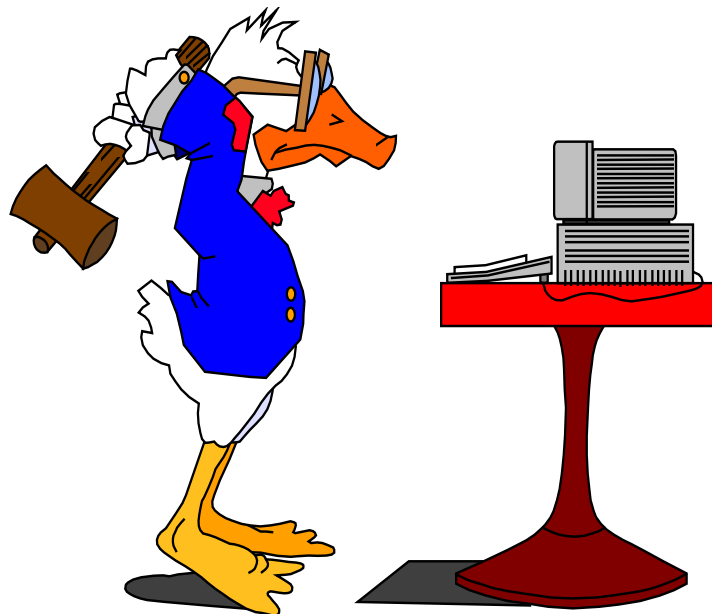
Definitions

(as applied in the VK3UM EME and Receiver Performance Calculator)

- *LNA Loss (Low Noise Amplifier)*
  This is the loss between the pre amplifier (LNA) and the antenna. It should include connectors, coax and relay insertion losses.
  The value is also displayed (above the dB figure) in degrees Kelvin.

- *LNA Noise figure. (Low Noise Amplifier Noise figure)*
  This is the measured or theoretical noise figure of the preamplifier.
  The value is also displayed (above the dB figure) in degrees Kelvin.

- *LNA Gain. (Low Noise Amplifier Gain)*
  This is the measured gain of the preamplifier in dB.

- *Cable Loss.* **(next stage)**
  This is the cable loss in dB between the pre amplifier output (LNA) and the next stage input.

- *Rx Nf .. (Second stage Receiver Noise Factor).*
  This is the noise figure of the following stage. The overall receiver noise temperature is derived from the above parameters by utilising the cascade amplifier method.
  The value is also displayed (above the dB figure) in degrees Kelvin.

- *Spill over.*
  This value is adjusted to the set position of your feed. The value can be set as the level at the dish rim in dB which is subsequently converted to °K. The default is -9.9dB or 30°K but can be varied in 1°K increments to reflect under or over illuminating the dish.
  The value is also displayed (above the dB figure) in degrees Kelvin and as a percentage.

- *Feed through.* ('Feedthru')
  The power radiated through and that received at the feed by nature that the reflector is not perfect. The size of the mesh, its diameter and its spacing along with the frequency of operation are the parameters that determine its value. This value is automatically calculated from the mesh dimensions of your antenna and the frequency of operation. The computed value is in dB.

References

[1] IPS Learmonth
   http://www.ips.gov.au/Solar/3/1

[2] VK3UM EME and Receiver Performance Calculator (EMECalc.exe)
     See below for down load sites.

[3] John Drew (VK5DJ)
 http://vk5dj.mountgambier.org/Amateur_radio.html

[4] NOAA
   http://www.swpc.noaa.gov/ftpdir/lists/radio/rad.txt

[5] VK3UM Planner (EME2008.exe)
     See below for down load sites

[6] VK3UM Interdigital Filter Design Software (IDFilter.exe)
     See below for down load sites.

[7] VK1OD Software
 http://www.vk1od.net/

All VK3UM Software may be down loaded from either of the following Sites.
     http://www.vk3bez.org/
     http://sm2cew.com/download.htm
     http://www.ve1alq.com/vk3um/