



# TotalPower 7.0.0

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# TotalPower 7.0.0

*ChatGPT-3 viewpoint ....*

- **"TotalPower" is a software program used in the field of radio astronomy for data analysis and calibration. It was developed by *Richard Perley*, an astrophysicist specializing in radio astronomy, at *the National Radio Astronomy Observatory (NRAO)* in the 1990s ...**



# TotalPower 7.0.0

*ChatGPT-3 viewpoint ....*

- **The program TotalPower, used for measuring radio frequency noise, was written by *Joe Taylor*, a *professor emeritus* at *Princeton University* and a *Nobel laureate in Physics* ...**



# TotalPower 7.0.0

*ChatGPT-3 viewpoint ....*

- ***Thank you for the additional information.***  
***"TotalPower" is a free program created by Mario Armando Natali (callsign I0NAA) at the University of Bologna (UNIBO). It is used to measure the total power of signals using RTL-SDR (Software-Defined Radio) ...***

***..... Ooooh well I am in VERY good company 😊***



# TotalPower 7.0.0

*Little bit of history*

- ❑ **TotalPower was started as an exercise to improve my ability to develop programs with C++ and the initial goal was just to measure the RF noise with the low-cost SDR known as RTL-SDR.**



# TotalPower 7.0.0

*Little bit of history*

- ❑ **The program is Windows based and has been developed with *Embarcadero® C++ Builder 10.2 ( starter edition )* using the *SDL Delphi Component Suite* from **EPINA Softwares Lab** and the “classic” *FFTW* libraries for Fourier transformations.**



# TotalPower 7.0.0

*Little bit of history*

- ❑ **TotalPower has been downloaded more than 3000 times to date, is in use in many parts of the world and has been featured both on «Radio Rivista» and on «Dubus».**

**TotalPower is distributed for free through my website:**

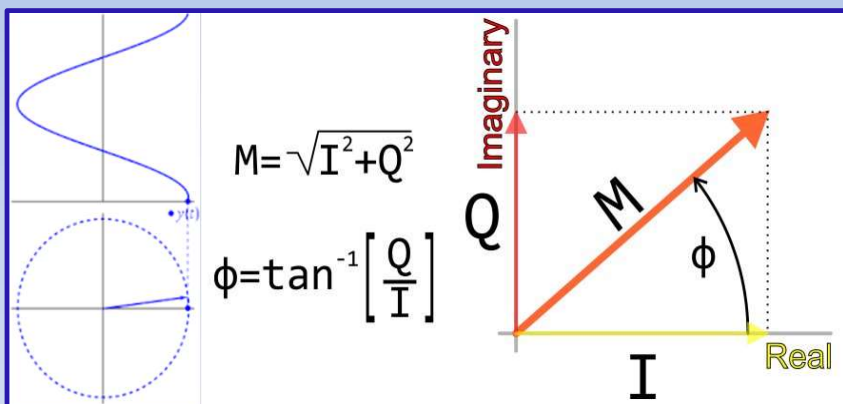
**<https://i0naa.altervista.org>**



# TotalPower 7.0.0

*Little bit of theory*

**We can describe the instantaneous state of a signal with complex numbers, called phasors, which can be represented on the complex plane by vectors containing amplitude and phase information.**



**The I and Q values represent the peak value of the in-phase and quadrature components of the RF signal vector. With I and Q we can describe the amplitude and phase of the signal and the associated power.**

**Basic equations :**

$$V_{Peak} = \sqrt{I^2 + Q^2} \quad \Rightarrow \quad V_{RMS} = \frac{V_{peak}}{\sqrt{2}} \quad \Rightarrow \quad V_{RMS} = \sqrt{\frac{I^2 + Q^2}{2}}$$

$$\text{50}\Omega \text{ system} \quad \Rightarrow \quad P_{RMS} = \frac{\frac{I^2 + Q^2}{2}}{50} = \frac{I^2 + Q^2}{100}$$

**For relative calculations :**  $P = I^2 + Q^2 \quad \Rightarrow \quad P = 10 \log_{10}(I^2 + Q^2)$





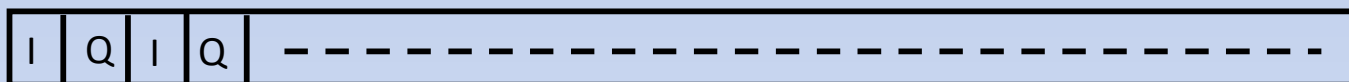
# TotalPower 7.0.0

*How to implement the measure with RTL-SDR*



**The RTL-SDR is a low-cost SDR that samples incoming analog signals and digitizes them making them available in a 65536 bytes long buffer that contains a sequence of I and Q values.**

***RTL-SDR data Buffer 65536 BYTES***

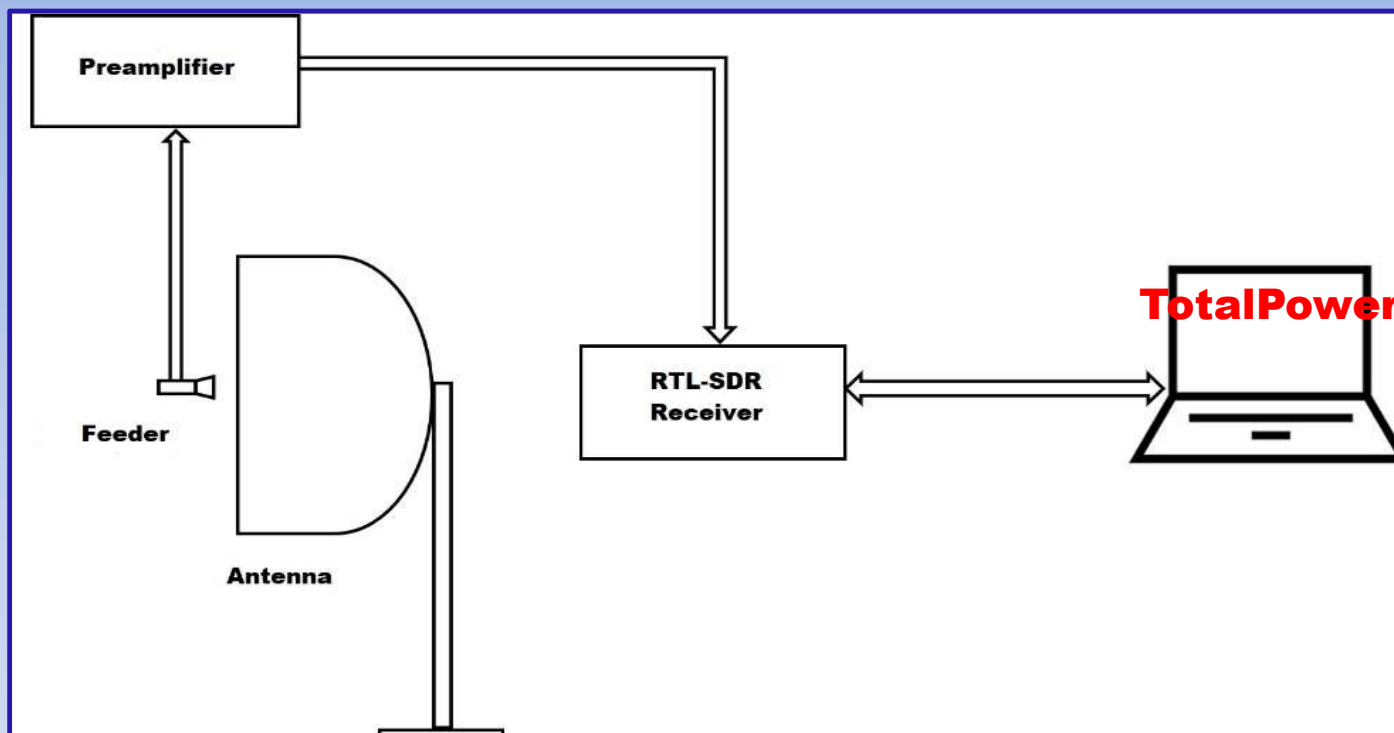


**The I and Q data acquired are in the form of 8-bit unsigned data. Each I and Q value then ranges from 0 to 255 (00000000 to 11111111). To get signed values, we must subtract 127.5 from each value of I and Q, thus obtaining the correct range from -127.5 to +127.5.**



# TotalPower 7.0.0

*The set-up*



**The main advantages of this configuration are the very low cost of hardware and the possibility of data processing thanks to DSP algorithms.**



# TotalPower 7.0.0

*Known problem*

**The main problem is related to the limits of RTL-SDR :**

- ✓ **Frequency stability**
- ✓ **Gain stability**
- ✓ **Performance drifts due to warm-up**
- ✓ **Birdies**
- ✓ **Intermodulation**
- ✓ **Aliasing**
- ✓ **Limited bandwidth**
- ✓ **Overload**

**Possible solutions :**

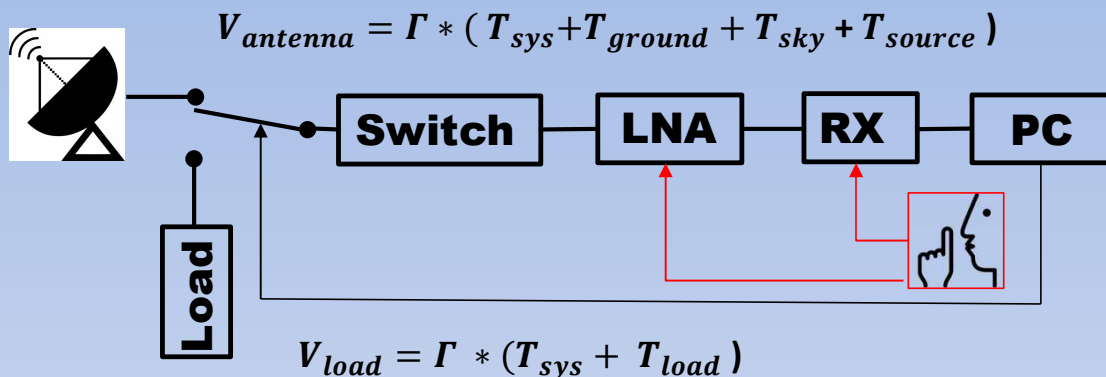
- **Use higher class SDR.**
- **Introduce Dicke-switch technique to eliminate the problem of gain stability.**



- $T_{sys}$  = total noise contribution from hardware
- $T_{ground}$  = noise contribution due to ground radiation ( spillover and scattering)
- $T_{sky}$  = noise contribution from sky background and atmospheric
- $T_{source}$  = noise from source under analysis
- $\Gamma$  = global system parameters ( targeted system gain-bandwidth )

# TotalPower 7.0.0

*Dicke-switch technique*



**A dish radio telescope, connected to a square-law detector ( TotalPower ) provides an output voltage proportional to the signal power detected.**

**The Dicke-switch technique alternatively connects the RX chain to the antenna and to a matched load allowing fluctuations in the RX chain to be minimized.**

$$\Delta_v = V_{antenna} - V_{load} = \Gamma * ( \cancel{T_{sys}} + T_{ground} + T_{sky} + T_{source} - \cancel{T_{sys}} - T_{load} )$$

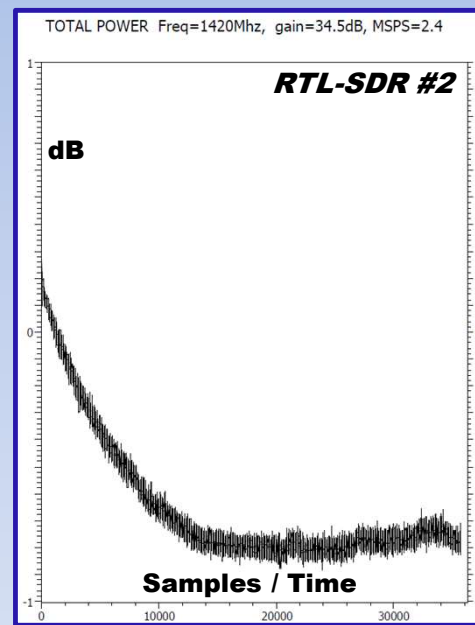
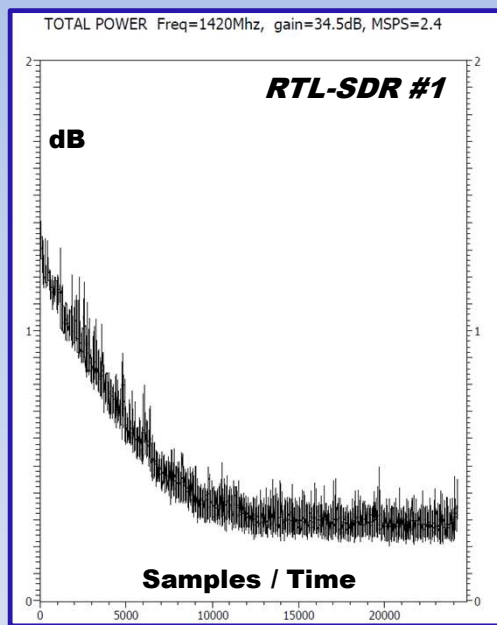
**... Very good solution, but a dedicated hardware is required ...**



# TotalPower 7.0.0

... But the RTL-SDR it is not so bad ...

**Plot of a two-and-a-half-hour recording made by connecting two different RTL-SDRs to a (stabilized) noise generator.**



**Deltas are less than 1dB and the stability after warm-up is not so bad for amateur radio applications.**



# TotalPower 7.0.0

Main screen

Observation site

Main settings

3D Plots repository

User interface zoom

RTL-SDR parameters *should not contain wild characters*

Operating modes

Support functions

- The proper installation of the RTL-SDR is a prerequisite before starting the program.
- RTL-SDR **MUST** be installed as **interface 0**.



# TotalPower 7.0.0

*Main functions : Set location*

TotalPower 7.0.0 BETA 13 July 2024

**Location** Beviglie  
**Latitude** 43.0938 **Longitude** 12.5792  
**UTC time** Sun Jul 14 09:30:28 2024  
**Local time** Sun Jul 14 11:30:28 2024  
Current Time Zone Name : ora legale Europa occidentale (DST)

**Samplig rate** 0.3 MSPS **Moving average filter length** 50 **Time stamp** OFF

**Gain** 44 dB

**RTL-SDR Frequency** 1300 Mhz  
**LO converter frequency ( if present )** 0 Mhz  
System receiving frequency 1300 Mhz

Device: Generic RTL2832U OEM  
Manufacturer: Realtec  
Product: RTL2838UHIDIR

**3D plots directory**

- mario
- Dropbox
- CLOUD TotalPower**
- Perugia

- 3c273\_052721\_1729.ttp
- 3c273\_060122\_1726.ttp
- 3c273\_060122\_1731.ttp
- 3c273\_060122\_1740.ttp

**Enter location** Analyze RX chain performances

Noise plot Band explorer sky explorer

3D data analyzer

+ Save settings Check for updates Help

- Rev. History Reset to default EXIT

Form21

Set observer location with sexagesimal notation ( DMS )

Set observer location with QRA locator

Set observer location with decimal notation (D.DDD)

**Latitude (DMS)** 43 5 32 N **43.0922** **Calculated QRA Locator** JN63GC92

**Longitude (DMS)** 12 34 38 E **12.5772**

Confirm

**QRA Locator** JN63GC92 **Calculated Latitude (D.DDD)** 43.0938

Confirm **Calculated Longitude (D.DDD)** 12.5792

**Latitude (D.DDD)** 43.0922 **Calculated Latitude (DMS)** 43 05 31.9200 N

**Longitude (D.DDD)** 12.5772 **Calculated Longitude (DMS)** 12 34 37.9200 E

Confirm

**Name of location** Assisi-Beviglie **Assisi-Beviglie** 43.0938 12.5792

Reset Location DB Save data

Close and return to main screen

Click on location to select

**The SET LOCATION function allows to store the coordinates of the observation sites in different formats.**



# TotalPower 7.0.0

*Main functions : Band Monitor in the time domain*

TotalPower 7.0.0 BETA 13 July 2024

Location: Beviglie  
Latitude: 43.0938 Longitude: 12.5792  
UTC time: Sun Jul 14 09:30:28 2024  
Local time: Sun Jul 14 11:30:28 2024  
Current Time Zone Name: ora legale Europa occidentale (DST)

Sampling rate: 0.3 MSPS Moving average filter length: 50 Time stamp: OFF

Gain: 44 dB

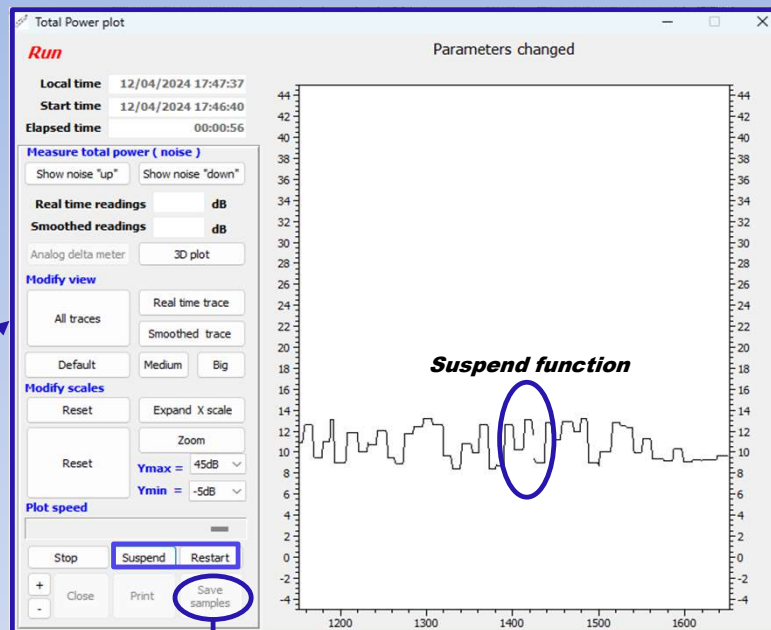
RTL-SDR Frequency: 1300 Mhz  
LO converter frequency (if present): 0 Mhz  
System receiving frequency: 1300 Mhz

Device: Generic RTL2832U OEM  
Manufacturer: Realtek  
Product: RTL2838UHIDSR

3D plots directory:  
mario  
Dropbox  
CLOUD TotalPower  
Perugia  
3c273\_052721\_1729.ttp  
3c273\_060122\_1726.ttp  
3c273\_060122\_1731.ttp  
3c273\_060122\_1740.ttp

Noise plot Band explorer sky explorer

3D data analyzer  
+ Save settings Check for updates Help  
- Rev. History Reset to default EXIT



Form22

Save RT ( Real Time ) samples Close

File saved in working directory as :  
\_\_\_\_\_

**LEGENDA**  
RT = Real Time samples  
F = Frequency  
G = Gain  
MSPS = Mega Samples Per Second  
ET = Elapsed time ( (hhmmss) )  
DT = Date represented as ddmmyy and time represented as hhmmss

Please note that the first element of saved file is coded as "1 XXXXX"  
where XXXXX is the number of samples saved

**The SAVE SAMPLES function allows to save all the samples acquired during the observation session in .csv format so that more in-depth off-line analyses can be carried out.**

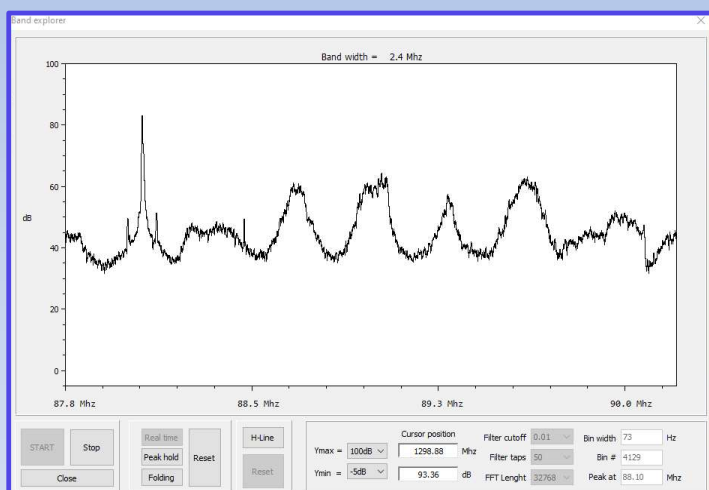




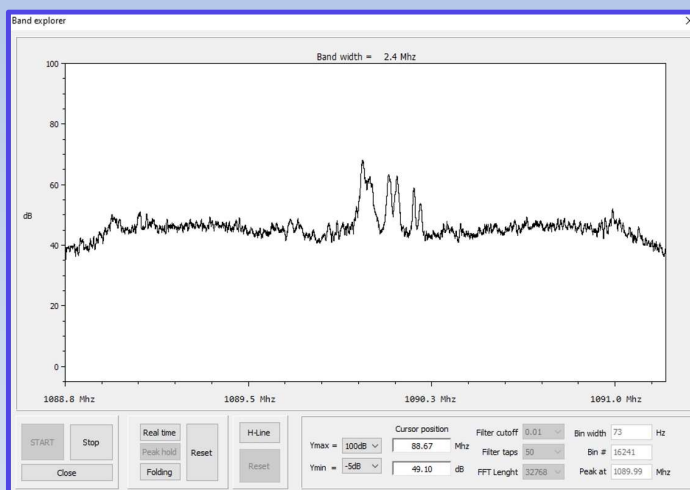
# TotalPower 7.0.0

*Main functions : Band explorer in the frequency domain*

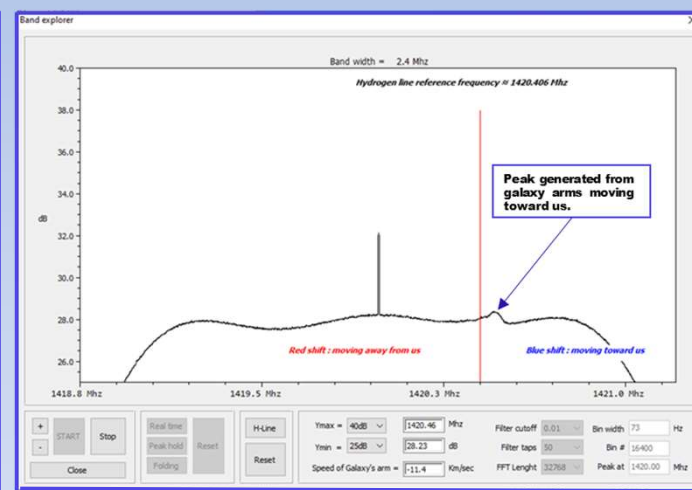
**The “BAND EXPLORER” mode works in the frequency domain ( using FFTW ) and offers three different operating options :**



**Real time mode**



**Peak hold mode**



**H-line mode ( folding )**



# TotalPower 7.0.0

Main functions : Automatic 3D sky noise map

Location: Beviglie  
Latitude: 43.0938 Longitude: 12.5792  
UTC time: Sun Jul 14 09:30:28 2024  
Local time: Sun Jul 14 11:30:28 2024  
Current Time Zone Name: ora legale Europa occidentale (DST)

Sampling rate: 0.3 Mbps  
Moving average filter length: 50  
Time stamp: OFF

Gain: 44 dB  
RTL-SDR Frequency: 1300 MHz  
LO converter frequency (if present): 0 MHz  
System receiving frequency: 1300 MHz

Device: Generic RTL2832U OEM  
Manufacturer: Realtek  
Product: RTL2838U-HDSDR

3D plots directory:  
mario  
Dropbox  
Perugia  
CLOUD TotalPower  
3C273\_052721\_1729.ttp  
3c273\_060122\_1728.ttp  
3c273\_060122\_1731.ttp  
3c273\_060122\_1740.ttp

Noise plot button circled in blue.

Run Parameters changed

Local time: 12/04/2024 09:47:37  
Start time: 12/04/2024 09:46:40  
Elapsed time: 00:00:56

Measure total power (noise):  
Show noise "up" Show noise "down"

Real time readings: dB  
Smoothed readings: dB  
3D plot button circled in blue.

Modify view: All traces, Real time trace, Smoothed trace  
Default: Medium, Big

Modify scales: Reset, Expand X scale, Zoom, Ymax = 45dB, Ymin = -5dB

Plot speed: Stop, Suspend, Restart

Scan

GO  
Save readings  
3D Plot  
STOP  
Close  
PstRotator Settings

Enter object name: Sun  
Azimuth limits (Min, Max in deg.): 0, 360  
Elevation limits (Min, Max in deg.): 0, 90  
Antenna oscillation damping time (msec): 500 ms  
Azimuth / elevation steps (deg.): 5.0 deg.  
System pointing accuracy (deg.): 0.1 deg.

Azimuth correction for non zero elevation: NO  
At the end of the scan activate MANUAL mode and stop

NOISE MAP (dB)

13	14	15	16	17
12	3	4	5	18
11	2	1	6	19
10	9	8	7	20
25	24	23	22	21

Elevation  
Azimuth

ROTATORS POSITION

	Current	Next
Azimuth	280.8	
Elevation	58.0	

Position: 1  
Status: Idle

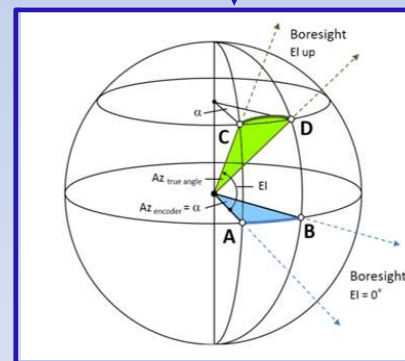
PstRotator - Registered to IONAA v15.94

Communication Setup Tracker RA/DEC GeoSets Maps My Maps Google Maps SCP Map APRS EME DSH View Show Preset Help

QRZ: km  
QTH Locator: 1 7  
GO to Locator  
BD 0 30

Local Time: 09:24:34

Mode: Manual Tracking  
AZ: 243.1 243.1  
EL: 35.7 35.7



**Azimuth correction allows spherical arc length of the travelled azimuth to be independent from elevation.**

**TotalPower, working together with the program PstRotator, measures and records automatically the noise of an area of the sky.**



# TotalPower 7.0.0

Main functions : Automatic 3D sky noise map

The screenshot displays the TotalPower 7.0.0 software interface with several windows open:

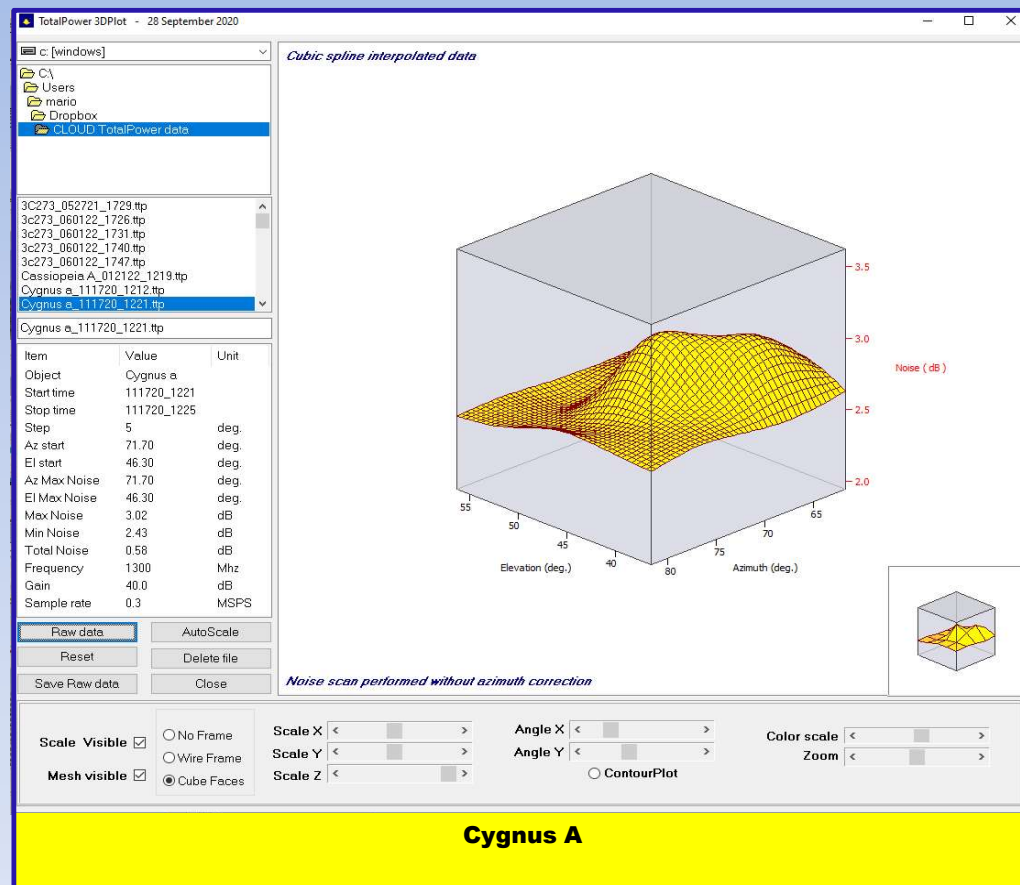
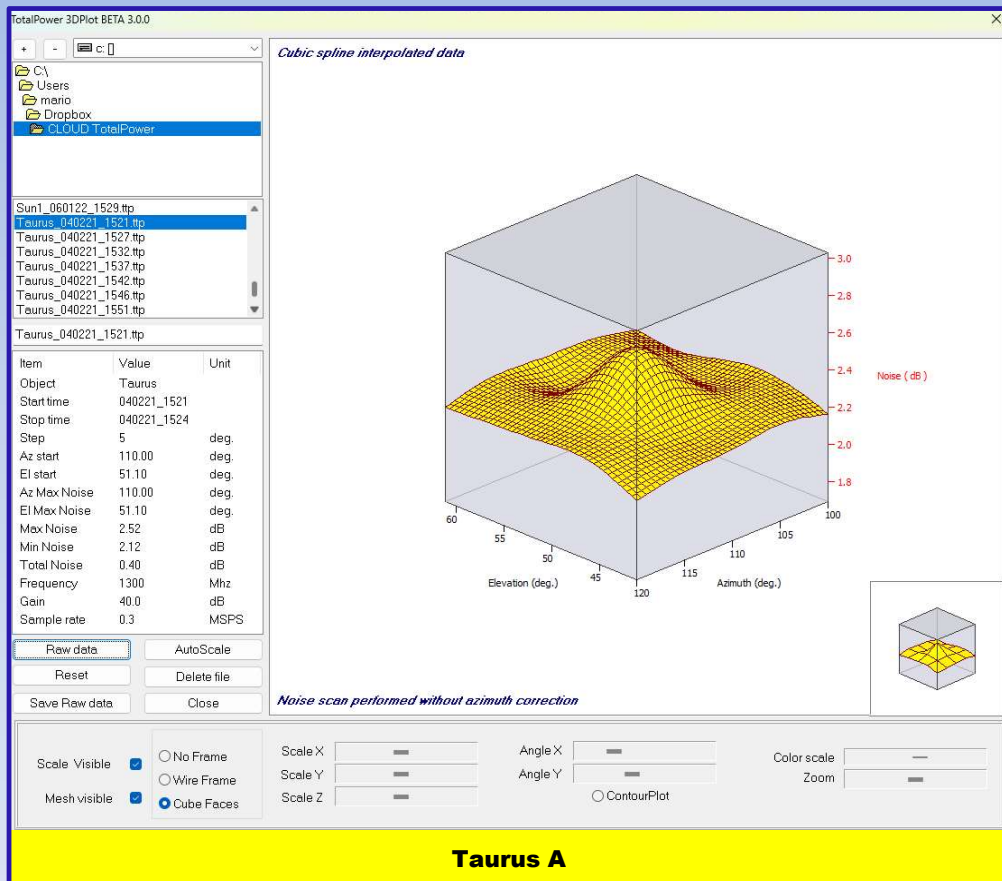
- TotalPower 7.0.0 B...:** Shows location (Bevigne, 43.2038, 12.5792), UTC time (Sun Jul 14 16:16:46 2024), and various frequency and system settings.
- Total Power plot:** A graph titled "TOTAL POWER Freq=1300Mhz, gan=44..." showing a noise floor around -0.03 dB.
- 3D Scan:** Configuration window for a 3D scan. Object name is "Moon". Azimuth limits are 0 to 360 degrees, and elevation limits are 0 to 90 degrees. It includes a "NOISE MAP (dB)" table and "ROTATORS POSITION" data.
- Noise readings meter:** A semi-circular gauge showing real-time noise levels. Current values are -0.04 dB (Real time) and -0.01 dB (Smoothed).
- PstRotator - Registered to IONAA v17.66:** A rotator control window with a circular display and various settings like QRB, QTH, and DXCC.





# TotalPower 7.0.0

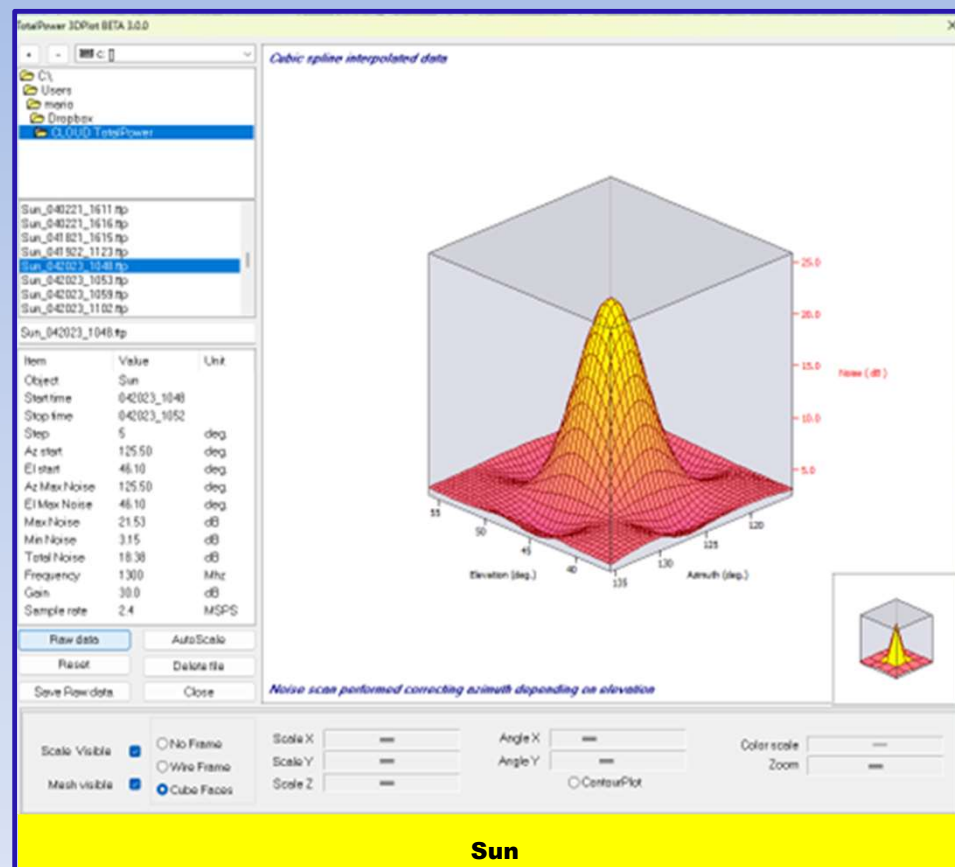
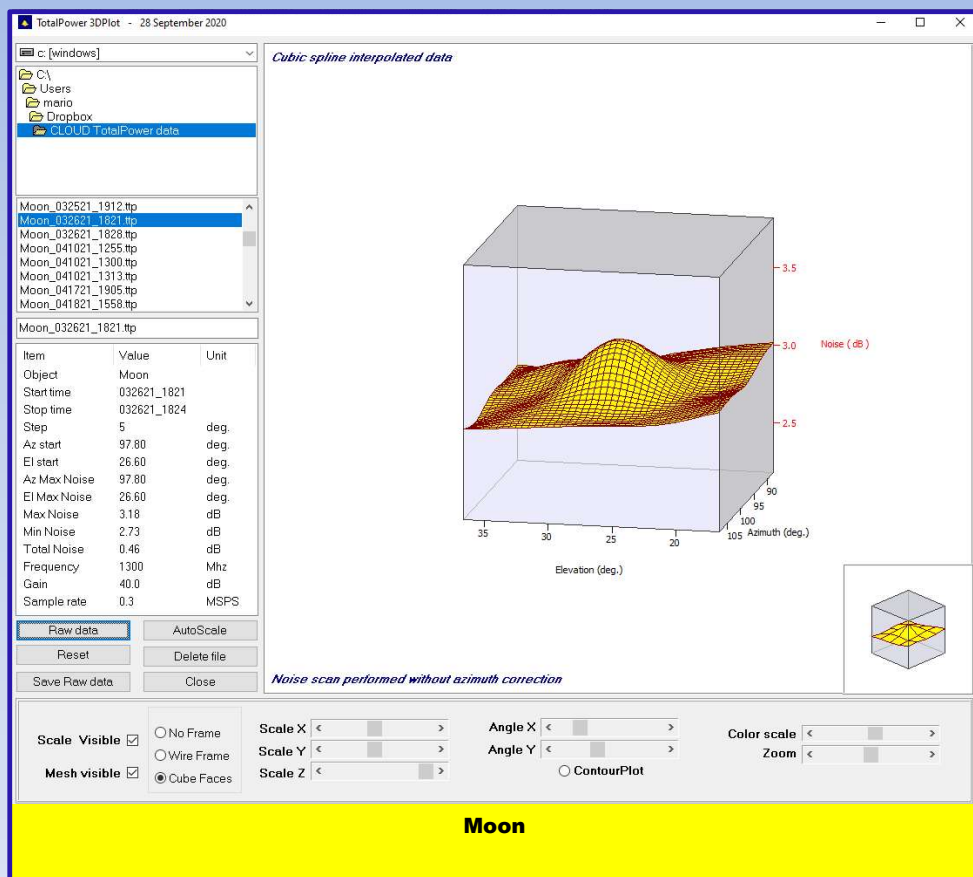
Main functions : Automatic 3D sky noise map





# TotalPower 7.0.0

Main functions : Automatic 3D sky noise map





# TotalPower 7.0.0

Main functions : Sky Explorer

SKY Explorer

All sky 408 Mhz galaxy projection created with Max-Planck institute Survey tool

Mouse position	
Declination	-83.68
Azimuth	186.44
Right Ascension	01:17:55
Elevation	-47.50

Close

PRESET TARGETS	
<input type="radio"/> Sun	<input type="radio"/> Sagittarius A
<input type="radio"/> Moon	<input type="radio"/> Virgo A
<input type="radio"/> Cygnus A	<input type="radio"/> 3C273
<input type="radio"/> Taurus A	<input type="radio"/> FRB 20220912A
<input type="radio"/> Cassiopea A	<input type="radio"/> FRB 20201124A

Hide objects names

Tracking target	
Declination	Target
Right Ascension	Azimuth
	Elevation

Track

Stop

PstRotator not in execution : TRACKING DISABLED

The SKY EXPLORER function uses a 408 Mhz noise-based galaxy map generated with a tool of the Max-Planck Institute and, in addition of automatic tracking of preset objects, offers the **Click-And-Point (CAP)** function.



**New in TotalPower 7.0.0**

# TotalPower 7.0.0

*Main functions : System evaluation*

RX Chain calculations

Calculate RX Chain performances | Calculate expected noise from main cosmic radio sources

<i>RX chain main parameters</i>	<i>Calculated RX chain performances</i>
Dish diameter <input type="text" value="5"/> m	Wave length <input type="text" value="0.23"/> m
Dish efficiency <input type="text" value="69"/> %	Effective ant. aperture <input type="text" value="13.5"/> m <sup>2</sup> <input type="button" value="i"/>
Frequency <input type="text" value="1303"/> Mhz	Dish area <input type="text" value="19.63"/> m <sup>2</sup>
Line loss before LNA <input type="text" value="0.1"/> dB	Antenna gain <input type="text" value="35.06"/> dBi <input type="button" value="i"/>
LNA Noise figure <input type="text" value="0.23"/> dB	HPBW <input type="text" value="3.22"/> deg <input type="button" value="i"/>
LNA gain <input type="text" value="38"/> dB	System noise temp. <input type="text" value="36.98"/> K <input type="button" value="i"/>
Line loss after LNA <input type="text" value="0.5"/> dB	System noise figure <input type="text" value="0.52"/> dB <input type="button" value="i"/>
Receiver noise figure <input type="text" value="4"/> dB	G/T ratio <input type="text" value="19.38"/> dB/K <input type="button" value="i"/>
T sky <input type="text" value="4"/> K <input type="button" value="i"/>	Noise floor <input type="text" value="-138.68"/> dBm <input type="button" value="i"/>
T spillover <input type="text" value="10"/> K <input type="button" value="i"/>	
Bandwidth <input type="text" value="3000"/> Hz	

**The SYSTEM EVALUATION function derives the fundamental parameters of RX chain from the input parameters entered by the the user. The small buttons  , when clicked, show the equations and basic information.**



New in TotalPower 7.0.0

# TotalPower 7.0.0

Main functions : Noise prediction

Noise prediction

FREQUENCY 1303 Mhz

Download latest sun flow data and calculate sun noise      Calculate Noise for other sources

2024 Jul 10	Learmonth	San Vito	Sag Hill	Penticton	Penticton	Palehua	Penticton	Best set
Mhz	0500 UTC	1200 UTC	1700 UTC	1700 UTC	2000 UTC	2300 UTC	2300 UTC	
245	28	24	-1	-1	-1	-1	-1	28
410	52	54	-1	-1	-1	-1	-1	52
610	76	-1	-1	-1	-1	-1	-1	76
1415	135	139	-1	-1	-1	-1	-1	135
2695	192	190	-1	-1	-1	-1	-1	192
2800	-1	-1	-1	-1	-1	-1	-1	-1
4995	211	279	-1	-1	-1	-1	-1	211
8800	306	320	-1	-1	-1	-1	-1	306
15400	568	588	-1	-1	-1	-1	-1	568

Sun flux data downloaded from : <ftp://ftp.swpc.noaa.gov/pub/lists/radio/rad.txt> (-1 stands for data not available)

	Cassiopeia A	Cygnus A	Taurus A	Sagittarius A	Virgo A	3C273	Moon	Sun
Flux (Jy)	1947	1748	912	520	223	42	718	1287365
Noise Y-Factor (dB)	1.00	0.91	0.50	0.29	0.13	0.02	0.40	22.35

Moon distance (Km) 402929

Moon age (days) 4.41

Moon estimated surface temperature (K) 238.3

New Moon      Full Moon      New Moon

0 Days      7 Days      14 Days      21 Days      29.5 Days

Close

The predicted Sun Y-factor noise is calculated with a spline interpolation based on the latest solar flux data downloaded from NOAA sun observatories ftp site.





**New in TotalPower 7.0.0**

# TotalPower 7.0.0

*Main functions : Noise prediction*

Noise prediction

FREQUENCY 1303 Mhz

Download latest sun flow data and calculate sun noise      Calculate Noise for other sources

2024 Jul 10	Learmonth	San Vito	Sag Hill	Penticton	Penticton	Palehua	Penticton	Best set
Mhz	0500 UTC	1200 UTC	1700 UTC	1700 UTC	2000 UTC	2300 UTC	2300 UTC	
245	28	24	-1	-1	-1	-1	-1	28
410	52	54	-1	-1	-1	-1	-1	52
610	76	-1	-1	-1	-1	-1	-1	76
1415	135	139	-1	-1	-1	-1	-1	135
2695	192	190	-1	-1	-1	-1	-1	192
2800	-1	-1	-1	-1	-1	-1	-1	-1
4995	211	279	-1	-1	-1	-1	-1	211
8800	306	320	-1	-1	-1	-1	-1	306
15400	568	588	-1	-1	-1	-1	-1	568

Sun flux data downloaded from : <ftp://ftp.swpc.noaa.gov/pub/lists/radio/rad.txt> (-1 stands for data not available)

	Cassiopeia A	Cygnus A	Taurus A	Sagittarius A	Virgo A	3C273	Moon	Sun
Flux (Jy)	1947	1748	912	520	223	42	718	1287365
Noise Y-Factor (dB)	1.00	0.91	0.50	0.29	0.13	0.02	0.40	22.35

Moon distance (Km) 402929

Moon age (days) 4.41

Moon estimated surface temperature (K) 238.3

New Moon      Full Moon      New Moon

0 Days      7 Days      14 Days      21 Days      29.5 Days

Close

**The predicted Moon Y-factor noise is calculated with an experimental algorithm that takes into account the estimated temperature of the lunar surface with a 3-day lag factor on the Moon's age .**



**New in TotalPower 7.0.0**

# TotalPower 7.0.0

**Main functions : Noise prediction**

Noise prediction

**FREQUENCY 1303 Mhz**

Download latest sun flow data and calculate sun noise      Calculate Noise for other sources

2024 Jul 10	Learmonth	San Vito	Sag Hill	Penticton	Penticton	Palehua	Penticton	Best set
Mhz	0500 UTC	1200 UTC	1700 UTC	1700 UTC	2000 UTC	2300 UTC	2300 UTC	
245	28	24	-1	-1	-1	-1	-1	28
410	52	54	-1	-1	-1	-1	-1	52
610	76	-1	-1	-1	-1	-1	-1	76
1415	135	139	-1	-1	-1	-1	-1	135
2695	192	190	-1	-1	-1	-1	-1	192
2800	-1	-1	-1	-1	-1	-1	-1	-1
4995	211	279	-1	-1	-1	-1	-1	211
8800	306	320	-1	-1	-1	-1	-1	306
15400	568	588	-1	-1	-1	-1	-1	568

Sun flux data downloaded from : <ftp://ftp.swpc.noaa.gov/pub/lists/radio/rad.txt> (-1 stands for data not available)

	Cassiopeia A	Cygnus A	Taurus A	Sagittarius A	Virgo A	3C273	Moon	Sun
Flux (Jy)	1947	1748	912	520	223	42	718	1287365
Noise Y-Factor (dB)	1.00	0.91	0.50	0.29	0.13	0.02	0.40	22.35

Moon distance (Km) 402929

Moon age (days) 4.41

Moon estimated surface temperature (K) 238.3

New Moon      Full Moon      New Moon

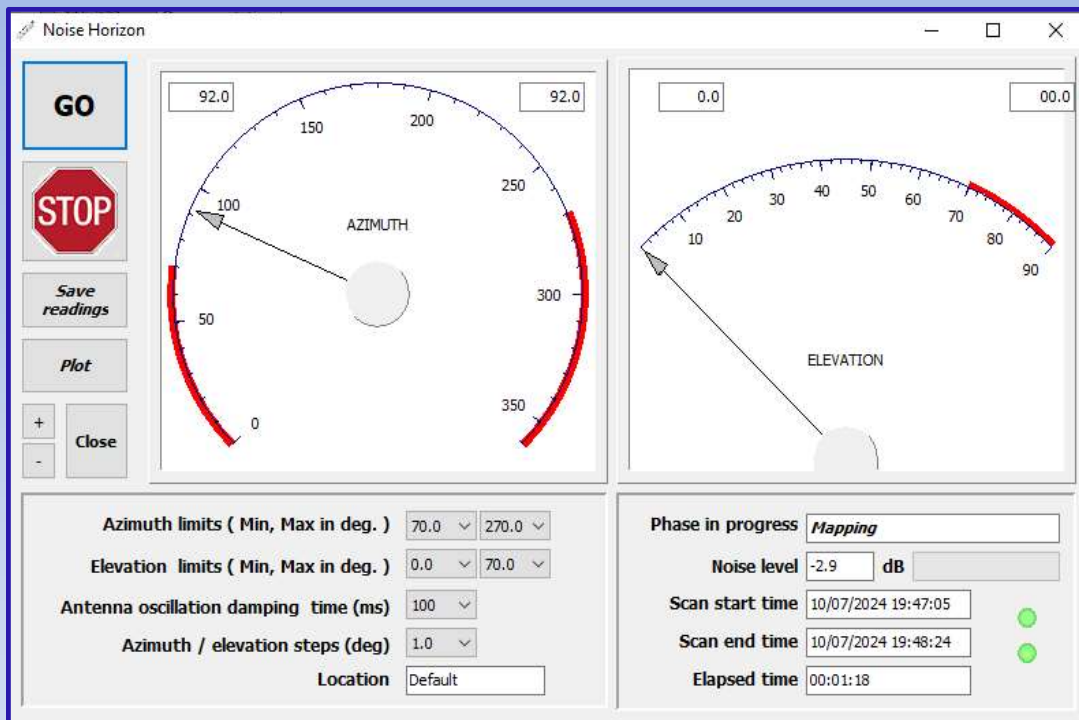
0 Days      7 Days      14 Days      21 Days      29.5 Days

Close

**The predicted Noise Y-factor for the other objects is derived from the interpolation of the data published in the papers reported in the visual manual.**

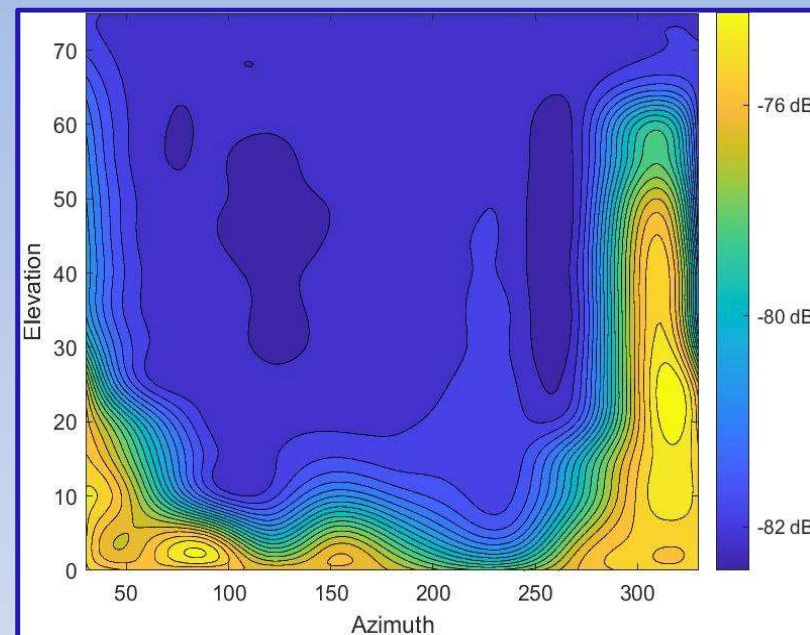


**Future function**



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**Future function : Noise Horizon**



**Noise Horizon at my site @ 1300 Mhz**

**The NOISE HORIZON function, working together with PstRotator, generates a "contour plot" that can be archived and then executed regularly to monitor changes at the observation site.**



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*What's next*

**Few more functions / improvements are in plan :**

- ✓ **NOISE HORIZON** with his own 3D analysis tool.
- ✓ **Linearization of frequency domain plots.**
- ✓ **Visibility improvements to operate under the sun.**
- ✓ **Introduce a new SDR : Air spy ... Adalm Pluto... B200.... need to define.**

**... any input and request will be much appreciated !**



**TotalPower 7.0.0**

**Grazie !**

**Thank you !**