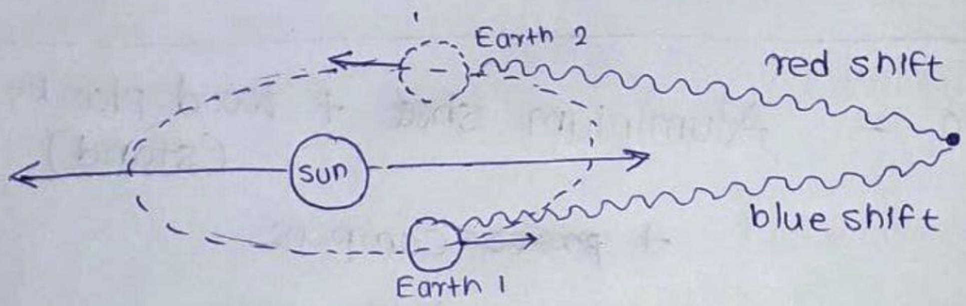
1

Design

Neutral hydrogen radiates at 1420.4 MHz.

And,
studies show that the red and blue shift of 2MHz may be observed.

Hence,
our goal is to design a horn antenna to recieve signal upto a range of 1420.4 ±2 MHz.



The antenna is just the length of copper wire cut to $l = 5.25$ cm about a quarter of wavelength $\lambda = 21.1$ cm

Keeping this numbers in mind,
we have to design a waveguide and horn to efficiently direct desired frequency towards the antenna. (copper wire)

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②

Wave-Guide :-

Simplly,
it is a hollow metal pipe used to carry radio waves.

The EMW in the wave guide can be imagined as travelling down the guide in a zig-zag path,
beiong repeatedly reflected between opposite walls of guide.

Now,
for rectangular wave-guide,
it is possible to derive propagation modes and cut off ~~frequencies~~ frequency.

→ Hence,
signals can progress along a waveguide using number of modes.
However,
the dominant mode is the one that has lowest cut-off frequency.

For rectangular wave-guide it is TE-10

Now,
TE means Transverse electric and indicates that the electric field is transverse to the direction of propagation.

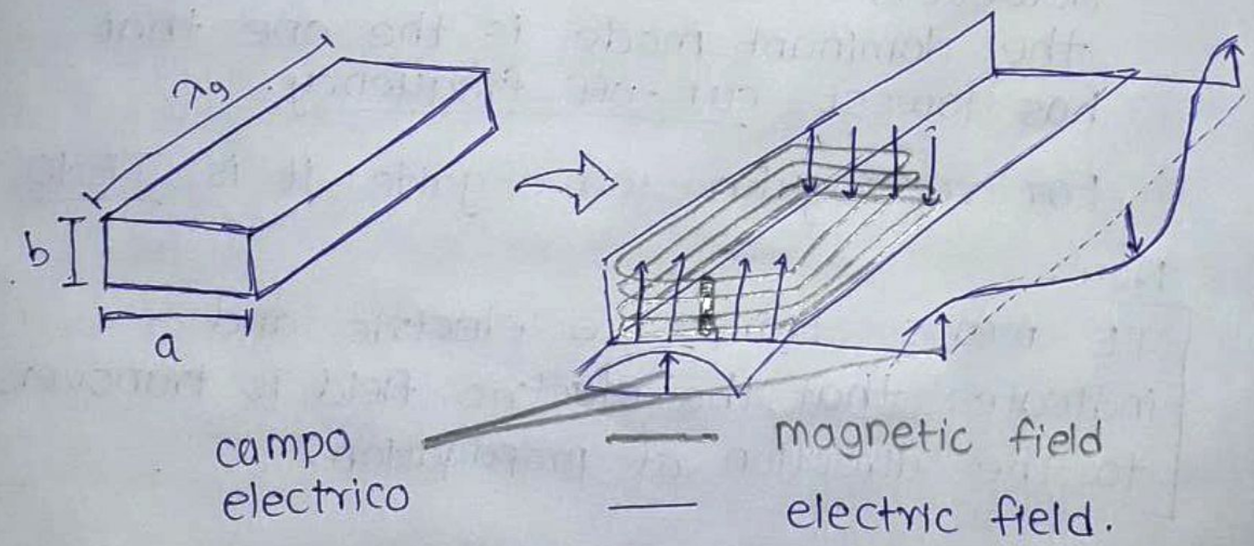
③

The direction of antenna determines the polarization direction of the wave that is picked up,
the E-field is polarized vertically, parallel to antenna.

The intensity is zero, on the surface of metal waveguide, & max intensity is reached inside the waveguide in a position depending on the wavelength of radiation.

wave-guide wave length (λ_g)

$$\boxed{\lambda_g = \frac{\lambda}{\sqrt{1 - (\lambda/2a)^2}}}$$



(4) The <u>cut-off wave-length</u>,
maximum wavelength that can propagate in waveguide in direction of the side 'a' is $\underline{\lambda_c = 2a}$

This equivalent saying that the wave-guide acts as a high pass filter with cut off frequency of $\boxed{\nu = c/\lambda}$

Now,
In order to minimize dispersion in velocity down the wave-guide in range of interest a wave-guide should be used for frequencies <u>greater than</u> $\underline{1.25 \times \nu}$

Also,
in order to ~~spress~~ suppress higher order modes the frequencies used should be <u>less than</u> $\underline{1.9 \times \nu}$

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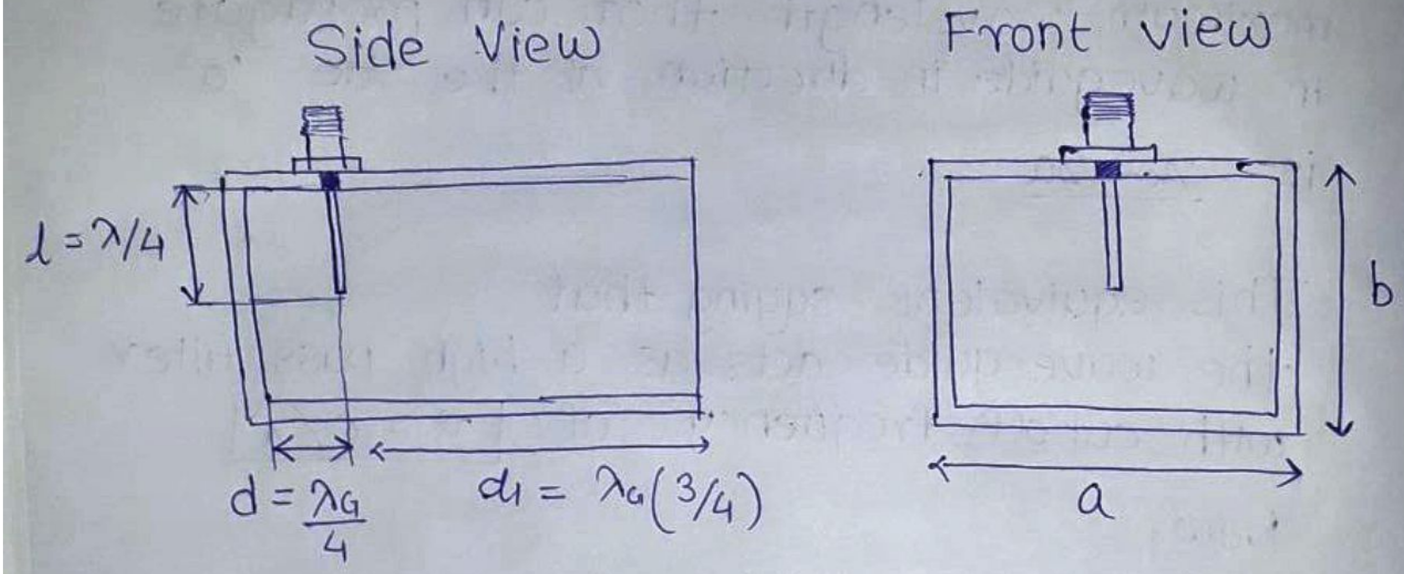
5



Radio Emission Data

$$f = 1420.405 \text{ MHz}$$

$$\Delta f = 2 \text{ MHz}$$

$$f = 1420.405 \pm 2 \text{ MHz}$$

$$\lambda = 21.1 \text{ cm}$$

$$l = \lambda/4 = \underline{5.25 \text{ cm}}$$

Wave Guide Dimensions

a

b

Wave Guide Cut-off Frequency

$$\lambda_c = 2(a)$$

$$f_c = c/\lambda_c$$

Now,

$$f > 1.25(f_c)$$

$$f < 1.9(f_c)$$

⑥
Antenna Positioning

$$\lambda_G = \frac{\lambda}{\sqrt{1-\left(\frac{\lambda}{2a}\right)^2}}$$

$$d = \frac{\lambda_G}{4}$$

$$d_1 = \lambda_G\left(\frac{3}{4}\right)$$

Hence,

$$\boxed{\lambda_G = d + d_1}$$

HORN

It is an antenna that consists of a flaring metal waveguide shaped like a horn to direct radio waves in a beam.

Advantage -

They have no resonant elemement

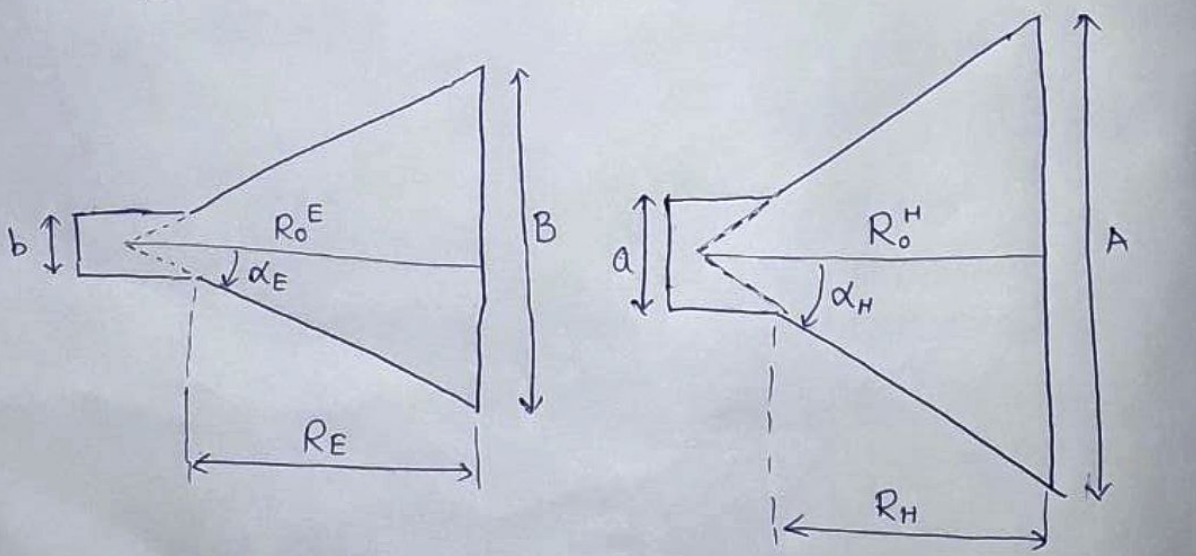
Hence,
they can operate over wide range of frequencies, i.e. a wide bandwidth.

Our antenna is

Pyrimidal horn a horn antenna with horn in the shape of four-sided pyramid, with rectangular cross-section.

Side view

Top View



$A = 750$ mm

$B = 600$ mm

$R_E = 700$ mm

$R_H = 700$ mm

[redacted]

8

Gain between 10-20 dB

↳ max radiation intensity produced by antenna as compared to that given by a lossless isotropical radiator supplied with same level of power.

Also,

Angular resolution of antenna is given by

$$\boxed{\theta = \frac{\lambda}{D}}$$

$$\theta = \frac{21\ cm}{75\ cm} = 0.28\ rad$$

$$= \underline{16^{\circ}}$$

Material - 1.2 mm raw aluminium sheet

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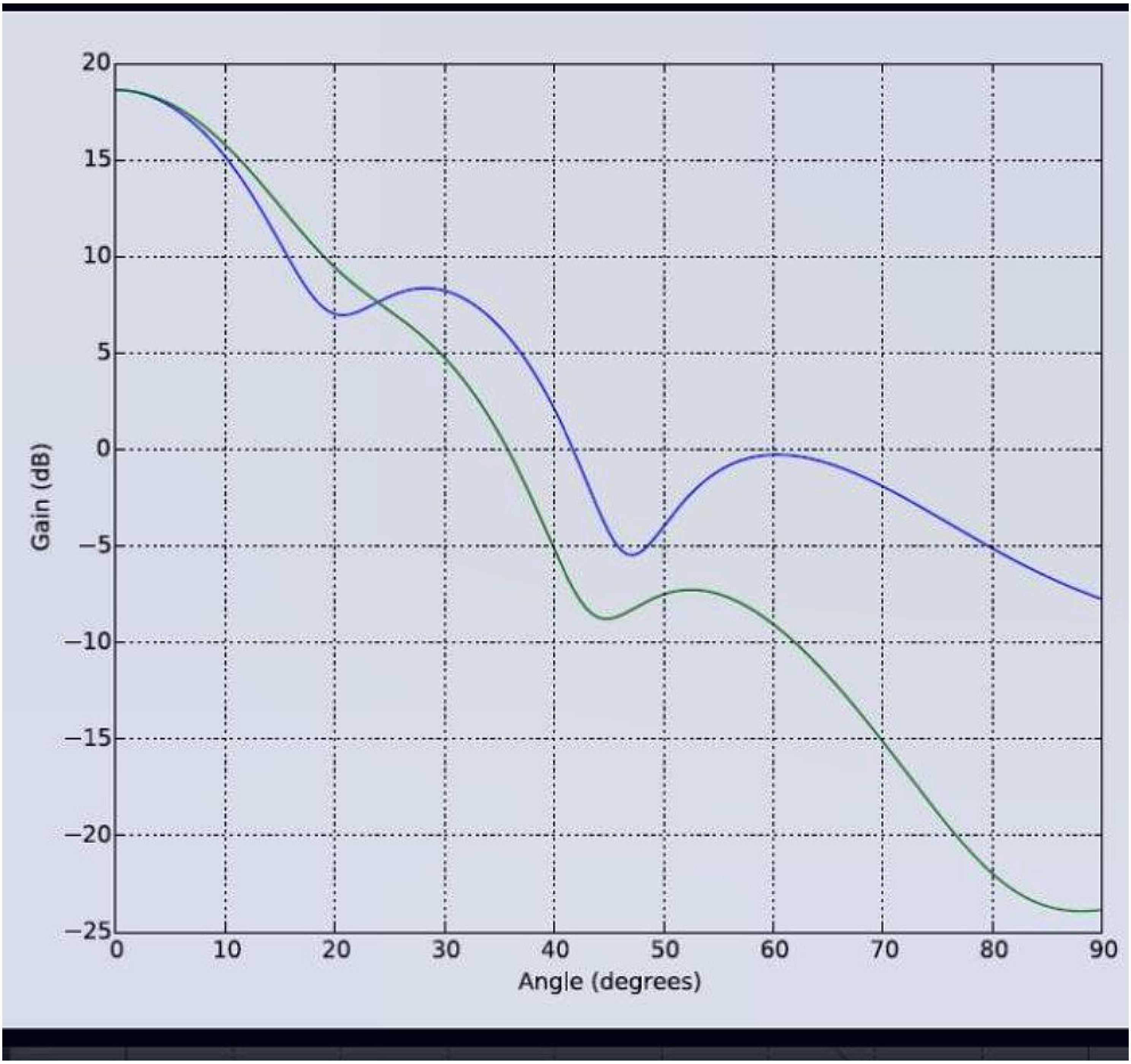


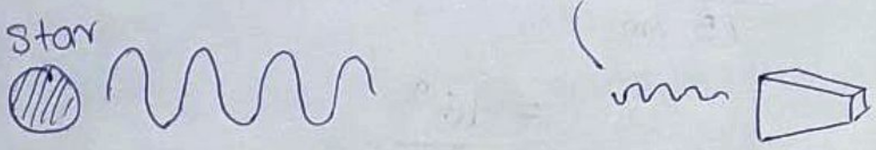
20
15
10
5
0
−5
−10
−15
−20
−25
Gain (dB)
0
10
20
30
40
50
60
70
80
90
Angle (degrees)

Low noise amplifier

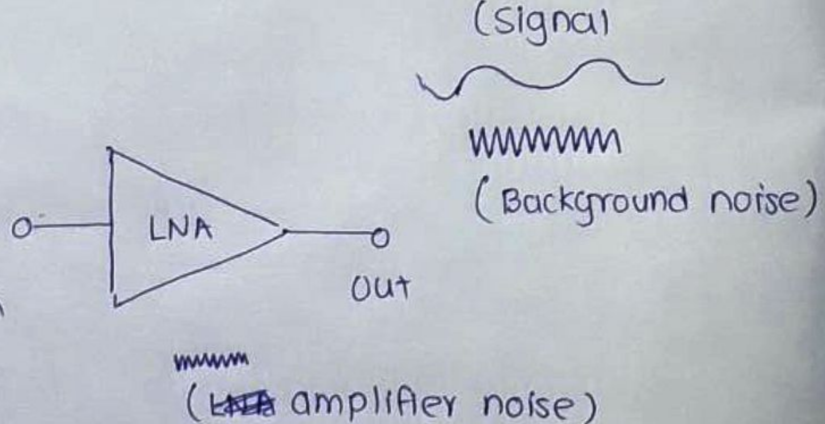
LNA is electronic amplifier that amplifies a very low-power signal without significantly degrading its signal to noise ratio.

[An amplifier increases the power of both the signal and noise present at its input]

Power is absorbed.



in other words
amplitude of signal is reduced due to environment it travels through.



Due to active & passive components.

(10)

$$SNR_{in} = \frac{\text{Signal Power}}{\text{Noise Power}}$$

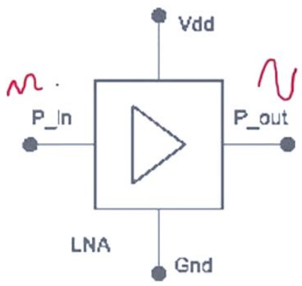
Ideal case

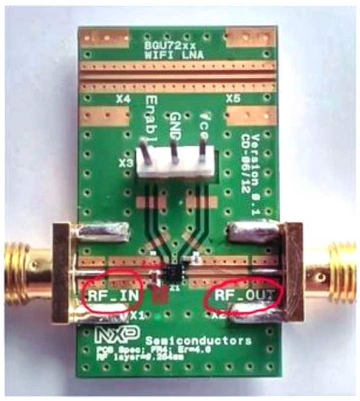
$$SNR_{out} = \frac{\text{Gain} \times \text{Signal Power}}{\text{Gain} \times \text{Noise Power}}$$

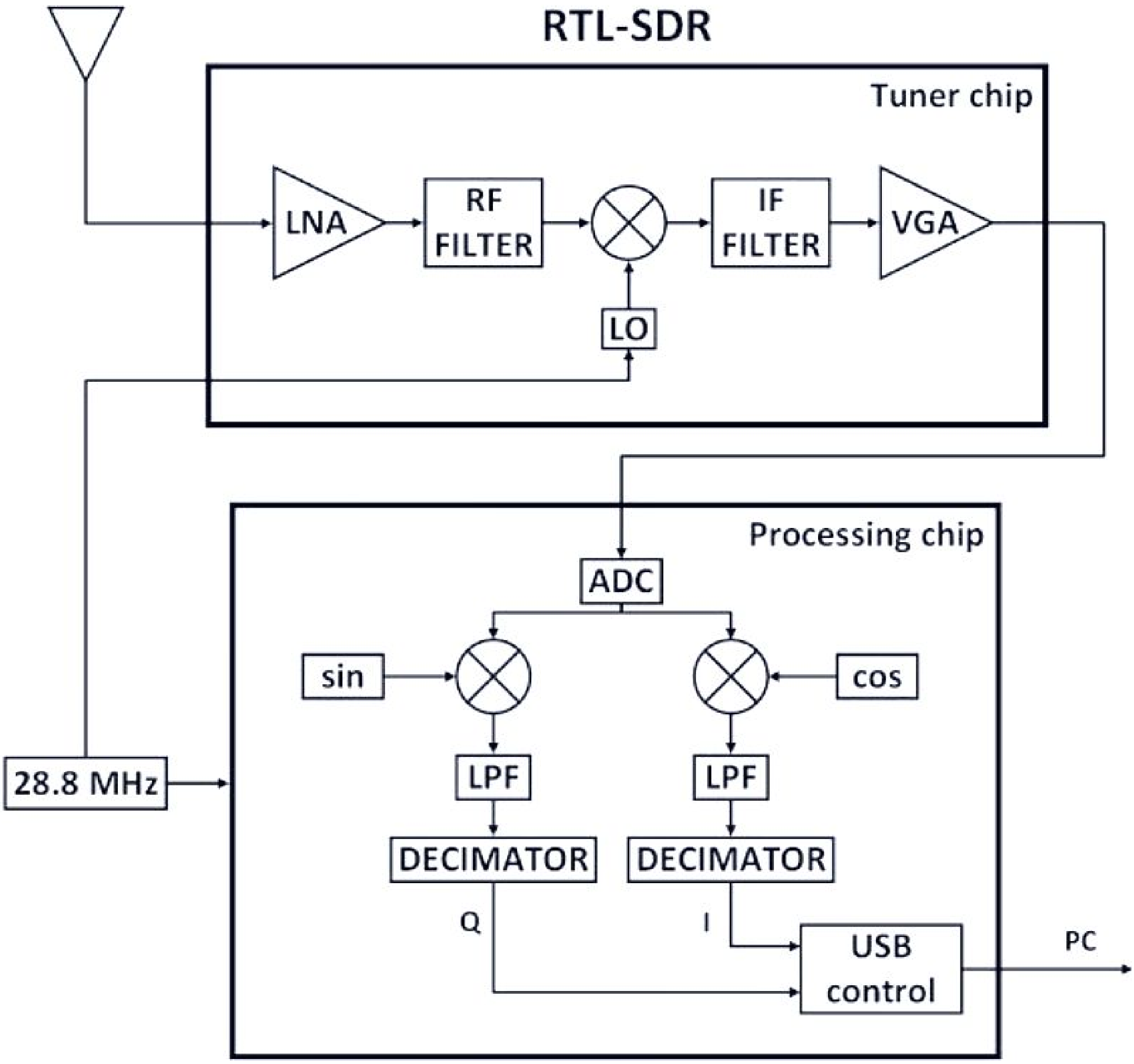
Real Case

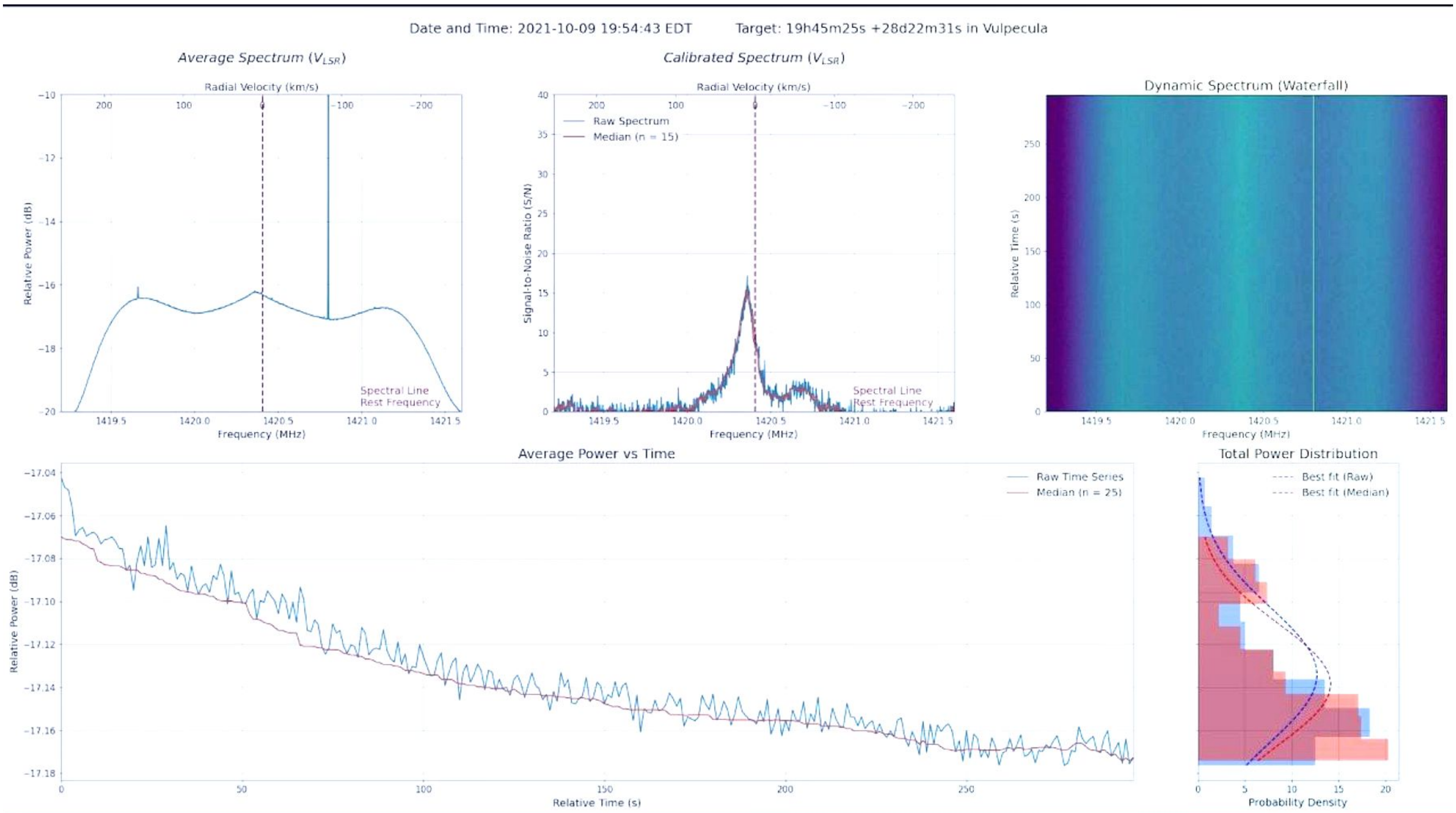
$$SNR_{out} = \frac{\text{Gain} \times \text{Signal Power}}{\text{Gain} \times \text{Noise Power} + \text{Amplifier Noise}}$$

OM7869: BGU7224 WLAN LNA evaluation board






RTL-SDR
Tuner chip
LNA
RF FILTER
IF FILTER
VGA
LO
Processing chip
ADC
sin
cos
LPF
LPF
DECIMATOR
DECIMATOR
Q
I
USB control
PC
28.8 MHz



Date and Time: 2021-10-09 19:54:43 EDT
Target: 19h45m25s +28d22m31s in Vulpecula
Average Spectrum (V_{LSR})
Calibrated Spectrum (V_{LSR})
Dynamic Spectrum (Waterfall)
Radial Velocity (km/s)
Relative Power (dB)
Signal-to-Noise Ratio (S/N)
Raw Spectrum
Median (n = 15)
Spectral Line
Rest Frequency
Frequency (MHz)
Relative Time (s)
Average Power vs Time
Raw Time Series
Median (n = 25)
Total Power Distribution
Best fit (Raw)
Best fit (Median)
Probability Density