ISSN: 2663-5798 || Arab Journal for Scientific Publishing

الإصدار السابع – العدد الرابع والستون
تاريخ الإصدار: 2 – شباط – 2024م

www.ajsp.net

"Design of a Weather Ground Station based on Software Defined Radio"

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https://doi.org/10.36571/ajsp645

AJSP
المجلة العربية للنشر العلمي
ISSN: 2663-5798 || Arab Journal for Scientific Publishing
الإصدار السابع – العدد الرابع والستون
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Abstract:

There is a widespread misconception that for building a ground station to receive satellite images, firstly an authorized license is required and secondly, huge parabolic dishes with specialized RF receivers are necessary and much more costly devices. This is however, not the case. While the space industry keeps growing, the need for low cost solutions increases. This applies also to the ground station systems.

In this paper, we describe how to build a lowest cost reception ground station for meteorological satellites and how to use some necessary software to track, receive and decode the images sent every day.

National Oceanic and Atmosphere Administration (NOAA) has a group of satellites that provide weather data continuously. The data also helps humanity in disaster management since the satellite launch. The NOAA weather satellites, broadcast an Automatic Picture Transmission APT signal, containing a weather picture of any zone in the world. These signals show up at around ~137 MHz, and just when a satellite is passing overhead. Each satellite has a different frequency.

In this research, a ground station weather receiver designed with the help of the cheapest SDR option Real Tech Software Defined Radio (RTL SDR), combined with an easy Homemade Quadrifilar Helix QFH antenna and WXtoImg, a free weather satellite decoding program which can decode the APT signal, and also tell you the times and frequencies of the NOAA satellites passing overhead.

The SDR software component is built with GNU Radio, an open source toolkit with a rich set of signal processing features.

The results show that the design of a weather ground station based on SDR is possible. This station is able to receive the APT pictures from NOAA 15, 18, 19 satellites.

This design system aims to provide a low cost comprehensive solution for receiving Automatic Picture Transmission from NOAA satellites of quite good resolution can be obtained.

Keywords: Software Defined Radio (SDR), Ground Stations, Satellites, RTL-SDR, QFH antenna, GNU radio.

Introduction:

At the beginning, the design of a reception station required considerable means, for that only specialized institutions approached these techniques. Nowadays, in view of the current improvement of micro-computers and signal processing, it is now possible for every amateur to have its own station able to receive mages from certain meteorological Satellites such as NOAA and METEOSAT satellites with reasonable costs (GUGLIUZZA et al., 2018).

The techniques of weather satellites images reception has immediately advanced in the most recent decade. Satellite Image reception is one of the most explored domains in satellite communications since the beginning of the space age. Those weather satellites can be either polar orbiting (Polar Operational Environmental Satellites) or geostationary (Geostationary Operational Environmental Satellites).Conventionally; geostationary satellites have been used for imaging and remote sensing applications. Availability of the images throughout the day, near global coverage are some of the benefits of using GEO satellites. Among them we may mention the European satellite

METEOSAT and the two American satellites GOES. The Polar Orbiting Satellites evolve at much lower altitude (a few hundred km), Much higher spatial resolution combined with imaging from a much closer range make the POES satellites the best suited for localized weather monitoring.

NOAA satellites belong to the Polar Orbiting Satellites category (ARDIZZONE et al., 2018) .From the space , those satellites bring us information about temperatures, ocean currents, sea surface temperatures, air and water pollutants, severe weather conditions, vegetation , ozone content of the atmosphere, volcano eruptions, and different components that influence our everyday lives.

National Oceanic and Atmosphere Administration (NOAA) is an American agency that is responsible for an environmental satellite system, which launched 19 satellites for collecting data in order to monitor weather change and extreme weather events These satellites are placed in low orbits and transmit their information in real time. The NOAA in charge of the exploitation of the meteorological satellites with low earth polar orbiting (P. A. LANVIN Jean, 2015) . Currently NOAA 15, NOAA 18 and NOAA 19 are active. Each one of those weather satellites broadcasts an Automatic Picture Transmission (APT). These automatic picture transmissions (APT) signals are sent at 137 MHz and are available twice a day to anyone on the earth. (DAVIS, G., 2015).

The Polar Orbiting Satellites evolve at much lower altitude (a few hundred km), consequently, their period of revolution is shorter1 (GUGLIUZZA et al., 2018). The system consists of a pair of satellites, which guarantees that all parts of the Earth is regularly observed no less than twice every 12 hours. (MITCHELL et al., 2016)

NOAA's mission is to understand and predict changes in Earth's climate, weather, oceans, and coasts, share that knowledge and information with others, and conserve and manage coastal and marine ecosystems and resources.

NOAA works to make new discoveries and expand its understandings of the oceans and atmosphere and apply this understanding to issues such as the causes and consequences of climate change, the physical dynamics of high-impact weather events, the dynamics of complex ecosystems and biodiversity, and the ability to model and predict the future states of these systems (T. P. R. Q. Patricia Huff, 2017) .

Most weather satellites had two format of picture services, a digital transmission format with high resolution data named HRPT, and an analogical transmission format of lower resolution APT.

APT data, that we receive daily, means Automatic Picture Transmission. It is a system, created in the 1960s, made to transmit low-resolution analog image for weather satellites. Advanced Very High Resolution Radiometer (AVHRR) produces the Automatic Picture Transmission data which is basically infrared and visible imagery

.An entire APT picture takes around 12 minutes to be developed at a rate of 2 lines for every second (MAHMOOD et JAFFER., 2016).

The Automatic Picture Transmission (APT) system utilizes information streams to transmit a visible image during daylight using channel A and an infra-red image on channel B throughout the day and night long. The APT analog signal is transmitted continuously via NOAA satellites. This signal was designed especially for inexpensive receivers and ground stations (CRISAN et CREMENE., 2012)

This APT transmission format needs limited technical resources for reception and decoding. For that a Software-defined radio SDR receivers combined with a good antenna and an efficient software systems are required.

Software defined radio SDR is a radio transceiver that is consist of two parts, the software part (GNU Radio, GRC, Matlab…) and the hardware part (RTL-SDR, USRP…).

Traditional RF receivers are the most widely used architecture in wireless transceivers so far. But its adaptation to different applications is difficult since the hardware module need to be re-designed. While in case of SDR receivers, with same software we can do different applications, because we just need to change the software program alone. Decreasing equipment costs have made SDRs affordable for most institutions (Abid, & Souani., 2018). Software-defined radio (SDR) is a technique for turning a computer into a radio. But not only have an AM/FM radio, by using the computing power we can listen and decodea wide variety of broadcasts. SDR can turn your computer into a weather-band receiver, a police/fire report scanner, a music listening station, and more (STEWART et al., 2015)…

Most SDR-based prototypes were built using GNU Radio software and embedded key RTL-SDR dongle (NESDR Smart), the RTL-SDR is a small, compact, and easy-to-use USB stick device that is capable of receiving RF radio signal (ABIRAMI et al., 2013)

In 2012 it was discovered by hardware hacker Eric Fry, Linux driver developer Antti Palosaari and the Osmocom team that the RTL2832U chip had a special mode which enabled it to be used as a general wideband SDR. Today, by using custom software drivers, a commonly found and low cost TV dongle can be transformed into a sophisticated SDR receiver with features that would have until recently cost in the hundreds to thousands of dollars (GONZALEZ, & FUNG., 2017).

Obviously, the performance of these dongles won't coordinate a dedicated SDR, however they perform extremely well for the price. They are capable of receiving any signal in the range their tuner operates over. This range varies from device to

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device depending on what components have been used, but is most commonly from 25 MHz to 1.75 GHz (STEWART et al., 2015).

The block diagram of the RTL-SDR represented in figure 2-5. RF signals are received at the antenna, quadrature downconverted by the RTL-SDR, and In Phase/ Quadrature Phase (IQ) samples are presented to the computer .The receive design is implemented using the appropriate DSP algorithms to demodulate the signal to baseband and extract the information signal. This might be audio,video ,images, or data (STEWART et al., 2015)

The main advantage of the key RTL-SDR is fast and economical, which is why GNU Radio users choose to work on this key to implement real-time applications (MESHRAM et KOLHARE., 2019). GNU radio is a free and open-source software development tool, which builds signal- processing blocks to implement software-defined radio systems (Al Masri, A. 2012).

The goal of GNU Radio is to write applications to transmit and receive data in digital form. GNU Radio applications are written using the Python programming language for high level blocks as well as for creating graphics, the so called low level blocks are implemented in C ++ which is used for the critical signal processing path using the processor floating point extensions. GNU radio is used with external RF equipment; in our case, we are using a universal software radio device as RF hardware (Muslimin, & Jusoh., 2016).

RTL-SDR set and the GNU Radio software tool constitute a Software Radio platform based on architecture with a General Purpose Processor.

Ceylan, O., Caglar, A. (CEYLAN et al., 2016) present an SDR modem and ground station system for CubeSats. The requirements for project, usually have to design an SDR modem and ground station system for CubeSats, both to be used in satellite communications. The final project was 100% an undergraduate student effort. The system works at 433.92 MHz with 2-FSK modulation. The standard data rate is 9.6 kb/s, and a data rate of up to 115.2-kb/s is available. Space conditions were also considered in the design, and the SDR modem was tested in a TVAC. The worst-case measured BER was 0.015% under space conditions.

Ramón Martínez Rodríguez-Osorio and Sergio R. Díaz-Miguel Coca (MARTÍNEZ et VEDAL., 2010) discuss “Educational Ground Station Based On Software Defined Radio”, this paper, they present a novel GS concept based on software defined radio technology that can be integrated in a global network for satellite tracking. The design must fulfil the requirements of low cost, remote operation, and flexibility to operate in different frequency bands.

Nozhan Hosseini, David W. Matolak (HOSSEINI et MATOLAK., 2017) present Software Defined Radios as Cognitive Relays for Satellite Ground Stations Incurring Terrestrial Interference. In this paper, they describe a cognitive SDR testbed that has been developed based on the Universal Software Radio Peripheral (USRP) and the GNU radio software platform. One of our testbed’s aims is to evaluate error performance improvements of satellite signal relays in the presence of interference. they report on performance evaluation in terms of bit error ratio (BER) as a function of carrier-to-noise ratio (CNR) and in the presence of interference.

Our work is divided into three parts; at the beginning, we present the general methodology of the Design of our Ground Station based on SDR. First, the hardware part of the station discussed; we described the NESDR Smart RTL-SDR dongle that we use, also the Quadrifilar Helix Antenna that we made. second, Simulations, Results and interpretation are explained in section 2. this part descute the software part of the ground station; we presented our GRC flow graph for NOAA receiver, Gpredict for satellites tracking, Wxtoimg APT decoder and the audio piping method. section 3 presents our conclusions and we discuss possible future work

Methodology:

Our weather satellites images reception station is a system that aims to provide a low cost comprehensive solution for receiving Automatic Picture Transmission from NOAA satellites based on SDR. This station consist of two parts: hardware and software as shown in figure 1 The Hardware part consists of; the Quadrifilar Helix Antenna for the reception of NOAA APT signal, and RTL-SDR Dongle Receiver. The Software part consists of ;GNU Radio, to create our application for NOAA Satellite image reception , Gpredict ; Software to predict the tracks of meteorological satellites and WXTOIMG ,Software for decoding the APT signal Automatic Picture Transmission.

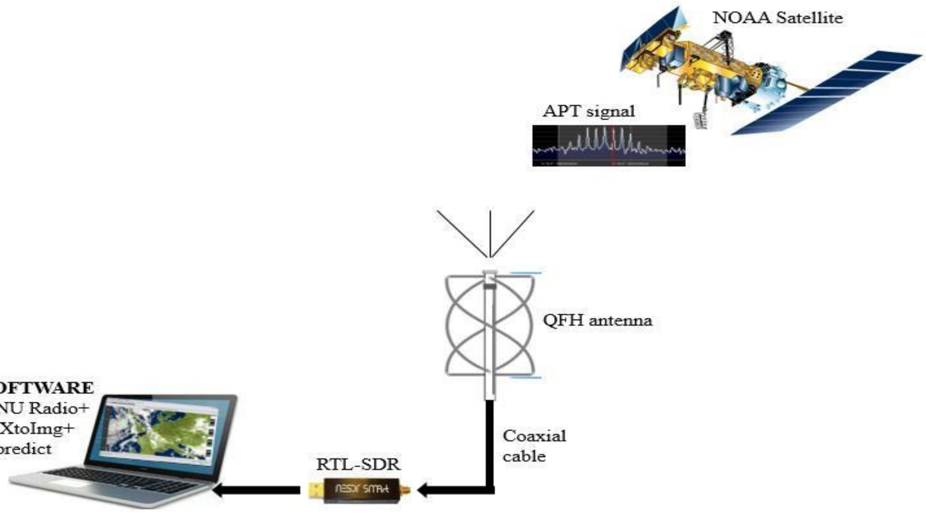

Fig. 1 description of System design of the meteorological station

Quadrifilar Helix Antenna

The SDR tuner will enable us to get the transmission however we require a good antenna tuned to the APT signals in order to receive a clear picture. This is where the QFH Antenna comes in. In fact there are a wide range of antenna designs for catching pictures from weather. The ideal antenna for random polarization would be one with a circularly polarized radiation pattern. Tow commonly used methods for obtaining circular polarization are the cross Yagi, as shown in Figure 2 and the Quadrifilar Helix Antenna Figure 3, as described later in this section. The crossed Yagi is mechanically simple to construct, but harder to adjust than its helical counterpart (ABULGASEM et al., 2021).

Fig. 2 Cross Yagi Antenna

The QFH Antenna was used in commercial, military and amateurs satellites. The basic form of the Quadrafilar antenna was developed by Dr C. C. Kilgus of the Applied Physics Laboratory, Johns Hopkins University, who has published several papers that establish the theoretical basis for its operation (AHMAD, et KHAN., 2015) (SLADE, Bill., 2015) .

Fig. 3 QFH antenna

The QFH antenna features

It's a right hand circular polarization antenna consisting of 2 loops performing a rotation of 90 ° in the vertical plane, the terminals of each loop are fed 180°. The QFH antenna has a particularity, which is very good performance, without the need to use complex and expensive rotors (GUPTA et CHOPRA., 2019)
it suits excellently to the reception of signals from satellites or from aircrafts without the need of pointing. Also it does not need a reflector. This antenna is applicable for general use in the frequency range above 30 MHz.
The QFH is very easy to make and is an omnidirectional antenna, implying that we don't need to aim it to have it pick up the signals and it has excellent performance over the entire sky; this means you can get the signal from a NOAA satellite when it is just above the horizon, and will lose it when it's just about set on the other horizon (DONAT, Wolfram., 2021) .

Building the QFH antenna

The Basics of Building a QFH Antenna, first of all the QFH antenna is relatively easy to build; it can be a homemade antenna. There are a few things that need to be highlighted before construction can begin on the QFH. First it's actually two antennas, a small one inside a bigger one that is of the proper dimensions so that it blocks out surrounding interference and receives signals very well on the 137.5 MHz frequency band that the NOAA satellites transmit around. Second, you can build QFH Antennas of different sizes that are delicate to various frequency bands, because the dimensions of the antenna are directly proportional to the frequency you wish to receive, but we'll be concentrating on the dimensions for 137.5 MHz.
For the measurements of our antenna, firstly we should calculate the size of our QFH antenna: the central mast and the supports which will hold the components. To do this we used the following great online calculator made by John Coppens (J. Coppens. [Online].). Us we motioned before the most important variable to select on the calculator is your design frequency, this is because the design frequency chooses what satellite band your antenna will be advanced for. In our case, we selected a design frequency of around 137.500MHz. 137.500MHz is a great frequency to use for a QFH antenna to receive APT from NOAA satellites once we have selected our design frequency the calculator give us all the measurements that we need, it's represented in this Table1 and Figure 4.

Table. 1 QHF Measurement

Frequency	137.5 MHz
Big loop1	
D1	374mm
H1	560mm
L1	812mm
Small loop2	
D2	356mm
H2	512mm
L2	758mm

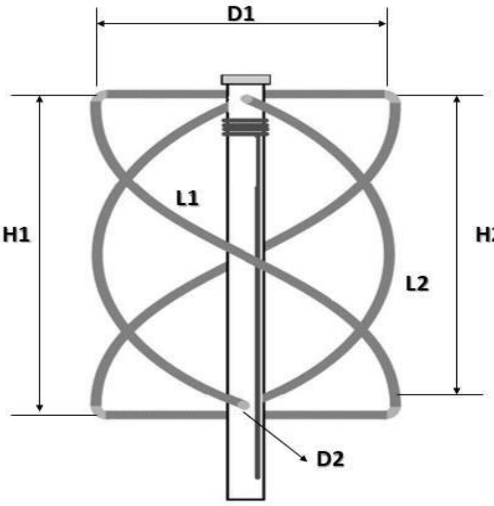

Fig. 4 QFH dimensions

Simulation, results and discussion:

NOAA receiver with GRC

GNU Radio Companion (GRC) is a graphical user interface that allows us to build GNU Radio flowgraphs using predefined DSP blocks. The software part of the NOAA receiver was built using the GNU Radio Companion, in this bloc diagram shown in Figure 5 we used the RTL SDR Dongle source block for GNU Radio.

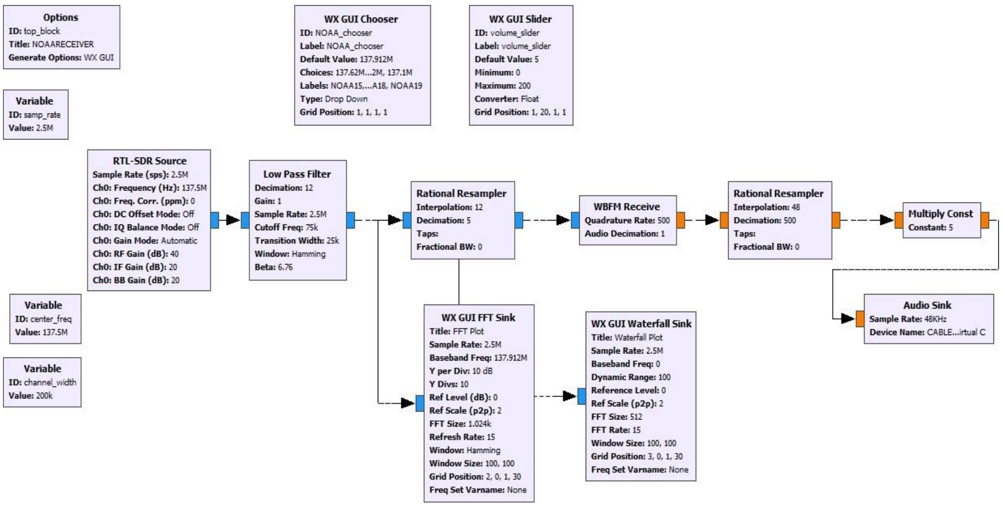

Fig. 5 The GNU Radio Companion flow graph of the NOAA 15, 18, 19 receiver

First we have to set our RTLSDR we can find it in Sources category on the right sidebar of GRC. Then, our signal input, we need to set its sample rate to 2.5M so that's will be our bandwidth, the sample rate is the number of samples per second. Here we will also set the frequency center of the NOAA stations we want to receive. Second, we need to filter out frequencies other than the one we centered in the previous step. In that task we will use a low pass filter block. It can be found on filters category. We here set cutoff frequency to 75Khz. transition width 25 KHz. Now we have to enter our NOAA 15,18,19 frequencies in bloc WX GUI Chooser. In order to view this wave we need to use graphical sinks: WX GUI FFT Sink and

WX GUI Waterfall Sink. The next step now and the most important is placing the FM demodulator. This block can be found on modulators menu. The Resampling block is used to change the sampling rate of a signal in order to meet the requirements of another system in our case the sampling rate of a sound card. In the second block we set constant to 'volume'. And finally we link Audio Sink block (found in Audio) with multiply const. Now it's only required to edit its rate and choose 48 Khz from a drop down list.

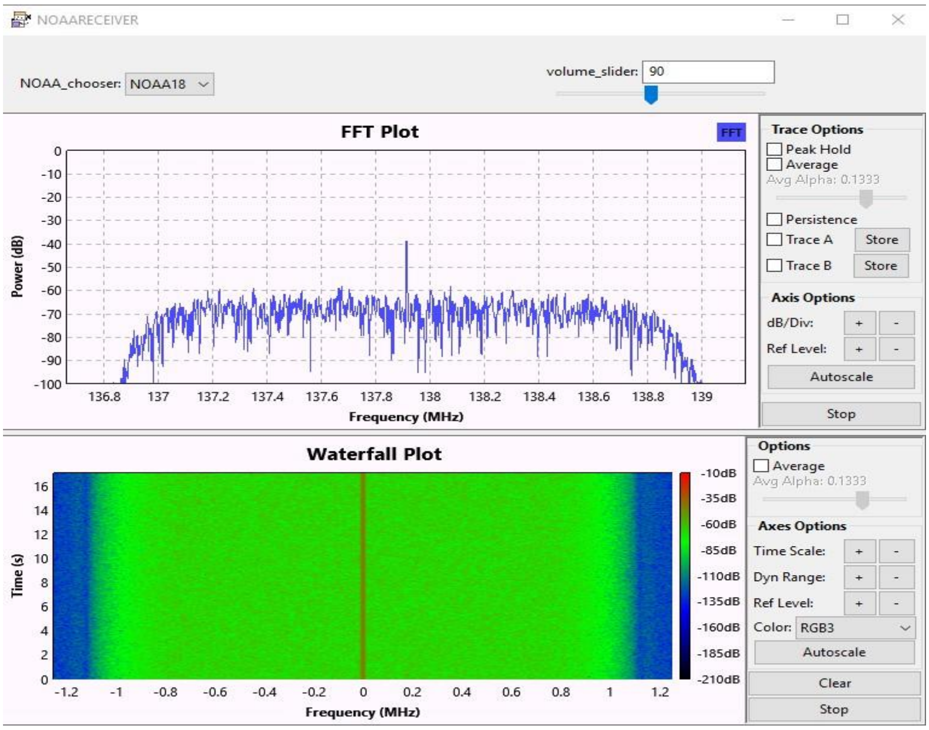

Fig. 6 The GRC interface for NOAA Receiver

Gpredict for NOAA tracking

A satellite tracking program is a computer program that predicts the position and speed of a satellite at a given time using a mathematical model of the orbit. Once the position and speed of the satellite is known other data can be calculated. Gpredict is a real-time satellite tracking and orbit prediction program. It can track an unlimited number of satellites and show their position and many other data in lists, tables, maps, and polar plots (radar view). Gpredict can also predict the time of future passes for a satellite, and give you detailed information about each pass. It is free software licensed under the GNU General Public License. This gives you the freedom to use and modify it to suit your needs.

For NOAA satellite tracking with Gpredict, First we started by setting up the ground station to do that we selected the coordinates of our location: Latitude (⁰) =35.3852 North, Longitude (⁰) =10.5325 East.

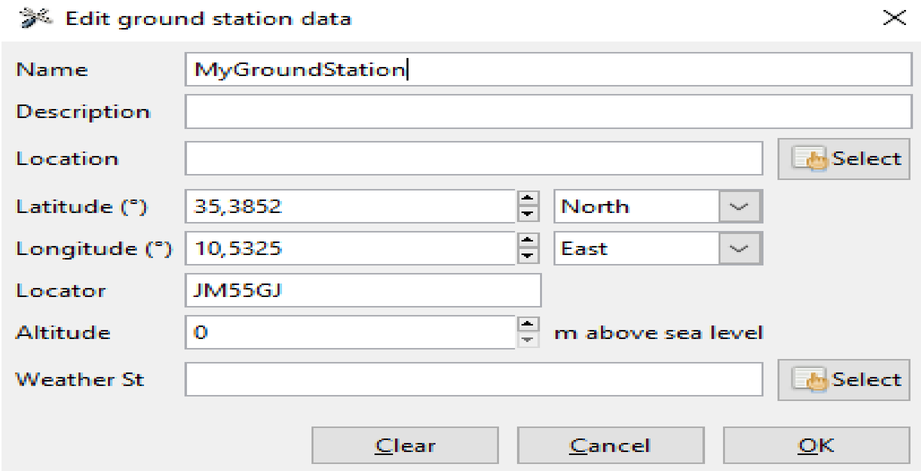

Fig. 7 The ground station editor window

Second we searched for NOAA and add the 15, 18 and 19 satellites to the tracking list

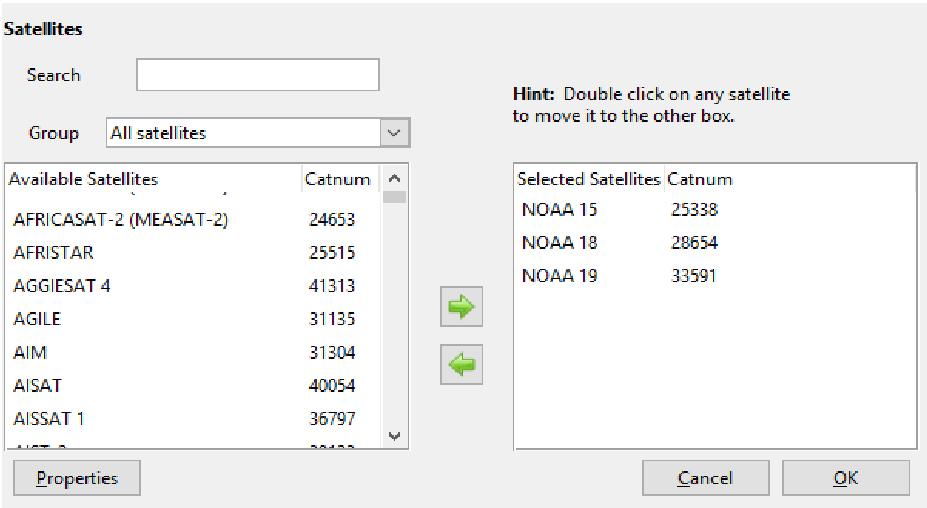

Fig. 8 The module configuration window

Finally, after we've done that the main window was updated. Now we can track all the NOAA satellites.

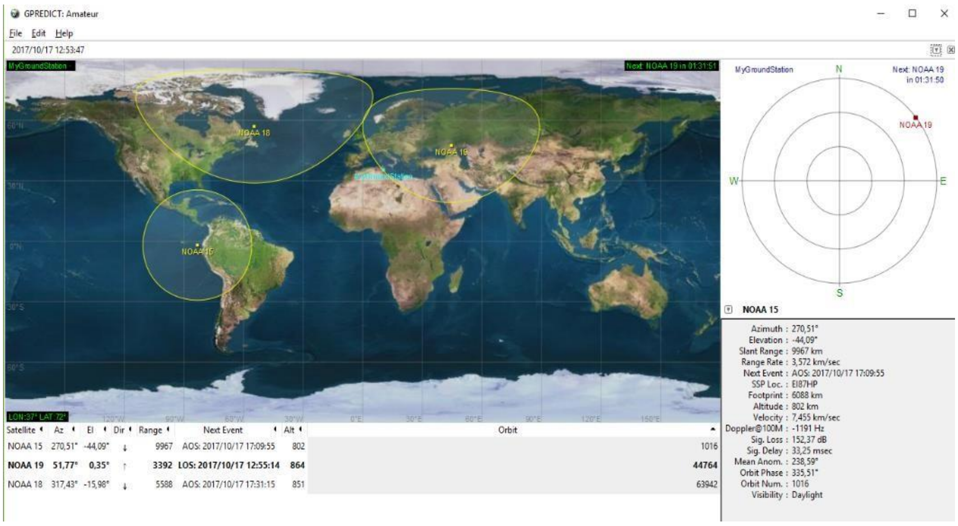

Fig. 9 The main window showing a module with three views.

In order to predict NOAA 18 satellite passes occurring in the near future, we have to right-click on it as shown in figure 10.

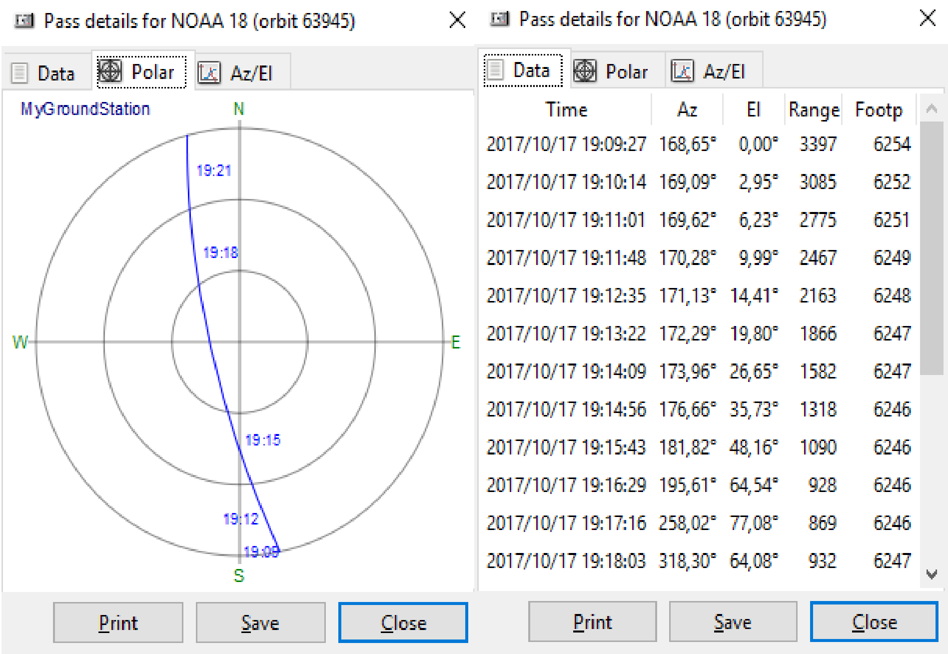

Fig. 10 Data presented about the next upcoming pass

WXtoimg APT decoder

The software used for image decoding is WXtoImg, this program is designed to decode audio signals APT in real-time for image generation (Carlo, & Linda,. 2016). It is a free weather satellite decoding program for Windows, Linux, OSX and even The Raspberry Pi. The signal capture by the receptor of the satellite is transformed into an audio that is decoded by the WXtoImg software that converts audio pulses bit lines to form a whole image (Carlo, & Linda,. 2016). WXtoImg is a free weather satellite decoding program, which can decode the APT signal, and also tell you the times and frequencies of the satellites passing overhead. (T. R. THE AUTHORS OF), it can also decode previously recorded WAV files, allowing the opportunity of

extensive post-processing, which can include any of a number of specialized filter options from NOAA for enhancing cloud and sea temperature detail. WXtoImg supports real-time decoding, map overlays, advanced color enhancements,3-D images, animations, multi-pass images, projection transformation, temperature display, GPS interfacing, computer control for many weather satellite receivers, AND MORE (BENMOKRANE, & Mohammed., 2018) For decoding APT signals with Wxtoimg, first we started by setting up our Ground Station Location by entering in an exact latitude, longitude.

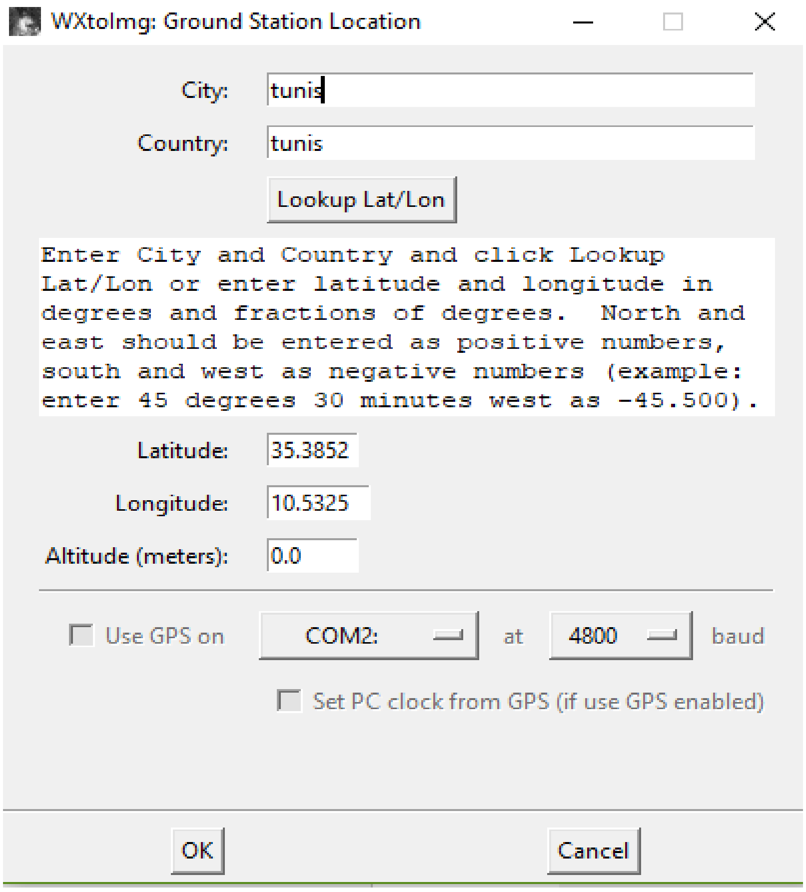

Fig. 11 Ground Station Location

Second, those coordinates that we entered are used to determine when a satellite will pass over our sky.

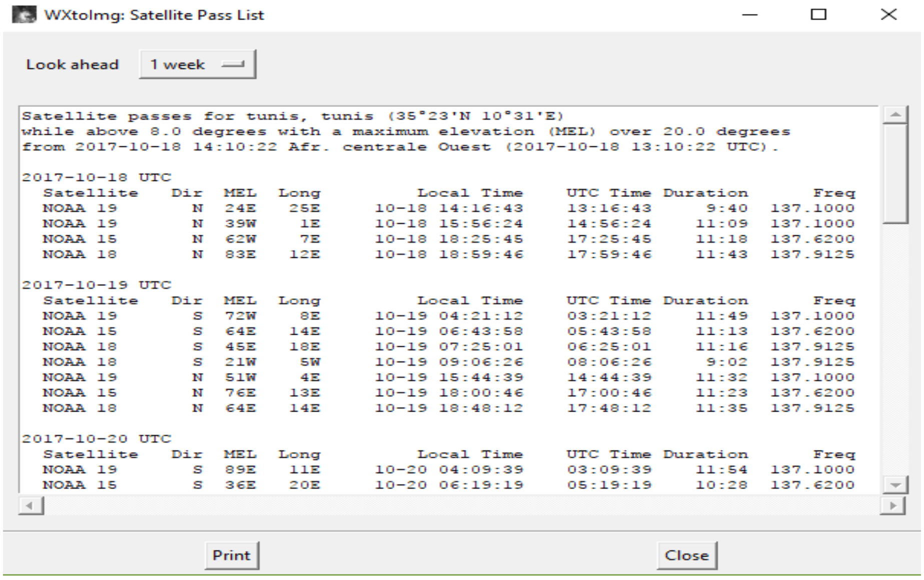

Fig. 12 Satellite Pass List

Finally the recording and decoding will begin when the satellite appears on our horizon, and stop when it goes out of view according to the times in the satellite pass list.

The audio piping method

The audio piping method needed to ensure the connection between the GRC application and wxtoimg decoder ; that's way we used the virtual audio cable VB_CABLE

VB-Audio CABLE is a a free Windows Audio Driver software working as Virtual Audio Cable, installs a new audio device that acts in a similar way to stereo mix.

The advantage with a program like VB Cable over stereo mix is that the audio will not play through your speakers. This is desired and required in applications like digital voice decoding, where it is desired to listen to only the decoded voice and not the noise of the digital signal (STEPHENS et al., 2021).

In our GRC flow graph we selected the audio piping method that we are using by entering the name of the audio device. Actually that is the INPUT of our audio.

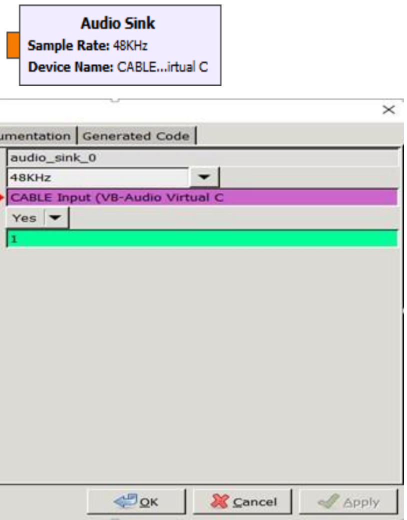

Fig. 13 audio sink block parameter

And for The OUTPUT we should set it in WXtoImg so we have to select the VB audio under the soundcard option.

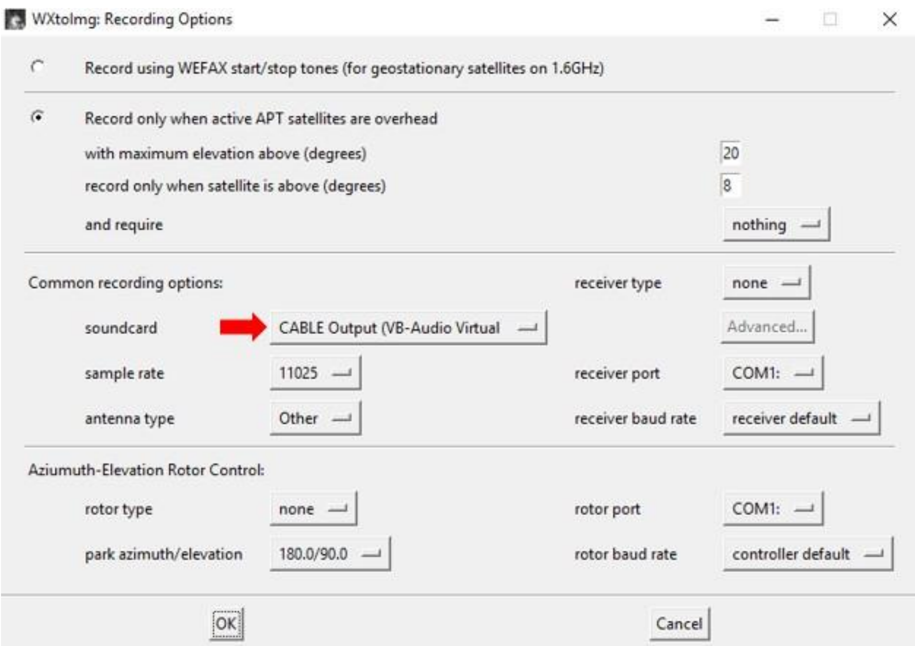

Fig. 14 WXtoImg parametr

Gpredict tracked the NOAA15 at 2017-10-12 satellite and showed his position .we can clearly see that the NOAA 15 satellite is above our ground station location .

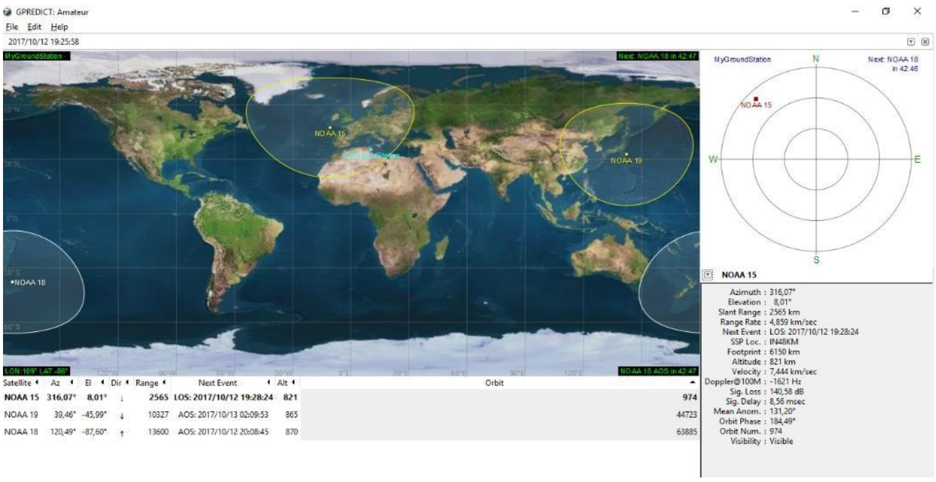

Fig. 15 The Gpredict main window showing the NOAA15 pass

GRC NOAA receiver application pick up the NOAA15 APT single . The end result of the receiver's operation on GRC is an audio file .That audio file was decoded into the image using WXTOIMG.

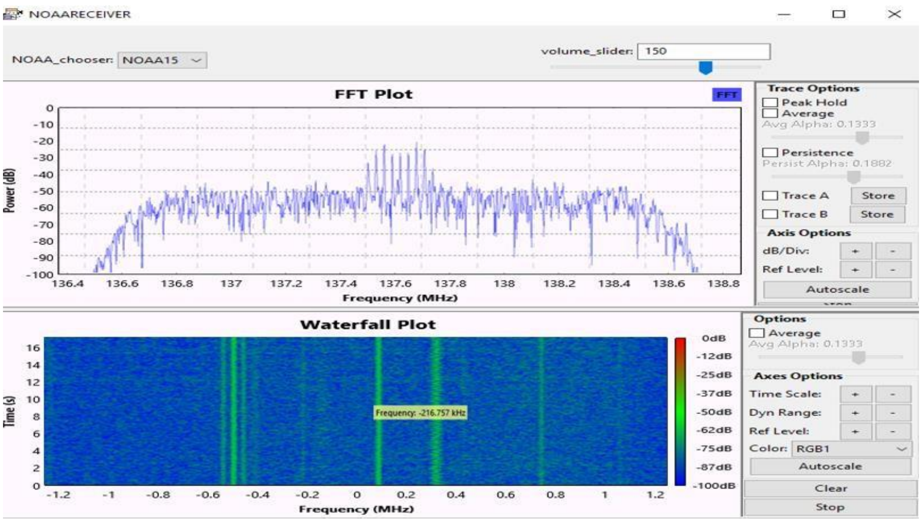

Fig. 16 The receiver in operation

APT transmissions from the NOAA weather satellites contain two channels A and B that are basically two images from two different instruments. Often, one channel will contain a visible light image and the other will contain and infrared image. In the figure 17 below we see the infrared image on the left and visible light on the right.

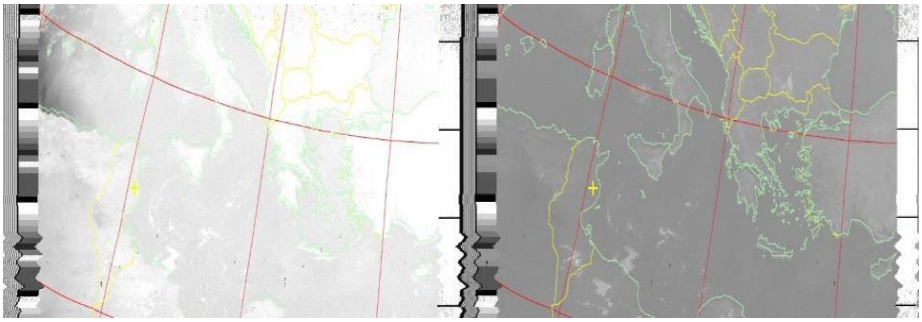

Fig. 17 NOAA15 image before processing

WXtoImg can combine the different images to create various false color images. So the image processing is performed automatically by WXTOIMG as shown in figure 18 below.

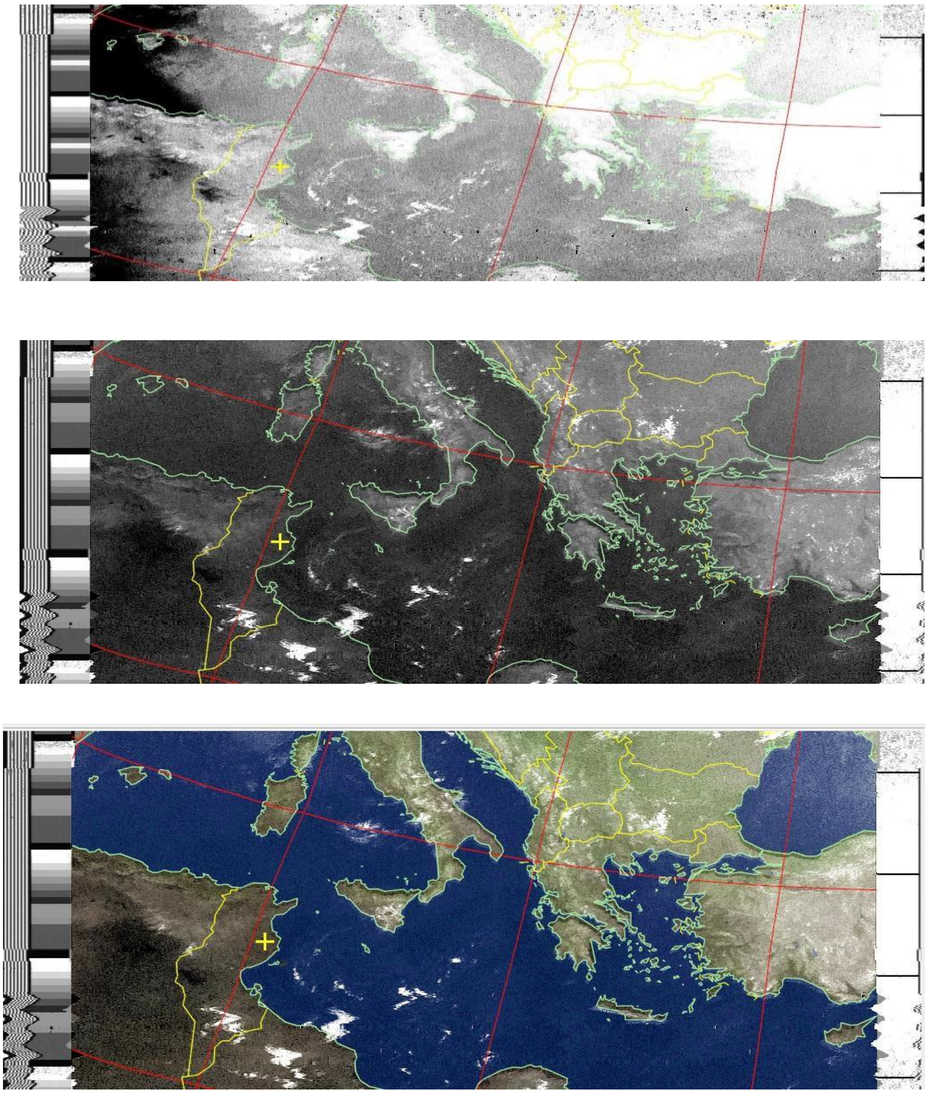

Fig. 18 NOAA15 with MCIR map color IP

This ground station prototype based on SDR technology can establish satellite communications with the chosen hardware. The station is ideal for educational settings. We were able to run multiple apps on the same hardware platform thanks to SDR technology. By simply upgrading the program, we might alter performance. As opposed to more traditional, constraining solutions, this provided us with a dynamic configuration and significant flexibility. The main benefit of this strategy is its affordable execution, which offers the same capacities as other university ground stations.

Conclusion:

In this paper we designed our land weather station and all the hardware and software parts was presented with detail. Finally, our ground station based on SDR ready to use and we have successfully received images from NOAA satellite.

This project focused on designing a land station based on SDR, it’s a weather ground station capable of receiving images from the meteorological satellites .We have presented overview of the Software Defined Radio (SDR), NOAA meteorological satellite and the Automatic Picture Transmission (APT) signal. The forth part presented our steps of building the ground station. This part divided into two parts; hardware part and software part, and we ended with the results.

Once we finish the design of our meteorological land station we may disclose the following advantages and limitations; The selection of the QFH antenna, with all his features, provide higher reception quality of satellite images .The QFH is very easy to make and is an omnidirectional antenna, meaning that you don't have to aim it to have it pick up the signals and it has excellent performance across the whole sky. A disadvantage of the QFH antenna is its high sensitivity to noise in the test environment, and that can affect the quality of received signal, that’s why we have to place it at the highest possible location directly under the sky.

Our station based on RTL-SDR technology dramatically reduces hardware infrastructure used in meteorology as well as the prototype can be moved swiftly and assembled very quickly. Also, the RTL-SDR is really inexpensive device compared to other SDR hardware platform. Unfortunately, this dongle can only receive signals .For both transmission and reception signals we propose other SDR hardware platform such as USRP.

In this research we discovered a software platform called GNU Radio Companion or GRC, it's really easy to use and contain all DSP blocks needed to create our NOAA image receiver application. Also, the APT decoder platform WXTOIMG, convert the audio file resulted from the GRC application to an image. However, it has limited features; it only gives weather images without explication. In fact, I think only weather experts can pick up information about weather like temperature or speed of winds from those pictures.

As a result of our work we successfully received the APT signal from NOAA satellite, that's means, we finally build a ground station base on SDR accomplished in a simple and cost effective manner.

As future work, we will try to use another kind of antenna and we will compare the results with what we found with the QFH antenna.

We had received the APT signal ,as future work we propose receive the HRPT signal from NOAA satellites which is a high resolution picture transmission , of course a high gain antenna is required.

The SDR is a key to the wireless world, besides receive image from satellite with really low cost equipment a lot off application can be done ,for example ; Receiving GPS signals, tracking aircraft positions, watching analogue broadcast TV and many other.

Acknowledge

No conflict of interest.

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"تصميم محطة أرضية للطقس تعتمد على الراديو المحدد بالبرمجيات"

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ملخص:

هناك اعتقاد خاطئ واسع النطاق بأن بناء محطة أرضية لاستقبال صور الأقمار الصناعية يتطلب أولاً الحصول على ترخيص معتمد، وثانيًا، تعد الأطباق المكافئة الضخمة المزودة بأجهزة استقبال الترددات اللاسلكية المتخصصة أجهزة ضرورية وأكثر تكلفة بكثير. ومع ذلك، هذا ليس هو الحال. بينما تستمر صناعة الفضاء في النمو، تزداد الحاجة إلى حلول منخفضة التكلفة. وهذا ينطبق أيضًا على أنظمة المحطات الأرضية.

نتناول في هذا البحث كيفية بناء محطة استقبال أرضية بأقل تكلفة لأقمار الأرصاد الجوية وكيفية استخدام بعض البرامج الضرورية لتتبع واستقبال وفك تشفير الصور المرسلة كل يوم.

تمتلك الإدارة الوطنية للمحيطات والغلاف الجوي (NOAA) مجموعة من الأقمار الصناعية التي توفر بيانات الطقس بشكل مستمر. تساعد البيانات أيضًا الإنسانية في إدارة الكوارث منذ إطلاق القمر الصناعي. تبث أقمار الطقس التابعة لـ NOAA إشارة APT لنقل الصور تلقائيًا، والتي تحتوي على صورة الطقس لأي منطقة في العالم. تظهر هذه الإشارات عند حوالي 137 ميجا هرتز، وذلك فقط عندما يمر القمر الصناعي في سماء المنطقة. كل قمر صناعي لديه تردد مختلف.

في هذا البحث، تم تصميم جهاز استقبال للطقس للمحطة الأرضية بمساعدة خيار حقوق السحب الخاصة الأرخص (راديو Real Tech Software Defined Radio (RTL SDR)، بالإضافة إلى هوائي Quadrifilar Helix QFH سهل الصنع محلي الصنع وWXtoImg، وهو برنامج مجاني لفك تشفير الأقمار الصناعية للطقس يمكنه فك تشفير إشارةAPT ، وتخبرك أيضًا بأوقات وترددات مرور الأقمار الصناعية التابعة لـ NOAA في سماء المنطقة.

تم إنشاء مكون برنامج SDR باستخدام راديوGNU ، وهو عبارة عن مجموعة أدوات مفتوحة المصدر مع مجموعة غنية من ميزات معالجة الإشارات.

أظهرت النتائج أن تصميم محطة أرضية للأرصاد الجوية على أساس حقوق السحب الخاصة أمر ممكن. هذه المحطة قادرة على استقبال صور APT من الأقمار الصناعية15 NOAA ، 18، 19.

يهدف نظام التصميم هذا إلى توفير حل شامل منخفض التكلفة لاستقبال الإرسال التلقائي للصور من أقمار NOAA الصناعية ذات الدقة الجيدة جدًا.

الكلمات المفتاحية: الراديو المحدد بالبرمجيات(SDR) ، المحطات الأرضية، الأقمار الصناعية، RTL-SDR، هوائيQFH ، راديو GNU.