The AMSAT® Journal

Volume 45, Number 6 November/December 2022

Go Green!

GreenCube

Microgreens cultivation in a CubeSat

[GreenCube logo/banner courtesy of ASI-Sapienza.]

In this issue —

Apogee View 3
by Robert Bankston • KE4AL

President's Club 2022 Members 4

GreenCube on Orbit 5

GreenCube is Now Designated Italy-OSCAR 117 (IO-117) .. 5
by Drew Glasbrenner • KO4MA

The IO-117 (GreenCube) Club Continues to Grow 5
by Doug Papay • K8DP

Adventures with the GreenCube Satellite 6
by Tom Van den Bon • ZR6TG

Working the GreenCube Digipeater 16
by Bertrand "Burt" Demarcq • FG8OJ

Working the ISS Repeater with a Baofeng UV5R From New Zealand 23
by Terry Osborne • ZL2TBAC

Write for *The AMSAT Journal*

The AMSAT Journal is looking for interesting articles, experiences and photos to share with other AMSAT members. Writing for the *Journal* is an excellent way both to give back to the AMSAT community and to help others learn and grow in this most fascinating aspect of the amateur radio avocation.

Find a quiet place, sit yourself down, get out your laptop or pick up a pen, and …

1. *Launch* your inner writer;
2. *Downlink* your knowledge and experiences to others by:
-- Sharing your adventures in the "On the Grids" column or
-- Describing your AMSAT career in "Member Footprints;"
3. *Transmit* lessons learned from operational and technical projects;
4. *Log* some of your more interesting passes across the sky; and
5. *Boost* others to a higher orbit of know-how and experience.

After your article lands in members' mailboxes, and the kudos start arriving for your narrative payload, you can enjoy the satisfaction of knowing you've elevated the collective wisdom of AMSAT to a higher trajectory. Send your manuscripts and photos, or story ideas, to: journal@amsat.org.

Our editors are standing by!

AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy satellite systems with the goal of providing wide-area and continuous coverage. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.

Radio Amateur Satellite Corporation (AMSAT)
P.O. Box 27, Washington, D.C. 20044

AMSAT Club Callsign: W3ZM
AMSAT Websites: www.amsat.org, launch.amsat.org (Member Portal)

Editorial Office: Joe Kornowski KB6IGK, 3310 W. Braker Ln., Suite 300-322, Austin, TX 78758. Please e-mail *Journal* submissions to: journal@amsat.org,

The AMSAT Journal (ISSN: 1407-3076) is published bi-monthly (Jan/Feb, Mar/Apr, May/Jun, Jul/Aug, Sep/Oct, Nov/Dec) by AMSAT.

The AMSAT Journal staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to journal@amsat.org using plain text or word processor files; photos or figures in TIF, GIF or JPG formats. Kindly do not embed graphics or photos in your manuscript. We prefer receiving those as separate files. AMSAT reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations.

Apogee View

Robert Bankston, KE4AL
President

I begin this Apogee View by thanking all of our AMSAT volunteers. With your selfless service, we are able to accomplish everything we do. I also thank all our members for your continued support of AMSAT's mission — to develop experimental amateur radio satellites, share what we learn, encourage technical and scientific innovation, and promote the training and development of tomorrow's satellite and ground system designers, builders, and operators.

As 2022 comes to a close and we take our first steps into 2023, I propose beginning a serious conversation on what AMSAT and amateur radio in space will look like going forward.

It is all too easy to focus on the here and now — projects we currently have on the workbench, existing technologies satellites already in orbit, and the way we now communicate. However, with typical lead times of 10-15 years, the time is now to start conceptualizing the what, where, and how we want to be. Unfortunately, we have no magical crystal ball that we can look into. Instead, we must systematically explore predictions and possibilities about the future and how they can emerge from the present.

Science and technology have progressed to the point where what we build is only constrained by the limits of our imagination. Computers that once filled entire rooms now fit in our pockets. Telephones, once tied to a wall and processed through a human switchboard, now communicate digitally over wireless networks from wherever we are. Satellites, which started out as beacon-only spacecraft with non-rechargeable batteries, now provide for continuous global and deep space exploration. Science fiction has become science fact.

Amateur radio in space is not exclusive to the United States or even North America but rather a global service. As such, any initiative to develop, design, and build the next generation of amateur radio satellites should be a collective effort that taps into a worldwide community of talented dreamers through open-source hardware and software development.

Of course, standing in our way is a regulatory environment that will only become more restrictive and expand globally with each successive launch. Currently, U.S. spacecraft that terminate satellite operations in or pass through the low-Earth orbit region (below 2,000 kilometers altitude) must complete disposal as soon as practicable following the end of the mission and no later than five years after the end of its primary mission. In addition, spacecraft operating and terminating above low-Earth orbit must move away from Earth's orbit and stay away no later than 25 years after the end of the mission. Therefore, where our satellites go and how we plan for their return must be essential considerations in this discussion.

To facilitate this discussion, we will establish the necessary infrastructure to freely exchange ideas, develop a conceptual framework, and bring those dreams to reality. I will let you know as soon as we go live, and I encourage you to join in the conversation. In the meantime, if you can attend the 2023 Orlando Hamcation, February 10th through the 12th, the future of amateur radio in space will be the focus of our forum discussion. I look forward to meeting with you.

AMSAT is committed to advancing the capabilities and functionality of satellites, and, with your help, we can shape the amateur satellite world of tomorrow.

Until the next time, Onward & Upward!

President's Club 2022 Members

AMSAT 2022 President's Club Members Raise $63,717

In 2022, a total of 78 members and friends of AMSAT contributed a total of $63,717 and were recognized with membership in the AMSAT 2022 President's Club. We thank them for their generous support and helping to Keep Amateur Radio in Space!

Membership levels begin at $120 and can be paid in one lump-sum or in monthly installments. For complete details on AMSAT President Club membership, see the ad at the end of this edition of *The AMSAT Journal*.

Titanium ($4,800+)
Barry A. Baines, WD4ASW
Alan P. Biddle, WA4SCA
John D. Botti, KC8OKB
William G. Brown, K9LF

Platinum ($2,400+)
Steve Belter, N9IP
Ronald G. Parsons, W5RKN
Cheryl Printon

Gold ($1,200+)
Anonymous
Dwight Aussieker, K9QJ
Douglas Besemer, K0VPL
Burns Fisher, WB1FJ
James Hain, W2IMY
Joseph Lynch, N6CL
John R. Kludt, K7SYS
Glenn Miller, AA5PK
Mary Lou Monteiro
John Pinkham, K3PER
Thomas Schaefer, NY4I
Michael Stipick, KC4RI
Douglas B. Tabor, N6UA

Silver ($600+)
John Boehme, K4PRK
Warren Fugate, W3WE
Mark Johns, K0JM
Jean-Louis Maridet, F5DYD
Patrick Maroney, KD0YMO
Bruce Paige, KK5DO
David A. Vine, WA1EAW
Chuck Weaver, W3VAR

Bronze ($300+)
Anonymous
Scott Danzer, N1XCY
Robert Grattan III, N4MRV
Allen Kenney, KK4AK
Donald J. Lum, WA6ICW
Bruce Perens, K6BP
Donald Pettigrew, K9ECT
Scott Shaheen, WB8OOJ
Thomas Talley, K0CFI
Dave Taylor, W8AAS
Rickey N. Walker, K4TD

Core ($120+)
Oscar Alonso, N6PAZ
Dwight Aussieker, W9QJ
Steve Bachhuber, K9SJB
Robert Brennan, KC3CKV
Burlington Amateur Radio Club
George Carr, WA5KBH
Michael Caughey, N2BT
Jim Clary, ND9M
Richard Dittmer, KB7SAT
Todd Dugdale, KD0TLS
John Flowers, K4ZMR
James Gallagher III, KB3SQS
George Gallis, AL7BX
David Grebe, WA4LM
David Hartrum, WA3YDZ
Stephen Howard, AB0XE
Nels E. Knutzen, W0PEC
Edward Krome, K9EK
Gailen Marshall, N5GDM
Brendan McNeil, ZL3BAM
Juan Munoz, TG9AJR
Andrew Northam, KE8FZT
Art Payne, VE3GNF
Maxwell Rathbone, W3POI
Larry Schroeder, KD4HSL
Jay Schwartz, WB8SBI
Jason Schwarz, N4JJS
Alton Simpson, WA5TJB
Carl Starnes, W4EAT
Paul Stoetzer, N8HM
Dennis Turner, K0DIS
Arun Vijayshankar, K6ARV
Christopher Wachs, WA2KDL
Stefan Wagener, VE4SW
Wayne Wagner, AG1A
Jim Wellinghoff, W0NBC
Jeremy Wyatt, KA2PFD

Share Your Experiences as an AMSAT Member

The AMSAT Journal is looking for you to share your satellite radio experiences, likes and dislikes, how you work the birds, and what you like about *The AMSAT Journal*. We'll publish a selection of responses in upcoming issues of the Journal under a column we're calling "Members Footprints." Photos are strongly encouraged! Thanks!

Please send the information requested below to journal@amsat.org --

- Your Name
- Call Signs Held
- Primary Grid Square
- Favorite Satellite Contact
- First Satellite Contact
- First Satellite Ground Station Description
- Current Satellite Ground Station Description
- Reasons You Are an AMSAT Member
- Favorite AMSAT Memory (a satellite contact, symposium, engineering project, event that would never have happened without AMSAT, etc.)
- Favorite Topics Appearing in The AMSAT Journal (could include things like building a homebrew antenna, assembling a ground station, using tablets and smartphones, news of upcoming launches, portable operations, ARISS, etc.

Please Provide a Hi-Resolution Photograph (see www.amsat.org/?page_id=1709).

Smile for AMSAT at Amazon.com

When making purchases from Amazon, you can select a charity and Amazon will donate .5% of a qualified purchase towards that charity. Select smile.amazon.com when making your Amazon purchases and make Radio Amateur Satellite Corporation (AMSAT) your chosen charity.

Having selected a charity, when you go to amazon.com, you will be prompted to go to smile.amazon.com. However, you can put everything you want in your cart at the original amazon.com site, then leave the site and go to smile.amazon.com and all your items will still be in your cart.

GreenCube on Orbit

GreenCube Designated Italy-OSCAR 117 (IO-117)

Drew Glasbrenner, KO4MA
OSCAR NumberAdministrator

On July 13, 2022, the GreenCube satellite was launched on a Vega-C launch vehicle from the Centre Spatial Guyanais in Kourou, French Guiana. The Italian Space Agency (ASI) and the Department of Aeronautics, Electric and Energy Engineering (DIAEE) of Sapienza University of Rome manage the satellite project, with the participation of ENEA (the Italian National Agency for New Technologies, Energy and Sustainable Economic Development) and the University of Naples. The satellite carries environmental and thruster payloads as well as a 70 cm digipeater for amateur radio use.

At the request of the GreenCube teams, AMSAT has designated the satellite as Italy-OSCAR 117 (IO-117). We congratulate all the involved teams, thank them for their contribution to the amateur satellite community, and wish them continued success on this and future projects.

The IO-117 (GreenCube) Club Continues to Grow

Doug Papay, K8DP

Because of the increasing interest and the quick appearance of instructional material on making digipeated contacts through IO-117, the "GreenCube User Club" has rapidly grown to more than 300 members, as reported by Doug Papay, K8DP (see section below). Doug and Burt DeMarcq, FG8OJ, describe their respective operational setups for taking advantage of the new satellite's great DXCC and VUCC opportunities. In addition, Burt presents some nicely-detailed instructions and good advice (see article below).

Fabio Roccatagliata, F5VKV, writes on the AMSAT-BB mailing group that the UZ7HO Soundmodem is very useful for IO-117. He explains how one must download **uz7.ho.ua/greentnc.zip** for success as the tone spacing is shifted from those typical for APRS. He continues, "Use the SSB modem, 1600 main frequency in the spectrum. (Put the) Radio in USB, AGC off if possible (or fast), no noise blanker/reduction. You should receive the packet when the signal is within the bandwidth bar you see in the sound modem spectrum. Adapt the DCD threshold accordingly, usually by half. In the GreenCube GUI window, you should see the decoded packets in the sound modem data."

Joe Pereira, VK5EI, suggested on the AMSAT-BB mailing group that the summary by Tom Van den Bon, ZR6TG, is particularly helpful for newcomers. See Tom's blog post at **bit.ly/3Uqpm9B**.

IO-117 (GreenCube) Statistics

Unique callsigns: 499 (This count includes stations using portable identifiers, e.g., /R, as unique callsigns and excludes busted and/or pirate callsigns.)

Number of unique callsigns heard in the last 24 hours: 197

Number of grid squares (4-digit) activated: 290

Most active grid square (# callsigns): PM95 (25)

Number of DXCC entities activated: 69
Top 5 most active DXCC entities (# callsigns):

United States (149)
Japan (67)
Italy (58)
Spain (34) and
China (17)

Number of DXCC entities with only one active callsign: 27

DXCC entities activated by DXpedition only:

Hawaii
Liechtenstein
Luxembourg

Most recent DXCC entity activated:

Hungary

IO-117 (GreenCube) DXCC List:

Alaska
Argentina
Asiatic Russia
Australia
Azerbaijan
Azores
Balearic Islands
Belgium
Brazil
Bulgaria
Canada
Canary Islands
Chile
China
Colombia
Croatia
Curacao
Czech Republic
Denmark
Ecuador
England
Estonia
European Russia
Fed. Rep. of Germany
Finland
France
Georgia
Greece
Guadeloupe
Guernsey
Hawaii
Hong Kong
Hungary
India
Indonesia
Ireland
Isle of Man
Israel
Italy
Japan
Kaliningrad
Kazakhstan
Liechtenstein
Luxembourg
Mauritius
Mexico
Montenegro
Netherlands
New Zealand
Northern Ireland
Philippines
Poland
Portugal
Puerto Rico
Republic of Korea
Romania
Saudi Arabia
Scotland
Slovenia
South Africa
Spain
Sudan
Sweden
Switzerland
United Arab Emirates
United States
Uruguay
Venezuela
Wales

Adventures with the GreenCube Satellite

Tom Van den Bon, ZR6TG

Introduction

GreenCube is a new satellite designed by S5Lab, with lots of exciting parts. Most amateur radio satellites we usually play with are in LEO (low earth orbit), meaning they orbit only a couple of hundred kilometers away. The GreenCube satellite is in MEO (medium earth orbit) at a distance of 5800+ km. That altitude makes satellite communication more challenging. The original goal of the GreenCube is to demonstrate an autonomous biological laboratory for growing plants in space which is very important for future long-distance space travel.

The satellite hosts an amateur radio digipeater along with a very cool experiment. The altitude of its orbit provides a large footprint for radio amateurs to play in. Figure 1 shows a comparison of footprints between the ISS in LEO, QO-100 in GEO (geosynchronous earth orbit) and the GreenCube (MTCube-2) in MEO.

I've included notes on the software and hardware I used to play with this satellite. This represents less of a tutorial than just notes for my future self. Maybe it will help others get on the air as well.

Equipment Used

On the antenna side, I'm running my homebrew rotator project with a 70 cm (UHF) Wimo X-Quad antenna (Figure 2). I initially tried to receive this satellite without any pre-amplifier, and even though I could see the data packets, I could not decode them. So, I added an SHF Low Noise Pre-Amplifier (MV 342-VOX) into the mix, and only then could I successfully decode it (Figure 3).

The pre-amplifier is hooked up (Relay Board on Raspberry Pi) to my Ground Station Node-Red Dashboard so I can switch it on and off as needed.

Other antennas use something as simple as the standard dual-band arrow antenna, so many possibilities exist (Figure 4).

Initially, I started listening with an SDR (Airspy SDR) to try to receive and decode the telemetry; from there onwards, I moved to using an Icom IC-9700 hooked up to my

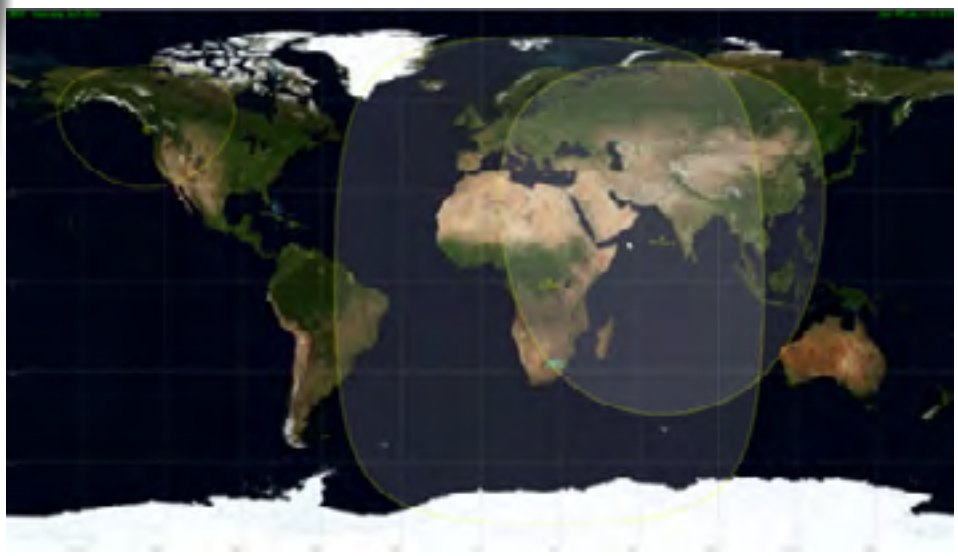


Figure 1.

Figure 2.

Figure 3.

Figure 4.

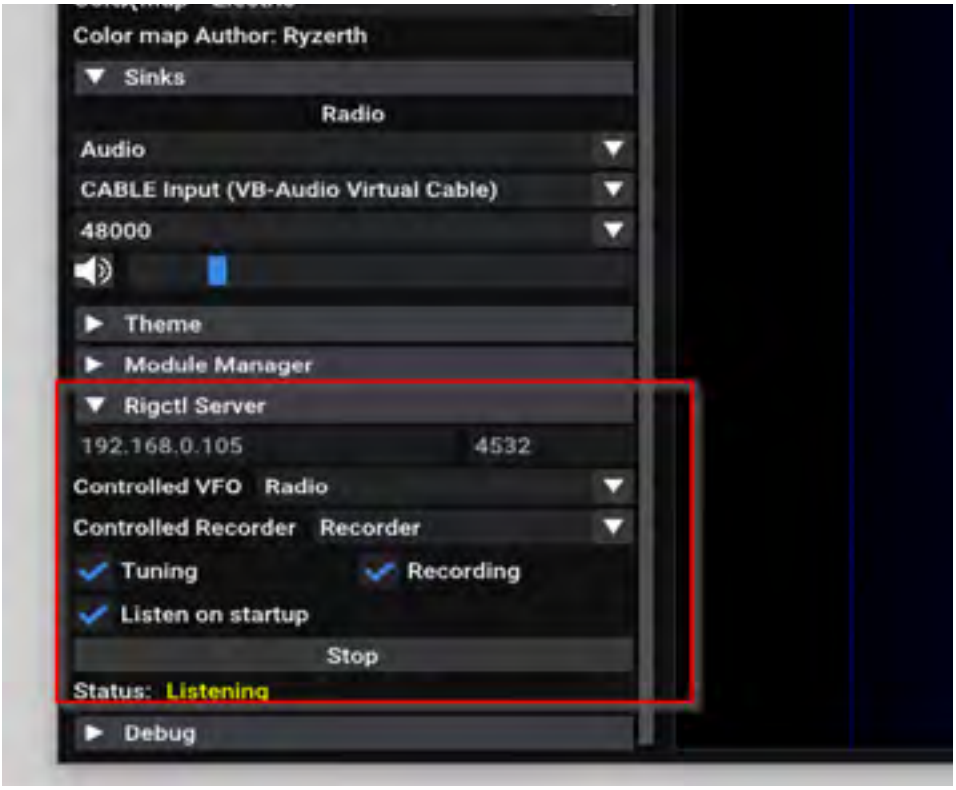


Figure 5 — Rigctl Server on sdr++.

computer for receiving and transmitting.

Software – Tracking/Doppler

Depending on what you want to do, lots of software are involved in playing with this satellite. Again, depending on your hardware and operating system, you can use different ways of doing this. First, you need to be able to predict the satellite position and control the Doppler on your radio/SDR. Then, the received signal goes into a TNC that decodes it and makes it available for other software, like the digipeater client or telemetry viewer, and sends the data to SatNOGS.

For tracking and radio Doppler control, I used Gpredict. I decided not to use my satellite server for this one as I'm still determining the accuracy of the tracking on MEO objects. However, since the initial reception was done with an SDR, I used sdr++, which has a built-in rigctl server (Figure 5). This allows Gpredict to set the frequencies during the pass.

My config on Gpredict for the radio interface appears in Figure 6.

As Gpredict tracks the satellite, it will also apply the Doppler to the frequency in sdr++.

If all goes well on your next pass, you will see data packets received from the satellite (Figure 7).

Our next step now is to see if we can decode these packets. You need a TNC/Sound Modem for this (Figure 8).

Software – Sound Modem/TNC

To decode the packets, we use the SoundModem software developed by UZ7HO (Figure 9). It includes a version for FM reception as well as SSB reception. However, I've only tried the SSB TNC.

The download also includes the digipeater client (more on that later). If you are using an SDR to receive the packets, you must use virtual audio cable software to link the two together. If you are using a radio, then make sure you select the audio in your devices. You should be seeing your packets on the waterfall. But you will notice that they are off-center. Adjust your frequency so that the center of the packet is roughly around 1500 Hz between the two markers.

The default frequency for the digipeater and telemetry is 435.310 MHz (same downlink/uplink), but I had to change my offset to 435.305926 MHz to get successful decodes. I changed this in Gpredict so that it uses

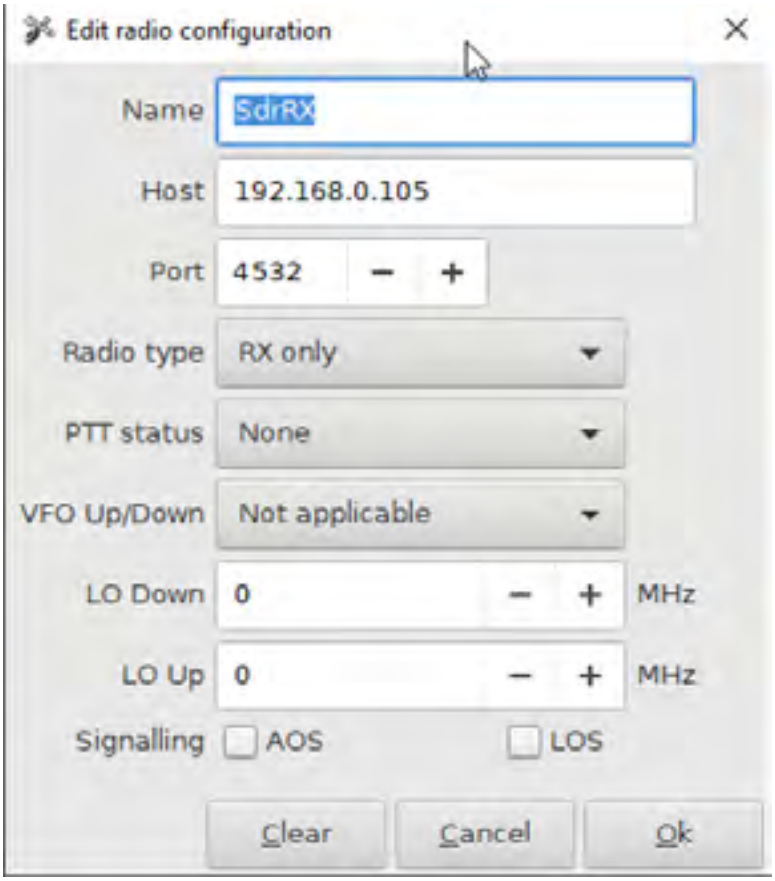


Figure 6.

my frequency change and still applies the Doppler to it (Figure 10).

I have also noticed a difference between the offset on my SDR and my Icom IC-9700. Therefore, you should adjust your frequency so the packets look something like what appears in Figure 11.

It's a bit finicky, but once tuned, it should be the same on every pass. On decodes, you will see all kinds of messages in the window that don't necessarily make sense. You need a telemetry decoder and the Digipeater client to make sense of those. The Sound Modem makes this data available on a KISS port for other applications to connect to. You can have multiple applications connected to the same port so that you can run the telemetry and digipeater client at the same time.

Software – Telemetry/GetKiss+

The telemetry application that decodes the gibberish into something more sensible was written by DK3WN (Figure 12). While there, grab the latest GetKiss+ software. The telemetry app needs to connect to your Sound Modem, so make sure the KISS port is configured in both to the same port. When you receive a packet on the Sound Modem and the data received is a telemetry packet, it will show on the telemetry app with all kinds

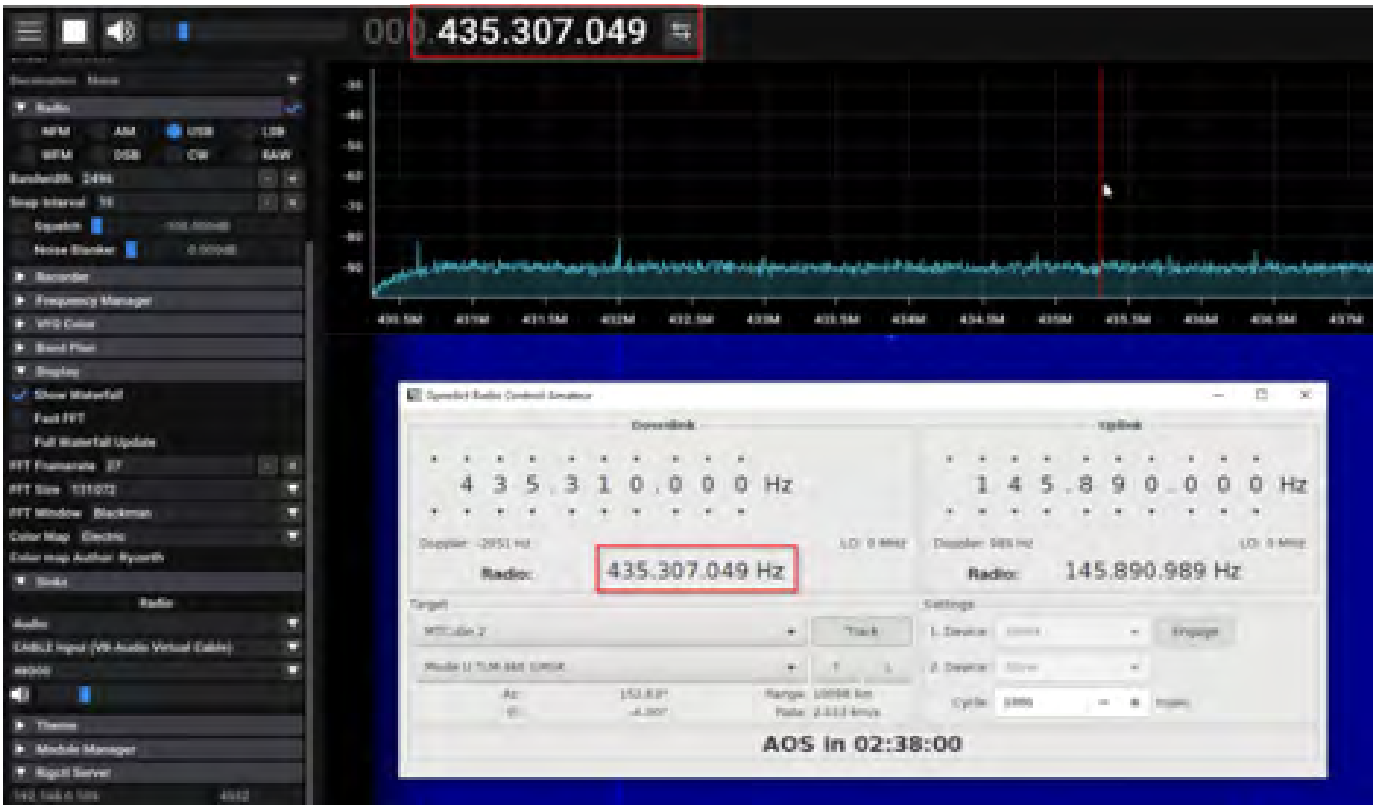


Figure 7.

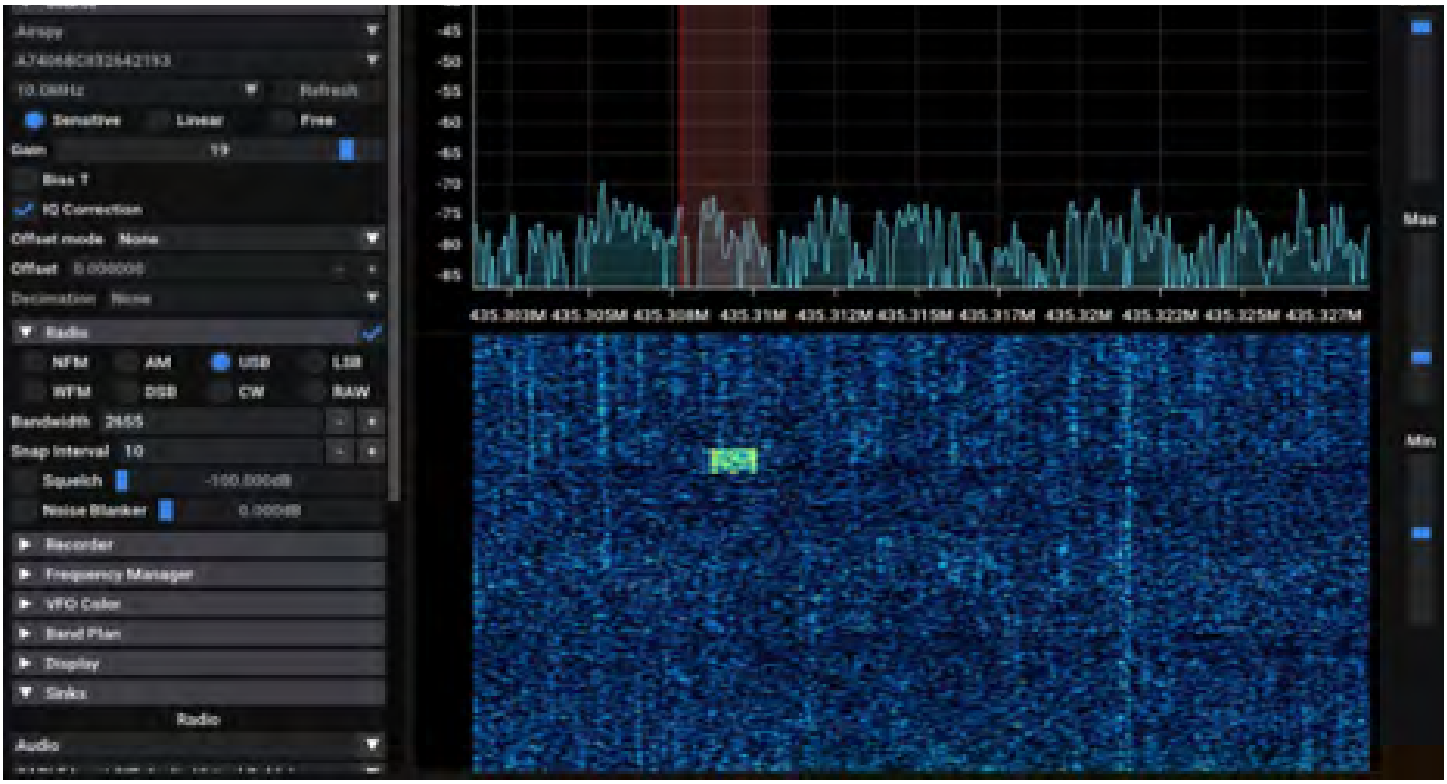


Figure 8.

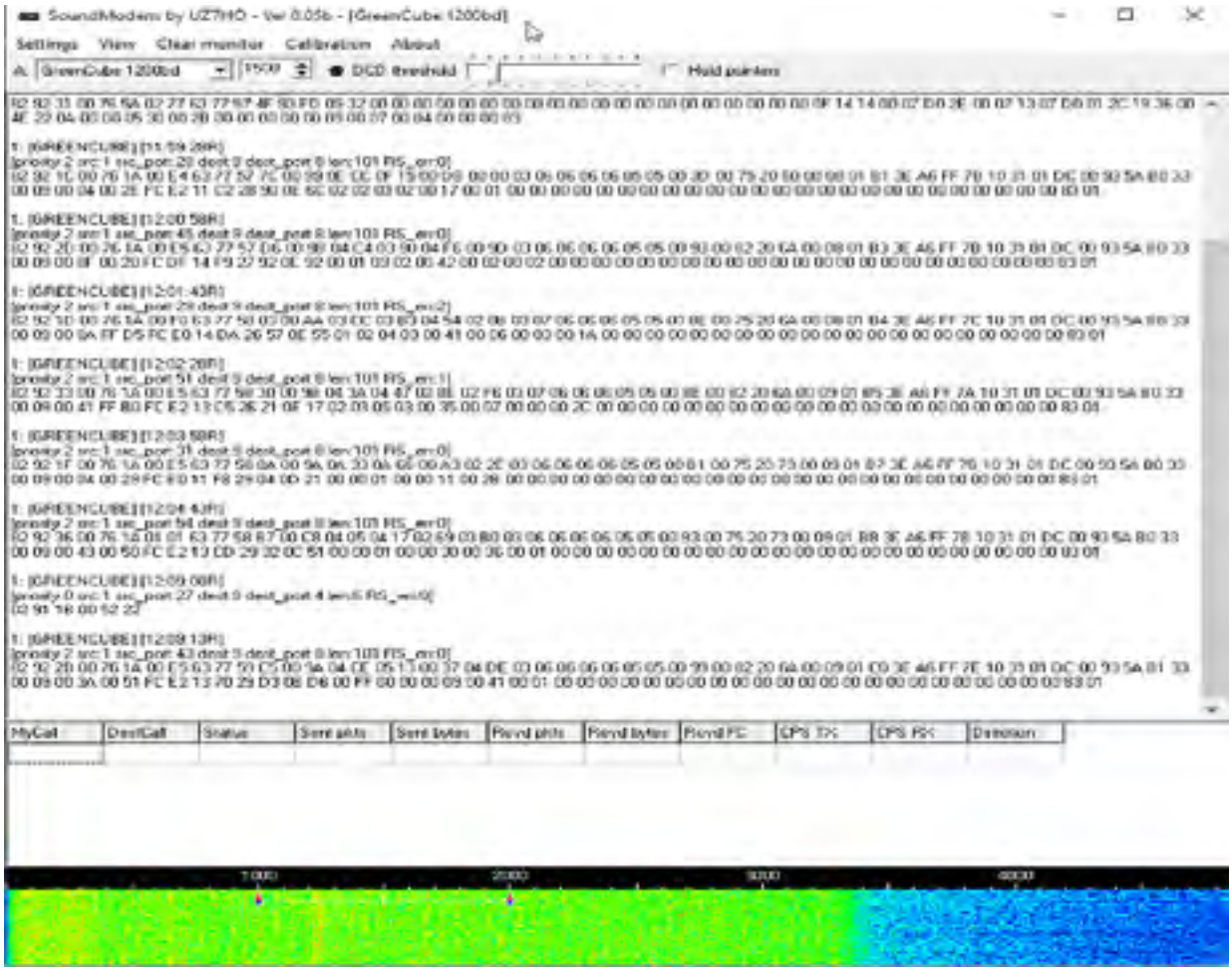


Figure 9.

Figure 10.

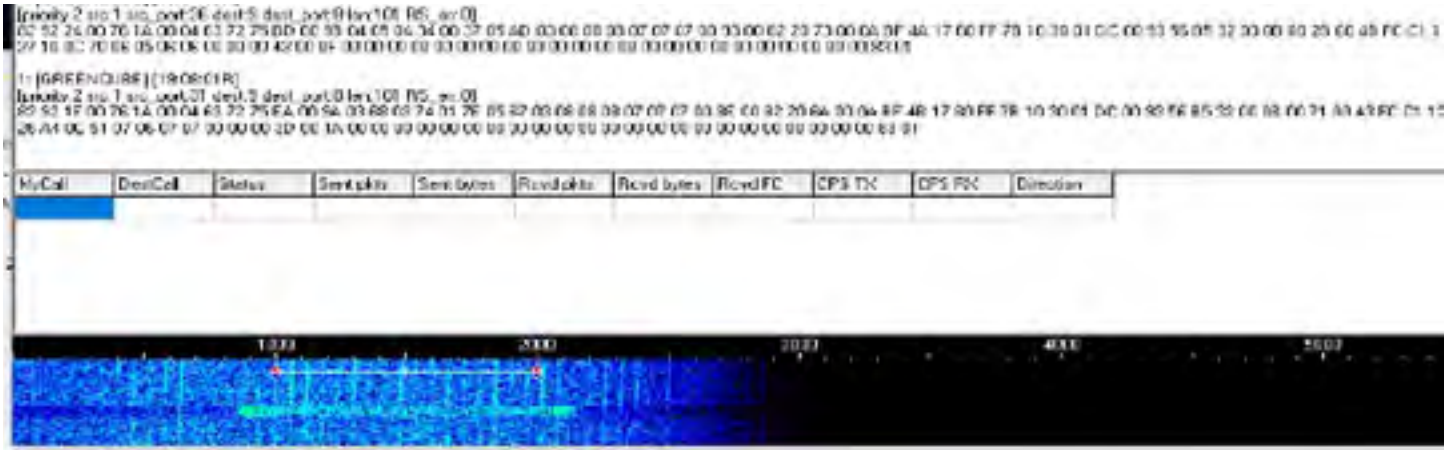


Figure 11.

of fun data from the satellite. Digipeater packets will also show in the application under the digipeater tab.

Once you have that working, it would be a good idea to configure and get the GetKiss+ software going (Figure 13). It is a data forwarder and forwards all received packets to SatNOGS. Remember that most of the satellites we play with have been launched by amateurs/universities etc. They don't need to provide amateur radio aspects to their satellites, but they do. In exchange, we can help their project by collecting the telemetry and sending it to a central server (Figure 14). In this case, the central server is SatNOGS. You can still play with the satellites while GetKiss+ is running in the background, and it won't affect anything.

Software – Digipeater

If all the above works and you can receive and decode packets, it's time to look at the digipeater. The digipeater concept is similar to the APRS digipeater on the ISS. You send a message to the satellite, and it repeats it. Since the footprint is enormous, someone in Brazil can see your message from South Africa (depending on the pass).

The only changes to the above are ensuring output is configured on your soundmodem and that it can control your PTT. This depends on your hardware (the next section shows what I'm doing with the IC-9700). The digipeater client will be part of your Sound Modem package.

The digipeater client is fairly simple to use (Figure 15). You specify your callsign and the callsign to which you want to send a message — or ALL if you are calling CQ. Keep your messages short and simple. The only other thing to mention is the ReTX Delay. The value you put in there tells the satellite in how many seconds you want this message transmitted. This means that you can send a message to someone on the other side of the world. I made a simple calculator showing you where your message will end up based on the number of seconds specified.

Jean Marc (3B8DU) has used it to send himself a message for the next pass over his QTH, so it works well (Figure 16). This feature doesn't get used much, but it is cool.

Remember, kids! Make sure you can receive and decode first before you try to transmit (Figure 17). That's the rule when using these satellites. Since we use more power than usual for satellites, follow this rule.

IC-9700 Interface

This section is very hardware dependent, but once I had it working on the SDR, I wanted

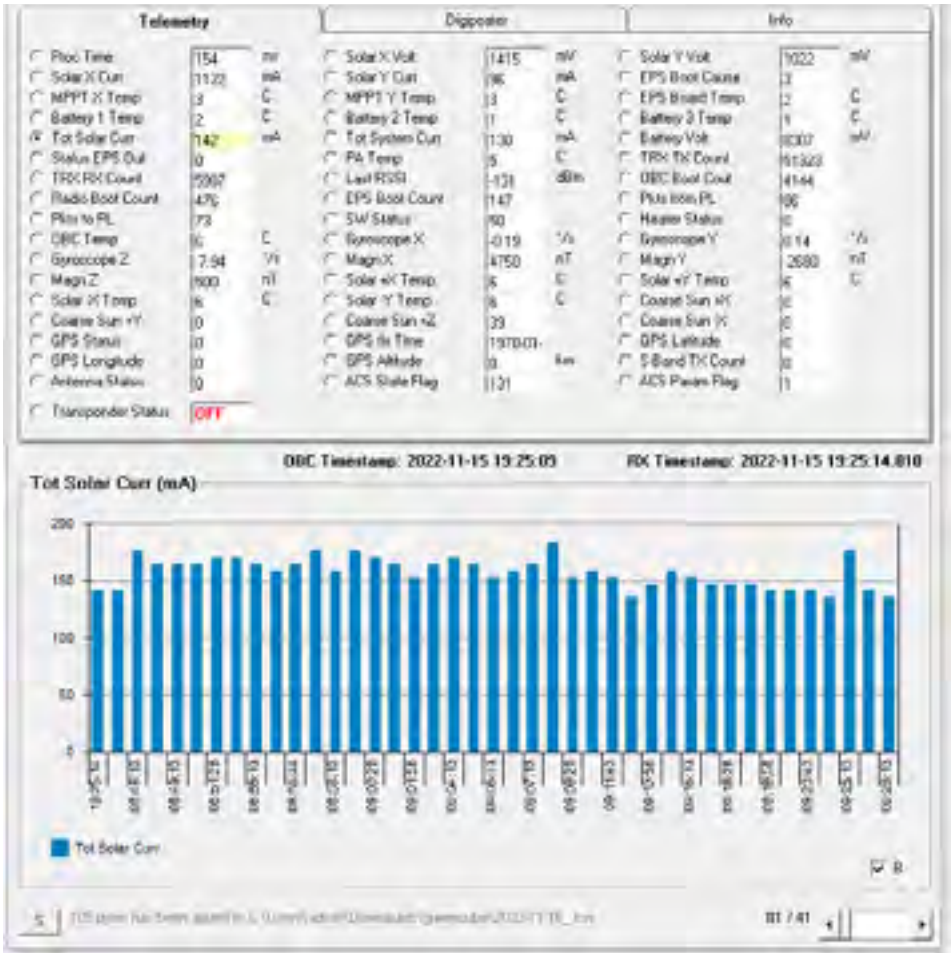


Figure 12.

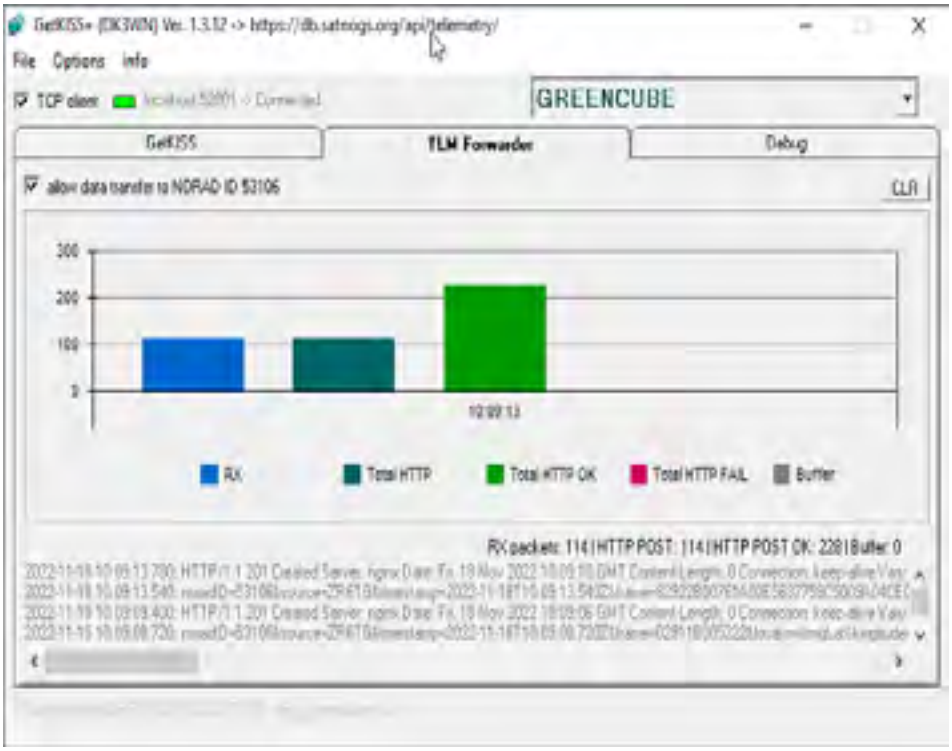


Figure 13.

to move it to the radio so I could transmit it into the satellite. The same rules apply as all the above, except I'm using the sound card enumerated from the radio as my input and output on Sound Modem. Same as the SDR, your radio needs to be Doppler controlled. I used rigctld from the hamlib tools to connect it to the radio.

I started rigctld with the following parameters:

c:\tools\hamlib-w64-4.5\bin>rigctld.exe -m 3081 -r com2 -s 115200 -vvvvv

The 3081 specifies my radio model (IC-9700), and the com2 is the comport that the serial port enumerates on my PC. (The IC-9700 enumerates two serial ports; only one will work, try either.) I kept the same settings for most digital applications on the radio side. But, again, different settings work for other people. For me, I have the radio set to USB-D, using FIL1 or FIL2, AGC, as well as noise blanker, and noise reduction is turned off as it can interfere with the signal.

My Gpredict configuration for working with the icom is shown in Figure 18.

I also had to set my Sound Modem TX delay to 800 to give Gpredict time to detect the PTT before changing the frequency (Figure 19).

New Method for Switching PTT – Updated 2022/11/21

I initially used the method documented below for PTT switching from the sound modem. Still, I am now using the second port that is enumerated from the Icom and setting it to trigger PTT directly from sound modem by triggering the DTR line on that USB port. This means I don't need two CAT ports anymore, but just one for the Doppler control from gpredict, and the second USB port from Icom is used without CAT. The setting on the IC-9700 is shown in Figure 20.

And my sound modem configuration appears in Figure 21.

So I don't need to use the cat.dll anymore, which simplifies things. I've left the info on my old method below.

Old Method

Things get more tricky on the PTT signal since I already use the USB for my CAT port. So you need a second CAT port so that Sound Modem can control it. There are many different ways of doing this. The first is

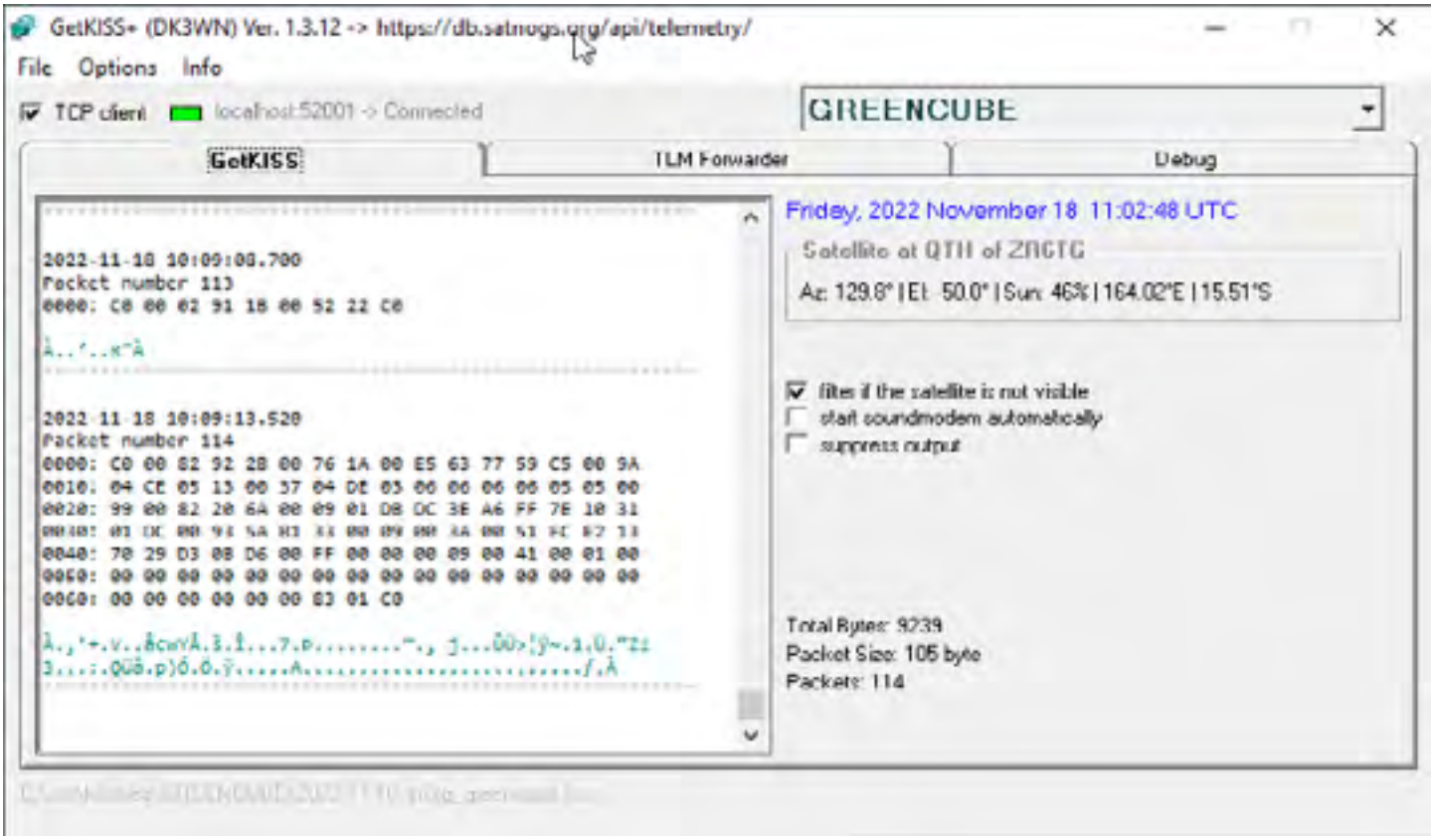


Figure 14.

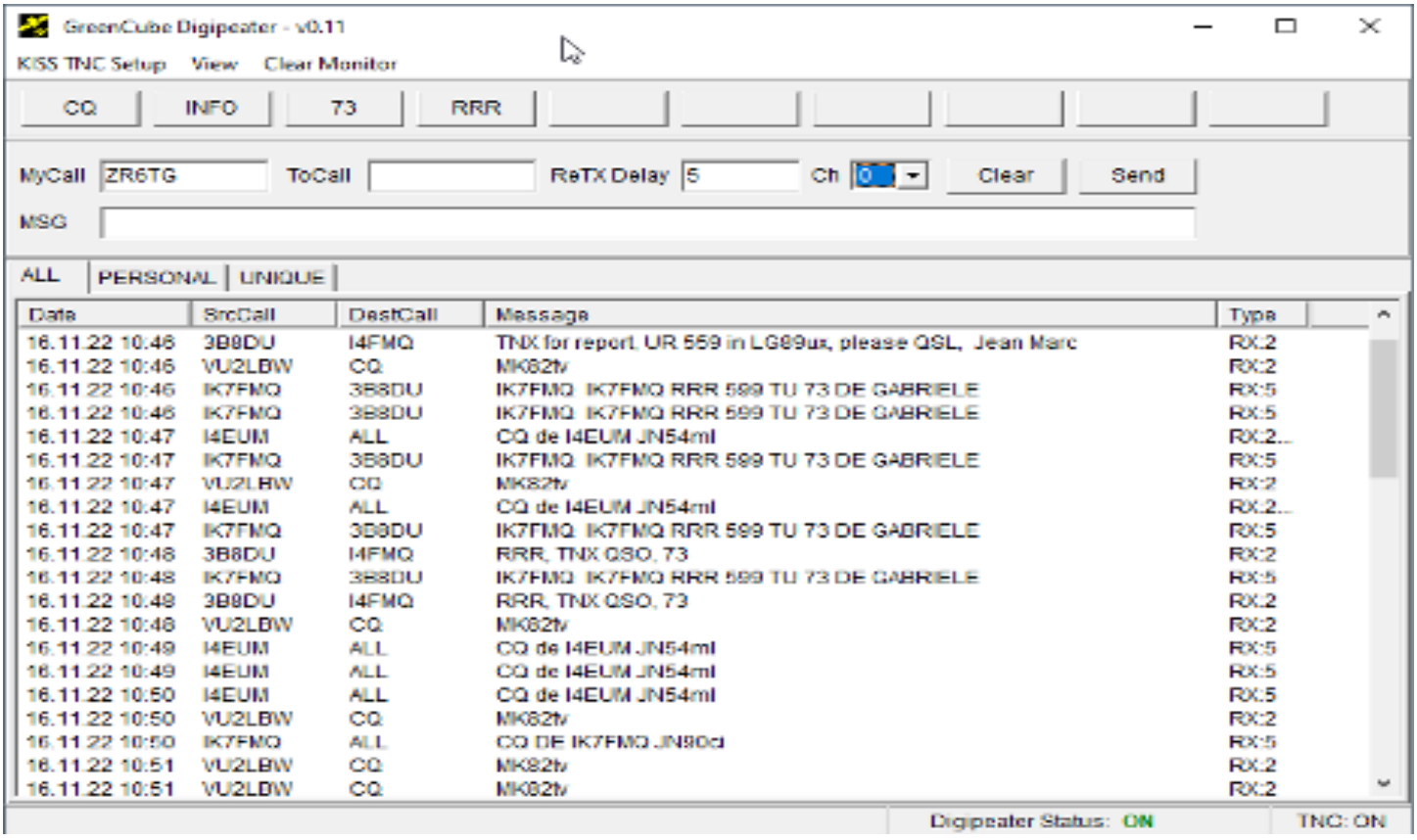


Figure 15.

Figure 16.

17.11.22 11:06	IK4JQQ	ALL	CQ GCUBE DE IK4JQQ JN54KP	RX:5
17.11.22 11:06	IK4JQQ	ALL	CQ GCUBE DE IK4JQQ JN54KP	RX:5
17.11.22 11:08	F4BKV	ALL	CQ IN95	RX:5
17.11.22 11:08	F4BKV	ALL	CQ IN95	RX:5
17.11.22 11:11	3B8DU	3B8DU	Testing Tom (ZR6TG) Tx Delay Calculator with 13000 delay, 73 Jean _	RX:13000
17.11.22 11:11	3B8DU	3B8DU	Testing Tom (ZR6TG) Tx Delay Calculator with 13000 delay, 73 Jean _	RX:13000
17.11.22 11:21	FG8OJ	3B8DU	BJR JEAN-MARC 73 DE GUADELOUPE	RX:21500
17.11.22 11:21	FG8OJ	3B8DU	BJR JEAN-MARC 73 DE GUADELOUPE	RX:21500
17.11.22 11:26	ZR6TG	ALL	73 from ZR6TG - Testing	RX:0
17.11.22 11:52	VK2ZAZ	CQ	CQ from QF53 Geoff	RX:5
17.11.22 11:56	ZL3MH	ALL	CQ RE56gi Murray	RX:5
17.11.22 11:57	VK2ZAZ	ZL3MH	See U on FO-29 in a few minutes	RX:5

Figure 17.

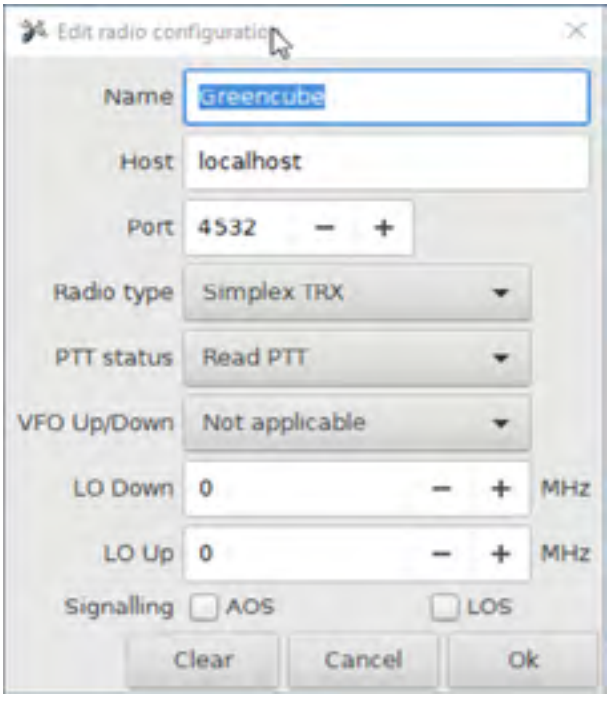


Figure 18.

wiring a UART module into the cat socket on the radio, and the second is using virtual serial port drivers to share a serial port. I decided to take the lazy option using wfview. Since my radio is network-connected, I can open up wfview, which connects to the radio via ethernet and exposes another CAT port for me to use via virtual serial ports (Figures 22, 23).

To get Sound Modem to talk to my radio for the PTT, I had to download and copy cat.dll and ptt.dll into my Sound Modem folder. You can also download this from UZ7HO's site. (ptt-dll.zip). Inside your Sound Modem you choose CAT as your PTT port and then use Advanced PTT settings to configure your cat port (Figure 24).

IC-9700 – Switching off AGC

As per the comment below from Wolfgang, when you first try to switch off your AGC, you will notice that it only shows SLOW/MID/FAST options. So hold the AGC button in the Function menu to switch it

Figure 19.

Figure 20.

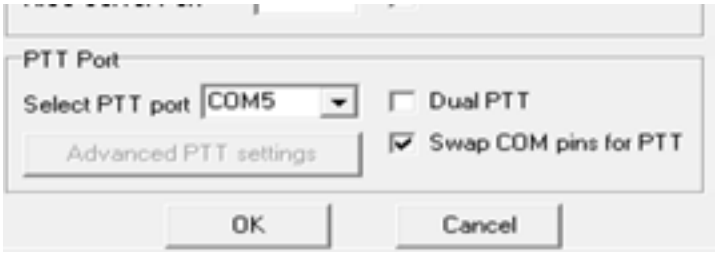


Figure 21.

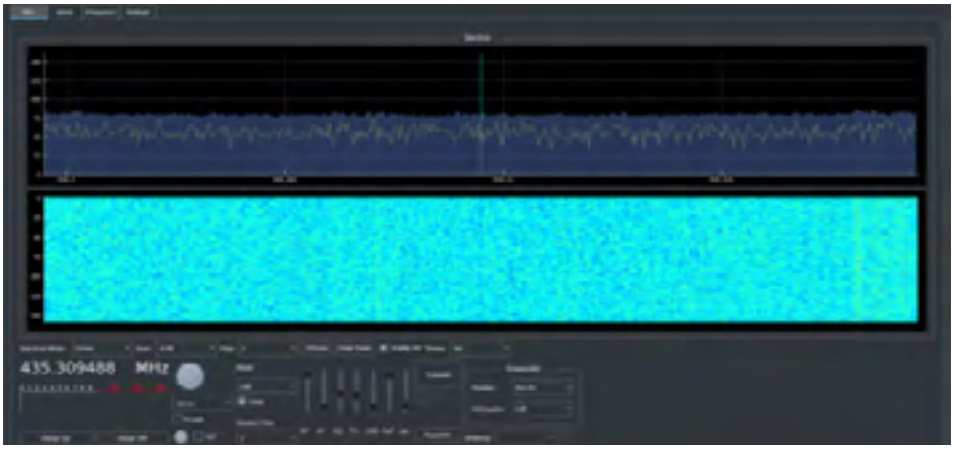


Figure 22.

Figure 22.

Figure 23.

Figure 24.

Figure 25.

Figure 26.

Figure 27.

Figure 28.

off (Figure 25).

Then select one of your AGC options, and with the tuning wheel, you can turn it down until it shows OFF (Figure 26).

The one you changed to OFF will now be available as OFF in your function menu (Figures 27, 28).

Conclusion

I understand that the information above is a lot, and also, keep in mind that working GreenCube is not the easiest satellite to play with, but don't be discouraged and keep at it even if you only aim to try to receive it.

You can also ask for help on Twitter. Lots of information is available there, and most people on that list helped me. See you on the satellite soon.

eBay Sellers Donate to AMSAT

Are you an eBay seller? One item, ten items, or a full-time business you can donate a percentage of your winning bid to AMSAT.

To do so, do not list your item with the basic listing tool, select advanced tools. eBay will give you a warning message that it is for large volume sellers, however this is where the eBay for Charity tool is found.

You can "select another nonprofit you love" and search for either AMSAT or Radio Amateur Satellite Corporation. Choose the percentage amount of the sale you would like to donate to AMSAT, and boom!.

When your item sells and the winning bidder pays, eBay will deduct the percentage from your take and forward it to AMSAT.

Please consider giving a piece of the pie to a new satellite and choose AMSAT for your eBay Charity.

Working GreenCube Digipeater

Berstrand "Burt" Demarcq, FG8OJ

The GreenCube satellite is a microgreens cultivation CubeSat satellite developed for MEO (medium earth orbit) that carries a 1200 baud packet radio digipeater on UHF. MEO is a game changer because of its fantastic 5,800 km apogee, allowing an amateur radio operator to work up to 13,000 km versus 8,000 for Oscar 7 or RS-44 LEO satellites.

S5Lab, an Italian Space Systems and Space Surveillance Laboratory from Roma University, has built GreenCube in the framework of a collaboration agreement with the Italian Space Agency (ASI). The digipeater was developed in collaboration with AMSAT Italia.

My distance record QSO is 11,761 km with A65BR, but I am sure my record will exceed 12,500 km soon. The distance to the satellite necessitates a good setup with a high-gain Yagi (10 elements) and a good LNA to decode packets. My setup can decode packets with less than 5° elevation but not below that. Even if I can hear the packets, the amount of loss prevents decoding them.

Follow S5Lab on Twitter for updates: **twitter.com/S5Lab**.

Setup

Hardware :

- Icom IC-9700 with 2 CAT interface
- 18 elements V/H polarization DK7ZB Yagi (10 dBi at least recommended)
- Yaesu G5500 rotator with EA4TX ARS-USB direct controller (not using the poor Yaesu controller)
- Low loss mast mounted LNA and Polarization mast switch with M5stack console **github.com/fg8oj/RemotePolarisationSwitch**

Software (Windows 10):

- PstRotator v17.28 **www.qsl.net/yo3dmu/index_Page346.htm**
- with
- Omnirig **dxatlas.com/Download.asp**
- OR
- SatPC32ISS v12.10 **www.dk1tb.de/SatPC32ISS_2.zip**
- And for decoding/transmitting GreenCube packets:

- SoundModem by UZ7HO ver 0.05b **uz7.ho.ua/greentnc.zip**
- DK3WN GREENCUBE Telemetry Decoder v1.1 **www.satblog.info/software/.**
- DK3WN GetKISS+ v.1.4.2 (Transfer to SATNOGs)

www.satblog.info/software/

Icom IC-9700 USB has two ports that will let you use the first serial port for PstRotator Doppler CAT control, but you will also need the second IC-9700 serial port to let SoundModem control TX via PTT RTS command. Therefore, you must update your IC-9700 settings to change the PTT control to the B port. To do that, you'll need to go to Menu/SET, then Connectors, USB SEND/Keying, and select "USB (B) RTS" in the USB SEND Menu.

My Icom IC-9700 has AGC turned OFF for DATA modes which is very important for decode quality. The Noise Blanker and Noise Reductor should also be turned OFF for digital communications. You should adjust the baud rate and, of course, port.

You must also check your IC-9700 setting using USB-D (USA-DATA) mode. Set the USB audio card input to Set/Connectors/Mod Input/Data Mod, set-> USB. If you use the IC-9700 USB, the DATA OFF MOD parameter is typically set to MIC.
Be sure to differentiate these two mods; otherwise, you will key your microphone audio during your transmission, and nobody wants to hear all the wickedness you say when digipeating fails.

Also, check that no other software uses your

USB card to avoid accidental transmission. That's a common mistake on FT8 frequencies.

PstRotator

Omnirig is a CAT interface for PstRotator and needs to be set up with your usual first port. Your setup may be different from my configuration.

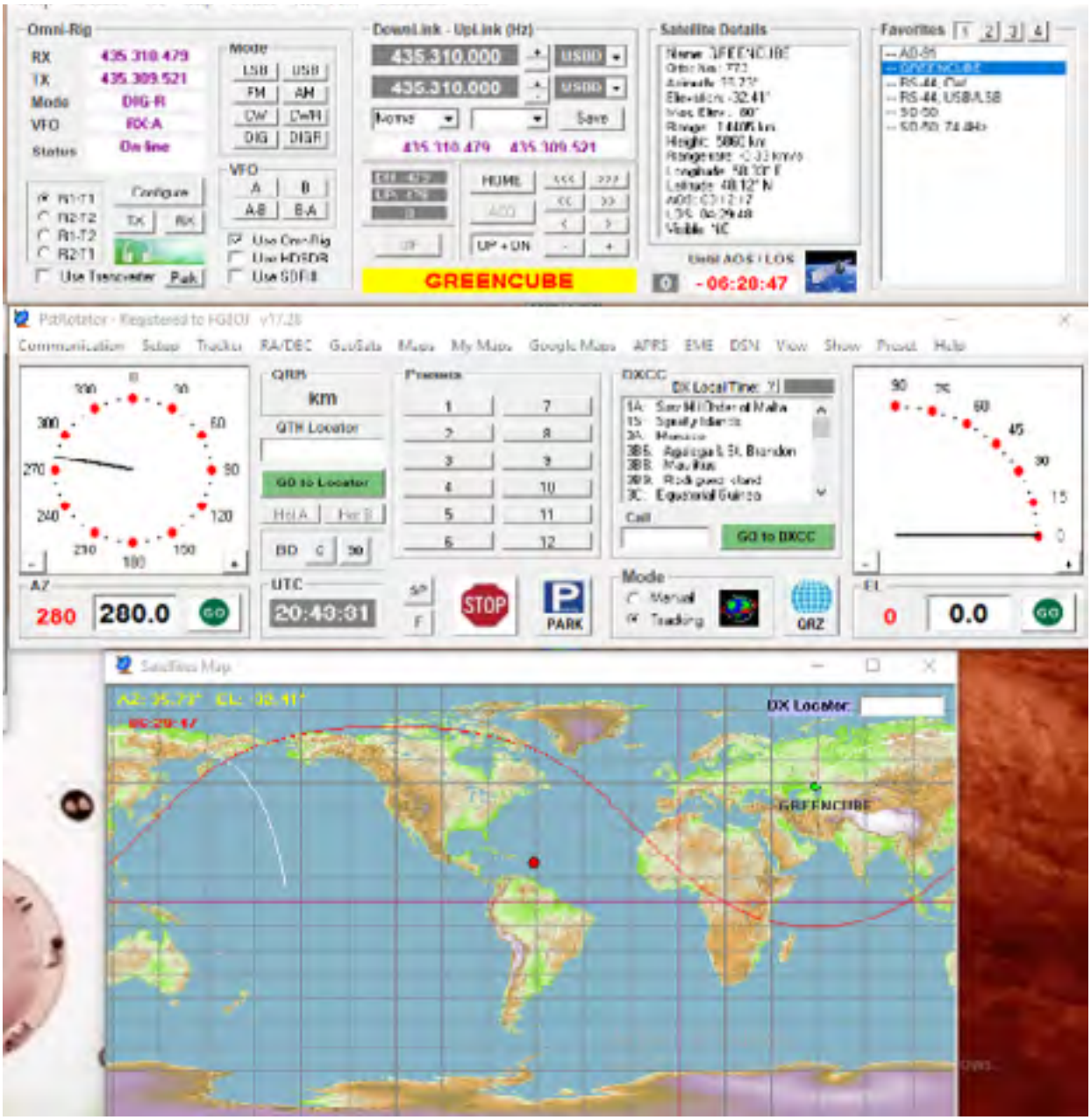
PstRotator antenna and Doppler correction:

After you have downloaded, registered (yes, that's ham radio life — not free, but this software is impressive even if a Linux version doesn't exist), and configured to run your antenna manually and set up your home grid location.

To access satellite tracking, launch Tracker/ Satellites and change the mode to Tracking on the main window. Then, a new window will appear for Satellites Tracking. You can launch a third window with the Satellites Map from this window.

Then you will need to update TLE in the menu. First, you must remove celestrak, add amsat.org nasabare TLE file, and click the update button.
Second, in the Satellites menu, add GREENCUBE

Third, in Favorites, click on Greencube, then click on the UP+DN button and enable "Use OmniRig." After that, your transceiver should start to use the same frequency as



the PstRotator screen. You may also need to change the mode to DIGR to enable USB-D mode

You should now have the same frequencies on your transceiver and PstRotator on both RX and TX (yes, you can click the TX button to test TX without audio).

SatPC32ISS

SatPC32ISS needs to be updated to version v12.10 or higher to have the ability to run GreenCube specificities. You need to add this line to Doppler.SQF :

GREENCUBE,435308.5,435308.5,USB-D,USB-D,NOR,0,0

If you already use SatPC32, you don't need to change anything. Just adapt the frequency in the CAT window. I am using 435308.5 with GPSDO, but you would adapt it to your TCXO precision. This version now supports USB-D, so you will not have to change to this mode manually. And the Doppler correction doesn't stop working in the middle of a pass like before.

Decoding GreenCube packets

Now, you can start SoundModem and launch Settings. You will select the second COM port of your Icom in "Select PTT port" in Settings. If you don't know which USB ports are used, you can look at your Windows Microsoft Management Console.

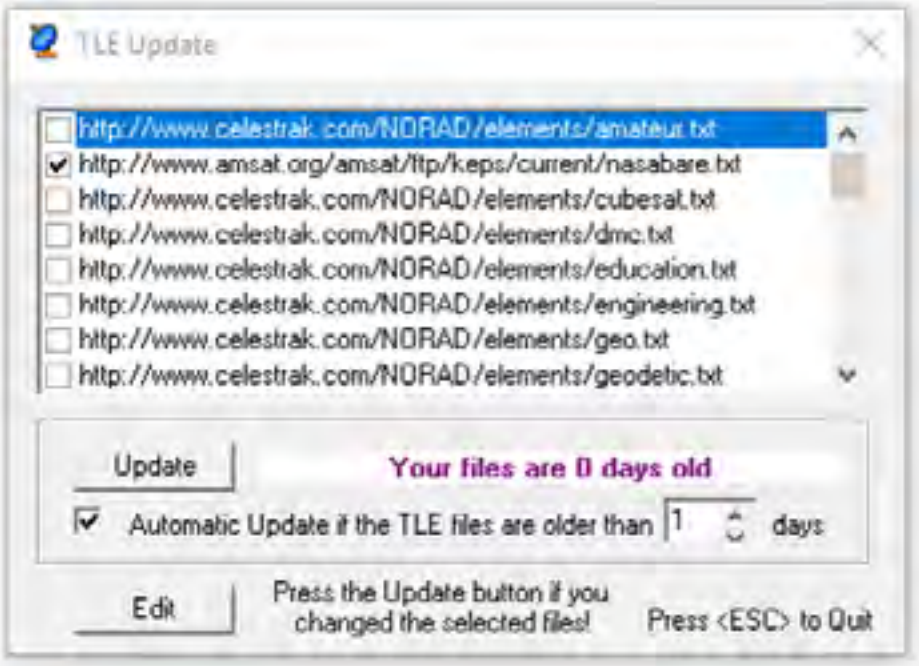
Due to the sound card sample rate, Oliver, DL6KBG, advised me to set the TX/RX SampleRate to 12000 Hz (Maximum available value). You can also check the Color waterfall, which makes the waterfall more readable.

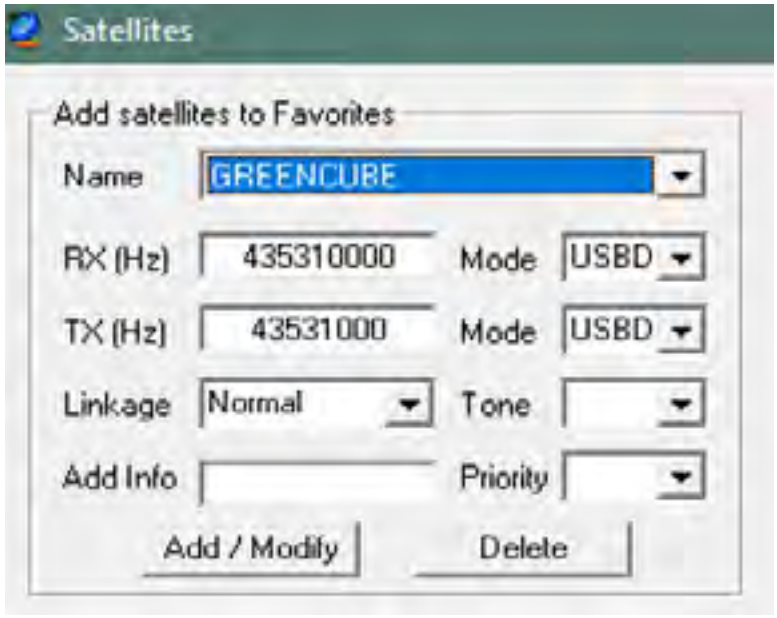
In Modem settings, check your TXDelay 400 ms for the old transceiver, but 80 ms of TXdelay and 1 ms tail is perfect for Icom IC-9700. Everything should be as default.

Check to make sure you can send packets, and also, please check your transmitting power is reduced to 0 and try to listen with a local receiver.

From this point, wait for a GreenCube pass and try to receive packets. Next, you will need to adjust Doppler to your receiver. Since I am using a GPSDO source, I found a -1300 Hz difference, but you need to change it with the arrow on the PstRotator window.

Before transmitting, wait to see that the transponder is active and that you can receive all incoming packets. If not, don't try to





transmit! You will also have to wait until the Digipeater Status is no longer "undefined" on the bottom page of GreenCube Digipeater software.

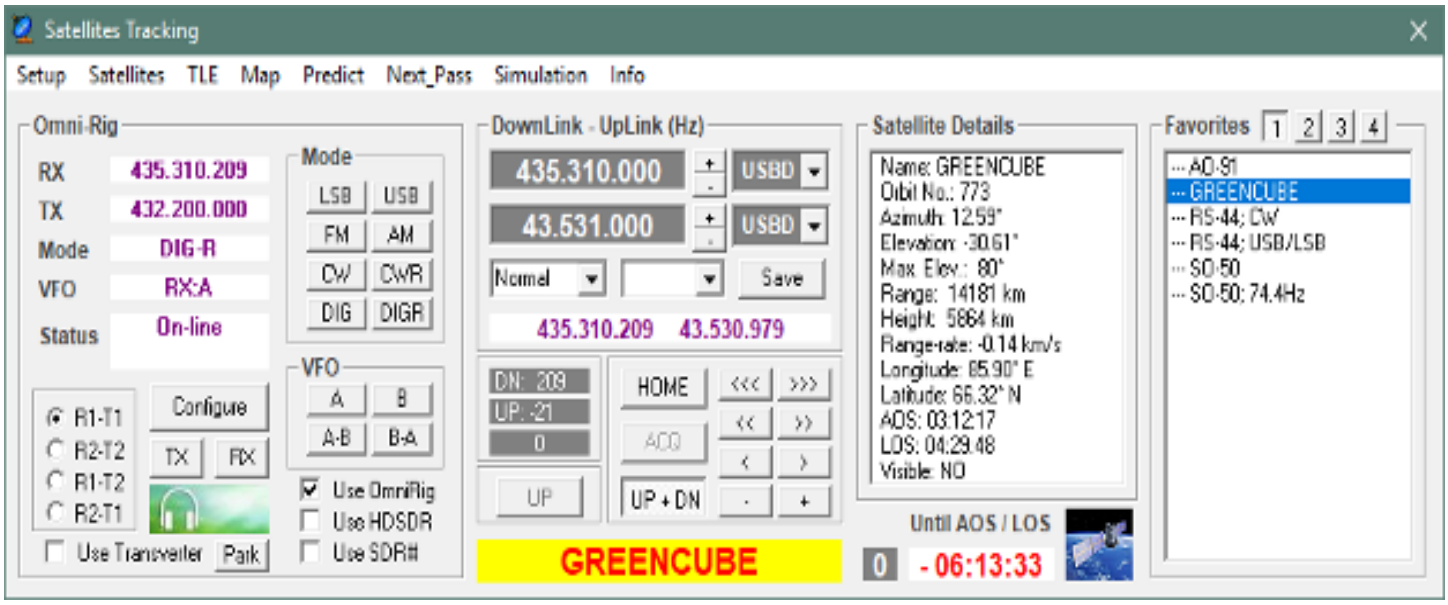
If the digipeater is OFF, DO NO TRANSMIT. The command station may be sending data to the satellite, so don't disturb the operations but participate in collecting the telemetry by sending them to SatNogs DB.

You will get a minimum of one packet every 45 seconds. You can send the telemetry packet to SatNogs with both DK3WN software.

Hearing packets is very easy, but not decoding them. GreenCube will be 6,000 to 10,000 km away from you.

Polarization match, good decodes

Polarization mismatch, no decodes:



Also, check that the arrow horizontal line is perfectly centered on the packet. PstRotator calculates Doppler correction with very high accuracy, so you should not need to change it during a pass except perhaps for IC-9700 TCXO precision trouble. Because I am using my 9700 also for EME, I have a LeoBodnar GPSDO and injection board installed, which is a good help for GreenCube Doppler correction.

If you have difficulties decoding packets below 20°, that's normal. It is very challenging. But if you have problems above 20°, you need to check the following:

- sufficient gain coming from your antenna (7 elements is a minimum)
- no coaxial loss or the LNA not working
- rotator doesn't have a positioning problem
- polarization (Circular is -3dB loss, wrong polarization is -20dB).

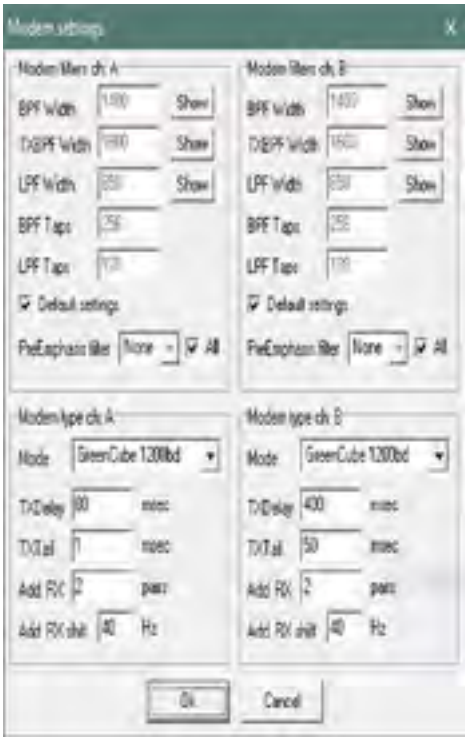
I am adapting polarization under 20° for best reception to optimize decodes. If you lose the packets for more than a few minutes: check the polarization harness or see that the switching is good. Suppose you only have one polarization (horizontal or vertical). In that case, you will lose the digipeater frequently. During a pass, satellite antennas look vertical to horizontal due to relative orientation (the satellite doesn't change its orientation, but you are changing).

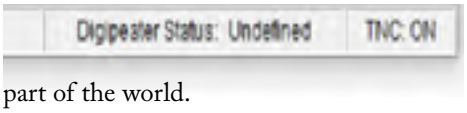
Using the Digipeater

If the Digipeater is ON, DON'T TRANSMIT packets if you can't read them! Respect the usual AMSAT best practices: only call CQ once per minute; don't try to do more than one QSO at a time; don't call CQ or answer if there is already too much QSO in progress.

GreenCube Digipeater software is a great piece to be able to make QSOs. Macros let you do easy stuff, but the MSG input text area allows you to transmit specific messages. The longer the message, the more time it takes to transmit, and the error risk is higher.

The digipeater stores and forwards packets. The ReTX Delay is the delay after the digipeater retransmits your packet. If the delay is equal to 0 (that I recommend), the digipeater will retransmit your packet as soon as you transmit it. If the delay is more than 0, the digipeater will answer with an "ACK" packet that will add more traffic to the digipeater. If you use this function, please don't call CQ but use it to send your greetings to other continents based on the time in seconds the bird will move to this part of the world.

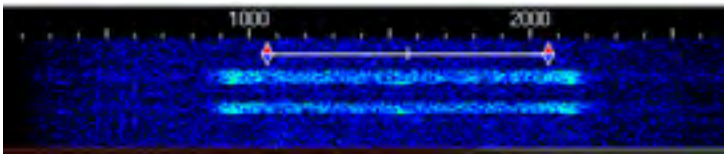


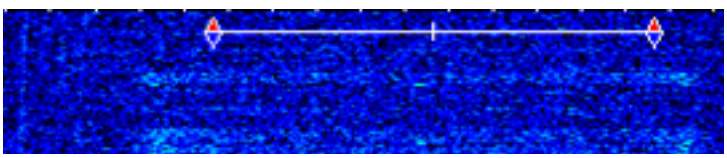


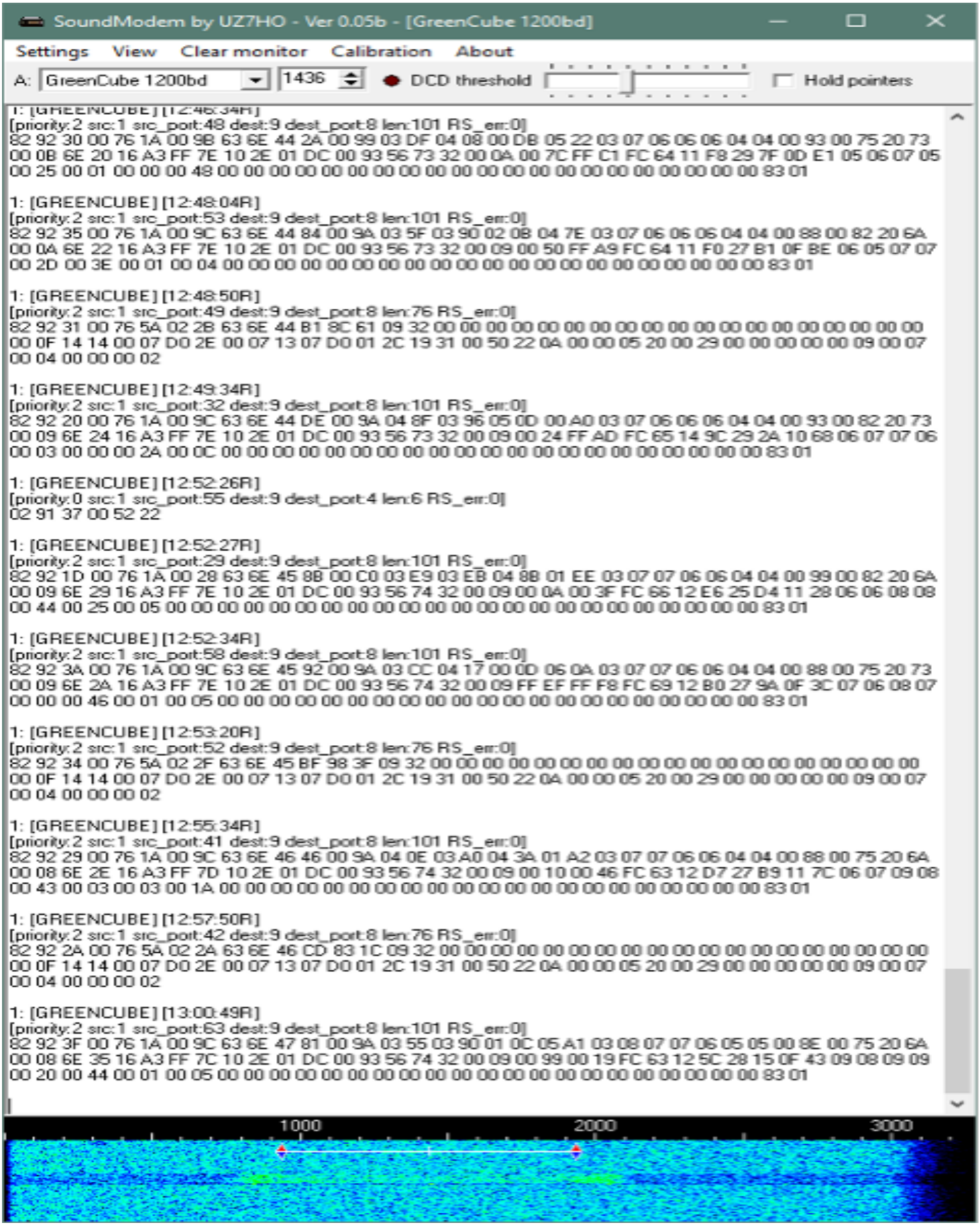
Most of the time, your first goal will be to make QSOs with stations nearby, so this delay needs to be to 0.
For the best chance of decoding, use short messages and restrict message length to essential data.

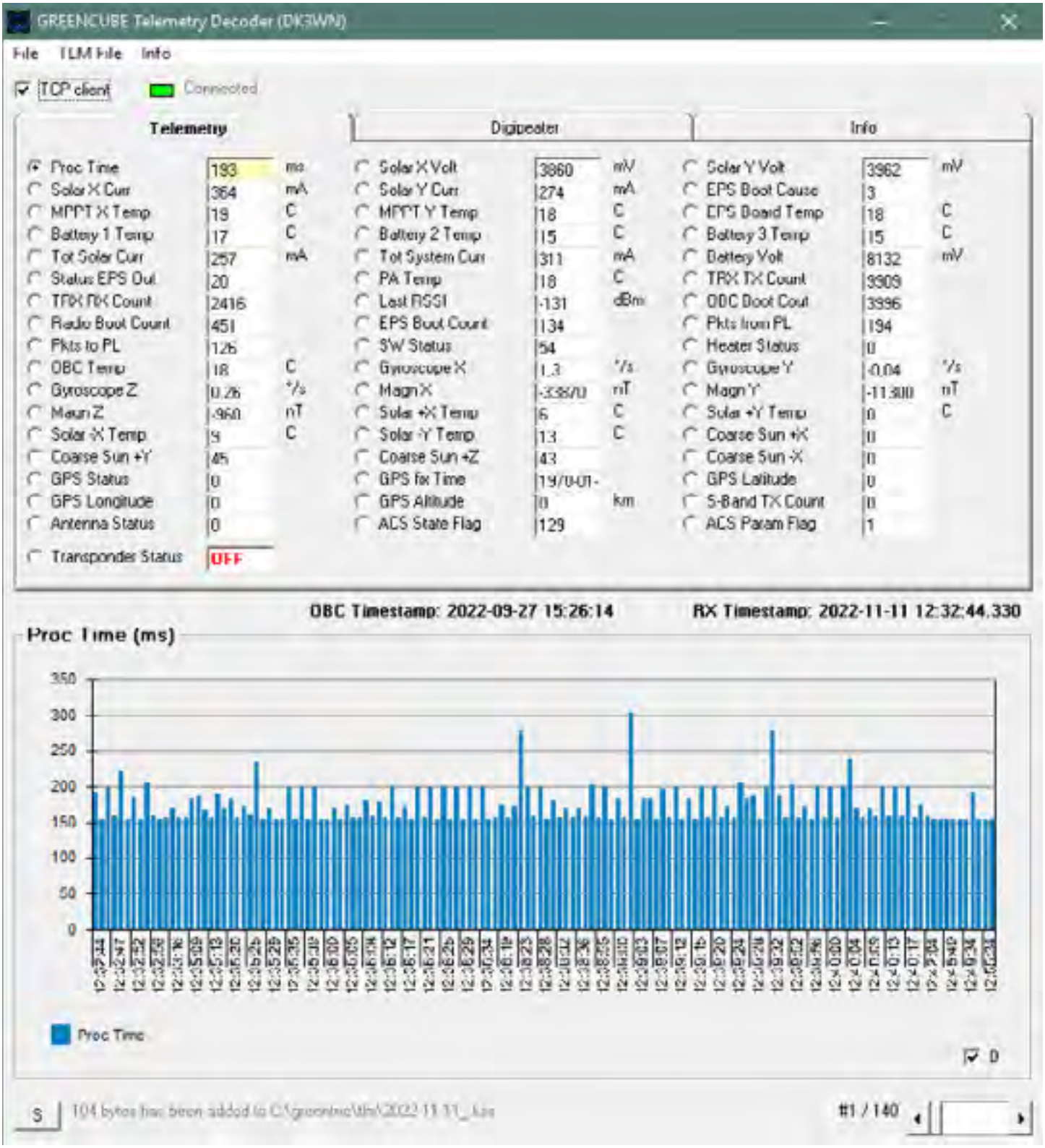
Not a good idea :
CQ DE XXXXX Michael in Boumourt sur Oise BA22ZE85 <-:>

Good idea :
CQ XXXX BA22
Read and Send the telemetry to SatNogs :






SoundModem by UZ7HO - Ver 0.05b - [GreenCube 1200bd]
Settings View Clear monitor Calibration About
A: GreenCube 1200bd
1436
DCD threshold
Hold pointers
1: [GREENCUBE] [12:46:34R]
[priority:2 src:1 src_port:48 dest:9 dest_port:8 len:101 RS_err:0]
82 92 30 00 76 1A 00 9B 63 6E 44 2A 00 99 03 DF 04 08 00 DB 05 22 03 07 06 06 06 04 04 00 93 00 75 20 73
00 0B 6E 20 16 A3 FF 7E 10 2E 01 DC 00 93 56 73 32 00 0A 00 7C FF C1 FC 64 11 F8 29 7F 0D E1 05 06 07 05
00 25 00 01 00 00 00 48 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 83 01
1: [GREENCUBE] [12:48:04R]
[priority:2 src:1 src_port:53 dest:9 dest_port:8 len:101 RS_err:0]
82 92 35 00 76 1A 00 9C 63 6E 44 84 00 9A 03 5F 03 90 02 08 04 7E 03 07 06 06 06 04 04 00 88 00 82 20 6A
00 0A 6E 22 16 A3 FF 7E 10 2E 01 DC 00 93 56 73 32 00 09 00 50 FF A9 FC 64 11 F0 27 B1 0F BE 06 05 07 07
00 2D 00 3E 00 01 00 04 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 83 01
1: [GREENCUBE] [12:48:50R]
[priority:2 src:1 src_port:49 dest:9 dest_port:8 len:76 RS_err:0]
82 92 31 00 76 5A 02 2B 63 6E 44 B1 8C 61 09 32 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 0F 14 14 00 07 D0 2E 00 07 13 07 D0 01 2C 19 31 00 50 22 0A 00 00 05 20 00 29 00 00 00 00 00 09 00 07
00 04 00 00 00 02
1: [GREENCUBE] [12:49:34R]
[priority:2 src:1 src_port:32 dest:9 dest_port:8 len:101 RS_err:0]
82 92 20 00 76 1A 00 9C 63 6E 44 DE 00 9A 04 8F 03 96 05 0D 00 A0 03 07 06 06 06 04 04 00 93 00 82 20 73
00 09 6E 24 16 A3 FF 7E 10 2E 01 DC 00 93 56 73 32 00 09 00 24 FF AD FC 65 14 9C 29 2A 10 68 06 07 07 06
00 03 00 00 00 2A 00 0C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 83 01
1: [GREENCUBE] [12:52:26R]
[priority:0 src:1 src_port:55 dest:9 dest_port:4 len:6 RS_err:0]
02 91 37 00 52 22
1: [GREENCUBE] [12:52:27R]
[priority:2 src:1 src_port:29 dest:9 dest_port:8 len:101 RS_err:0]
82 92 1D 00 76 1A 00 28 63 6E 45 8B 00 C0 03 E9 03 EB 04 8B 01 EE 03 07 07 06 06 04 04 00 99 00 82 20 6A
00 09 6E 29 16 A3 FF 7E 10 2E 01 DC 00 93 56 74 32 00 09 00 0A 00 3F FC 66 12 E6 25 D4 11 28 06 06 08 08
00 44 00 25 00 05 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 83 01
1: [GREENCUBE] [12:52:34R]
[priority:2 src:1 src_port:58 dest:9 dest_port:8 len:101 RS_err:0]
82 92 3A 00 76 1A 00 9C 63 6E 45 92 00 9A 03 CC 04 17 00 0D 06 0A 03 07 07 06 06 04 04 00 88 00 75 20 73
00 09 6E 2A 16 A3 FF 7E 10 2E 01 DC 00 93 56 74 32 00 09 FF EF FF F8 FC 69 12 B0 27 9A 0F 3C 07 06 08 07
00 00 00 46 00 01 00 05 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 83 01
1: [GREENCUBE] [12:53:20R]
[priority:2 src:1 src_port:52 dest:9 dest_port:8 len:76 RS_err:0]
82 92 34 00 76 5A 02 2F 63 6E 45 BF 98 3F 09 32 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 0F 14 14 00 07 D0 2E 00 07 13 07 D0 01 2C 19 31 00 50 22 0A 00 00 05 20 00 29 00 00 00 00 00 09 00 07
00 04 00 00 00 02
1: [GREENCUBE] [12:55:34R]
[priority:2 src:1 src_port:41 dest:9 dest_port:8 len:101 RS_err:0]
82 92 29 00 76 1A 00 9C 63 6E 46 46 00 9A 04 0E 03 A0 04 3A 01 A2 03 07 07 06 06 04 04 00 88 00 75 20 6A
00 08 6E 2E 16 A3 FF 7D 10 2E 01 DC 00 93 56 74 32 00 09 00 10 00 46 FC 63 12 D7 27 B9 11 7C 06 07 09 08
00 43 00 03 00 03 00 1A 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 83 01
1: [GREENCUBE] [12:57:50R]
[priority:2 src:1 src_port:42 dest:9 dest_port:8 len:76 RS_err:0]
82 92 2A 00 76 5A 02 2A 63 6E 46 CD 83 1C 09 32 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 0F 14 14 00 07 D0 2E 00 07 13 07 D0 01 2C 19 31 00 50 22 0A 00 00 05 20 00 29 00 00 00 00 00 09 00 07
00 04 00 00 00 02
1: [GREENCUBE] [13:00:49R]
[priority:2 src:1 src_port:63 dest:9 dest_port:8 len:101 RS_err:0]
82 92 3F 00 76 1A 00 9C 63 6E 47 81 00 9A 03 55 03 90 01 0C 05 A1 03 08 07 07 06 05 05 00 8E 00 75 20 6A
00 08 6E 35 16 A3 FF 7C 10 2E 01 DC 00 93 56 74 32 00 09 00 99 00 19 FC 63 12 5C 28 15 0F 43 09 08 09 09
00 20 00 44 00 01 00 05 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 83 01
1000
2000
3000



Telemetry packets every 45 seconds DK3WN GREENCUBE Telemetry Decoder software in action. You need to click on the TCP client to enable it.

DK3WN GetKiss+ software. It will allow you to send packets to the SatNogs database. To enable it, you will need to check TCP Client and select GREENCUBE in the top right select menu, and then, in the TLM Forwarder tab, select allow data transfer to NORAD ID 53106.

SatNogs GreenCube telemetry dashboard **dashboard.satnogs.org/d/E_SiV4vVk/greencube?orgId=1.**

A huge thank you to Scott, K4KDR, and Doug, K8DP, for the great help enabling me to get on this bird.

Working the ISS Repeater with a Baofeng UV5R From New Zealand

Terry Osborne, ZL2BAC

The ISS Cross band Repeater is usually active. For the current status see **www.ariss.org/current-status-of-iss-stations.html**.

I noticed recently that there were overhead passes in the early afternoon. So I wondered if my Baofeng UV5R would be able to hear anything and even be able to get a signal through the repeater.

1) Tracking: Using my cheap Android phone, I found that "Look4sat" was the best of the many apps available. [1]

This one is tricky to run but has a very useful "Countdown to AOS" feature. See Figure 1.

2) Programming the UV5R: Clint Bradford K6LCS gives many hints on his website [2].

I used "Chirp" to program my UV5R [3], and you can see my Chirp file here [4].

Figure 1.

Use the "Baofeng_UV-5R_20200927.img" to program the UV-5R using Chirp. North American readers should ignore my local repeater channels 1-5.

You can set up the frequencies manually using five channels to cover the Doppler shift.

Ch1 Rx 437.810 Tx 145.99 with67 HZ CTCSS tone (for start of pass AOS)
Ch2 Rx 437.805 Tx 145.99 with67 HZ CTCSS tone
Ch3 Rx 437.800 Tx 145.99 with67 HZ CTCSS tone (for mid-pass)
Ch4 Rx 437.795 Tx 145.99 with67 HZ CTCSS tone
Ch5 Rx 437.790 Tx 145.99 with67 HZ CTCSS tone (for end of pass LOS)

With the launch of CAS-5A (HO-118) with an FM transponder, the Chirp file Baofeng_UV-5R_20221223 has been updated to add the frequencies for this satellite.

The Channels are:

CH10 -14 ISS
CH15 -20 SO-50
CH21 -25 AO-91
CH30-34 HO-118

The new file is in dropbox **www.dropbox.com/sh/t2mgkw2nuscu9vf/AADzGxkqs7eJJ3uU_uPp0E-Ua?dl=0.** Same as the original link.

3) Results: I used the stock UV5R antenna, not expecting to hear much, but about 5 minutes into the pass, I heard a couple of VKs chatting. Then ZL2TAZ came up and worked a couple of stations and, finally, the CW ID NA1SS. All signals were noisy but quite readable.

I could not get in on transmit. You need full-duplex to hear yourself and know if you are getting in.

Conclusions: The Baofeng UV5R will work but needs a better antenna than the standard whip.

A good dual-band mobile would be a better choice for a radio to provide full-duplex operation.

Horizon obstruction and low signal levels mean that "Look4sat" appears to be early by a few minutes but checking with GPredict on the main PC shows that it is giving the correct access times.

I also wrote a quick spreadsheet to check the theoretical performance, which is also in GitHub [4] (ISS CrossBand Repeater_Path Calcs).

References:

[1] **f-droid.org/en/packages/com.rtbishop.look4sat/**

[2] **www.work-sat.com/**

[3] **https://chirp.danplanet.com/projects/chirp/wiki/Home**

[4] **github.com/TerryOz/ISS-Crossband-Repeater-with-UV5R**

Location	Name	Frequency	Duplex	Offset	Tone	rToneFreq	cToneFreq	DtcsCode	DtcsPolarity	Mode
1		439.925	-	5		88.5	88.5	23	NN	FM
2		146.85	-	0.6		88.5	88.5	23	NN	FM
3		147.075	+	0.6		88.5	88.5	23	NN	FM
4		147.1	+	0.6		88.5	88.5	23	NN	FM
5		147	-	0.6		88.5	88.5	23	NN	FM
10		437.81	split	145.99	Tone	67	88.5	23	NN	FM
11		437.805	split	145.99	Tone	67	88.5	23	NN	FM
12		437.8	split	145.99	Tone	67	88.5	23	NN	FM
13		437.795	split	145.99	Tone	67	88.5	23	NN	FM
14		437.79	split	145.99	Tone	67	88.5	23	NN	FM
15		436.795	split	145.85	Tone	74.4	88.5	23	NN	FM
16		436.805	split	145.85	Tone	67	88.5	23	NN	FM
17		436.8	split	145.85	Tone	67	88.5	23	NN	FM
18		436.795	split	145.85	Tone	67	88.5	23	NN	FM
19		436.79	split	145.85	Tone	67	88.5	23	NN	FM
20		436.785	split	145.85	Tone	67	88.5	23	NN	FM
21		145.96	split	435.24	Tone	67	88.5	23	NN	FM
22		145.96	split	435.245	Tone	67	88.5	23	NN	FM
23		145.96	split	435.25	Tone	67	88.5	23	NN	FM
24		145.96	split	435.255	Tone	67	88.5	23	NN	FM
25		145.96	split	435.26	Tone	67	88.5	23	NN	FM

Support AMSAT

AMSAT is the North American distributor of SatPC32, a tracking program for ham satellite applications. Version 12.8d features enhanced support for tuning multiple radios. Features include:

1. The CAT commands of the IC-9100 have been extended again. The program now also controls the DV mode (DV for 'Digital Voice') of the radio. With the FT-817 the program now additionally supports the CWR mode.

2. All SatPC32 programs now process significantly larger Keplerian element source files. Especially because of the numerous new Cubesats, the number of data sets contained in the source files has increased significantly. For example the file Cubesat.txt currently contains data for nearly 400 satellites.

3. In all programs (SatPC32, SatPC32ISS, Wisat32, WinAOS and WinListen), the list of satellites contained in the source file ('Available' list in menu Satellites) is now displayed in alphabetical order to facilitate locating individual satellites.

4. The program SatPC32ISS now also allows the creation of up to 12 satellite groups. The new Cubesats have also increased the number of 'in-band' satellites. Originally, in-band operation in amateur radio was only available at the ISS.

5. In order to accelerate a change between the individual satellite groups, the 'Groups' window can now be called up by clicking on vacant areas of the main window, except in the Satellite menu. Such free positions are located on the right and left of the frequency window.

6. In the Satellites menu the data sets of the satellites contained in the active source file can now be displayed. When called, the data set of the currently selected satellite is displayed. The feature helps you to immediately know the identifier of the satellite.

7. The program has improved control of the sub-audible tone required by some satellites. The program can now automatically switch the sub tone on/off when switching between PL tone satellites and others, changing between u/v and v/u satellites, changing the group, closing the program, etc.

A registration password for the demo version may be obtained for a minimum donation of $40 for members and $45 for non-members.
Order by calling 1-888-322-6728. The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.

Join the 2023 AMSAT President's Club

And Help Keep Amateur Radio is Space!

Last Year, President's Club members raised over $67,000 to help move AMSAT programs forward:

The **GOLF** program to return Amateur Radio satellites to HEO has taken great strides with the development of entirely new 3U spaceframe with deployable solar panels; software defined radios; housekeeping circuits, power generation and management; attitude detection and control capabilities.

The **FOX-PLUS** program continues to build on the original and wildly popular FOX satellites. This new generation of LEO satellites will continue to provide affordable access to space communications to entry-level users as well as to provide payload capabilities for advanced educational programs and scientific experiments.

With your membership, AMSAT is pleased to recognize your generosity. All members receive:

Commemorative Coin 2" with 4-color enamel accents and polished gold finish.

Full-Color Membership Certificate

Cork Beverage Coasters with 4-Color Logo Imprint

Higher tier members receive even more benefits! You can join with a single payment or with twelve affordable monthly payments with your credit card. For payment by check or electronic transfer, contact Frank Karnauskas, VP-Development at f.karnauskas@amsat.org.

Go to AMSAT.org/donate and Join Today!

Tier	Core	Bronze	Silver	Gold	Platinum	Titanium
Annual Donation	**$120 +**	**$300 +**	**$600 +**	**$1,200 +**	**$2,400 +**	**$4,800 +**
Journal Listing	X	X	X	X	X	X
Certificate	X	X	X	X	X	X
Coin	X	X	X	X	X	X
Iron-on Logo Patch	X	X	X	X	X	X
Desk Plaque			X	X	X	X
TAPR/AMSAT Dinner @ Dayton				X	X	X
Symposium Admission					X	X
President's Symposium Lunch					X	X
Symposium VIP Recognition						X

Recognition items available for U.S. addresses only. For contributions from elsewhere please contact Frank Karnauskas, VP-Development at f.karnauskas@amsat.org. AMSAT is a 501(c)3 corporation. Donations may be tax deductible. Check with your tax advisor. President's Club membership does not include AMSAT Annual Membership.

With a 50-year Legacy of Success, AMSAT Volunteers …

Build satellites that Keep Amateur Radio in Space!

Promote space education through ARISS and STEM-based initiatives.

Manage satellites in orbit and ensure they are available for public use.

Create and maintain vital partnerships with government, industry, educational institutions, and amateur radio organizations to foster space research and communication.

Learn, teach and share innovations and best practices in space communications with other radio operators, students, government and the public.

Show and share their passion for amateur radio in space everywhere they go!

Will take amateur radio to the Moon, to Mars and to deep space … with your help!

Go to https://www.amsat.org/volunteer-for-amsat/ and help create AMSAT's future legacy!

AMATEUR RADIO IN SPACE
AMSAT®