The AMSAT® Journal

Editor-in-Chief
Joe Neil Kornowski, KB6IGK

Assistant Editors
Bernhard Jatzeck, VA6BMJ
Douglas Quagliana, KA2UPW/5
W.M. Red Willoughby, KC4LE

Volume 38, Number 6 — November/December 2015

AO-85 Now Orbiting and Operating!

Photo: United Launch Alliance

in this issue ...

Periodicals
POSTAGE PAID
At Kensington, MD
and at additional
mailing offices

AMSAT-NA
10605 Concord St., Suite 304
Kensington, MD 20895-2526

AMSAT Announcements

2015 Officer Elections

The following AMSAT-NA Officers for 2015-2016 were elected by the Board of Directors at its annual meeting in Dayton, OH.

President	Barry Baines WD4ASW
VP Engineering	Jerry Buxton N0JY
VP Human Space Flight	Frank Bauer KA3HDO
VP Operations	Drew Glasbrenner KO4MA
Secretary	Paul Stoetzer N8HM
Treasurer	Keith Baker KB1SF/VA3KSF

The Executive Vice President, Vice President User Services and Vice President Marketing remain open.

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.

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The AMSAT Journal (ISSN: 1407-3076) is published bi-monthly (Jan/Feb, Mar/Apr, May/Jun, Jul/Aug, Sep/Oct, Nov/Dec) by AMSAT-NA, 10605 Concord St., Suite 304, Kensington, MD 20895-2526. Telephone: 301-822-4376, fax: 301-822-4371. Periodicals postage paid at Kensington, MD and additional mailing offices.

Postmaster: Send address changes to *The AMSAT Journal*, 10605 Concord St., Suite 304, Kensington, MD 20895-2526.

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 JPEG formats. Kindly do not embed graphics or photos in your manuscript - we prefer receiving those as separate files. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations.

Apogee View

Barry Baines • WD4ASW
President
wd4asw@amsat.org

Success! October was an immensely successful month for AMSAT on several fronts, and 2015 is ending on a high note.

AMSAT is Back in Space

On October 8, 2015, we enjoyed the successful launch of Fox-1A on the ELaNa-XII Mission, subsequently given the designation AO-85. AMSAT's first CubeSat is now in commission (as of November 17), with amateurs around the world benefiting from the FM repeater capability and Vanderbilt University's Institute for Science and Defense Electronics gaining from its scientific payload and the data being provided.

Many amateurs around the world are now serving as telemetry downlink stations, utilizing the ground station software developed by Chris Thompson, AC2CZ, to view and forward the telemetry data to AMSAT's central server. Indeed, there is a bit of competition going on to see who can successfully downlink and forward the most data to AMSAT.

AMSAT Vice President of Engineering, Jerry Buxton, observed the launch at Vandenberg AFB and participated on a NASA panel the day before, during which he described Fox-1A's capabilities to media personnel. It is fair to say that how well AMSAT's CubeSat performed impressed both NASA and the government personnel involved with the launch.

While the spacecraft does have its own "personality," including a RF uplink reception issue, our engineering team believes it has identified the problem and is working to ensure that the issue does not recur on future Fox-1 satellites. Nonetheless, AO-85 is working, and users can communicate through it.

The family of former AMSAT Vice President of Engineering, Antony Monteiro, AA2TX (SK), also attended the launch, with his widow, Mary Lou, daughter, Veronica (the "voice" of AO-85), and other family members witnessing in person Fox-1A being placed in orbit. Tony played a critical role in the development of the Fox-1 program. Having his family present to witness Tony's work being carried aloft was truly special.

Wait, there's more …. We look forward to the launch of Fox-1Cliff and Fox-1Delta, currently scheduled for the first quarter 2016, as part of the Sherpa commercial launch, and RadFxSat/Fox-1B in November, as part of the ELaNA-XIV launch. Stay tuned for further developments.

AMSAT Space Symposium

This year's Symposium took place in Dayton, Ohio, the weekend of October 16, under the leadership of Symposium Chair Steve Coy, K8UD, and hosted by the Dayton Amateur Radio Association (DARA). The Board of Directors meeting took place on Thursday, October 15, and ended at noon on Friday. The Symposium then kicked off at 1300 with presentations that lasted until 1700. A reception that evening was followed by an auction, led by "Master Auctioneer" Drew Glasbrenner, KO4MA, giving attendees the opportunity to bid on a variety of space-related articles.

At times the bidding got fierce, with bidders vying for a number of interesting items from both the U.S. and Russian space programs along with AMSAT items of historical interest. The net result was over $3,000 raised for AMSAT. Thank you to our winning bidders, as well as to Drew, KO4MA, who did a masterful job of egging people on to build interest (and increase the bidding) for the items offered.

Presentations continued Saturday, along with the AMSAT Annual Meeting and a banquet that evening. Sunday opened with the Field Ops Breakfast and bi-annual IARU Satellite Advisor's Meeting. Monday's highlight was a trip to the National Museum of the United States Air Force. AMSAT Engineering also took the opportunity on Sunday to meet about engineering projects.

Some observations:

1. Symposium attendance was up over the past several years, in part, because students participated from Virginia Tech (VT; Blacksburg, VA), Morehead State (Morehead, KY) and University of Cincinnati. VT students presented several papers they had submitted for publication in the *Proceedings of the AMSAT-NA 33rd Space Symposium and AMSAT-NA Annual Meeting*, October 16-18, 2015 (*Proceedings*).

2. Foreign participation included representatives from the University of the Philippines who presented on their university's interest in CubeSats and space technology.

3. For the first time that I'm aware of, the presentations were streamed on line as they were given, thanks to the efforts of DARA.

4. This year's *Proceedings* was one of the largest editions published thanks to both the number of papers submitted and the amount of information about the Fox-1 program that was placed in the public domain.

5. Interacting with the VT students in an informal setting provided a wonderful opportunity to exchange ideas and observations as well as build relationships between the "old hands" of AMSAT and the next generation of satellite builders. These students are excited to have the chance to "talk spacecraft" in a way that they don't on campus, and we could see them soak up what they learned speaking with AMSAT Engineering team members and others. Demonstrations of the work they developed at VT was impressive. I consider having engaged these students in Symposium activities one of the weekend highlights.

The January/February 2016 issue of *The AMSAT Journal* will include coverage of the 33rd AMSAT Space Symposium and Annual Meeting, with photos.

The 34th AMSAT Space Symposium & Annual Meeting already is being planned, and we expect to make a formal announcement before Christmas. Some details remain to be worked out before we can announce anything publicly, but I will note that "Cruising to Symposium in November 2016" is a phrase that is certainly apropos. Stay tuned for further developments. The 2016 AMSAT Space Symposium and Annual Meeting will be unlike anything we've done before, and we hope it will result in significant interest by AMSAT members (and their families) in joining us for this event.

Transition of *The AMSAT Journal*

One other success in October worth noting is the transition of *The AMSAT Journal* (*Journal*) to new leadership. Joanne Maenpaa, K9JKM, announced her resignation as Editor in September due to family issues that required her dedicated time and energy. Something had to give in her life, and clearly family responsibilities take precedence over a "hobby." The September/October 2015 issue was her last as editor.

JoAnne became editor of the *Journal* in the fall of 2012, and enhanced its quality and substance during her tenure. The magazine has been published on time with quality articles. As many of our members view the *Journal* as the primary benefit of their membership, and others see the *Journal* as a reflection of AMSAT itself, the importance of the *Journal* cannot be overstated. It takes a unique individual with the appropriate technical skills, writing skills, ability to work with authors and editorial staff, a passion and vision to make the *Journal* a success. JoAnne has done a masterful job, and she clearly put the time, energy and passion into her role as editor. The results reflect highly her ability and dedication.

When JoAnne informed me of her decision to resign, I asked her for a recommendation as to whom I might approach about becoming our next editor. She recommended a member of her editorial staff, Joe Kornowski, KB6IGK, of Austin, Texas, who has served as an assistant editor since 2014. Subsequent conversations with Joe convinced me not only of his eminent qualifications, but his deep interest in taking the *Journal* to a higher level, as well as developing the managerial team that would reduce the workload necessary for putting an issue together, allowing more time to focus on developing content and building the infrastructure to allow a broader diversity of materials and ideas.

Joe's professional background includes service as an attorney, as well as over 14 years of professional experience in writing, editing, and content creation in various fields, including law and legal publishing, technology, health and wellness, and creative/media. Joe is a professional writer who assists companies with their management of various media and content creation, such as articles, blogs and newsletters.

After our conversations, Joe agreed to attend the AMSAT board meeting in Dayton to introduce himself to the AMSAT leadership and to propose how he would like to move forward, recognizing that his immediate task was to get the next issue (November/December 2015) out the door on time. This issue is his first product.

Looking forward, Joe intends to work on enhancing the quality of the *Journal* by developing and implementing a style guide for the editorial staff to use as a means of setting standards on content editing, developing a pool of materials by encouraging members and AMSAT leaders to submit articles, and creating a pipeline whereby work on future issues is done in advance of expected publication dates. For example, as the November/December issue is being put to bed, work already is underway to finalize articles for the January/February and March/April 2016 issues.

He also is looking toward using software tools to help the editorial team work more effectively together in managing content through collaborative editing that will simplify the editing process and allow our volunteer editors to more effectively provide corrections and suggested changes to submitted materials.

One of Joe's goals is to better coordinate materials between various AMSAT media outlets, such as ANS and social media (Facebook, Twitter, etc.). The User Services Teams, under a process led by ANS editor Joe Spier, K6WAO, have established a collaboration to benefit from each other's efforts. Welcome Aboard, Joe, KB6IGK!

Phase 4-B Developments

As noted previously, AMSAT and VT are collaborating on the development of an amateur payload to be installed on a U.S. Government spacecraft and placed in geosynchronous orbit. Before this payload can be placed on this spacecraft, the satellite builder must conduct a "Payload Accommodation Study" to determine the feasibility of that placement, as well as to ensure that the amateur payload does not cause issues for the primary purpose of the spacecraft. The Accommodation Study results will help the U.S. Government determine whether it will allow our payload to be placed on its spacecraft and provide the satellite builder the knowledge it needs to incorporate our requirements into the spacecraft.

To date, AMSAT's roles and responsibilities in this project cover these areas:

1. pay for the Payload Accommodation Study as the "customer" for this project,

2. develop the ground terminal necessary to enable communication between the ground and the spacecraft,

3. meet IARU frequency coordination requirements as the amateur payload "owner," and

4. operate the amateur payload once in orbit.

VT is the designer and developer of the amateur payload and has the responsibility for raising the funds necessary to construct the payload and to fly it. At this point, AMSAT volunteers are not directly engaged in payload development and construction under AMSAT Engineering management, but that may evolve once the Payload Accommodation Study is completed.

The spacecraft builder has presented a proposal to AMSAT to conduct the Payload Accommodation Study. AMSAT has formally accepted the proposal and is in position to pay the $100,000 cost of that study which will take eight weeks to complete. We anticipate completion of the study in late January 2016.

Meanwhile, VT and AMSAT also have been working on developing support for this program because the payload will be able to support emergency communications during times of disasters, such as hurricanes. Fully aware of the proposed capabilities of this payload, the ARRL intends to incorporate these capabilities into the ARES (Amateur Radio Emergency Service) operating plans in support of state and local agencies. ARRL, VT and AMSAT have briefed FEMA officials on the potential benefits of the payload.

The justification for placing this payload on a U.S. Government spacecraft is based upon emergency communications. VT's fundraising efforts will support 100 ground terminals to be dedicated to ARRL for support of emergency communications. AMSAT's goal is to develop an affordable portable ground terminal (uplink and downlink) that would cost less than $1,000 per terminal and could serve not only P4-B but also other programs, such as the CubeQuest Challenge (CQC) and a potential 6-Unit High Elliptical Orbit (HEO) satellite.

AMSAT's own development efforts for the ground terminal are proceeding independently of the P4-B program because both CQC and potential HEO operations need this capability.

As 2015 comes to a close, AMSAT has much to be proud of. The successful launch and placement in service of Fox-1A/AO-85 is certainly the key highlight of the year. We announced new initiatives earlier this year to place amateur radio payloads in geosynchronous orbit (P4-B) and HEO (P3-E). While both initiatives are not yet definite, our collaboration with VT is opening doors for potential missions that would not otherwise be available.

We've encouraged new talent to become engaged in AMSAT's various activities, from AMSAT Engineering to the Senior Leadership Team, including the selection by the board of Paul Stoetzer, N8HM, as Corporate Secretary.

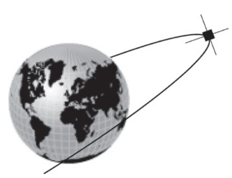
We continue to develop relationships with universities, reflected in the submission of a CubeSat Launch Initiative (CSLI) proposal in November by Vanderbilt University to fly RadFXSat-2/Fox-1E, a linear transponder satellite. We should know in February 2016 whether this satellite has been selected for an ELaNa launch. Likewise, University of Washington is submitting a CSLI proposal in November where it will be using the Fox-1 Class RF boards as part of its satellite design. Our participation in the ElaNa and CubeSat conferences has opened new doors with various universities, as well as built a reputation for engineering excellence within the NASA CubeSat community.

AMSAT was approached by Ragnorak Industries to join its team to compete for the NASA CQC, and our volunteers, under Project Manager Howard DeFelice, AB2S, are now developing the communications payload for this 6U satellite.

In 2016, we look forward to the scheduled launches of three Fox-1 class spacecraft as well as determination of whether the P4-B and P3-E missions will be a "go." The CQC process will include a determination on which teams will be awarded slots to fly on the inaugural flight of SLS-1 that will provide the ride to lunar orbit.

Meanwhile, we also look forward to the 2016 Dayton Hamvention as well as the 2016 AMSAT Space Symposium ("Cruising to Symposium in November 2016").

What a great year 2015 has been for AMSAT, and I look forward to an even better year in 2016!



Share Your Experiences for New Column!

As a way to better serve our readers, *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 thinking of 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)

Cruising to the Space Symposium in November 2016

Stand by for details!

Engineering Update

Jerry Buxton • NØJY
Vice President, Engineering

Now that AO-85 (aka Fox-1A) is in orbit and operating, AMSAT Engineering has expanded its activity from just designing, building, and launching to include testing and commissioning of our first Fox-1 satellite.
In this column I will share some notes about the launch, as well as AO-85 discoveries and developments since launch from an engineering standpoint.

Launch

Several members of the Fox-1 Engineering Team attended the launch at Vandenberg Air Force Base on October 8, 2015. United Launch Alliance (ULA) sponsored a "Friends and Family" event for the launch of their Atlas V, including a launch viewing from the ULA hanger. We stayed for a subsequent animated look at the deployment of the CubeSats manifested on the NRO Government Rideshare Advanced Concepts Experiment (GRACE) mission that included Fox-1A as part of NASA's Educational Launch of Nanosatellites (ELaNa) XII mission.

Launch went smoothly, and Fox-1A was successfully deployed as planned from P-POD 2, along with our 1-Unit CubeSat partners ARC1 from Alaska and BisonSat from Montana. At deployment, our timer started counting down, and per the "day in the life" testing, the transmit antenna should have deployed at 51 minutes, 21 seconds, after Fox-1A left the P-POD, followed by the receive antenna deployment at 51 minutes 32 seconds after P-POD separation. At 54 minutes, 12 seconds, the first voice ID beacon should have been sent.

After watching the P-POD deployment simulation, we returned to our gathering point and headed back to our hotel. Shortly after arrival at the hotel, the first telemetry came into the server, and we knew Fox-1A was working!

The next phase of work began. We spent several hours on the phone with the Fox-1A on-orbit checkout team, which included several engineering representatives and Drew Glasbrenner, AMSAT VP of Operations. We monitored telemetry as hams around the world helped by listening to Fox's beacon with the FoxTelem software and submitting reports. We were able to visualize and eventually graph the results. All of the results were pleasing, while some also were very interesting.

Battery

The Fox-1A commissioning roadmap, developed well before launch, consisted of several steps to work through in sequence as we verified systems via telemetry and reports of the voice ID. We moved through the steps fairly quickly, primarily because the battery was fully charged right from the first telemetry reception. That was the first interesting item, as the satellite had been untouched in the P-POD since March 25, and we expected the battery to be significantly discharged after more than six months. Some even speculated that it might have been completely discharged. The observed readings from the engineering model battery, which showed just over 0.1 V drop after sitting three months, apparently were an accurate measure of satellite reality. Fox-1A probably had discharged to somewhere in a range of nominal cell capacity (1.2 V, for 3.6 to 3.7 V at deploy) and quickly recharged, having been deployed into sunlight that provided 50 minutes of recharging before the antenna deployed and the transmitter switched on.

The battery continues to perform well and appears to be recharging fully in each sun cycle, with discharge limited to only about .2 V per eclipse -- well within our desired <20% depth of discharge to maintain a long battery life.

Temperature

Another interesting and immediately apparent revelation from the telemetry was the satellite's temperature. Our thermal design and modeling predicted a nominal 0°C operating temperature. NiCad batteries do not live long if they are charged below freezing. That is why we installed heaters on the battery cells to keep them warmed for charging (Figure 1).

Telemetry showed the temperature of the receiver (second board from the bottom of the stack) and the power supply unit (PSU, just below the middle of the stack) in the mid-20 C degrees and rising quickly! With no concern for the battery freezing, our new concern was that the battery cells might become too hot. As the temperature continued to increase, we struggled to find a satisfactory explanation, suspecting perhaps

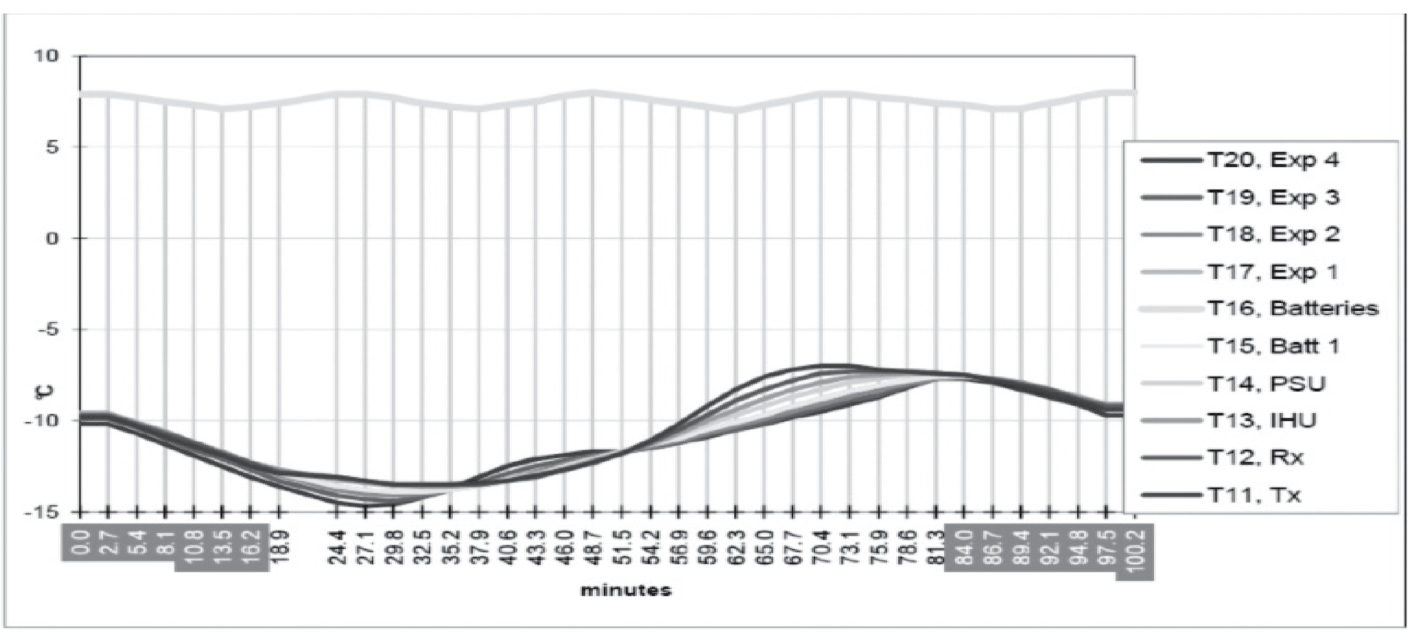


Figure 1 - Temperature Modeling PCB temperatures for 33% eclipse orbit

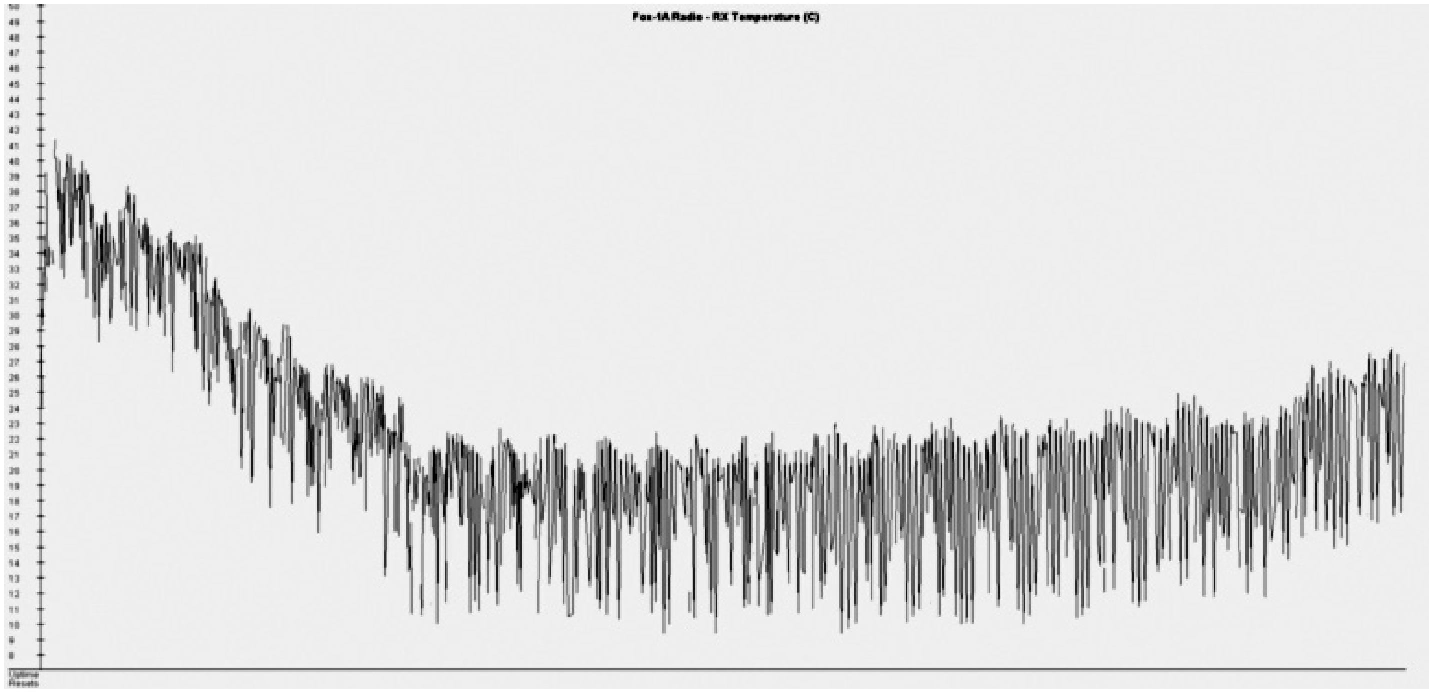


Figure 2 - Observed temperatures from FoxTelem

heat had been generated by the battery's initial charging. The temperature continued rising for about the next 24 hours. The phenomenon remains unexplained.

As the week progressed, the temperatures trended downward and continued decreasing until they appeared to reach equilibrium. The temperatures also are affected by the eclipse cycle, and they started back up as we got closer to a few weeks of full sun. How high they will go remains to be seen (Figure 2). Still, those temperatures are 25 to 30 degrees higher than predicted.

With good signs from the satellite and many of us traveling to the AMSAT Space Symposium the second week of October, we decided to put AO-85 (Fox-1A by then having received its OSCAR designation) in Transponder Mode on Friday, October 9, for the duration of Space Symposium. This decision was driven by two primary reasons:

- First, the travel and meetings would give us little time to monitor AO-85 or perform any further tests; and
- Second, very importantly, by enabling Transponder Mode, we would send telemetry continuously (as long as the transmitter was operating) and therefore gather lots of data for later study.

That unfolded as expected, with hams throughout the world sending a large quantity of telemetry data to the server. The large amount of data proved invaluable and enabled us, through FoxTelem and our access to the data on the server, to take snapshots of the real-time data at any point in time and to analyze data graphs. We also could see that Vanderbilt University's radiation experiment, part of the Fox-1A payload, was working well. We provided Vanderbilt with its data for analysis. Thrilled at what they saw, the Vanderbilt team confirmed that its experiments were working as intended.

Operationally, satellite users quickly noticed that the transmit frequency was about 1.7 kHz lower then the published 145.980 MHz. This was no surprise given that the transmitter had been calibrated for 0°C, and the 20° to 30° temperature differential we observed on the spacecraft at the time corresponded with what was observed in testing on the ground at room temperature.

Users also observed that the satellite's receive frequency was about 10 kHz lower than the published 435.180 MHz. While this, too, may be a temperature factor, that is not yet determined. We will perform tests on the upcoming Fox-1Cliff and Fox-1D satellite receivers at these higher temperatures to assess what effect that has on frequency. In addition, Fox-1Cliff and D will have their transmitters and receivers tuned for a warmer temperature environment, likely around 18°C based on observations to date.

Repeater Sensitivity

Probably the most notable observation about AO-85 has been an apparent lack of the repeater's sensitivity, with difficulty in turning on the repeater with the 67 Hz CTCSS tone before the repeater is activated, and keeping it on by the presence of the CTCSS.

The sensitivity problem surprised us, and we set out in earnest to determine the cause, whether it would or could affect future Fox-1 satellites, and how to correct it. Trying to determine what is going on in a situation like this is difficult. Obviously, we can't examine or test the satellite directly, so we are looking at the flight unit photos, reviewing the build process with the antenna, and investigating and measuring the antennas on Fox-1Cliff (Figure 3).

We know there was an incident with the Fox-1A receive antenna that came loose during the last stages of flight unit assembly. This occurred very close to the drop-dead date for making

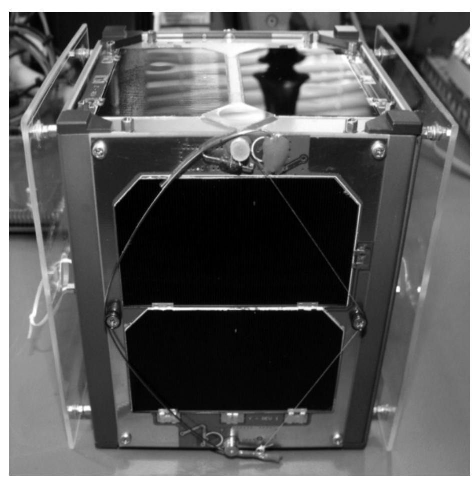


Figure 3 - Receive antenna

the launch, so we explored the limited options. Given the personnel and tools available, we determined that conductive epoxy could safely be used to reaffix the antenna on the spacecraft.

Photos indicate that the conductive epoxy and/or some normal epoxy which is holding the antenna in place may be overlapping portions of the solar panel printed circuit board such that they are producing a capacitive effect and detuning the antenna matching components underneath. Further investigation indicates that the wire loop epoxied to the end of the antenna (used to provide a tie point for the stow line) was larger than anticipated and would also both alter impedance and add length.

Examination of the Fox-1Cliff solar panel revealed that a solar cell had overlapped the RF trace that runs to the antenna, causing more capacitive interference to the circuit. On Fox-1Cliff, the trace/cell overlap has been corrected as will be done with Fox-1D. Based on analysis of the Fox-1Cliff antennas, the sensitivity problems with AO-85 apparently resulted from the antenna build process, coupled with the antenna pattern, causing several dB loss at the antenna.

The signal loss then interacted with the CTCSS tone detection, making it harder to bring up the repeater. With the modeling of Fox-1A indicating that battery heaters would be required, we were concerned with the power budget. Any uncertainty whether the heaters may have needed to run even in sunlight made us conservative about the transmitter's operation. To conserve power, we limited the data mode to a 15-minute interval and initially limited the hang timer to 30 seconds. (That was later extended to 60 seconds for flight, but still half of the 120 seconds called for in the original specification.) The hang timer is what keeps the transmitter on after loss of CTCSS detection, allowing contacts to continue near the horizon when signals become weak and the tone is more difficult to detect.

Testing revealed that the international housekeeping unit (IHU) would think it detects a tone when there is no signal. This occurred often in our on-the-air testing. The rate of false detections was great enough to cause concern that, in orbit, where many other signals may be detected over a wider area, the transmitter/hang timer may turn on more often; that would impact the power budget based on the battery heaters.

Accordingly, the CTCSS detect was tightened to require about 1 ½ seconds of tone to activate the hang timer. For Fox-1Cliff and Fox-1D (and RadFxSat/Fox-1B), we will loosen that a bit now that we have evidence our thermal design will keep Fox-1 warm enough without battery heaters. That should make bringing up the repeater much easier.

FoxTelem Anomalies

Those using FoxTelem or other means of decoding and observing telemetry data may have noticed a few anomalies in the readings. FoxTelem users will see that the systems are presented as boxes with the related telemetry values grouped inside the box.

First is Computer, where the Spacecraft Spin has shown some interesting numbers. Users might not notice right away, but the spin is reversed. In the spin calculation, the direction around the Z axis is reversed such that a counterclockwise spin as viewed looking down on the +Z is considered negative spin while that is really the direction the satellite is expected to spin. Further, any spin in the expected direction was not accounted for correctly and generated incorrect numbers. Since the world we work in as volunteer engineers building satellites often involves individual contributors being unavailable for short periods because of life demands, this situation came up at a time when the contributor was not available to fix the code. With the deadline fast approaching, we decided to fly Fox-1A with the known code bug and pursue the fixes for subsequent Fox-1 satellites.

Also in Computer, notice the Battery I^2C shows FAIL. That is a true reading. During flight unit construction, we discovered that the battery board had a problem with an unknown source drawing a (relatively) high current on the sensor power line that powers the components used in telemetry gathering. We were unable to identify which component(s) were causing the problem in the short time we had before the drop-dead date. We suspect one of the ICs had an anomaly that only appeared when power was applied.

The current drew down the sensor power supply voltage enough that it could not power the chips, so the problem perhaps prevented us from easily determining which chip(s) might be at fault because they could not power up. To prevent harming the IHU (source of the sensor power) or interfering with telemetry from other systems, we removed a resistor so that sensor power was removed from the Battery telemetry sensors and system. This caused data loss on individual cell pair voltages and total battery voltage, battery current, and battery board temperature.

The loss of total battery voltage is compensated, however, by a software routine which, upon detection of Battery failure telemetry (hence the I^2C FAIL state as displayed), will fill that field in the telemetry downlink with battery bus voltage as seen by an independent reading built into the STM MCU. The flight spare battery exhibited the same type of problem so there was no opportunity to swap boards. The exact cause has not yet been determined -- perhaps a bad lot of some component – but will not exist on Fox-1Cliff/D. Note also, that with the IHU reading the bus voltage, the voltage while the sateillite is in sun represents the value of the power supply voltage being applied to the bus and not the actual battery voltage.

In the PSU box, Current appears to be more of an on/off situation than an actual reading, if you look at the graphs. While this is still under investigation, it appears that an error occurred in a component that sets the value of the sensed voltage that represents current. We will share more information as we learn more.

Finally, in the +X Panel, +Y Panel, and +Z panel the values for Rotation (dps) as taken from the MEMS gyro experiment provided by Penn State Erie students, while not known to be defective, was showing some very erratic numbers until just before October 26. This likely is an expected result of the helium purge done on the rocket prior to launch. Helium is known to affect MEMS devices so we expected to see anomalistic readings for an undetermined period of time.

Operational Guidelines

AO-85 should be formally commissioned by the time this article is published. The following guidelines are provided for users:

1. Uplink power should be on the order of minimum 200 W EIRP for full quieting. Your mileage may vary. With an Arrow, 5 W has been used successfully to make contacts.

2. Polarity is important. The satellite antennas are linear. So, if you are using linearly polarized antennas, you will need to adjust throughout the pass. Full duplex operation facilitates these adjustments while transmitting and is highly recommended.

3. The downlink is very strong and should be heard well with almost any antenna.

4. Downlink audio is 5 kHz deviation, as expected. Many will perceive that the audio is "low." This is an effect of the filtering below 300 Hz, which provides for the DUV telemetry, coupled with any noise on the uplink signal resulting from lack of full quieting or being off frequency. That makes for less fidelity than a typical receiver in terms of audio

frequencies passed.

5. Transmit (downlink) frequency varies with temperature. Due to the wide range of temperatures we are seeing in the eclipse cycle, the transmitter can be anywhere from around 500 Hz low at 10°C to near 2 kHz low at 40°C.

6. Receive frequency has been generally agreed to be about 435.170 MHz, although the AFC makes that hard to pin down and also helps with the uplinks that are off frequency.

We must remember that science is the reason behind these satellites. Not only does science help with the launch cost, it provides a great amount of educational value both from the science payload and in amateur radio itself. The data-under-voice (DUV) telemetry is an excellent way to provide the science without sacrificing the use of the satellite for communications, which would be the case if higher speed downlinks were needed. DUV provides constant science as long as the repeater is in use, which in turn provides more downlink data for the science – a mutually beneficial combination.

Fox-1A is AMSAT-NA's first in a series of Fox-1 CubeSats. Many new techniques are incorporated and lessons will be learned, as with any new product. A total of five will be built and flown. Launches are scheduled for the next three, and a new NASA CubeSat Launch Initiative proposal will be submitted for the fifth. We will incorporate changes from what we learn in each subsequent Fox-1 launch, to the extent possible.

Of the four NASA sponsored CubeSats on the ELaNa XII launch October 8, I am sad to report that ARC1 was never heard from and BisonSat was lost after a few weeks of operation. I extend my deepest sympathy to the people who worked so hard on these projects. To our members, I want to say that we on the Fox Team are very proud and pleased that our first CubeSat is very successful and hopefully will be for some time.

Fox-1 Satellite Telemetry – Part 1: On The Satellite

Burns Fisher • W2BFJ
Fox-1 Flight Software

Fox-1A launched on October 8, 2015, and is now orbiting and operating as new amateur radio satellite AO-85. The first four Fox-1 1-Unit CubeSat amateur radio satellites, Fox-1A through Fox-1D[1], are FM repeaters with 200 bps data-under-voice (DUV), frequency-shift keying (FSK) telemetry and a special high-speed 9600 bps FSK telemetry mode. This article describes the telemetry generation and modulation, as well as the software audio path, in these satellites. In this article, "Fox-1" refers only to these FM/FSK/DUV satellites.

FSK Modulation

In order to describe Fox-1's telemetry, we need to understand FSK modulation and its relationship to FM transmitters. We typically think of FSK modulation as a carrier switched between two frequencies, one frequency representing a digital 1 (mark) and one frequency representing a digital 0 (space). A simplified diagram of this concept is shown in Figure 1 while Figure 2 shows the data versus RF waveform.

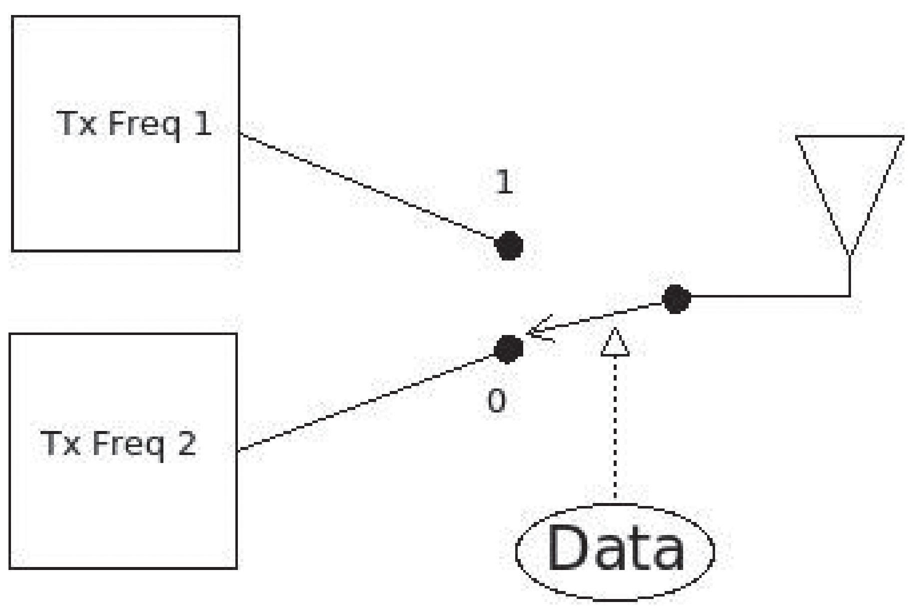


Figure 1 - Conceptual drawing of ideal FSK transmitter

But how does this relate to an FM transmitter? Remember that an FM transmitter uses a central carrier frequency that is increased and decreased depending on the amplitude of the modulating signal. If the modulating signal is a square wave of fixed amplitude, then the FM transmitter shifts between two frequencies. We can say that the "high" voltage of the square wave represents "mark," and the "low" voltage represents "space," and we have exactly what we want, the output shown in Figure 2 with an FM transmitter. An FM receiver, which is designed to reproduce the waveform input to the transmitter, would output the same square wave.

This describes an ideal case, assuming infinite frequency response. In the real world, however, signals with fast changes (like the square corner on a square wave) and non-sinusoidal shapes (like the flat top on a square wave) have high frequency content. A typical band-limited FM transmitter/receiver pair, if given a perfect square wave to transfer, would output a signal with rounded corners, "ringing," and wavy tops like Figure 3.

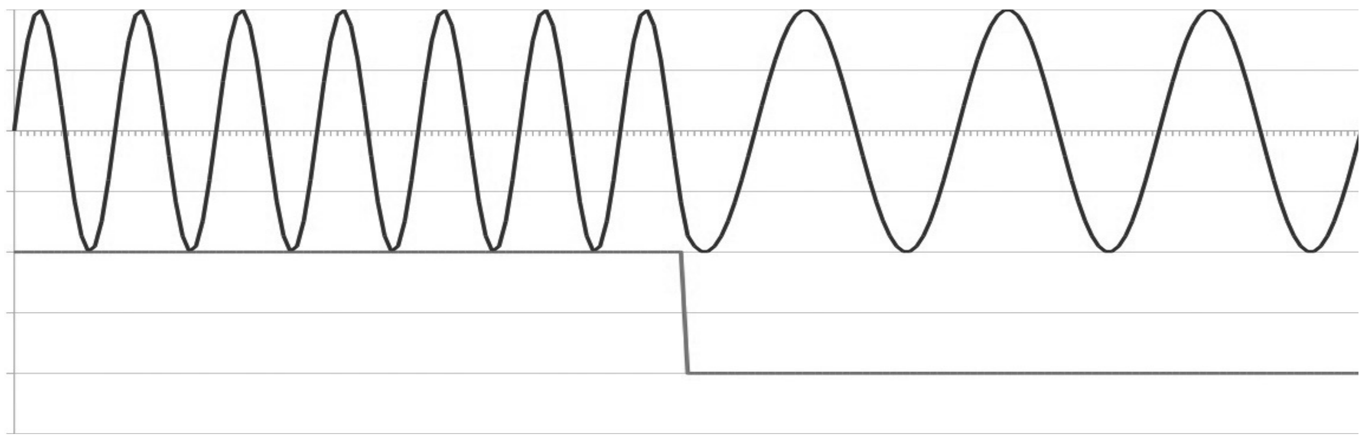


Figure 2 - Data into (bottom) and RF out (top) of an ideal FSK transmitter (not to scale)

Audio Path

Knowing how audio is processed on Fox-1 allows us to see how telemetry is incorporated into it. The Fox-1 designers chose to reduce the number of components on the crowded RF boards by passing the audio path, by default, through the Internal Housekeeping Unit (IHU, i.e. the onboard computer) so that the 67 Hz tone detection, as well as some filtering and the telemetry mixing, could be done in software. A block diagram of the path is shown in Figure 4.

The uplinked audio from the UHF receiver is routed to an Analog-to-Digital Converter (ADC) in the IHU. The voltage of the audio signal is sampled and converted into numbers from 0 to 4095 -- the higher the voltage, the higher the number. The processor then manipulates that data and sends it on to the VHF downlink transmitter by way of a Digital-to-Analog converter (DAC), which turns the samples into voltages.

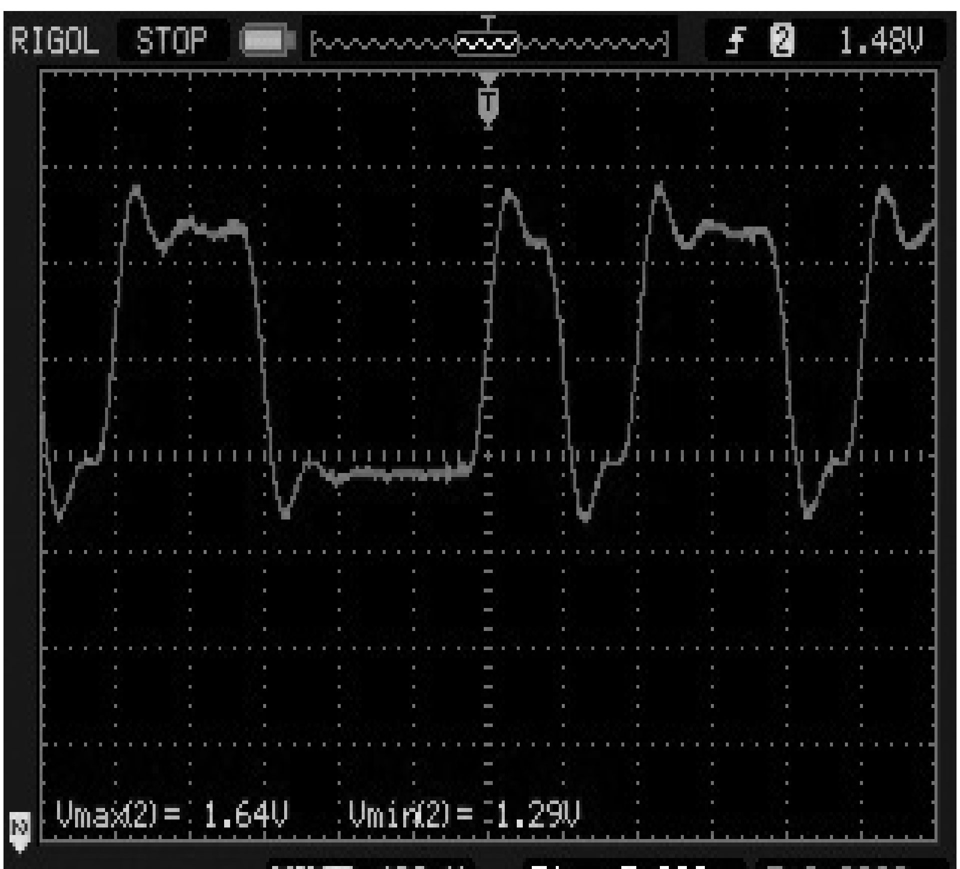


Figure 3 - Frequency limited square waves

Since we plan for the Fox-1 satellites to be operating for a long time, we also designed a fallback in case the computer fails. In that case, there is a direct analog audio path between receiver and transmitter called COR (Carrier Operated Relay). Under COR, the transmitter is keyed when the receiver detects an uplink carrier. The receiver audio is passed directly to the transmitter, with no tone detection and no telemetry.

More specifically, the processor samples the input signal at 48 KHz; 48 12-bit samples per millisecond are delivered to an input buffer via direct memory access direct memory access (DMA). There are two input buffers so that while one is being filled the other can be processed. Every millisecond, the processor performs a number of digital signal processing steps on the samples that arrived the previous millisecond, as follows:

- Reduce the number of samples from 48 to 8 (i.e., a sample rate of 8 KHz) by a process known as decimation. Decimation also acts as a low-pass filter on the signal so frequencies above 4 KHz will not cause aliasing.[2]
- Enter each sample into a signal processing method known as a "Goertzel" algorithm and look for a 67 Hz tone.
- Pass the samples though a high-pass filter to remove any frequencies below around 300 Hz.
- If the transponder is running, the resulting samples are used. If we are sending a voice ID, use instead on-board voice ID samples (pre-filtered to leave a gap below 300 Hz).
- Inject telemetry into the "gap" below 300 Hz.
- Raise the sampling rate back to 48 KHz through interpolation.

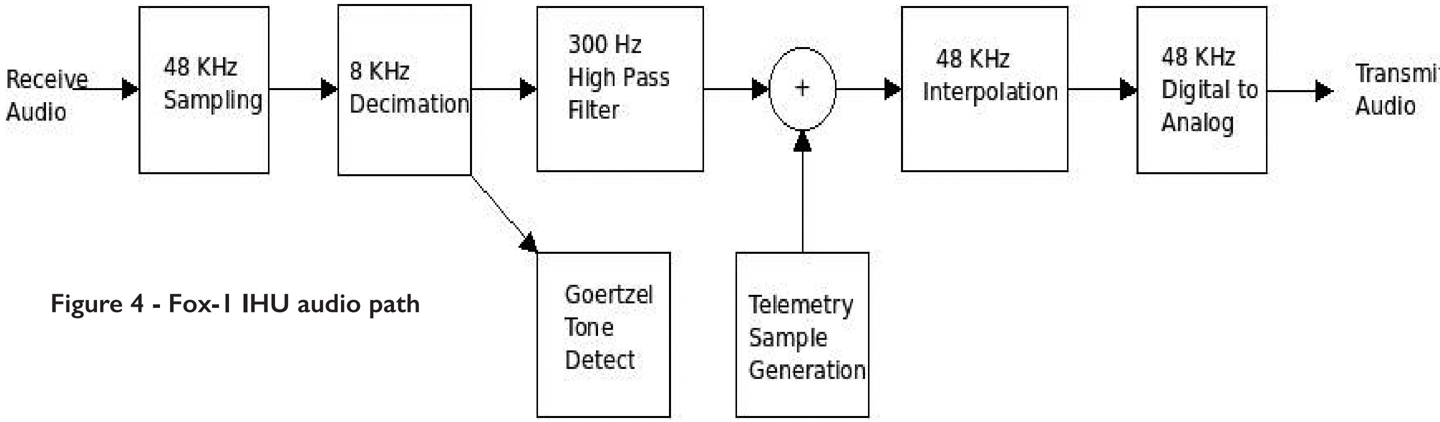


Figure 4 - Fox-1 IHU audio path

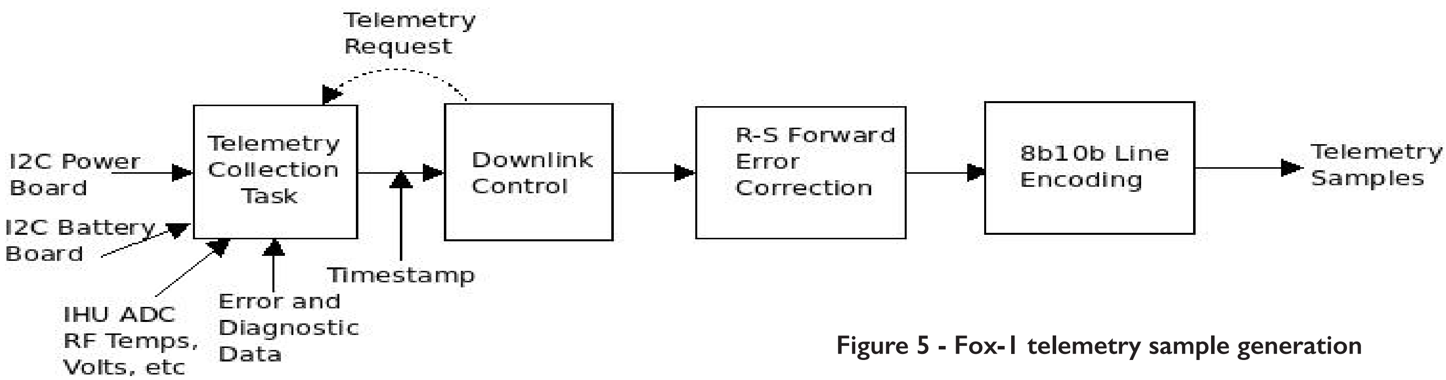


Figure 5 - Fox-1 telemetry sample generation

During the next millisecond, the samples are output via DMA through the DAC to the transmitter. The length of the audio delay in Fox-1 satellites' audio path is 2 ms, broken down as follows:

- 0 to 1ms, input audio is collected
- 1 to 2ms, it is processed, and
- 2 to 3ms, it is transmitted.

The 2 ms time interval is comparable to the amount of time required for an uplink signal to reach an LEO satellite and is unnoticeable to the ear.

Why start at 48 KHz, reduce to 8, and then increase back to 48 again? The reason for 8 KHz in the middle is to reduce the work required by the low-power and fairly slow IHU processor when it performs tone detection, filtering, and telemetry injection. There are several reasons for running the ADC and DAC at 48 KHz. We will see later that high-speed data mode must use the DAC at 48 KHz. The ADC and DAC are synchronized together so they have the same clock speed, and it is simplest to run the ADC and DAC all the time and not switch frequencies. And finally, a 48 KHz sample rate simplifies the analog filtering required on input and output to avoid aliasing issues.

Data Under Voice

To understand how DUV works in Fox-1, first assume that Fox-1 is receiving an unmodulated carrier, so the receiver is experiencing full quieting and is sending no audio to the ADC. In that case, we simply put numerically high samples into the output buffer for a mark and numerically low samples for a space. This makes a square wave and produces FSK modulation as described above.

In terms of the number of required samples, 200 bits of telemetry per second means 5 ms per bit. At 8 samples per millisecond, that is 8 x 5 or 40 samples per bit.

We said earlier that square waves contain high frequencies. However, we only have allocated a bandwidth of 300 Hz for the telemetry. The solution is to use a low-pass filter on the square wave that represents the data, reducing it to about 200 Hz. (The 100 Hz cushion allows us to use a fairly simple and not very sharp filter.) This produces a signal more like Figure 3, with a wavy top, rounded corners and some ringing or oscillation around changes between mark and space. Notice, though, that the signal is relatively stable in the middle of the bit. The decoder knows the spacing of the bits, so it can look in the middle to identify a mark or space.

With DUV, suppose that the uplink is carrying voice modulation. The buffer where we want to put the telemetry already has samples representing the uplink voice. We must decide what percentage of the downlink modulation will be voice and what will be data. If we want 90% voice and 10% data, we scale the uplink samples by 90% and ensure that the data samples we generate do not exceed 10% of the maximum value. Then we simply numerically add the value of each filtered data sample to the corresponding filtered data sample.

What does this mean for the output carrier frequency? Remember that the carrier frequency varies depending on the voltage of the input modulation. By adding the data to the uplink sample, we have increased or decreased the corresponding output signal voltage depending on whether we are adding a mark or a space. This increased or decreased signal voltage increases or decreases what the frequency of the carrier would be without the data. Imagine a graph of the entire carrier frequency versus time shifting higher or lower with the data. You can still consider this Frequency Shift Keying, but it is just not quite traditional.

To decode the data, we use an FM receiver and work with the resulting audio. We use a sharp low-pass filter around 200 Hz (we have more processing power on the ground). Now we have reproduced approximately the data samples that we injected into the audio stream in the satellite. Imagine talking over an audio link with a hum or buzz in the background and filtering out the hum with a high-pass filter or the voice with a low-pass filter. This scheme is completely analogous.

We can now see why you cannot just plug FoxTelem, the telemetry decoder, into the speaker port of your FM receiver. CTCSS tones, which you typically use to trigger a repeater, are in the range of 67 Hz to 250 Hz. Thus, most ham FM receivers filter out these low frequencies so you don't hear them. However, that is just the frequency range where Fox-1 data is located. If it gets filtered out, there is no data.

Many ham FM receivers have special high-speed TNC output ports. Some of these will work fine for telemetry, but you must look at the low frequency specifications for them. High-speed TNC output has reduced or eliminated the low-pass filter to allow high frequencies to pass through, but it still may have a high-pass filter that blocks the low frequencies we care about.

One important point is that, while the data is in the bottom 200 Hz of the audio, when transmitted on FM and mixed with the voice uplink, data is spread all across the FM channel's bandwidth.

High Speed Data

Data mode allows us to send data at 9600 bits per second. The main purpose of this mode is to send data from on-board experiments for which 200 bps is insufficient. For example, Fox-1Cliff and Fox-1Delta will have a camera experiment supplied by Virginia Tech. While AO-85 does not strictly require data mode, we included it to validate the concept. In addition, it gets more satellite health data to us more quickly, which is an advantage during commissioning.

High-speed data is implemented in the satellite as follows:

- First, save some processing power by discarding the uplink samples. We don't spend processor time decimating or filtering them, or looking for the 67 Hz tone.
- The extra processing time is used to collect and encode telemetry and experiment data faster.
- A speed of 9600 bps requires much more than the 4 KHz bandwidth that can be accommodated by an 8 KHz sample rate, so we put the data directly into the 48 KHz buffer. (Note: 9600 bps means .104 ms per bit multiplied by 48 samples per millisecond, which is five 48 K samples per bit.)
- We do not need to filter the data samples because there is hardware anti-aliasing to match the 48 KHz rate.
- With no voice and much less low-pass filtering, Fox-1 data mode is just traditional FSK.

On-board Telemetry Collection

The telemetry collection path in the satellite is shown in Figure 5. Note that telemetry, with few exceptions, gets collected asynchronously from its transmission to the ground. Telemetry is collected every 4 seconds on the satellite, and each value (where it makes sense) is compared with the previous minimum and maximum for that value. If necessary, a new minimum or maximum is stored along with the time (in seconds since last reset and number of resets) that a min or max changed.

The telemetry modulator uses a double buffer scheme so that, when data from one buffer is being transmitted, the other buffer can be filled. When one telemetry buffer is empty (about every 5 seconds while the transponder is on), the modulator uses the next full buffer, while the downlink manager requests the telemetry collection task to return a new packet of the data that is already collected. It is at this point that the downlink time is filled in.

The entire packet of data is now passed through the forward error-correction routines to generate Reed-Solomon check blocks as well as through an 8b10b line coding algorithm (see "Coding and Modulation Design for AMSAT Fox-1", Phil Karn, KA9Q in *AMSAT Symposium 2013 Proceedings*). The buffer is finally marked "ready" for the telemetry modulator to take when it is needed. When the telemetry modulator frees the buffer that it was working on, the cycle begins again.

Telemetry Values

While some telemetry values are true and false (for example "Antenna deployed"), and some telemetry values are encoded states or counts (for example, "Hard error type"), many values are analog measurements that originated from one of several 12-bit ADCs. The data is either collected directly by the ADC on the IHU board or sent by an I^2C bus from other boards. All data are sent to the ground unprocessed. In other words, they are sent as a number between 0 and 4095, leaving it to the ground software to convert them to degrees, volts, or amps.

When low-speed data is being sent, four types of telemetry frames alternate according to a set pattern. Type 1 contains the real time values. These values are current readings on the satellite within the last few seconds. Type 2 contains the minimum values along with a few extra bits that are not required frequently. These are the minimum values that have been seen since the satellite min/max memory was reset by ground command. Type 3 is similar to Type 2 but uses the maximum values. Type 4 contains low speed experiment data. Each high-speed frame contains all of the above types as well as experiment data.

A future article will discuss FoxTelem, our ground-based telemetry decoder, in more detail.

Notes

1. Fox-1C has been renamed Fox-1Cliff in honor of Cliff Buttschardt, K7RR (SK).

2. For those unfamiliar with digital signal processing, you must sample at least twice the rate of the highest frequency component in the input signal to reproduce the signal faithfully. Too slow sampling leads to an error called "aliasing." Our initial 48 kHz rate can reproduce a signal containing up to about 24 kHz frequencies. However, our decimated 8 kHz sample rates can only work with frequencies up to about 4 kHz.

A Raspberry Pi Net Server/Client for Antenna Rotor

Tom Doyle • W9KE

Net Server

A net server is a device used to create a network connection to an antenna rotor system. A net server can be especially useful when operating portable or from a remote location. While there are many different ways to do this, such as running GPredict software on a Raspberry Pi computer, the particular solution presented here is designed to use the Raspberry Pi with as much of your existing hardware and software as possible.

In the solution described here, the Yaesu G-5500 serves as the rotor and an LVB Tracker (USB interface) as the controller. The Raspberry Pi Net Server (Net Server) optionally can control four relays using a very high quality board currently available for about $10 on Amazon. These relays can control things like antenna polarity switches and amplifiers, or they can be used to turn equipment on and off remotely. The relay board is not required and could easily be added later. If you are interested in only the remote control relays, the programs will run without an LVB Tracker connected.

The hardware is a Raspberry Pi 2 shown in Figure 1, along with the relay board for controlling other devices. Three cables are connected to the Raspi: an RJ-45 network cable, a USB cable from the LVB Tracker, and a power cable that goes to a common USB charger. Five wires connect the Raspi to the optional relay board.

If you do not already own a Raspberry Pi, the Raspberry Pi 2 Model B (Raspi) is an excellent choice. If you purchase a Raspi, select the default Raspbian version of UNIX while doing the initial setup. For more information, see **www.raspberrypi.org/help/quick-start-guide/**.

The initial setup of the Raspi requires that a keyboard, mouse and monitor be connected to the device. After the initial setup, the keyboard, mouse and monitor may be removed and the device operated using what is referred to as a remote desktop connection. Since the Raspi uses a multi-tasking operating system, it can run the Net Server program and another server program to allow access from a remote device at the same time. This means that you do not need a monitor, keyboard or mouse connected to the Raspi after the initial setup. It also means the little two line LCD monitor we often see on these devices is not required. A Raspi operated this way is often referred to as "headless."

There are two parts to a remote desktop connection. The first part is a program named "xrdp" that runs on the Raspi. This program can easily be installed by entering the following command into a terminal window after the initial setup: sudo apt-get install xrdp. Once xrdp is installed and you have rebooted your Raspi, you can forget about xrdp. It will start automatically every time your Raspi boots up.

The other part of the system is the remote desktop client that runs on your device. The device can be a PC, Mac, or even an iPad.

Windows includes a remote desktop client called Remote Desktop Connection. When you run this program on your device, you should see a screen like that depicted in Figure 2.

Enter the address for your Net Server in the Computer text box and click on the Connect button. Note you do not have to enter a port number; the default RDC port number is selected automatically. When the connection is made, you should see a screen that looks like the depiction in Figure 3. Leave the Xvnc Module selected, enter your Net Server username (defaults to pi) and password (defaults to raspberry), then click on the OK button. You will then be taken to a standard Raspi GUI window.

For the iPad, you will first need to download a free app from the Apple app store called Microsoft Remote Desktop (Figure 4). This is an excellent app and, in some ways, is easier to use than the PC version.

After you have downloaded and run the app, create a connection to your Net Server by tapping on the little + in the upper right corner of the app screen. This will be stored, so you only have to do it once. Tap on the connection that you created and you will see a screen that looks like Figure 5. Enter the user name and password as usual and tap on Done. This will take you directly to the Net Server GUI.

You may not realize how powerful the Net Server remote desktop connection is. Figure 6 shows a partial screen shot of the iPad running Microsoft Remote Desktop connected to the Net Server, which is currently running GPredict. This also can be done from a PC using Remote Desktop Connection. It is a bit easier on a PC than the iPad because you can use a mouse on the PC, but both work fine.

Figure 1

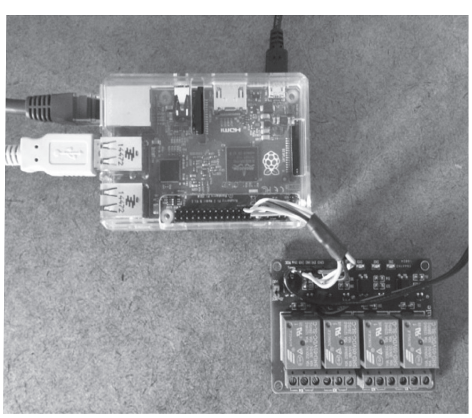
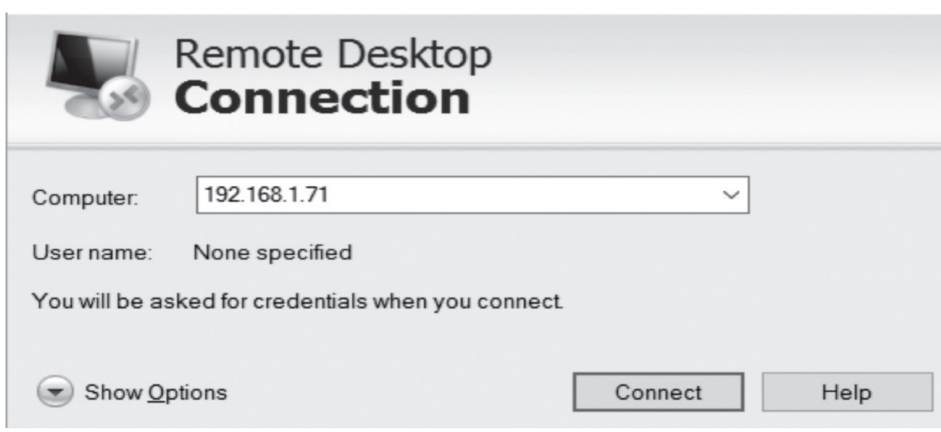


Figure 2



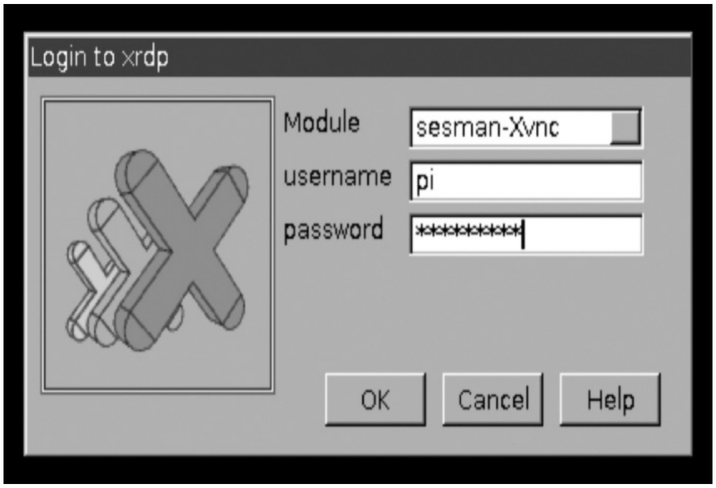


Figure 3

Figure 4

You also can use the remote desktop connection software on a PC or an iPad to connect to standard PCs. If you are using a "Pro" version of Windows, the server side software is built in. Figure 7 shows a partial screen shot from the iPad running Microsoft Remote Desktop connected to a Windows 7 Pro desktop running SatPC32. If you are not using Windows Pro, other third party remote desktop servers are available.

We have come a long way thanks to the great work done by Erich, DK1TB, with SatPC32 on the PC, Mark, N8MH, with SAEBRTrack on the Basic Stamp, and Howard, G6LVB, with LVB Tracker on the PIC. As they say, "the only reason we can see so far is we stand on the shoulders of giants."

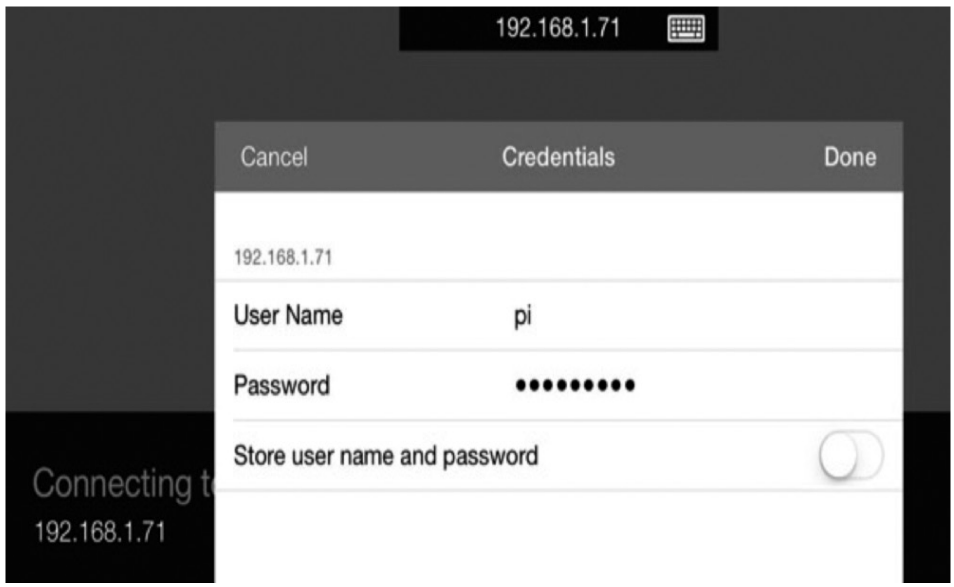


Figure 5

After you have established the remote desktop connection, you can operate your Raspi from your device the same way you would operate if you were using a keyboard, mouse and monitor connected directly to the Raspi. This helps reduce clutter in the shack and also reduces the cost of the system. It is also a very important advantage when operating portable.

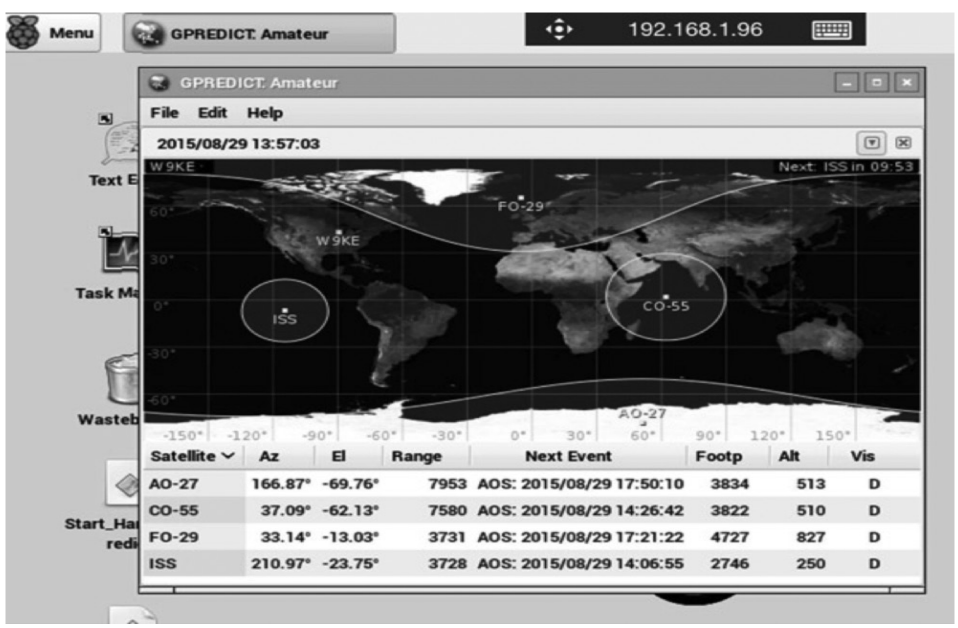


Figure 6

When Raspi is up and running, create a directory under your home directory for the Net Server program. The directory name is not critical. I used "net_server" for the directory name. You can use the Raspi GUI or a terminal window.

Download and install the Wiring Pi interface library. This library provides access to the input/output pins on the Raspi GPIO connector. For more, see **wiringpi.com/download-and-install/**.

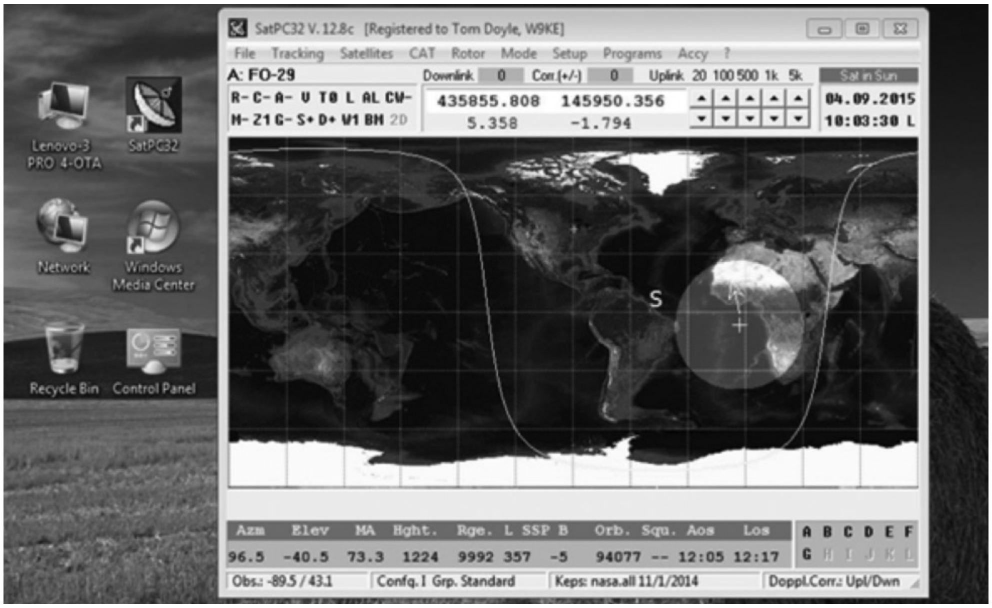


Figure 7

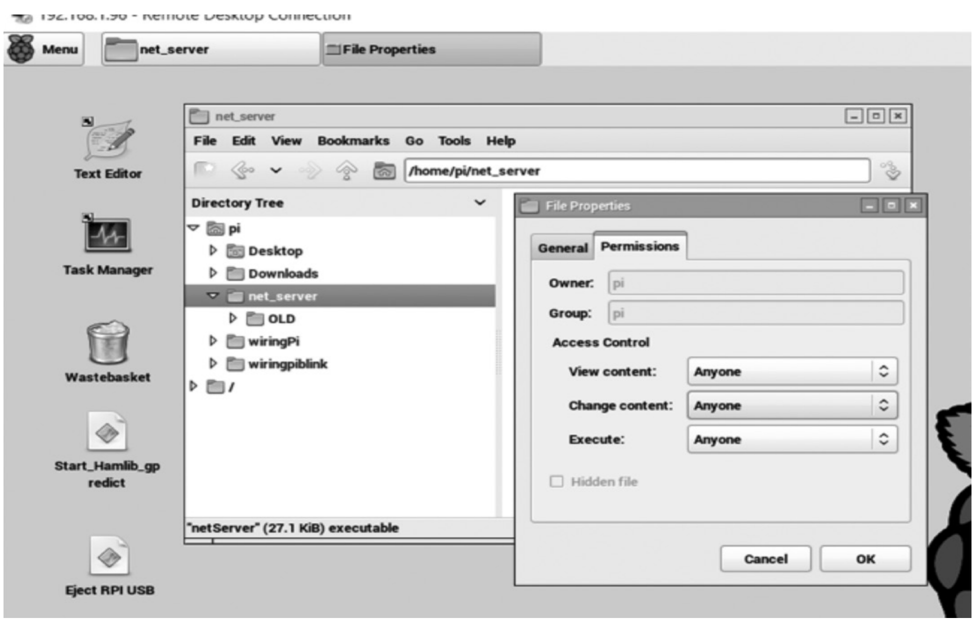


Figure 8

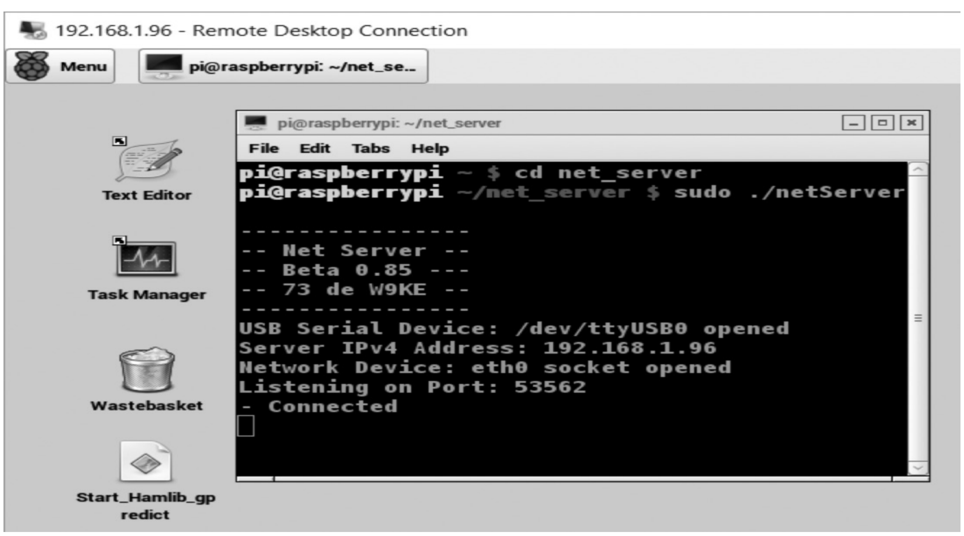


Figure 9

When you are ready to try out the program on your Raspi, send me an email, and I will send the program to you. It is a compiled binary named netServer designed to run on the Raspi, not X86 boxes.

Copy the program into the directory you created earlier. UNIX security probably will not permit you to run the program until you change the access rights. You can do this with "chmod" in a terminal window, but I find it easier to use the File Manager program available in the Raspi GUI. Note in Figure 8 that all the permissions for the netServer file have been set to "anyone."

You should now be able to run the netServer program. This is a console program designed to run from a terminal window. For this example, I opened a terminal window in the GUI. When you open a terminal window, it defaults to your home directory. The default user name is "pi," so I left it as-is for this example.

In the terminal window image (Figure 9), you can see the two commands necessary to start the program:

- 'cd net_Server' moves you into the directory we created earlier that contains the netServer program, and
- 'sudo ./netServer' causes the program to run.

The "USB Serial Device" is the USB connection to the LVB Tracker. If you do not have the LVB Tracker plugged in, it will complain. That is fine. Just shutdown and, if you have one, plug the tracker into the Raspi and start the Raspi back up (you probably could do a hot swap but just to be safe, power down and reboot). You can continue even if you do not have the LVB Tracker connected.

The "Network Device" is the Ethernet connection to your network through the RJ-45 connector. You will need the IP address and the port number later, so write them down.

When the program runs, a configuration file will be created in the same directory as the program named NetServerConfig.txt (Figure 10). You can see it opened in the Raspi GUI Text Editor. This editor is very nice. Having been stuck with VI for many years back in the day, it is a real treat to use this editor. If you need to change the port, network device, or USB device, you can do it here. Do not change any of this unless you are sure you know what you are doing.

Net Client Beta

The Net Client program, a Windows program, communicates over the network with the Net Server. When you run it, you should see something similar to what is shown in Figure 11. Ignore any message about the Serial Port not being configured; we do not need the serial port at this time. Enter the IP address and Port number you saw in the terminal window for the Raspi when you ran the netServer program. After you have entered the correct IP Address and Port, click on the Save/Restart button at the bottom of the window (the button should have turned yellow when you changed a value to remind you to save it). When you do this, updated values will be saved and the program will restart. The little button to the right of the Network label should turn green if you have a good network connection (it was most likely red when you first ran the program).

If you have an LVB Tracker connected to the Raspi, you should see the current AZ and EL for your rotor in the lower left part of the window in the section labeled "Rotor." This value is updated at an interval shown in the "Interval ms" box. Unless you have some really old slow hardware, you should not have to change it. If you make the value too low, you will have an unsatisfactory user experience.

The group of four buttons and indicators in the bottom right of the window (S1-S4) control the four relays you saw in the images of the Raspi Net Server system. For example, if you click on the S1 button, a message will be sent to the Net Server telling it to activate relay 1. When this is done, the Net Server will send back a message indicating that relay 1 is activated, and the little button indicator to the left of the S1 button will turn from red to green. This means that the indicator button will not turn green immediately after you click on the button, or it may not change at all if you do not have a network connection and a working Net Server. This system is smart in that it waits to see if the message was received by the Net Server. However, it is not brilliant because it cannot tell if you have a relay board installed.

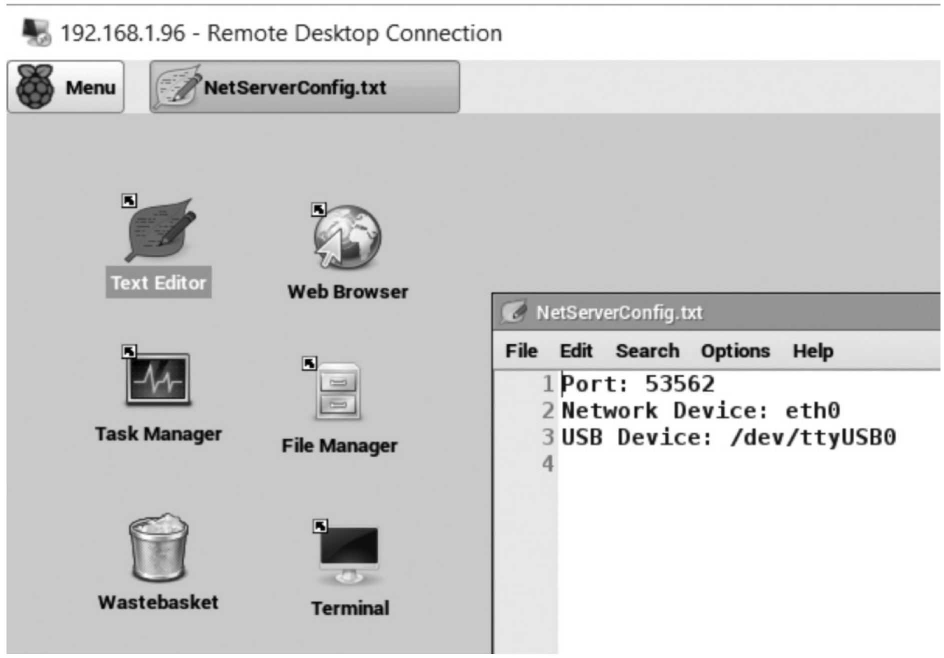


Figure 10

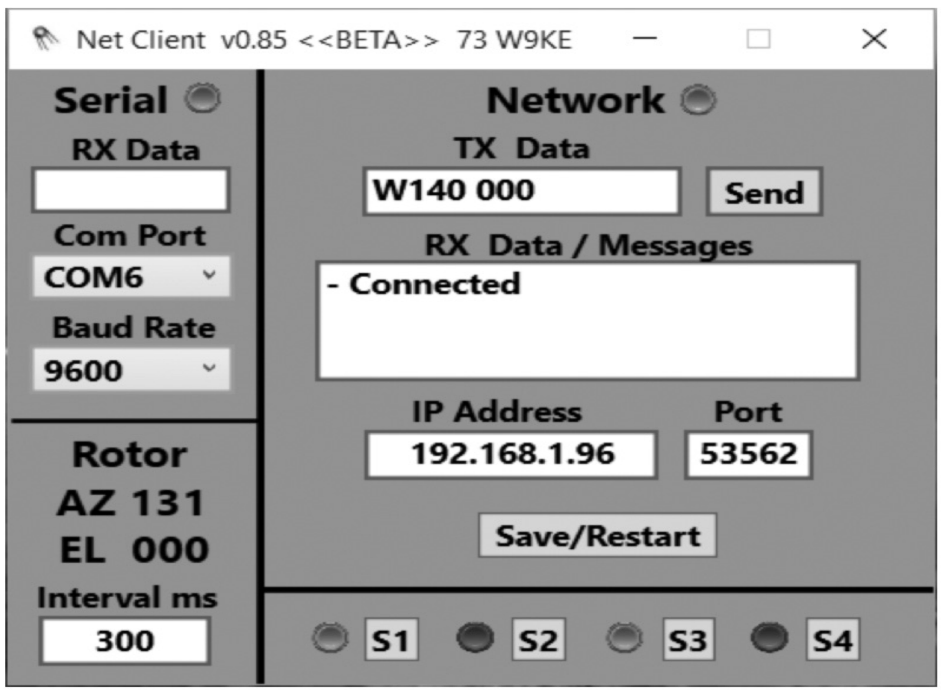


Figure 11

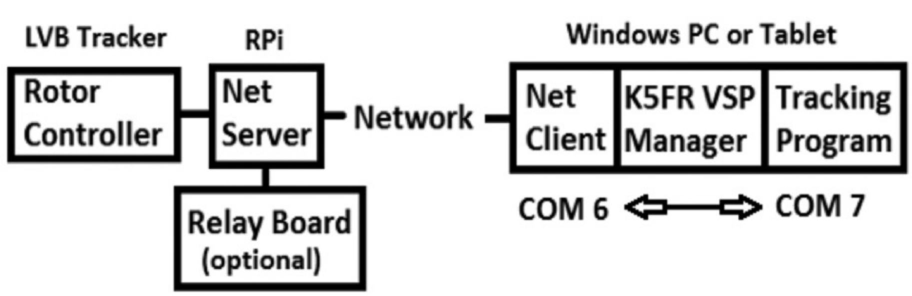


Figure 12

If you enter a valid LVB Tracker/Yaesu GS-232 command to move rotors, like "W140 000," as shown in Figure 11, and then click on the Send button, the rotor should move to the new position. The position information shown in the Rotor portion of the display will track the move with updates at an interval specified in the "Interval ms" text box.

If you make any changes to the values in the window other than the "TX Data" text box, the Save/Restart button will turn yellow to remind you to save your changes. When you click on the Save/Restart button, the values will be saved and the program will automatically restart. When deciding what to hook up to the relays, remember that the relays will all be turned to the off state whenever the Net Server starts up.

The Serial portion of the screen shows the controls used to configure the serial port that is used to connect Net Server to satellite tracker programs that have a serial interface. Use the K5FR VSP Manager program to set up a pair of virtual serial ports. Connect one of the ports to your tracker program and the other port to Net Client using the boxes in the Serial part of the Net Client window.

When the serial port connection is made, the indicator button to the right of the word Serial will turn green. For this example, I have Net Client connected to virtual port COM6 at 9600 Baud and the other virtual port of the pair COM7 connected to the tracking program. This way the tracking program can control the rotor. Figure 12 shows the path from the tracking program to the rotor controller and relay board. It is not quite as complicated as it looks.

When you are ready to try the Net Client program, send me an email at tomdoyle1948 at gmail dot com, and I will send you the program.

The only supported platform is the Raspberry Pi model 2 B with the default raspbian wheezy installed. This does not mean it will not work on other platforms; it just means if you use something else and it does not work, I probably will not be able to help.

A Dual Band Low Noise Amplifier for 2 Meters and 70 Centimeters

Jim Kocsis • WA9PYH
wa9pyh@arrl.net

This article describes constructing a dual band low noise amplifier (LNA) for use on 2 meters and 70 centimeters. Bypass capability is included to permit transmitting on either band while listening to the downlink signal on the opposite band of a VHF/UHF satellite.

LNAs are needed when you have a long run of coax between the antenna and receiver. LNAs must be mounted as close to the antenna as is practical because, once you've lost the signal in your coax, there is no way to get it back. LNAs mounted at the antenna amplify the weak signals before they are attenuated in coax.

Total project cost is around $172, depending on what you can rummage from your or your friends' junk box and your hamfest/eBay shopping prowess. The design includes a weatherproof enclosure. The noise figure is around .5 dB on 2 meters and .8 dB on 70 centimeters with 20-25 dB gain. The power handling capability is limited by the relays and the coax. The relay manufacturer rates its units at 50 W up to 1 GHz. The coax used here withstood 50 W from a satellite transceiver.

A low-pass filter on the 2-meter LNA rejects 70-centimeter signals from the transmitter and a high-pass filter on the 70-centimeter LNA rejects 2-meter signals from the transmitter. This prevents overloading the LNAs while listening on one band and transmitting on the other (i.e., when listening to your uplink signal on the satellite downlink).

Performance

While I have not yet measured the noise figure on either band, I perceived a slight improvement with the LNA on SSB but a very noticeable improvement on FM. I performed testing for desense/overload on each band by listening to a very weak signal on a dipole on one band while transmitting 50 W on the opposite band with a dipole. The antennas were eight feet apart aligned parallel to each other. There was no degradation in signal.

The measured filter losses were:

- 2 meter low pass: -.1 dB @ 144 MHz/-70 dB @ 436 MHz
- 70 centimeter high pass: .4 dB @ 436 MHz/- 52 dB @ 144 MHz.

Parts

While at a yard sale, I noticed a home satellite TV multi-dish switch box for 50 cents (Figure 1). I had to have it but with no idea how I would use it. While my satellite TV multi-dish switch box came from a yard sale, they also are available on eBay. I bought my second one at a hamfest for $2. See the pictures showing various stages of disassembly.

The LNAs are available on eBay for $18.95 each ($2.45 shipping) from Chuck Steer, WA3IAC; you will need two. Download the datasheet for the low noise IC (a MiniCircuits PGA-103) to see the lead layout. You can also examine the impressive specs for yourself at **www.minicircuits.com**.

The four relays are available on eBay for $30 or less each. Make sure you get the type you need, latching or non-latching (see discussion below under "Issues and Modifications"). Latched relays need only a short pulse of voltage to switch position and the pole is always connected to one port or the other; non-latched relays must have voltage applied full time to one coil or the other.

The high and low pass filters use silver mica capacitors and air wound coils. Check hamfests and your ham friends' junk boxes for the capacitors and wire.

The N connectors are the hardest part to find. The thread that screws into the chassis is the same as that found on a type F connector. I found two in my junk box but obtained three more from old satellite TV downconverters and surplus LNA/LNBs. They are from the "old" C band satellite TV days when nine-foot dishes were the norm. See Figure 2.

I purchased the SMA cables on eBay for $1.45 each. You will need eight. They are 6" (15 cm) long with male connectors (center pin) on both ends. I had some doubts about the quality of the units I bought on eBay since they are not made in the U.S., so I tore

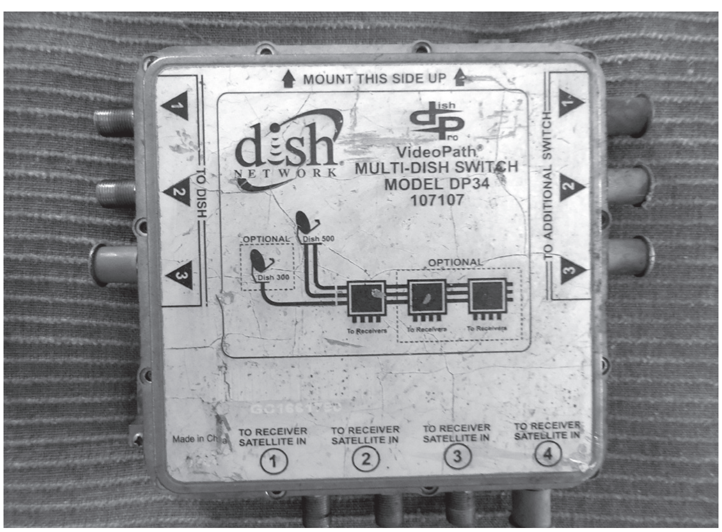


Figure 1 - Original chassis

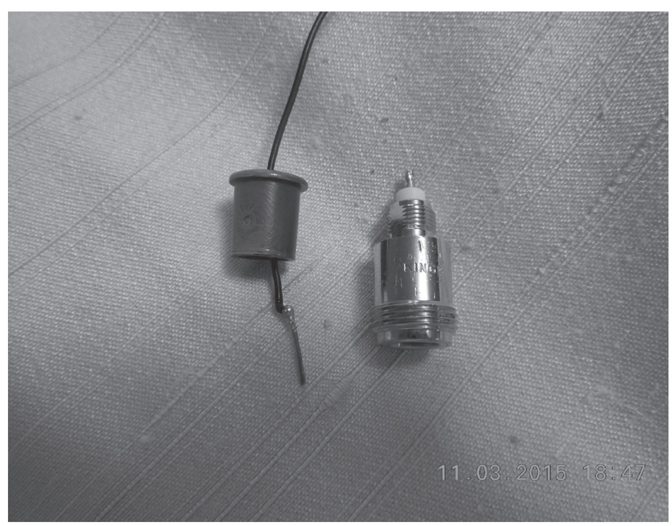


Figure 2 - N connector and plastic cap with wire connection to F connector

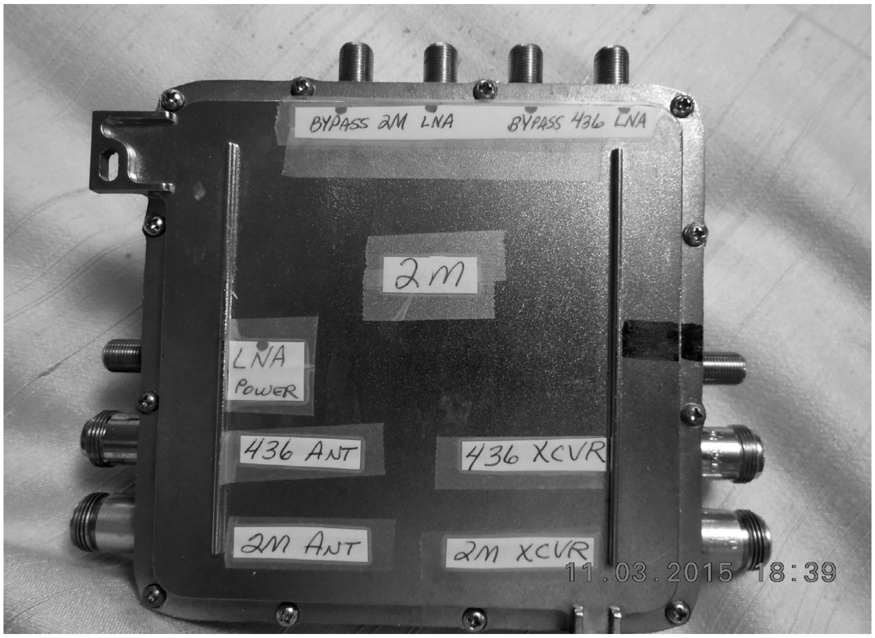


Figure 3 - Labels showing connections

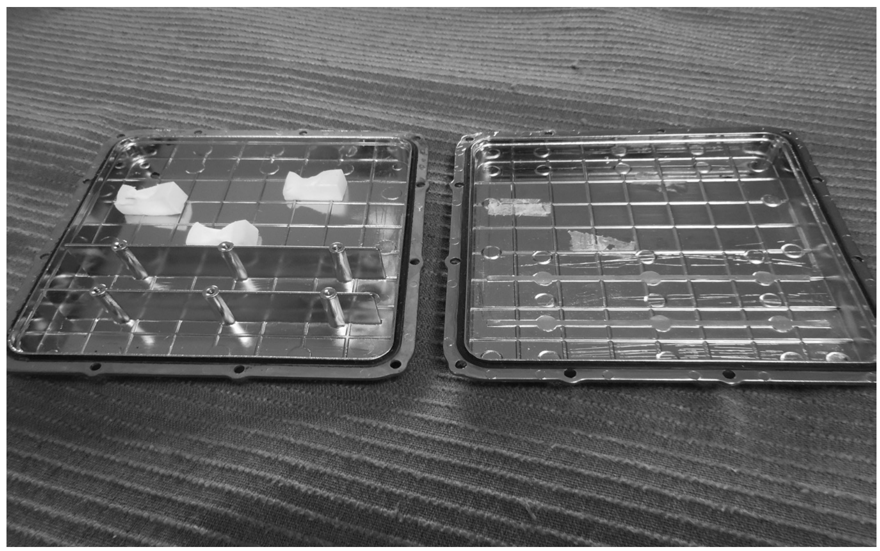


Figure 4 - Metal webs before and after

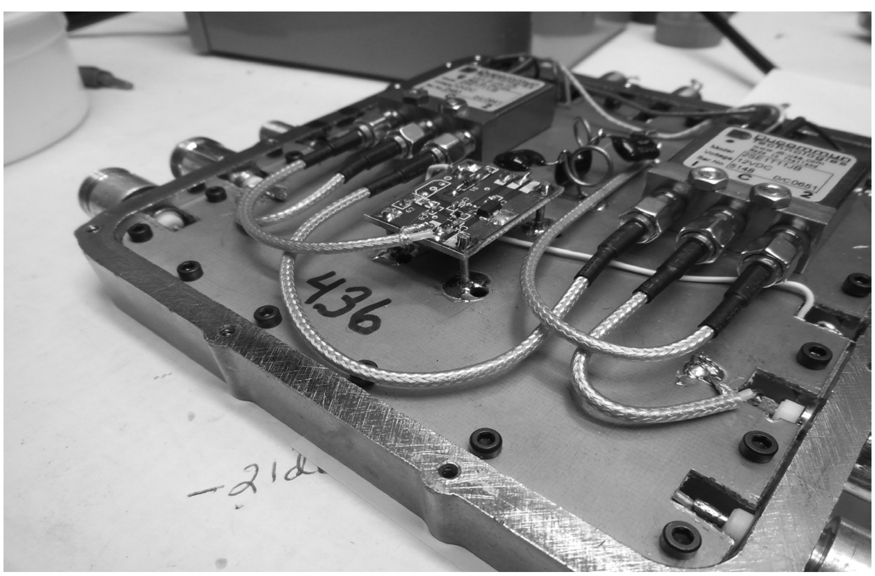


Figure 5 - LNA board mounted on wire standoffs

apart one end to verify they were properly assembled. Only two cables are used as-is. The others need one connector removed, the cable cut shorter, and tinned for soldering to the LNA, filters and N connectors.

Construction

Before removing the screws and covers, mark both covers and the center part of the chassis to show which cover goes on which side. I didn't mark them and spent a lot of time figuring out which cover goes on each side. I suggest a Dremel tool or etcher to make the marks. See Figure 3.

After marking, remove all the screws. The lids will not come free so you will have to pry them loose. Be careful not to damage the gasket around the edge. Once the covers are off, you will see the white blocks of foam that held them on so securely (Figure 4).

Unsolder all the connectors; de-soldering braid works well. Do not damage the connector center pins. One of the covers has metal webs that go deep into the chassis to shield each stage from the others. You will have to remove this webbing. Also, do not bend the webs back and forth thinking you can just break them off. I learned this the hard way; the webs in mine broke off but also made a big hole in the cover (Figure 4).

You will need to remove four of the connectors and replace them with type N connectors. They are threaded in very tightly and glued. To remove them, secure the chassis to a bench with C-clamps and then use a 7/16" socket to remove them. Use a small wire brush to remove the glue left in the hole so you can easily thread in the new N connectors and provide a good ground connection.

The copper plate that holds all parts is double-sided glass epoxy printed circuit board. Start with a piece 5" x 5" x .0625". Then slowly file and curve the corners of the plate until it fits snuggly inside the chassis. You may have to file the straight edges slightly, but take your time and make it fit right up against all four inside edges of the chassis.

Next put the plate inside the chassis and mark all screw holes very accurately. Remove the plate and punch a mark at each location. Drill 1/8" holes and lightly deburr them. I replaced the Phillips-head metal tappingscrews with 6 mm length x 2.5 mm thread Allen Head machine screws.

Notches are needed where each coax connector's center pin extends inside. I used a nibbling tool for this. Alternatively, a file can be used. The plate is located on the same side of the interior rail as the deeper cover so that neither cover touches the relays, coils or other tall parts.

The LNA kits require that you solder SMD parts. Do not mount the SMA connectors because you will be wiring directly to the board input/output tracks. Some of the surface mount parts are very small (see the picture on eBay). Use a low power soldering iron and toothpick to hold them in place. If you don't feel comfortable, ask a friend who works with SMD parts.

Use bright lights and a magnifying lens and take your time when soldering. One slip and the part will either end up on the floor or soldered out of place. (Don't ask me how I know this, but I will admit to ordering a third LNA kit.) I mounted the regulators below the LNA board and bent them toward the board to get a low profile on the top of the board. It's okay if the tab of the regulator touches the copper plate, as the tab is ground.

Make sure you haven't reversed the leads of the regulator! The power to both LNAs is connected to a single existing F connector (Figure 3). The LNA boards mount directly to the plate on pieces of #14 (.064") copper wire that are soldered to both sides of the plate (Figure 5).

Use the bare LNA circuit board as a template to locate the holes for the support wires. At first I tried to mount the LNAs using screws and spacers but could not get the holes aligned. It turns out the #14 wire supports provide a better ground connection than screws and spacers. Check each LNA before mounting it. Each should draw approximately 100 mA. If you have access to test equipment (a signal generator and something to check the input and output levels), make sure the gain is approximately 20-25 dB. Clean them with flux remover after mounting and after attaching the filters and input/output leads.

The high and low pass filters must be constructed with the components oriented as shown. The coils must be at right angles to each other to minimize coupling between them. The capacitors should have their leads cut as short as possible. See Figures 6 & 7.

When attaching the SMA connectors to the relays, attach the center one first. You cannot reach the center connector with a wrench if either of the outside connectors is in place. Use a 5/16" open-end wrench to gently tighten them. All four relays are mounted to the plate using machine screws that go through the plate.

The voltages to switch the relay positions and supply power to the LNAs pass through the remaining F connectors. To provide a waterproof entry inside, use plastic covers for unused F connectors. It is likely that your chassis will have a few plastic covers. Punch a small hole in the plastic cap and pass a wire to a stiff copper wire that makes contact with the connector center connection (Figure 2). Alternatively, you can pass all wires through a hole that is available after you remove one F connector and epoxy the wires in place for a watertight seal.

Issues and Modifications

The noise figure (NF) isn't record setting because a .8 dB NF on 436 MHz isn't great. However, it does improve reception significantly on FM and some on SSB in my satellite radio (an Icom 821, with sensitivity specs equivalent to the newest satellite radios). The total NF is the loss in the filter plus the NF of the LNA itself. I'm working on a filter for 436 MHz with lower loss but, at this point, haven't been able to get it lower than .4 dB. Perhaps with some experimenting/juggling of coil/capacitor values, you can get the NF lower. Even so, these LNAs will help you hear much better if you have a long coax run with significant loss and will definitely help when operating FM.

You may want to use latching relays to reduce the internal heating that would come from non-latching relays. Or you may prefer to use non-latching relays so that the interior always stays warm which keeps the inside dry. When I built the first LNA assembly and saw that it worked fine, I proceeded to order two more relays but accidentally ordered non-latching units, so I have both types in my unit. There are pluses and minuses either way. If moisture is a serious problem where you live, I recommend the non-latching type to keep it warm but dry inside.

continued on page 22 ...

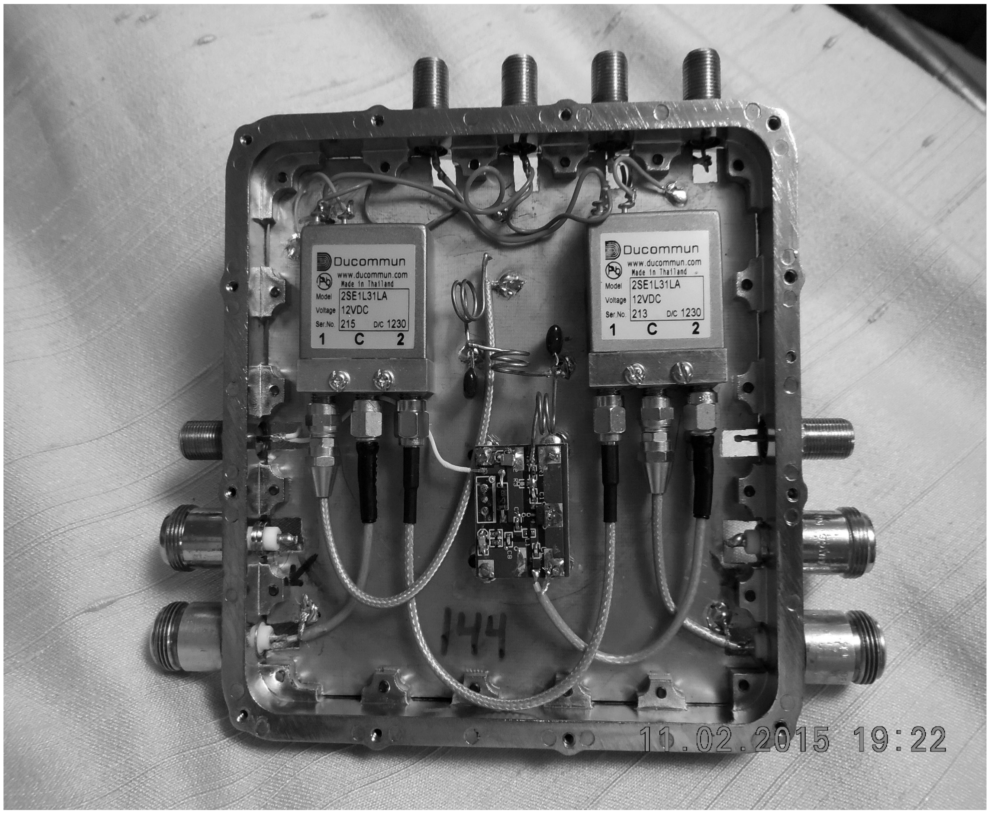


Figure 6 - The 436 MHz LNA complete

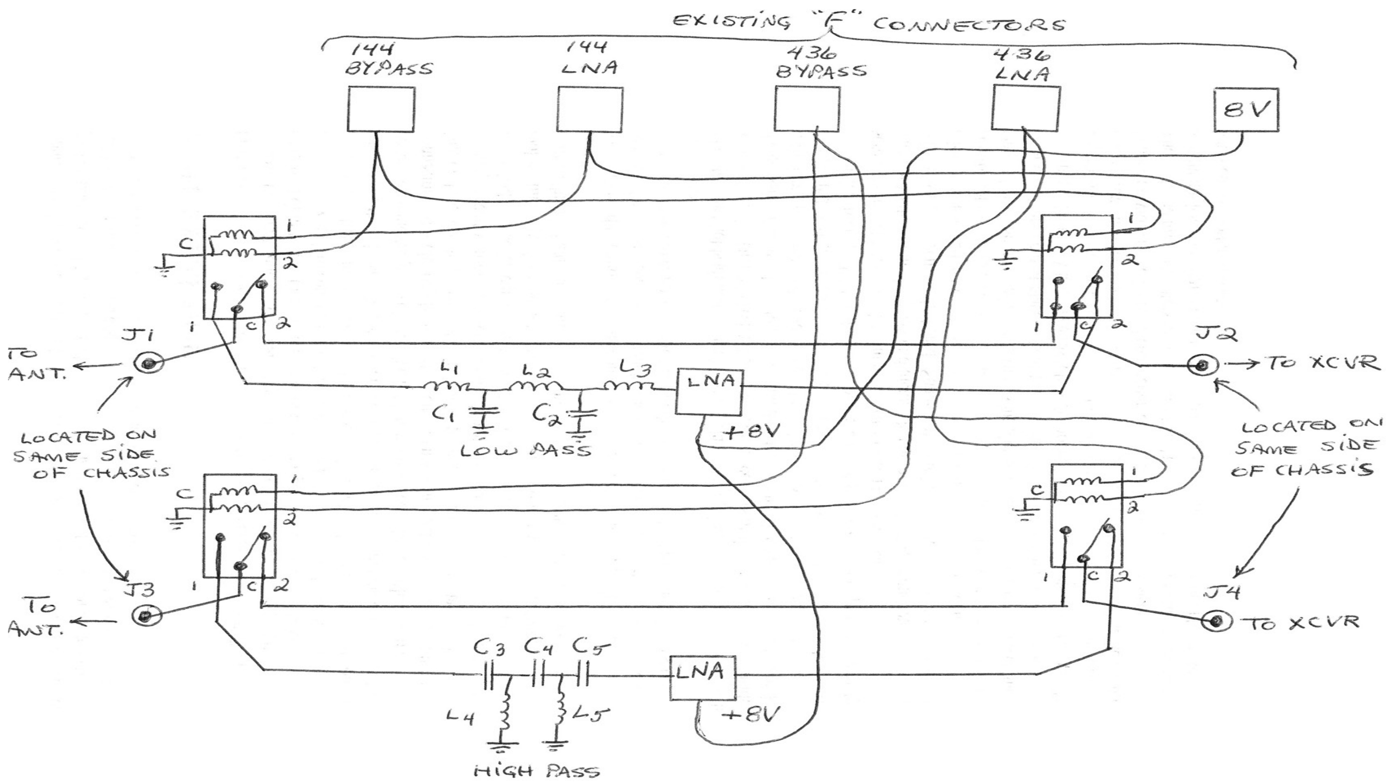


Figure 8 - Dual LNA schematic

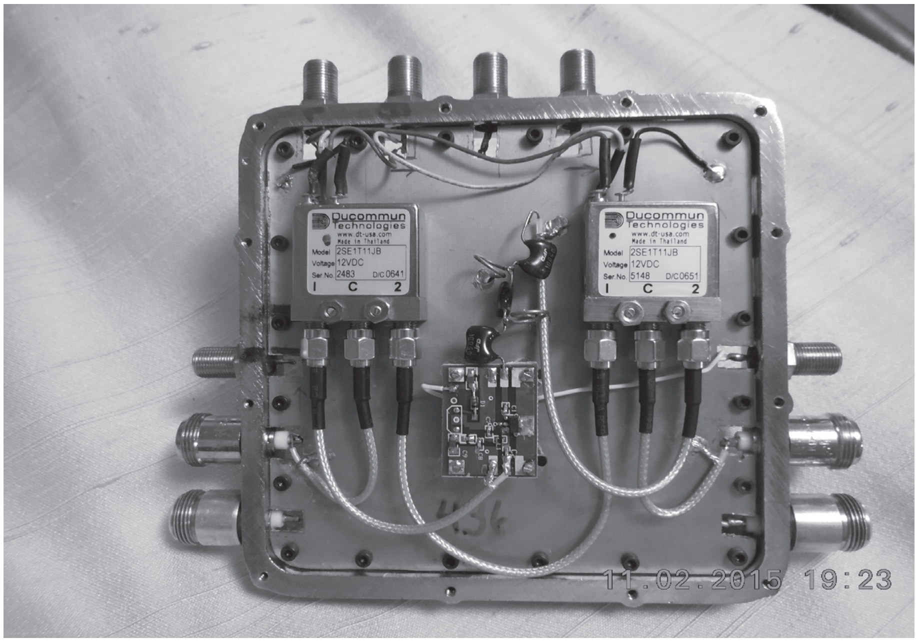


Figure 7 - The 144 MHz LNA complete

Using these LNAs for terrestrial operations requires a sequencer that switches the state of the relays before transmitting. For satellite operation, a simple toggle switch can be used to set one LNA to bypass (uplink) and the other to LNA (downlink).

A suitable filter for experimenters is detailed at **www.zs6wr.co.za/ham-mag/Diplexer.pdf**. It is inexpensive to make, physically small, has reasonable attenuation at the reject frequency and, most importantly, very low attenuation at the pass frequency (.15 dB).

The instructions for the LNA specify 12 V for the LNA, but I found the regulator got too hot to touch because of the current drawn by the regulator and required voltage drop. I suggest using 8-9 V instead.

When wiring the cables to the relays and N connectors, make very sure that you have the output and input to the LNA connected properly. The layout on one side is the mirror image of the other side if flipped over. Both antenna connectors should be on one side and both rig connectors should be on the other side. Check and double-check where the wiring goes before you solder and before you connect the coax cables and relay wiring! See Figures 3 & 8. Label each connector to show which signal goes where.

Parts List

- DISH Network Video Path Multi-Dish Switch Model DP34 107107, eBay, buy two if you see them at a hamfest or yard sale for a low price (spares are good to have just in case….)
- 5" x 5"x .0625" double sided glass epoxy copper clad board
- 4 type N connectors with thread same as F connectors, J1, J2, J3, J4
- Four 12 VDC SMA relays, Duocomm 2SE1T11JB or 2SE1L31LA (latching or non-latching)
- Two 12 pf silver mica capacitors, C1, C2 - Digikey 338-2819-ND
- Three 5 pf silver mica capacitors, C3, C4, C5 - Digikey 338-2818-ND
- 2 LNA kits, on eBay search for "PGA103 LNA" then scroll down to an LNA from seller "chuckwa3iac"
- #14 copper wire, 8 inches long, cut to 2 inch lengths
- 20 metric screws, Allen Head - 6 mm length x 2.5 mm thread
- Four 4-40 x 1-1/8" machine screws, four 4-40 nuts
- Coil dimensions, #18 tinned wire, 12"
- L1, L2, L3 - 2M low pass: 2 turns, 5/16" ID, spaced wire diameter
- L4, L5 - 436 high pass: 1 turn, 5/16" ID, spaced wire diameter

For any questions, please contact the author via email (**wa9pyh@arrl.net**).

FoxTelem Version 1.02 Now Available!

Chris E. Thompson • AC2CZ
chrisethompson@gmail.com

FoxTelem Version 1.02 is now available for download. Like the last release, you can patch your installation by downloading the patch file. In this case, it is a single file to replace.

You can download it from **amsat.us/FoxTelem/**.

Everyone should upgrade to 1.02 because this readies FoxTelem for transition to the new Telemetry Server, which will be more reliable.

Additionally, this release fixes a number of issues and adds the ability to download data from the Server to view/analyze in FoxTelem. If you download data, please make sure you save it to a separate directory to your local data, otherwise you will overwrite it. Of course, frequent backups of your data minimize this risk.

The release notes are as follows:

- Fixed bug where opening the Fox-1A spacecraft menu would cause a crash
- Added horizontal and vertical lines to the graphs if button clicked
- Fixed typo on measurements tab
- Fixed a bug where UTC was not displayed for the Diagnostic tables
- Capture the string version of the STP date in ENGLISH for all users, but leave other dates in local language
- Fixed bug where TCA date could be null and a SERIOUS error was reported
- Fixed issue where the tabs were always refreshed when the spacecraft menu closed
- Fixed bug where UTC date was sometimes wrong on the spacecraft T0 panel
- Ready FoxTelem for sending server data via TCP
- Support downloading server data

ARISS "Out of This World" Update

Frank Bauer • KA3HDO
Vice President, Human Spaceflight

Our new AMSAT Journal editor, Joe Kornowski, KB6IGK, has invited me and our international team to update you on ARISS happenings through a column in each Journal issue. So here starts our inaugural column!

Those who know me well know that I am a bit of a history buff, especially regarding air and space history. Attendees at the 2014 AMSAT symposium witnessed this through my invitation of Tuskegee Airman Col. Charles E. McGee as a special guest speaker. As this column goes to print, the ARISS team has some of its own history to share with you.

We have started celebrating a series of anniversaries that will continue through late next year. These include two 15-year anniversaries in November (first ARISS QSOs) and December 2015 (first ARISS school contact), and a 20-year anniversary in November 2016 (inauguration of ARISS with its first international meeting at the NASA Johnson Space Center in Houston, Texas). On November 2, 2000, a crew of three docked their Soyuz spacecraft with the International Space Station (ISS). This began the continuous human presence on the ISS. This first crew complement, designated Expedition 1, conducted an ISS "shakedown cruise," spending 136 days outfitting the ISS, performing experiments and preparing the ISS for ongoing occupation.

ISS Expedition 1 included U.S. astronaut Bill Shepherd "Shep," KD5GSL, as the ISS Commander, and Russian cosmonauts Yuri Gidzenko and Sergey Krikalev, U5MIR. On November 13, only 11 days after the crew entered ISS, the team set up the ARISS radio hardware and inaugurated the ham station in a series of QSOs with three amateur radio stations around the world.

The first was between cosmonaut Sergey Krikalev, U5MIR, and hams at Energia in Moscow, Russia, led by ARISS-Russia delegate Sergey Samburov, RV3DR. The next two contacts were with U.S. stations about seven hours apart using the ISS call sign, NA1SS. These included a connection between Shep, KD5GSL and the ARISS ground stations at the NASA Goddard Space Flight Center in Greenbelt, Maryland, NN1SS (now licensed as K6DUE), and at the NASA Johnson Space Center in Houston, Texas, W5RRR.

On the microphone at NN1SS was myself, ARISS-US hardware lead, Lou McFadin, W5DID, and NN1SS station lead Ken Nichols, KD3VK. In Houston, Gil Carman, WA5NOM, and astronauts Ellen Baker, KB5SIX, and Mike Foreman were on the microphone with the ISS crew. With these contacts completed, ARISS became the first operational payload on the ISS. After the Expedition 1 crew returned from space, Bill Shepherd stated that, when compared to any other form of ISS ground communication, the voice quality on ISS was best with the ham radio system. At the time, ARISS employed the Ericsson radio system in the ISS functional cargo block (FGB).

Just a few weeks after our inaugural set of test QSOs, ARISS initiated its first school contact. This contact was conducted on December 21, 2000, between Bill Shepherd, KD5GSL and students at the Luther Burbank School in Burbank, Illinois. Burbank science teacher Rita Wright, KC9CDL, applied for a SAREX (space shuttle) contact in 1996, but elected to wait nearly four years until ISS was outfitted with a crew complement and ARISS ham radio gear. Operating the ground station that day was ARISS volunteer Charlie Sufana, AJ9N. NA1SS was loud and clear in the Burbank school auditorium. Rita's 2004

Frank Bauer and Lou McFadin at NASA Goddard Space Flight Center, NN1SS

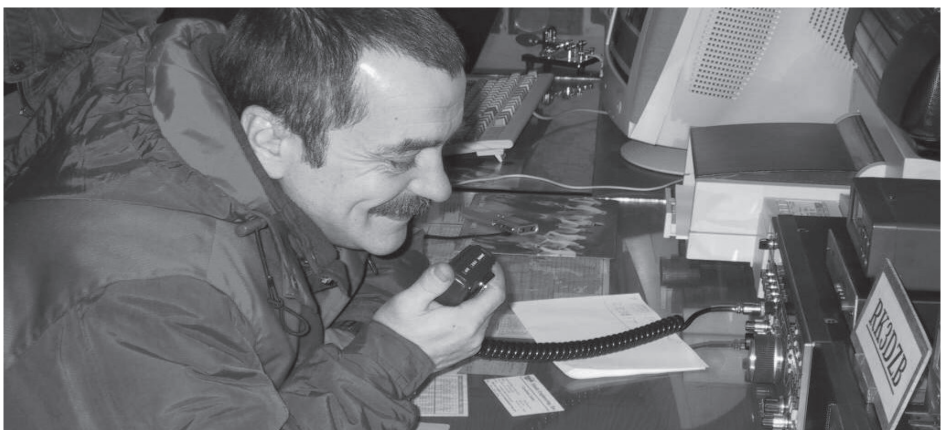
AMSAT symposium paper, "Remember, We're Pioneers!" chronicles the Burbank school's journey to the first ARISS contact and beyond. You are invited to download the paper at **www.dropbox.com/s/q8cmd0eu9y0imsz/REMEMBER--Burbank%20School.pdf?dl=0**.

Bill Shepherd successfully completed seven school contacts during his Expedition. Over the past 15 years, ARISS has continuously operated on ISS, with nearly 1000 school contacts under its belt (973 to date) during all 44 crew Expeditions. Also, ARISS volunteers have conducted numerous friends and family contacts with ISS crews and civilian space flight participants (e.g., Dennis Tito and Richard Garriott) and supported general ham voice QSOs, packet/APRS connections, SSTV operations and digital TV downlinks.

We have also deployed two satellites from ISS: SuitSat/Radioskaf-1 in 2006; and ARISSat-1/Radioskaf-2 in 2011. What a phenomenal ride it has been! My thanks and congratulations to our worldwide ARISS volunteers for making this happen -- and to all of you in AMSAT-NA for your support, as you have been instrumental in making ARISS a tremendous success!

The ARISS team plans a series of activities to commemorate our 15th and 20th anniversaries. Our first planned activity will be a set of special SSTV images that are tentatively scheduled for downlink in December. Stay tuned to ANS, AMSAT-BB and **www.ariss.org** for updates. These plans are contingent upon crew availability to set up and operate the SSTV downlinks.

United Kingdom astronaut, Tim Peake, KG5BVI, will launch to ISS this December. The U.K. Space Agency reported that Tim Peake wants to work with ARISS to talk to a minimum of three schools, and hopefully others from all over the world. Ciaran Morgan, M0XTD, from ARISS-Europe is coordinating these efforts and working with ARISS and the Tim Peake team on many excellent educational activities and venues to tie into ARISS. There is also a potential long-term connection with the Astro Pi/Raspberry Pi capability that will fly as part of Tim Peake's "Principia" education mission. More details will be provided through our standard media sources as Tim Peake's Principia mission nears.



Russia QSO - Nov. 13, 2000

Astronaut Ellen Baker at W5RRR, NASA Johnson Space Center

You can help with ARISS in two ways: first, by volunteering to make ARISS successful and/or, second, by donating (or soliciting donations from others) to help our cause.

We need volunteers for myriad activities, including school mentoring (we can train you), supporting hardware development (want to fly something you built in space?), helping with fundraising and corporate grant solicitation, developing content for our web pages, or helping develop and distribute ARISS awards to hams across the world. If you are interested in any of these, please contact me at **ka3hdo@verizon.net**.

Since ARISS is exclusively responsible for garnering the funding necessary to keep our program alive, we solicit ARISS donations from individuals as well as grants from corporations and foundations. Our targets for donations include the general public, hams, and friends and families of students that have been part of our ARISS program. Individuals can donate through the **www.amsat.org** website using the "ARISS donate" button on the AMSAT main page. We have initiated a fundraising campaign. Those that donate $100 or more to ARISS will receive a special ARISS Challenge Coin. Please consider a generous donation. Also, let your friends know about us and encourage them to donate, too. ARISS is all about piquing student's interest in science, technology, engineering, mathematics and the ham radio hobby -- all critically important for the future.

Upcoming ARISS Updates will include a 2015 year in review, further updates on Tim Peake's Principia mission, our initiative to improve the ham radio station in the Columbus module, and updates on Ham TV operations. Stay tuned and thanks for listening!

Luther Burbank School student Alex Bandyk asks CMDR Shepherd a question

Luther Burbank School ISS team

ARISS "Challenge Coin"

Close Encounters of the Law Enforcement Kind

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I have been working the satellites for almost 10 years, operating from hundreds of different locations across North America (and a few in Australia, during a 2011 trip). When operating in the field, there are times that law enforcement officers will take an interest in my radio activities. Common sense usually is the best way to handle these encounters, along with a little bit of outreach about amateur radio and amateur radio satellites.

Even when I travel around the U.S., I make sure to carry the wallet card form of my amateur radio license. I have never had to show it to anyone, but explaining that I have a license is usually enough to satisfy any law enforcement officer that has asked me about my operating. For those operating outside the U.S., having an official copy of your amateur radio license is sometimes a requirement, so make sure to carry it when traveling overseas with radio gear.

Some have asked me if my equipment can be used to track animals. It can, although I have never used my radios and antennas to do that. I realize that these officers have a job to do, and their job happens to coincide with my radio operating. In almost all cases, these encounters only last a couple of minutes. Only one encounter in the past 10 years lasted longer, as discussed below.

When doing a formal demonstration, I have an AMSAT banner I can display, and flyers/ brochures for anyone interested in amateur radio satellites. For other operating, I try to find spots that are not along busy highways, not marked as private property or displaying "NO TRESPASSING" signs, and – hopefully – not full of RF noise. Even if I'm not planning a public demonstration, I am ready to answer questions about my radios and satellite operating.

The first time I encountered law enforcement while working satellites was during an AO-27 pass in September 2009. I parked north of a highway intersection at the DM23vx/ DM24va grid boundary in western Arizona. AO-27 was only available for 7 minutes during afternoon passes over the Northern Hemisphere at that time, which made for some busy passes.

I started working stations from this rarely heard location and had a good rhythm until about 2 ½ minutes into the pass. An Arizona state trooper then approached me. Seeing the trooper driving up, I said, "Uh, one moment please. WD9EWK, highway patrol," and set my Elk antenna down.

The trooper saw me operating from the back of my truck, with its rear gate up, and said that someone called 9-1-1 to report seeing a broken-down vehicle off the highway. The trooper wasn't interested in seeing my driver's license or vehicle registration, but only wanted to make sure I was okay. After assuring him I was fine, the trooper drove off. I was off the radio for a minute, and was able to quickly resume working stations in the remaining 3 ½ minutes of this pass. Later, I took the audio I recorded from AO-27, combined it with photos I took from the area, and made a YouTube video of this pass (**www.youtube.com/ watch?v=4Ed7nmxLCwc**).

After that 2009 encounter, I have been visited periodically by local, state, or federal law enforcement officers. When I operate from locations near the U.S./Mexico border, almost every one of those activations would come with a visit by U.S. Border Patrol officers. They, like any other law enforcement officers, would check that I am okay, and sometimes stop by while I am in their area just to ensure that everything is fine.

In late 2010, after a visit to southern Arizona, I drove up to a U.S. Border Patrol highway checkpoint. The Border Patrol agent saw my Elk antenna in the back of my truck, along with my radio gear. After asking if I was a U.S. citizen and if anyone else was in the truck with me, the agent asked if I had a minute for a question. Since I was at his checkpoint, I said, "Sure." The agent brought me a Kenwood commercial VHF HT and explained that he bought the radio on eBay. He wanted to program it, and asked if I knew how. I had no idea and explained that there was a lot of information on the Internet about programming two-way radios, and where to get cables used in programming them. The agent thanked me, and I resumed my drive home.

The longest encounter I ever had with law enforcement happened at the start of the 2014 AMSAT symposium in Baltimore. On the Friday morning of that weekend, I had been working AO-7 and FO-29 passes just after sunrise. As I finished these two passes and was putting my gear away, two police vehicles drove up to surround me and my rental car. These vehicles had "NATIONAL SECURITY AGENCY POLICE" on them. I did not realize the NSA had its own police force.

Two officers approached me and asked what I was doing. I explained that I had just been using my radio gear to work a couple of satellites, and the officers then asked me for identification. Along with my driver's license, I had my symposium badge hanging around my neck.

They asked me why I was at the hotel. I explained there were 80 to 100 attendees at the symposium over the weekend and the symposium dealt with amateur radio satellites. As one of the officers called in my information to his dispatcher, a third officer drove up. This officer started asking me about the frequencies and modes I was using. I explained which bands I used, and that I was transmitting in SSB. As I explained my operating, one of the officers wrote down everything I said, and then all three officers returned to one of the police vehicles.

I sat next to my rental car as they discussed my situation. They all returned and assured me I was not breaking any laws or rules by operating at the hotel. They all encouraged me to go up the road away from the area of the hotel, without specifically explaining why. But I had a good idea why given that several office buildings in the area of the hotel were used by the NSA, including a large blockhouse down the street from the hotel with antennas on its roof. In the end, I – along with several other operators – made use of the parking lots at the hotel and a nearby building for more operating during the weekend, and the NSA Police never returned.

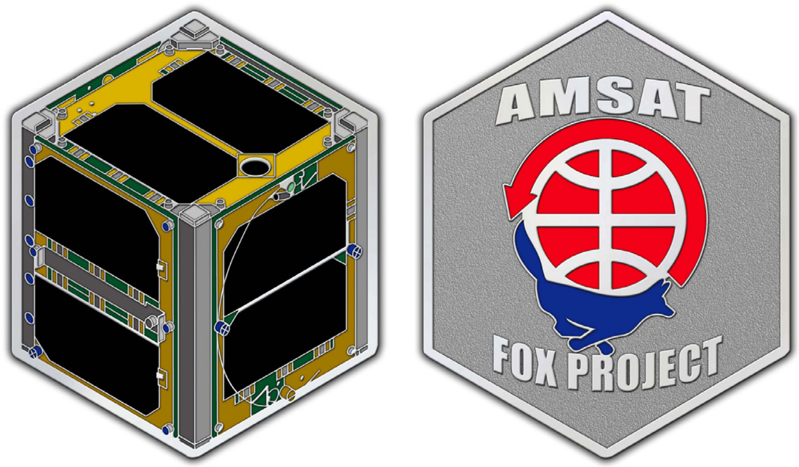
My most recent encounter with law enforcement occurred as I was writing this article. On November 7, 2015, I represented AMSAT at a hamfest near Tucson, Arizona. This was a half-day event, and I decided to drive west from Tucson about 120 miles to the Organ Pipe Cactus National Monument, near the U.S./Mexico border in the rarely-heard grid, DM31. I parked at the monument's visitor center, a few miles north of the border, and operated from there.

After about 90 minutes of operating, a U.S. Park Ranger drove up. The ranger asked if my car was broken down. I explained what I was doing, and we ended up chatting for about 15 minutes. We talked about my radios and amateur radio, along with his job being a federal law enforcement officer near an international border. He never asked to see any of my identification. Although I was not planning to stay there after sunset, the ranger said that the campground behind the visitor center would be a safe place to stay after dark. I did not have any camping gear with me, and planned on heading home in an hour, around sunset (after working passes of SO-50 and XW-2F, as I was there to work satellite passes and hand out contacts with grid DM31). Before the ranger drove off, he wanted to shake my hand. I considered that 15 minutes time well-spent.

In the end, my advice regarding encounters with law enforcement is simple. Don't be afraid of them, as they are just doing a job. Be ready to answer questions, and – if asked – show identification, including your amateur radio license. Most law enforcement officers probably don't know anything about amateur satellites and may have only the vaguest idea about amateur radio. These encounters can be great opportunities to talk about this aspect of amateur radio, while helping the officer/agent gain a better understanding for any future encounters with amateur radio operators.

AMSAT Fox-1 Challenge Coin Available for Donations at $100 or Higher

A premium collectable is available for qualifying donations to the Fox satellite program. AMSAT has commissioned a unique challenge coin for donors who have contributed at the $100 level or higher. This challenge coin is shaped as an isometric view of a Fox-1 cubesat, complete with details such as the stowed UHF antenna, solar cells, and camera lens viewport. Struck in 3mm thick brass plated with antique silver, and finished in bright enamel, the coin is scaled to be approximately 1:4 scale, or 1 inch along each of the six sides. The reverse has the AMSAT Fox logo.



Donations may be made via the:

- AMSAT website at **http://www.amsat.org**
- FundRazr crowdsourcing app at: **http://fnd.us/c/6pz92**
- AMSAT office at (888) 322-6728

Never too late to work the sats -- Hector (CO6CBF/W5CBF on right) introduces Mark (KE5HSW on left) to the birds. Though a ham for several years, Mark made his first three hamsat contacts while visiting the hamshack.

Photo: George Carr, WA5KBH

On the Grids: Working the United States/ Mexico Border

Clayton L. Coleman • W5PFG
w5pfg@arrl.net

Twice in 2014, my family and I traveled to the southwestern corner of Texas, known as the Big Bend, for holiday. This area forms the northern part of the Chihuahuan Desert, the second largest desert in North America and the third largest in the Western Hemisphere. We spent time camping in both the Chisos and Davis Mountain ranges. Between sightseeing, hikes, and photography, my family graciously and patiently waited as I worked numerous satellite passes, offering maidenhead grid squares to paper chasers across North America.

Camping in this area afforded me the opportunity to operate from some of the most rarely activated grid squares in the continental United States. The majority of our camping was done in DL89, DM70, and DM80. Between our two trips, I operated from DL79, DL88, DL89, DM70, DM71, DM80, and DM81.

According to QRZ.com's database, the number of licensed amateurs residing in the DL88 grid square is zero. No communities exist in the United States' portion of the grid square as it is fully encompassed by Big Bend National Park. Some of the neighboring grid squares contain less than 10 licensed amateurs according to the QRZ.com and government FCC databases. The last known amateur to operate satellite passes from DL88 was Jim, ND9M. The journey to DL88 began at Big Bend National Park headquarters in Panther Junction. From there, we were instructed to take a series of unpaved and sometimes unmaintained roads to DL88jx. We headed to a primitive backcountry camping area known as Talley #2 that was perfect for setting up the portable station.

While the journey was very slow, the rewards were great. This was one of the most peaceful and scenic places I've operated as a radio amateur. For safety reasons, we made the journey in daylight. Most satellite passes were either in the morning or early evening, so we could only stay long enough to operate one midday SO-50 pass from DL88jx. With more operational satellites in orbit, I intend to return on a date when satellite pass times are more favorable.

Operating from rare grid squares is not only fun but provides an opportunity to embark on new adventures and see new terrain. My dear wife and children graciously tolerate my hobby. The children often help me setup, and my wife serves as expedition photographer (see photos).

After the loss of AO-51 and AO-27, the number of portable, grid square-roving operators has decreased sharply. Operating the linear SSB transponder satellites portable is not impossible. It just requires a little practice. Simple gear such as a pair of Yaesu FT-817 transceivers combined with an Arrow or Elk antenna are more than adequate for AO-73, FO-29, and AO-7. A simple station without a laptop and modern trappings (AZ/EL rotor, etc.) works far better than one might imagine. With the hope of more satellites coming up over the horizon, grid square expeditions will become easier to accommodate in our holiday schedules.

Rotor Controller Box/Boards Available

LVB Tracker Box

- Reasonably priced and all profits go to AMSAT
- Serial interface standard
- USB interface may be easily added by user
- Open software
- Open architecture
- Built-in rotor interface cable with DIN connector
- Power supplied via the rotor controller cable
- Bi-directional interface allows the unit to read the rotor position
- LCD position readout
- Front panel manual control
- Self-programmable, allows for easy software upgrades
- Supported by the major tracking programs
- Uses GS-232A or Easycomm I/II protocols

Contact Martha at the AMSAT office 301-822-4376 to order.

The complete units will be built in groups, so get your orders in early. Units will be shipped as they become available.

Minimum donations requested for various configurations:

1) Bare board - $20 + S&H – no parts kits available
2) Custom Enclosure powder coat, silk-screened, drilled/punched - $50 + S&H
3) Complete unit - board, serial output, rotor cable, LCD, enclosure - $200 + S&H **our most popular

Documentation for the LVB Tracker can be found at: http://www.LVBTracker.com

Boards and complete units may be ordered from the AMSAT office at 301-822-4376 or from martha@amsat.org

Visit the AMSAT On-Line Store for details on the updated LVB Tracker Box: http://store.amsat.org/catalog

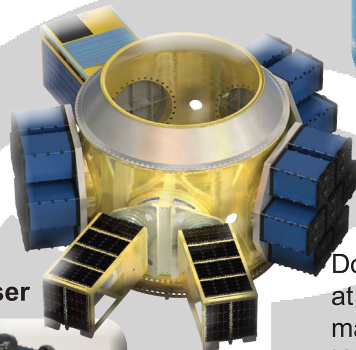
AMSAT Fox-1Cliff & Fox-1D $125,000 Launch Initiative Goal

AMSAT is excited to announce a launch opportunity for **BOTH** the Fox-1Cliff and Fox-1D Cubesats. In response to a breaking opportunity, AMSAT and Spaceflight, Inc. have arranged for Fox-1D to accompany Fox-1Cliff on the maiden flight of the SHERPA system on a SpaceX Falcon 9 in the 1st quarter of 2016.

Fox-1Cliff and Fox-1D will provide selectable U/V or L/V repeater capabilities on separate frequencies once in orbit, and will be capable of downlinking Earth images from the Virginia Tech camera experiment.

AMSAT has an immediate need to raise funds to cover both the launch contract and additional materials for construction and testing for Fox-1Cliff and Fox-1D. We have set a fundraising goal of $125,000 to cover these expenses over the next 12 months, and allow us to continue to keep amateur radio in space.

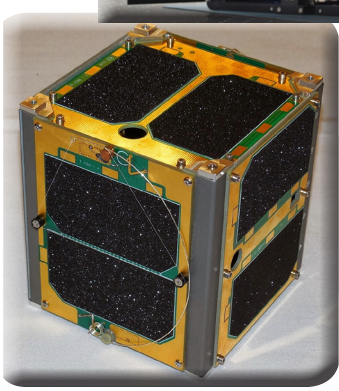
Spaceflight's SHERPA System



Spaceflight's SHERPA will deploy multiple cubesat payloads on-orbit

ISIS QuadPack Nanosatellite Dispenser

Donations may be made through the AMSAT webpage at www.amsat.org, by calling (888) 322-6728 or by mail to the AMSAT office at 10605 Concord Street, Kensington, MD 20895, USA. Please consider a recurring, club, or corporate donation to maximize our chance of success with this mission.



Your help is needed to get the AMSAT Fox-1Cliff and Fox-1D 1U Cubesats launched on the Spaceflight's initial SHERPA flight in 1Q 2016.

For the latest news on Fox-1 watch our website at www.amsat.org, follow us on Twitter at "AMSAT", or on Facebook as "The Radio Amateur Satellite Corporation" for continuing news and opportunities for support.

AMSAT President's Club
Support Fox-1Cliff and Fox-1D

Contribute to AMSAT directly through easy, automatic charges to your credit card. Since AMSAT is a 501(C)(3) organization donations may be USA tax deductible. (Check with your tax advisor.) To join contact Martha at the AMSAT Office by phone (888) 322-6728 in the US, or (301) 822-4376; e-mail martha@amsat.org.

Titanium Donors contribute at least US $400 per month	❒ $400 / month ❒ $4800 one time
Platinum Donors contribute at least US $200 per month	❒ $200 / month ❒ $2400 one time
Gold Donors contribute at least US $100 per month	❒ $100 / month ❒ $1200 one time
Silver Donors contribute at least US $50 per month	❒ $50 / month ❒ $600 one time
Bronze Donors contribute at least US $25 per month	❒ $25 / month ❒ $300 one time
Core Donors contribute at least US $10 per month	❒ $10 / month ❒ $120 one time

AMSAT is Amateur Radio in Space
... and YOU are AMSAT

Here are opportunities to launch your amateur radio experience to new heights ...

ARISS Development and Support

AMSAT's Human Space Flight Team is looking for volunteers to help with development and support of the ARISS program:

- Mentors for school contacts
- Support for the ARISS web
- Hardware development for spaceflight and ground stations
- Help with QSL and awards certificate mailing.

To volunteer send an e-mail describing your area of expertise to Frank Bauer at: ka3hdo@amsat.org.

AMSAT Internet Presence

AMSAT's information technology team has immediate needs for volunteers to help with development and on-going support of our internet presence:

- Satellite status updating and reporting.
- Add/delete satellites to ANS and the web as needed.
- Research and report satellite details including frequencies, beacons, operating modes.
- Manage AMSAT's Facebook and Twitter presence.

To volunteer send an e-mail to Drew Glasbrenner, KO4MA at: ko4ma@amsat.org.

AMSAT's web presence needs a site content editor and authors for content development for technical articles and feature development.

To volunteer send an e-mail to Alan Biddle, WA4SCA at: wa4sca@amsat.org.

AMSAT Engineering Team

AMSAT Engineering is looking for hams interested in developing ground station equipment for future satellites. An inexpensive L-Band uplink converter is something that is of interest right now for LEO satellites as part of the recently approved technology funding.

If you are interested in helping, please contact AMSAT Engineering by completing the form on the website to tell Jerry Buxton, N0JY, the Vice President of Engineering, how you can volunteer your time and skills to help AMSAT engineering build satellites and other required hardware/software:

http://ww2.amsat.org/?page_id=1121

Please remember to include your AMSAT membership number.

AMSAT User Services

AMSAT is looking for an on-line store co-manager. Your efforts will involve updating and refreshing the osCommerce based AMSAT Store web page when new merchandise becomes available or prices and shipping costs change. Shipping and credit card charges are handled by the AMSAT Office.

- Add new merchandise offerings
- Delete merchandise no longer available
- Update shipping costs as needed
- Add periodic updates for registrations for Dayton and the Symposium
- Interface with the AMSAT Office

To volunteer send an e-mail to JoAnne Maenpaa, K9JKM at: k9jkm@amsat.org

AMSAT Educational Relations Team

AMSAT's Educational Relations Team needs volunteers with a background in education and classroom lesson development ...

- Engage the educational community through presentations of how we can assist teaching about space in the classroom.
- Create scientific and engineering experiments packaged for the classroom.
- Create methods to display and analyze experimental data received from Fox-1.

To volunteer send an e-mail describing your area of expertise to E. Mike McCardel, KC8YLD at: kc8yld@amsat.org.

AMSAT Field Operations

AMSAT's Field Operations Team is looking for satellite operators to promote amateur radio in space with hands-on demonstrations and presentations.

- Promote AMSAT at hamfests
- Setup and operate satellite demonstrations at hamfests.
- Provide presentations at club meetings.
- Show amateur radio in space at Dayton, Pacificon, Orlando Hamcation.

To volunteer send an e-mail to Patrick Stoddard, WD9EWK at: wd9ewk@amsat.org

You can find more information on the web ...
www.amsat.org ... click AMSAT ... then click Volunteer