

KUMU A'O CUBESAT TELECOMMUNICATION SUBSYSTEM INTEGRATION AND TESTING

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ABSTRACT

The Kumu A'o CubeSat Telecommunication Subsystem will provide a communication link between the picosatellite and the ground station. The Telecommunication Subsystem and ground station was simulated to test the components that will be integrated into the CubeSat and University of Hawaii ground station. For the telecommunication subsystem, a laptop simulated the Command & Data Handling (CDH) Subsystem which is interfaced to a TinyTrak4 Terminal Node Controller (TNC) and then to the handheld Yaesu VX-3R Transceiver. On the ground station, a computer interfaced to a TinyTrak4 TNC and then to the Yaesu FT-847 Transceiver. Tera Term Pro and WINTNC are software tools to assist in the communication link. The TinyTrak4 TNC and interfaces between components were fabricated, integrated, and tested.

INTRODUCTION

The Kumu A'o (source of learning) CubeSat project began in the summer of 2007. The project originated from the four founding students from the LEONIDAS project and expanded into a team consisting of eleven electrical and mechanical engineering students. A satellite project is significant in giving engineering students at the University of Hawaii hands on experience in space exploration from concept design to operating a low earth orbiting (LEO) satellite. The Concept Design, Preliminary Design Review (PDR), and the Critical Design Review (CDR) were accomplished in the fall of 2007. The telecommunication subsystem has procured components and has entered into the component off the shelf (COTS) integration and testing phase.

INTEGRATION

TNC Fabrication

The TinyTrak4 TNC was fabricated in eight hours. The equipment used to fabricate the TinyTrak4 was eyeglasses, soldering gun, solder, an electronic component clamp, flux, wire cutters, alcohol, and a brush. The eyeglasses were used to protect from the solder or any small composites that could damage someone's eyes. The soldering gun and solder was used to solder the components onto the printed circuit board (PCB). Before soldering a component such as a capacitor onto the PCB, flux would be placed onto the point where it would be soldered. The flux is to help create a good soldering connection between the component and the PCB. An electronic component clamp is used to hold the PCB in place while soldering. After the component was soldered on the PCB, the exceeding legs would be cutoff using a wire cutter. This process would be done to all of the components. At the very end when all the components are soldered on to the PCB, then, the back of the PCB would be cleaned with using alcohol and a

brush. Finally, the TinyTrak4 TNC would be ready for testing. A total of two TNC's were fabricated.

Telecommunication Subsystem

The laptop is connected to the TNC using a USB serial adapter, a null modem, and a female to female mini gender changer. The USB Serial Adapter is used to create a connection between the TNC and Laptop. A null modem is a communication method to connect a serial to another serial. The computer and TNC both serve as hosts and this link needs a null modem to interchange the transmit and receive pins. A gender changer is used to continue a connection between two devices when both interfaces are of the same type. The USB serial adapter is connected to the laptop via USB. Then, on the serial port side of the adapter is connected to the null modem. The null modem is connected to the gender changer. Finally, the gender changer is connected to the computer DB9 serial port on the TinyTrak4. This concludes the interface between the laptop and TNC.

The TNC is connected to the Yaesu VX-3R Transceiver using a male to male mini gender changer, DB9 female serial port, 2kohm resistor, 10uF capacitor, power supply, CT-44 adapter, 2.5 mm jack, and 3.5 mm jack. First, the male to male gender changer continues the link between the two devices. A female DB9 serial port was created. (Shown in Figure 1) A female DB9 soldering cup, solder, and wires were used to create this connection. For instance, pin 1, cup 1 on the other side, was filled with solder by melting solder into the cup. Then, about a quarter inch of insulator was stripped off the 22 gauge wire and the copper showing was tinned.

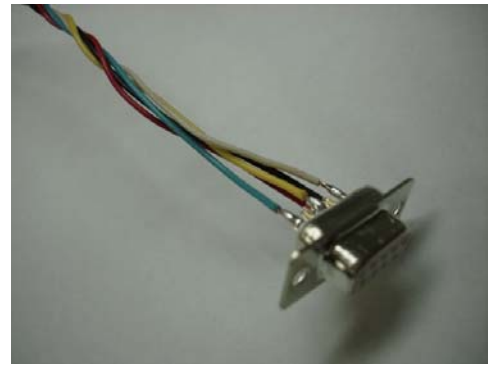


Figure 1: DB9 Female

To tin the copper wire is to place flux on the wire and then cover it with solder. This is to create a good soldered connection between the wire and cup 1. The solder in the cup was heated to melt the solder while sliding in the wire. This was done to pins 1, 3, 5, 6, and 7. The pin descriptions are shown in Table 1.

Table 1: TinyTrak4 Radio Interface

Pin	Function	Description
1	Audio Out	Packets or audio tones to be transmitted via the radio microphone jack
3	PTT Out	Grounded when the radio is transmitting. Connects to radio PTT input
5	Audio In	Packets or audio tones received from the radio speaker jack
6	Ground	Ground return for power, audio, and PTT
7	Power In	Power input for the TNC. 5V

The Schematic in Figure 2 shows the direct connection between the TNC and Yaesu VX-3R Transceiver. There is some circuitry needed to control the transmit line on the transceiver. A 2kohm resistor and a 10uF capacitor are placed onto a prototype board. On one side of the resistor is connected to the PTT out pin. The audio out pin (microphone) is connected to the cathode side of the capacitor. A universal power supply is used to power up the TinyTrak4 at 5 volts. The power is connected via ground (pin 6) and power in (pin 7). This is done on the prototype board with 22 gauge wires. A CT-44 adapter is used to connect both transmit and

receive jacks into one jack that is plugged in directly to the VX-3R Transceiver. This adapter is made specifically for this transceiver. A 2.5 mm jack was fabricated to connect the transmit connection between the TNC and Transceiver. The sleeve of the jack is soldered to a black wire which represents ground. The tip of the jack represents the transmit connection. This is connected directly to the capacitor and resistor on the prototype board. A 3.5 mm jack was fabricated to connect the receive connection between the TNC and Transceiver. The sleeve of the jack is ground and the tip of the jack is the receive connection. The receive connection is connected directly to the audio in pin on the prototype board. The 2.5 mm transmit jack and 3.5 mm receive jack is connected to the CT-44 adapter. The CT-44 adapter connects to the transceiver with a 2.5 mm jack that has a sleeve, two rings, and a tip. The sleeve is ground, first ring is receive, second ring is ground, and tip is transmit. This concludes the connection between the TNC and Yaesu VX-3R Transceiver.

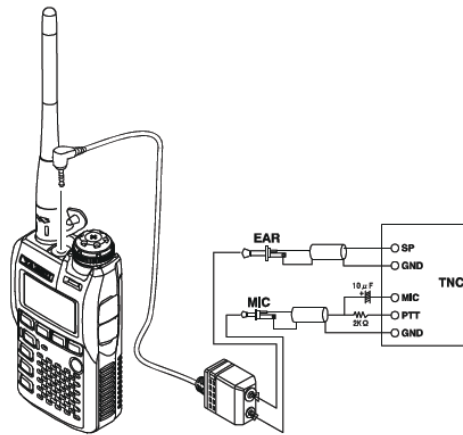


Figure 2: TNC and VX-3R Interface

The Laptop is connected to the USB Serial adapter, USB Serial adapter to the null modem, null modem to the gender changer, gender changer to the TNC, TNC to the gender changer, gender changer to the DB9 serial port, DB9 serial port to prototype board, transmit and receive pins to CT-44 adapter, CT-44 adapter to Yaesu VX-3R Transceiver (Illustrated in Figure 3). WINTNC software is used to send data in KISS packets. The TNC takes those KISS packets and modulates that data onto a carrier. Then, the transceiver transmits that data. In receiving mode, the transceiver receives that data and routes it to the TNC. The TNC demodulates the signal and sends the KISS packets to the laptop. Finally, the WINTNC software un-packetizes the data and shows it on the monitor window.

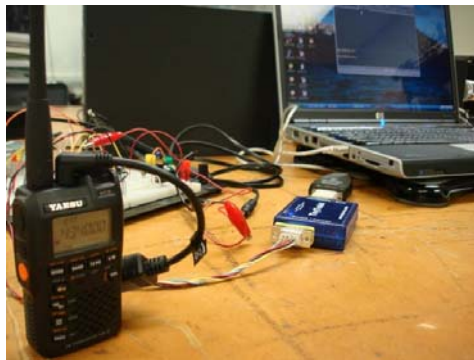


Figure 3: Telecommunication Subsystem

Ground Station

The interface between the Yaesu FT-847 Transceiver to the TNC is different from the VX-3R to TNC due to the fact that they are different types of transceivers. A mini-DIN connector was fabricated to interface with the transceiver (Shown in Figure 4). Four 22 gauge wires were soldered to the connector: data out, ground, PTT, and data in at 1200 bps (pin 1, 2, 3, and 5 respectively). The wires from the mini-DIN connector were placed into a prototype board. Similarly to the first TNC, the pins were connected to the respected pins to the mini-DIN connector via prototype board. This concludes the interface between Yaesu FT-847 Transceiver and TNC.



Figure 4: Mini-DIN connector

The interface between the TNC and computer is done by a gender changer, RS-232 serial cable, and a null modem. RS-232 serial cable is used to transfer data from device to device using serial communication. The TNC is connected to a mini gender, mini gender to RS-232 serial cable, serial cable to null modem, and null modem into the COM port of the computer (Illustrated in Figure 5). The data transfer is similar to the telecommunication subsystem.



Figure 5: Ground Station

TESTING

Tera Term Pro is software used as a boot loader. This allows downloading TinyTrak4 firmware file to the TinyTrak4 TNC. When initiating the program, it will ask to create a new connection which is by a computer serial port and then hit OK. Then, on the tool bar click on Setup and click on Serial Port to give you the Tera Term: Serial port setup window. The Baud rate would need to be modified to 19200 as that is the baud rate for the TNC. Then, hit OK. Initiating the TNC, it is needed to download the firmware onto the TNC for it to function. After the firmware is placed into the TNC, then it can be used for communication purposes. In order for the Tera Term Pro to take into effect, the TNC needs to be rebooted and this is simply done by turning it off and back on. Then, Tera Term Pro will ask to hit escape three times and this will give the Options Menu. Select “B” for Transmit Adjust and this will give choices of what type of tone you want the TNC to send. This is a simple exercise to test the TNC’s proper functionality.

WINTNC is a packet terminal driver program for multiple Baycom modems or KISS mode TNC’s which only used with Windows. This program is useful in sending and receiving

data to the TNC. First, click on General in the toolbar and click on Change Setup. The Setup Configuration window should pop open. In the Setup Configuration, the Port Configuration needs to be modified. The type should be changed to KISS, COM changed to its respected COM, and the Baud to 19200. Then, the TNC Configuration can be modified. If the user has his amateur radio license, he would place his call sign in the My Call box and click OK. To finish up Setup Configuration, click Cancel (not OK). It will ask you to reboot the program for any changes to take effect. Then, you would exit program and reopen. After the configurations are set, the WINTNC program is used for data communication. Sending a “K” will allow transmission and receiving data. The TNC window on the program is where the data is typed out to be transmitted. Towards the bottom of the screen or on the MON window, the data that was sent or receive will show to give proof of data transmission.

The Telecommunication Subsystem and Ground Station are set up in the lab. Telecommunication subsystem is the laptop to TinyTrak4 TNC to Yaesu VX-3R Transceiver. The Ground Station is the computer to TinyTrak4 TNC to Yaesu FT-847 Transceiver. The transceivers are separated by a distance of approximately six feet. Testing with Tera Term Pro is first done on both stations to verify that all components are functioning well. Then, both stations are rebooted and WINTNC program is opened on both monitors. On the TNC window, “test test 1” was sent from the telecommunication subsystem. WINTNC stated “?EH” because it did not understand the command. A “K” command needs to be sent in order for WINTNC to know that it is in transmit and receive mode. After “K” is sent the link is ready to send and receive data from the TNC. “Test test 2” was sent from the telecommunication subsystem. As shown on the bottom of the screen, “test test 2” was sent and this would also show up on the MON window on the monitor of the ground station. On the ground station, “test test 3” was sent and “test test 3” appeared on the MON window of the telecommunication subsystem. This confirms the data link between the two communication stations and that the components are functioning. (Illustrated in Figure 6)

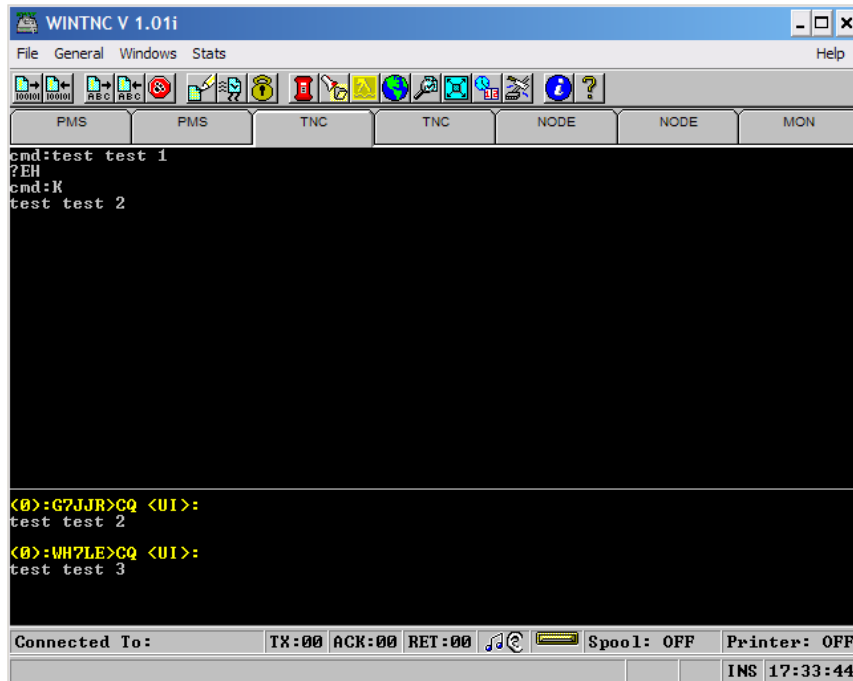


Figure 6: Data Link Confirmation

CONCLUSION

The Kumu A‘o CubeSat Telecommunication Subsystem COTS integration and testing was successful. The interfaces between components inside the telecommunication subsystem and ground station are verified. The TinyTrak4 TNC and Yaesu VX-3R Transceiver will be integrated into the CubeSat. In addition, the TinyTrak4 TNC will be integrated into the University of Hawaii UHF/VHF mobile ground station. It is feasible to create a communication link between the CubeSat’s telecommunication subsystem and the ground station with these COTS products.

ACKNOWLEDGMENTS

Thank you to Lloyd French for being my teacher, friend, and mentor. I have gained a great deal of knowledge and experience. Thank you Dr. Luke Flynn and Ms. Marcia Rei Sistoso for all the support you have given me in the past two years. Thank you to Dr. Wayne Shiroma and Byron Wolfe for all your help throughout this CubeSat project. Thank you to the Telecommunication Subsystem and Kumu A‘o CubeSat Team: Zachary Lee-Ho, Matthew Patterson, Jordan Torres, Michael Menendez, David Luis, Amy Blas, Isaac Rodriguez, Jeremy Chan, Windell Jones, Tyson Seto-Mook, and Reid Yamura. This project was based on the work done by the Kumu A‘o CubeSat Team and the Telecommunication Subsystem Team with their brilliant minds. It has been a long road and I want to thank everyone who made this a wonderful journey. Thank you for the great memories!

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