

How to Use the AMSAT CubeSatSim Lite vB3

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This file can be downloaded here: <https://cubesatsim.org/download/cubesatsim-lite-readme.pdf>

Videos are available at <https://cubesatsim.org/lite-videos>



These instructions are for the AMSAT® CubeSatSim Lite vB3. This is a beta release – your comments and feedback are most welcome! The CubeSatSim Lite consists of a Raspberry Pi Zero W (green board on the bottom) with the CubeSatSim Lite board (white board on the top) plugged in with 16 GB micro SD card inserted, secured with nylon standoffs, and a micro USB cable and power plug.

To use, just plug the micro USB cable into the “PWR IN” micro USB connector on the Pi Zero W board (the one closest to the edge) and plug the other end into the power plug, and plug into a wall outlet.

When it is first powered up, a small green LED on the Pi Zero W board will illuminate and flicker indicating that the Raspberry Pi is booting up. After about 30 seconds, the green LED on the white CubeSatSim Lite board will turn on indicating that the CubeSatSim software is running. Within 30 seconds of that, the blue LED on the white CubeSatSim board will turn on and off, indicating that the CubeSatSim is transmitting. If you have this, your CubeSatSim Lite is “nominal” and ready for use!

If you don't see these LEDs, checkout the Troubleshooting Guide at the end of this document.

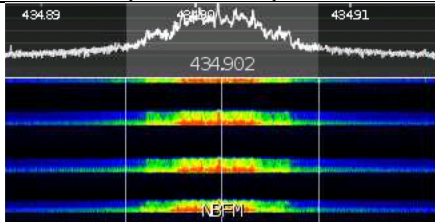
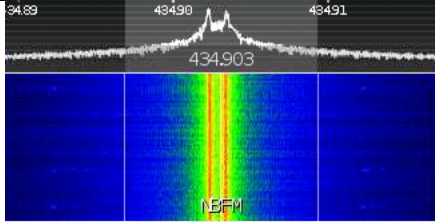
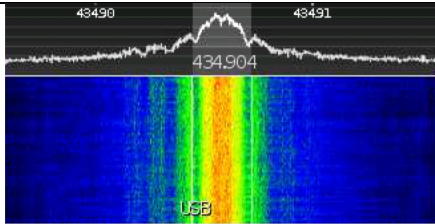
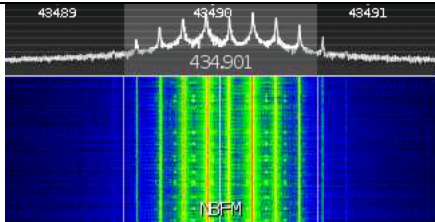
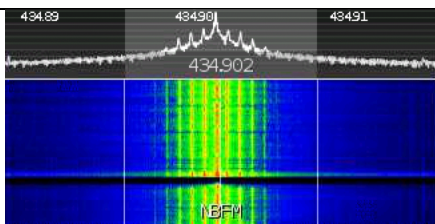
The next step is to listen for radio transmissions from the CubeSatSim Lite. You will need to receive FM modulated signals on 434.9 MHz +/- 15 kHz in the ham radio 70cm band/ISM band. A ham radio HT or scanner in the UHF band will work. Or, a radio USB dongle, known as a Software Defined Receiver (SDR) plugged into a computer will also work. There are many good SDRs, but this one, known as the RTL-SDR is one of the cheapest and works very well <https://www.amazon.com/gp/product/B0129EBDS2>

If you listen around 434.9 MHz (or 434900 kHz) you should hear a signal. You might have to tune up or down up to 15 kHz. If you don't hear the signal, see the Troubleshooting Guide at the end of this document.

At the start, you will hear a CW signal – Morse Code tones – a few seconds of silence, then a continuous transmission. If this is the first time you have used your CubeSatSim Lite, you should hear a sound like a low rumble or drumming sound. If you have used it before, when it powers up it will be in the last mode you were in before you shut it down. If your SDR has a visual spectrum indicator (“waterfall”), you should see a peak around this frequency. **IMPORTANT NOTE:** The CubeSatSim Lite will not always transmit on exactly 434.9 MHz. Sometimes, it will have a frequency offset of +/-5 kHz up to +/-15 kHz – this is normal. If you are listening on the exact frequency and it sounds strange, it might be because of this offset.

A reboot of the Pi will usually fix a frequency offset like this. To reboot, press and release the pushbutton S1 labeled “Mode Chg/Shutdown”. The button is close to the green LED. You have to press pretty hard on the button. If you can't press hard enough, try pressing with your fingernail or a pen. To reboot, you just have to press and release the button – don't hold it down at all. After a few seconds, the LEDs on the white CubeSatSim board will go out, and then the Pi will boot up again, with first the small green LED on the Pi Zero W flashing, then the green LED on the Lite board turning on again in about 40 seconds, then the blue transmit LED on the Lite board starting to blink. You should hear/see the transmitted signal again.

The table on the next page shows the five modes of operation of the CubeSatSim Lite.

Name	Mode	Description	Waterfall (Cubic SDR)
APRS	1	APRS or Automatic Packet Reporting System. This digital mode sends a packet of data with AFSK or Audio Frequency Shift Keying modulation. This mode transmits a burst of 1200 bps data every few seconds or so that sounds like an old dial-up modem. To decode, you need an SDR and AFSK Decoder or an APRS radio. http://countingfromzero.net/amsat/audio/AFSK.m4a	
FSK	2	FSK or Frequency Shift Keying. This mode transmits a continuous signal that makes a rumbling sound that emulates the AMSAT Fox CubeSats such as Fox-1C or AO-95. This mode is also known as DUV or Data Under Voice. You will need software called FoxTelem to decode. FoxTelem does automatic decoding and real-time graphing of telemetry values. Listen to this mode: http://countingfromzero.net/amsat/audio/FSK.m4a	
BPSK	3	BPSK or Binary Phase Shift Keying. This mode transmits a continuous signal that sounds like noise that emulates the AMSAT Fox-1E or HuskSat-1 CubeSats. You will need FoxTelem to decode. If you are using SDR#, you will need to decode using USB not NFM. Listen to this mode (correct USB demodulation): http://countingfromzero.net/amsat/audio/BPSK-USB.m4a Listen to this mode (incorrect FM demodulation): http://countingfromzero.net/amsat/audio/BPSK-FM.m4a	
SSTV	4	SSTV or Slow Scan TeleVision. This mode transmits stored images in Scottie 2 format which sounds like a series of tones. You will need SSTV decoding software such as MMSSTV (Windows) or QSSTV (Linux) to decode. Listen to the signal: http://countingfromzero.net/amsat/audio/SSTV.m4a	
CW	5	CW or Continuous Wave or Morse Code. This mode transmits a FM modulated tone at 20 words per minute Morse Code telemetry.	

Each of the five mode generates a different type of radio transmission. You can hear the difference between the different modes, and see a difference on your computer waterfall if you are using an SDR.

The default mode of the CubeSatSim Lite is FSK – Frequency Shift Keying, mode 2.

You can change modes using the pushbutton S1 labeled “Mode Chng./Shutdown”. When the button is pressed and held, the green LED blinks rapidly in this sequence: 1 quick blink, 2 quick blinks, 3 quick blinks, 4 quick blinks, 5 quick blinks, 3 slow blinks. Releasing the button during or just after one of the quick blink sequences will put the CubeSatSim in that mode, and the green LED will stop blinking. For example, in this video, the push button is released after the 3 blinks, so the CubeSatSim is in Mode 3. <http://countingfromzero.net/amsat/v1/blink.MOV> It might take a bit of practice to switch to the mode you are after.

The mode numbers are: 1: APRS, 2: FSK, 3: BPSK, 4: SSTV and 5: CW.

If you press and immediately release the pushbutton S1 (next to the green LED), the Pi should reboot. The green and blue LEDs will go out, then come back on after about 40 seconds.

When pressed and held until the green LED starts to blink slowly (see above for the LED blink sequence), the green LED will then blink slowly three times, then the Pi will shut down (the green Power and blue Transmit LEDs will go out, then the tiny green LED on the Pi will flash rapidly for about 10 seconds then go out). You can release the button as soon as the LED starts blinking slowly. This video shows the button shutting down the Pi: <http://countingfromzero.net/amsat/v1/shutdown.MOV> After the Pi is shutdown (no LEDs are on or blinking), you can safely disconnect the micro USB power cable.

When the Pi is off but connected to power, pressing and releasing the other pushbutton S2 labeled "Power On" which is next to the blue transmit LED will startup the Pi, as this video shows: http://countingfromzero.net/amsat/v1/power_up.MOV Alternatively, disconnecting then reconnecting the power will also cause the CubeSatSim Lite to boot up again.

Once your CubeSatSim is transmitting, you will need to setup your Ground Station to decode the telemetry. The full instructions are here <https://github.com/alanbjohnston/CubeSatSim/wiki/3.-Ground-Station>

The Ground Station for the CubeSatSim utilizes FoxTelem, the open source AMSAT telemetry decoding software by Chris Thompson, G0KLA/AC2CZ. The latest version fully supports the CubeSatSim and is available for free download here <https://www.amsat.org/foxtelem-software-for-windows-mac-linux/> This software can decode the FSK/DUV (mode 2) and BPSK (mode 3) telemetry modes. You will need an SDR to plug into a USB port on your computer such as the RTL-SDR. I recommend this one <https://www.amazon.com/gp/product/B0129EBDS2> but many others will work, including the FunCube Dongle Pro+.

The CubeSatSim Lite generates simulated telemetry. Once you are decoding telemetry frames in FoxTelem, you can select the Health tab and look at the telemetry data. Based on the simulated voltages, currents, and temperatures, you can figure out if the CubeSatSim is simulating a CubeSat in illumination (sunlight) or eclipse (darkness). You can also see the battery charging or discharging, and the battery voltage rising or falling.

To decode SSTV images (mode 4), you will need an application such as MMSSTV for Windows, QSSTV for the Raspberry Pi, Robot 36 for Android, or SSTV for iOS.

To decode APRS packets (mode 1), you can use Direwolf or Soundmodem. Note that the CubeSatSim only transmits on 434.9 MHz +/- 15 kHz, not any standard APRS frequency.

Connecting your computer to your CubeSatSim Lite

There's no need to login to the Pi, but if you want to customize or configure your CubeSatSim Lite, for example, to add your callsign for the CW ID or add your latitude and longitude for the APRS packets, there are multiple ways you can login to your Pi.

The username is **pi** and the password is **raspberrypi**, the same as the Raspberry Pi default. The hostname is **cubeatsim** (not raspberrypi the default). The first time you log into your Pi, you should immediately change your password by typing **passwd** or by running the Raspberry Pi configuration tool **sudo raspi-config**

If you have an HDMI monitor (connect using a mini HDMI adapter or cable) and a USB keyboard (connect using a micro USB to USB adapter or OTG cable plugged into the inner micro USB connector which is labeled "USB", not the one on the edge labeled "PWR IN", Power In), you can access the console directly and type in the commands described below. Once logged in, you can configure your WiFi network by typing **sudo raspi-config** then selecting *Network Options* then *WiFi*. SSH remote access is enabled on the image, so once your Pi is on your network, you can SSH into it using the IP address or hostname. VNC remote access can't be used since the CubeSatSim Lite does not run the Raspberry Pi Desktop graphical user interface.

You can also access your Pi from a computer using just a USB cable using SSH. This Ethernet over USB service is known as RNDIS on Windows and USB Gadget on Linux. On Mac or Linux, you don't need to install any software to use this. On Windows, you need the mDNS discovery program Bonjour. If you already have iTunes installed, you should have it. If not, you can download it from Apple using this link: <https://support.apple.com/kb/dl999> Note that it is called Bonjour Printer Services, since that is the most common standalone use for the application. Run the installer and reboot. On your Pi Zero W or Pi Zero, connect a micro USB cable to the inner micro USB connector which is labeled "USB", not the one on the edge labeled "PWR IN" (Power In). The USB cable will power the Pi Zero W or Pi Zero, so you don't need to plug anything into the Power In micro USB connector.

When you connect the USB cable to your computer, the USB cable will power up the Pi and after about a minute, you will have network connectivity to your Pi. For example, in the Terminal Window or Windows Command Prompt, you can type: **ssh pi@cubesatsim.local** and you can login using the default password raspberry. Alternatively, you can use a free application such as PuTTY on Windows. Download it here <https://www.putty.org/> and open it, setting the Host Name to **cubesatsim.local** and then click *Open* to connect. You will then have a terminal window and can enter the commands below.

Finally, you can connect your Pi to your WiFi network by following the steps listed here <https://www.raspberrypi.org/documentation/configuration/wireless/headless.md>. Then you would connect using SSH as described earlier in this document.

Once you login, you can set your callsign by typing this command then return: **CubeSatSim/config -c** (if this command doesn't work, you probably aren't in the /home/pi directory. Try typing **cd** return then type the command again.) The default in place of a callsign is AMSAT. You can set your latitude and longitude (for the APRS packets) by typing: **CubeSatSim/config -l** South latitude is entered as a negative number, and West longitude is entered as a negative number. The default latitude and longitude is Washington, DC. To see the full set of configuration options, type: **CubeSatSim/config** You can also update to the very latest CubeSatSim software by typing: **CubeSatSim/update**

As with any Raspberry Pi, you should gracefully shut down and not just turn off the power to avoid data corruption on the SD card. This can be done using the pushbutton S1 (labeled "Mode Chg/Shutdown"). If you are logged into the Pi, you can type this command to safely shut down: **sudo shutdown now** To boot up your Pi again, you can press the push button S2 labeled "Power On". On your Pi, you can disconnect then reconnect the power to turn it on again.

If you make any changes to your Pi, we recommend backing up your SD card. There are a number of suggested ways here <https://www.raspberrypi.org/documentation/linux/filesystem/backup.md> Note: upgrading this image by installing the Raspberry Pi Desktop software is not recommended as the Pi Zero W do not have enough CPU to run the Desktop and the CubeSatSim software.

All the CubeSatSim software is open source and available on GitHub at <https://github.com/alanjohnston/CubeSatSim> If you are a developer, you can contribute to the project by modifying the code and adding features.

If you have issues, feel free to email Alan Johnston, KU2Y, AMSAT VP Educational Relations at ku2y@amsat.org. We'd love to hear what you do with your CubeSatSim by sharing on social media with the hashtag **#CubeSatSim**.

Customizing your CubeSatSim Lite

Here are some ideas for customizing your CubeSatSim Lite.

As mentioned earlier, you can log into your Pi and customize by setting your callsign, and latitude and longitude.

Powering with batteries to make it portable. Any USB power pack will work. I like this one <https://avidopower.com/product/avido-cube-2600mah-pocket-sized-smart-portable-power-bank-charger/> because it is very small but will run the CubeSatSim Lite for tens of hours.

You can buy a Pi Camera and plug it in with a Pi Zero cable. This one works well: <https://www.amazon.com/Aokin-Raspberry-Camera-Module-OV5647/dp/B07RXKZ1KN/?th=1> In SSTV mode, the CubeSatSim Lite will automatically detect the camera and take pictures and transmit them. It will take about one photo per minute.

3D print a 1U CubeSat Frame <https://www.thingiverse.com/thing:4333605> and mount your CubeSatSim Lite inside it.

Connect an external SMA antenna. The CubeSatSim Lite board has a built in 433 MHz chip antenna. But if you like to solder, you can move inductor L1 to L5, you can then solder an SMA connector and connect that to your favorite antenna. Here is a link to the schematic: https://github.com/alanjohnston/CubeSatSim/blob/master/hardware/lite/vB3/cubesat-sim-lite-0.3_schematic.pdf

Get an AMSAT Remove Before Flight tag for that "ready to launch" look <https://www.amsat.org/product/amsat-remove-before-flight-keychain/>

Troubleshooting

Symptom: No LEDs illuminate when the micro USB cable is connected to the Pi Zero W and plugged into a wall outlet or computer.

Solution: Provide power to the Pi Zero W. Is the micro USB cable plugged into the Pi Zero W all the way? Sometimes, it needs a good push to get it inserted. Is the micro USB cable plugged into the “PWR IN” connector? Is the other end of the micro USB cable plugged into the power plug? Is the power plug plugged into a good power outlet?

Solution: There is no micro SD card plugged into the Pi Zero W. Is the micro SD card plugged into the Pi Zero W? Is it plugged in all the way?

Symptom: The green LED on the Pi Zero W flashes but never comes on steady and LEDs on the CubeSatSim Lite board never illuminate.

Solution: There is a problem with the micro SD card. Is the micro SD card plugged in all the way? Has the micro SD card failed? You can download a new image from the Internet or email to have a new micro SD card mailed to you.

Symptom: The micro USB cable is plugged into the CubeSatSim Lite and the plug is plugged into an outlet, but there are no LEDs illuminated and no radio transmissions.

Solution: The CubeSatSim has been powered off using pushbutton S1. You just need to press and release the pushbutton S2 “Power On” and the CubeSatSim will power up. You should see small Pi LED flash after a few seconds, the green LED on the Lite board illuminate after 30 seconds, and the blue transmit LED illuminate then blink after another 30 seconds.

Symptom: No signal received from the CubeSatSim Lite.

Solution: Radio receiver or SDR not working. Does your radio or SDR have an antenna connected? Is the gain and volume turned up? Is the CubeSatSim Lite close to the receiver? The CubeSatSim transmits a very weak signal, so it will not travel more than a hundred yards or less if there are walls. Can you receive other signals on your radio or SDR? With an outside antenna, try tuning to the 2m band 144.390 MHz to see if you get any APRS packets. Try tuning around 162 MHz to see if you receive NOAA weather radio.

Solution: The CubeSatSim Lite is transmitting on an offset frequency from 434.9 MHz. Tune your radio or SDR above and below 434.9 MHz to see if you hear it. In FSK mode, you will hear a low rumble sound.

Symptom: The CubeSatSim Lite is connected to a computer via a micro USB cable and is powered on but ssh on the computer fails after timing out.

Solution: If Windows, Bonjour Printer Services not installed. Download it here https://support.apple.com/kb/dl999?locale=en_US and install it.

Solution: The micro USB cable is plugged into the wrong USB port on the Raspberry Pi Zero W. Move the micro USB cable to the inner USB port labeled “USB” not the outer one labeled “PWR IN” and try again.

Solution: mDNS is not working on your computer. Try rebooting your computer with the CubeSatSim Lite plugged in.