

D-STAR ONE (Sparrow) Beacon data telemetry decoding

By John Wysocki ZL2TWS

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On the 27 December 2018 a satellite was successfully launched for D-STAR digital radio. D-STAR ONE is the first private German CubeSat and the first D-STAR communication spacecraft worldwide. D-STAR ONE was launched from Vostochny launch site jointly with the Meteor-M No: 2-1 mission of the Russian State Space Corporation ROSCOSMOS. Web site: <http://www.d-star.one/>

D-STAR (Digital Smart Technologies for Amateur Radio) is a digital voice and data protocol specification for amateur radio. The system was developed in the late 1990's by the Japan Amateur Radio League and uses minimum-shift keying in its packet-based standard. There are other digital modes that have been adapted for use by amateurs, but D-STAR was the first that was designed specifically for amateur radio.

D-Star ONE (Sparrow) (DP1GOS) half duplex repeater and beacon:

DV Uplink: 437.325 MHz/Downlink: 435.525 MHz.

Beacon 435.700 MHz RF-Power: 800 mW.

D-STAR One is a 3U CubeSat which is equipped with four identical radio modules with D-STAR capabilities, all being operated in a half-duplex mode. Two modules are used for telemetry and telecommand; and operate on identical frequencies. Telemetry can be received on 435.700 MHz. The format is 4k8 GMSK Mobitex. Both modules receive, and both modules answer. To prevent information loss, they answer after each other. So, each telemetry frame is repeated twice. The Beacon is repeated once every minute. The other two modules are dedicated to the radio amateur community. Both modules have the same frequencies, so one of them will be powered down as long as the other one shows no degradation effects. The modules are configured to work as D-STAR repeaters, so they retranslate the received D-STAR frames on the down link frequency. They also have a D-STAR voice beacon signal.

All modules are operated in a power save mode. This means that they are in idle for forty seconds and then in receive mode for twenty seconds. Once a signal has been received, the module switches to receive mode for five minutes. So, it might be necessary to "ping" the satellite a couple of times until an answer is received.

I was interested enough to investigate what receiving a 4k8 GMSK Mobitex format beacon was about.

To track satellites, I was already using Gpredict software for both Windows 7 and Linux Ubuntu 18. This tracking software also allowed the received Doppler shift (-9 kHz to +9 kHz on 435 MHz) to be compensated for with automatic VFO tuning. This was something I had wanted to do since I owned a Yaesu FT-817.

Note: Many radios can be used as detailed on the InterWeb or in the Hamlib and Gpredict user manuals.

Before I explain my method of decoding the beacon data I must give credit to Ross ZL1WN for guiding me in the right direction.

In true amateur satellite operator style, I set myself up with a couple of old FM rigs and quarter wave roof top mounted antenna. A preamp on the receiver and waited for a couple of passes of AO-91 and AO-92 FM Cube satellites. I thought there might be others active who were also looking for the new D-STAR ONE. As luck would have it I didn't have to wait long. Ross ZL1WN was calling CQ and I quickly answered him. A QSO started by asking if he had received any data from the new satellite. Yes, he said proudly and quickly told me where to download the sound card software to get me started. I had not seen any reports hearing D-Star ONE on the AMSAT Status web site. <https://www.amsat.org/status/>

Now was the time to let the world know ZL was hearing it and decoding telemetry Mobitex data. So off I went and downloaded the hs_soundmodem software by Andy UZ7HO http://uz7.ho.ua/modem_beta/other-versions.zip

The hs_soundmodem has a Winsock TCP/IP interface to link with client application AGW Online KISS.

Note: hs_soundmodem and AGW Online KISS run on Linux providing you have a functional Windows emulation 'Wine' installation and include missing VB6 files to the System32 and SysWoW64 folders.

Then download the DStar_ONE telemetry decoder and AGW Online KISS software by Mike DK3WN
http://www.dk3wn.info/files/dstar_one.zip http://www.dk3wn.info/files/agw_online_kiss.zip

Note: AGW Online KISS requires an edit of .ini file and TLE file location to run.

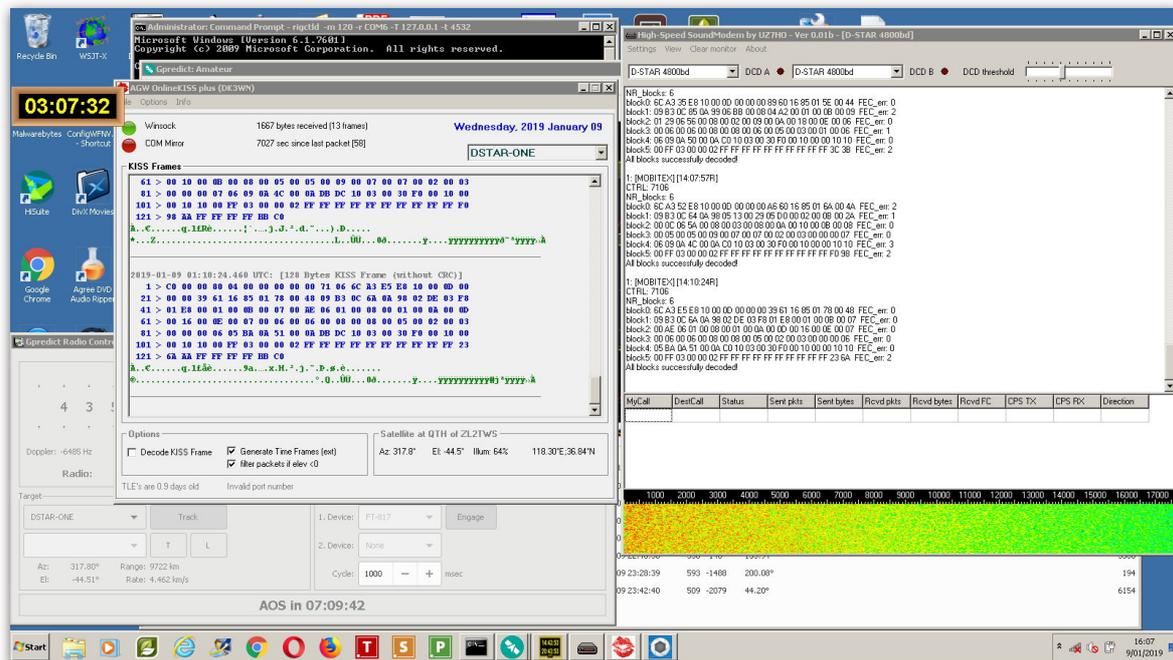


Figure 1: UZ7HO hs_ssoundmodem to DK3WN AGW Online KISS signal decoder combination.

DSTAR_ONE requires a KISS file to display telemetry. Next donate 10 Euros for each to help support these amateurs writing software for us to enjoy using.

Now for the difficult part, the hardware set-up. It was all well and good to have “the bright ideas department” swing into action but receiving an 800 mW UHF signal from space without tracking gain antenna systems is a bit like wishful thinking. Actually, it was not that hard to do as it worked out. What I used was a simple roof mounted 2dBi ground plane whip antenna fed with low loss coax into a home brew 15 dB 1 dB noise figure pre-amp. Note: Some rigs require a filter between rig and pre-amp.

The reason for such a simple antenna is to achieve a traditional donut shaped omni-directional pattern. Gain whip antenna have horizontal lobe patterns and although the satellite might be over your house, you will never hear it. The Yaesu FT-817 is used in 9k6 packet mode with audio from the radio DATA socket pin-4 connected to the computer sound card input. To start with I manually tuned the radio in 5 kHz steps (step size in FM or PKT mode) during passes and could capture some frames but was a bit random due to the RX being off frequency at times.

I must comment here that this would seem to be a most efficient way of sending data and saving satellite battery power unlike traditional techniques. By reducing the almost continuous power drain for beacons using CW or AFSK modulation the duty cycle of D-STAR One is 1 second every 60 seconds.

How good is that!

So, my thoughts then went in the direction of making the FT-817 radio track the satellite frequency so as to take out human error and not be compensating for Doppler shift. Because the data bursts were very short in duration I could not afford to be off frequency when signal was sent to my antenna. Keeping the RX centred on the beacon frequency at all times. Gpredict uses Hamlib drivers to control the radio. The information on how to use Hamlib is detailed in the Gpredict and Hamlib manuals and various InterWeb articles.

So, I downloaded Hamlib (hamlib-w32-3.3) <<https://sourceforge.net/projects/hamlib/>> ran the command lines required and started Gpredict.

Linux install use:- \$ sudo apt-get install libhamlib-utils

A nice feature of Gpredict is that it already knows an orbit satellite transponder frequency detail.

Because D-STAR ONE is very new, at the time of my setup and testing, a manual TLE and transponder frequency entry was required. With 435.700 MHz entered I clicked the “Track” button and immediately the radio tuned off centre frequency to match the Doppler shift expected on the next pass. With the radio tuning taken care of, pre-amp and antenna already connected I started the hs_soundmodem and AGW Online KISS software and waited for the next pass.

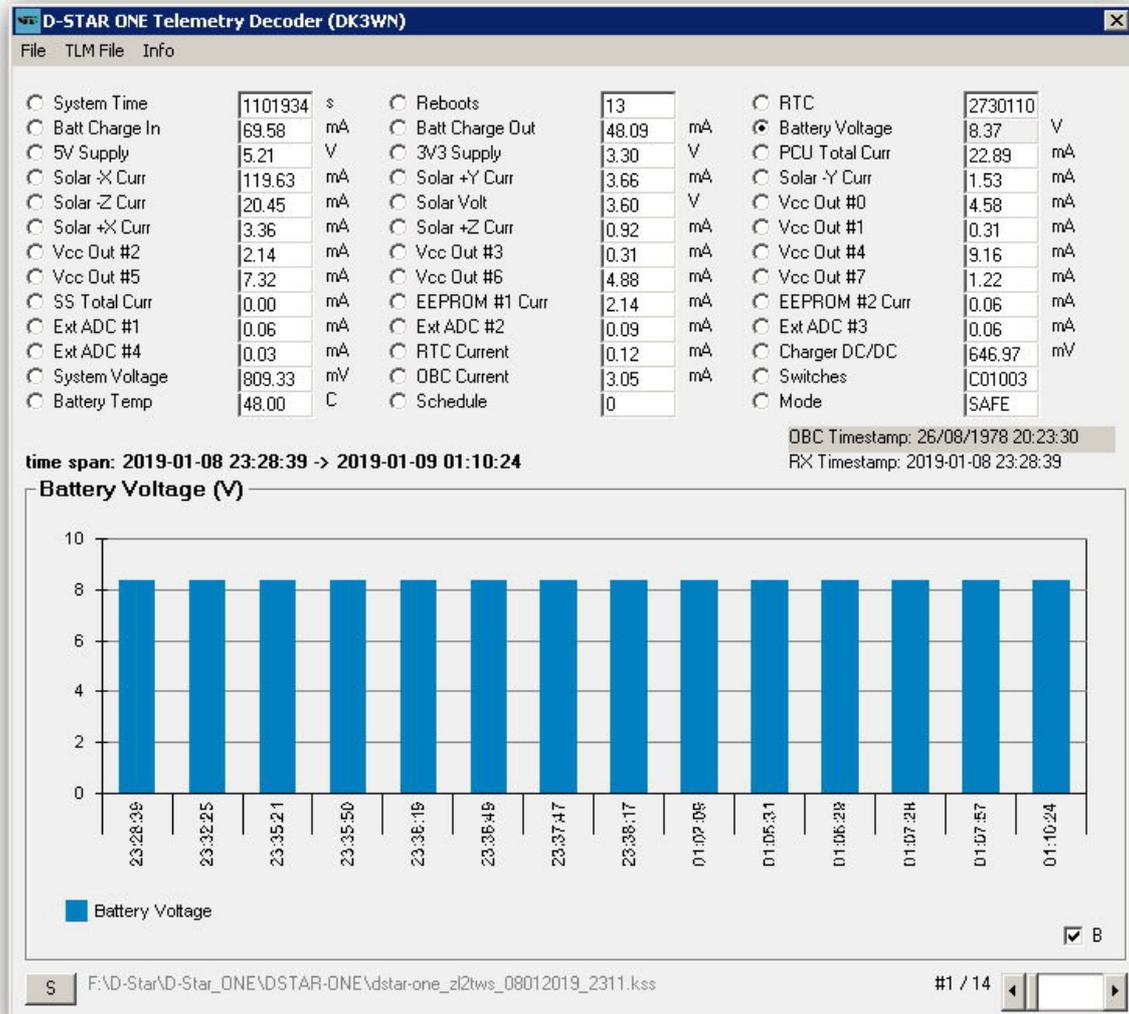


Figure 2: DK3WN DSTAR_ONE shows the decoded imported KISS files and satellite battery voltage status.

Packet frames were seen being decoded with valid error free frames held on the AGW screen. Opening the log file location and three KISS files can be seen. (Groups of three files for each pass) The final thing to do is to open the DK3WN DSTAR_ONE program and import the KISS file so it can display satellite recovered data.

RF and hardware set-up

1. FT-817 PKT 9k6 mode tuned to 435.700 MHz. (FT-857 and other rigs can also be used)
2. 15dB gain 1dB NF preamp.
3. 2dbi whip. (Omni directional doughnut shaped pattern)
4. 20 metres LDF-450 coax with short RG-213 connections to antenna and rig.
5. Gpredict satellite tracking software driving Hamlib rig control software. (runs on both Windows 7 SP1 – 64bit and Ubuntu 18 – 64bit)
6. Audio from Pin-4 of FT-817 PS2 DATA socket to laptop (PC) soundcard mic input.
7. Windows 7 SP1 64 bit with VB-6 installed.
8. Ubuntu 18 running ‘Wine’ with VB-6 files added to System32 & SysWoW64 folder for DK3WN AGW Online KISS & DSTAR_ONE decoder. Gpredict steps the radio continuously and seen on FT-817 display as 10 Hz steps even in FM or PKT mode.

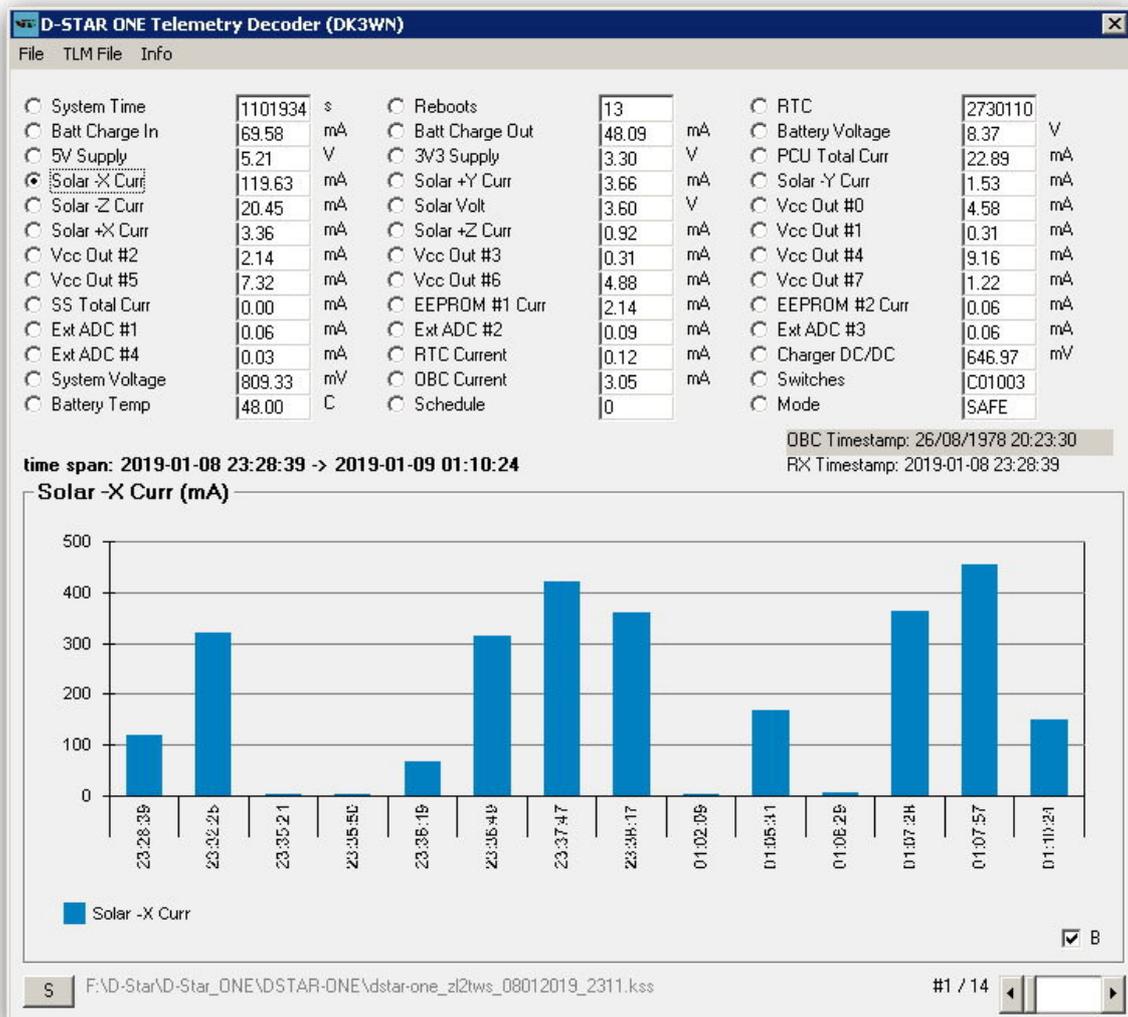


Figure 3: Status when radio button is changed to solar current on panel -X

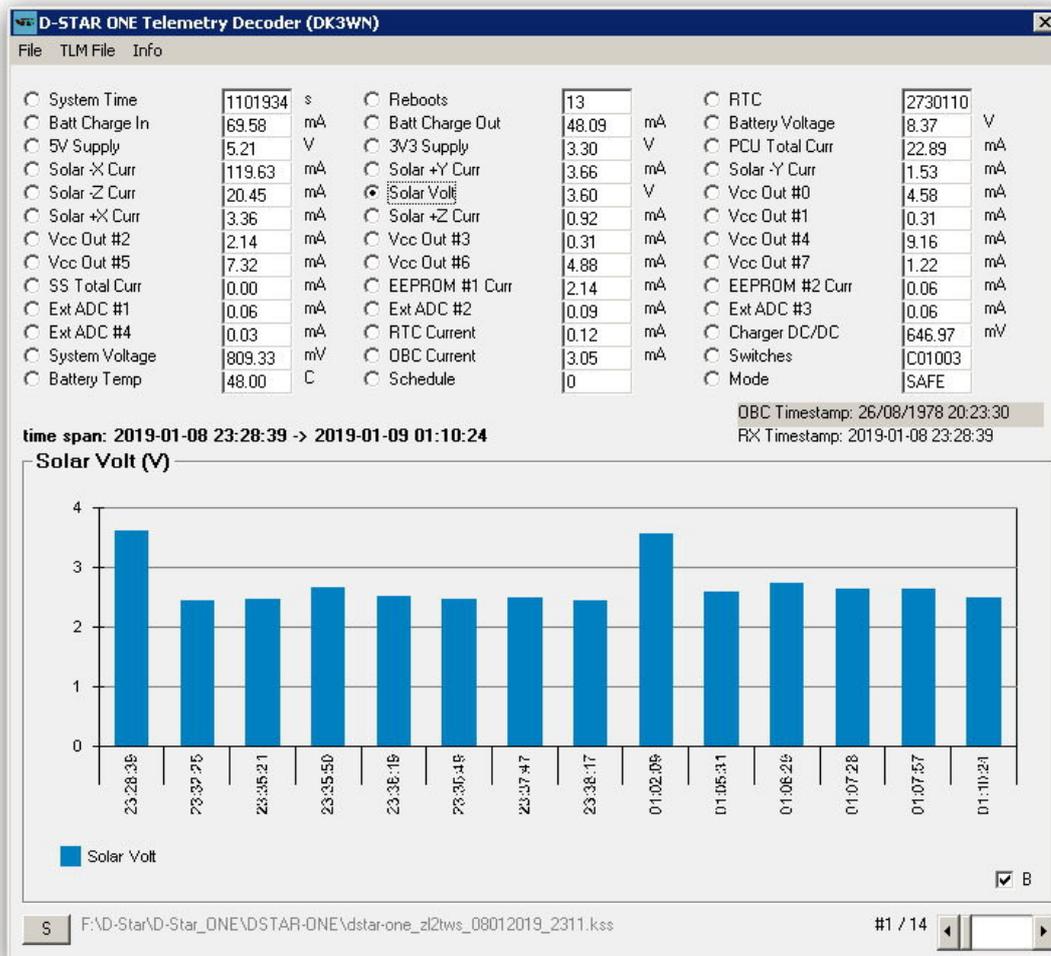


Figure 4: Status when radio button is changed to Solar Voltage. Variations can be seen over time periods during the pass (vertical bars) in these examples data is shown over two complete passes.

Enjoy the challenge of decoding D-Star ONE and other satellites using similar techniques.

73 and good DV,
John M Wysocki ZL2TWS