

Swiss Space Summer Camp 2016

Simple Ground Station (GS)

System Test Procedures

Main topics:	Verification of the system with terrestrial signal sources
Teaching materials:	Satellite basics, radio and software Installation, these instructions
Prerequisites:	Windows notebook with charged batteries, receiver dongle NESDR smart, preamplifier, quadrifilar-helical-antenna, cabling
Time requirements:	2 lessons (estimated)

M. Klaper, version 1.2

Dear participant of the Swiss Space Summer Camp 2016,
at the end of this session you will have tested your simple ground station on a system level with terrestrial signals. You will possess the following observable skills:

- You are familiar with the radio software
- You are able to divide appropriate tasks to each group member
- You are able to document your proceeding
- You are able to receive and decode a strong, a medium strong and a very weak signal.

The following text gives you information about the available terrestrial radio sources and provides a skeleton for a system test. Please feel free to perform additional tests if time permits.

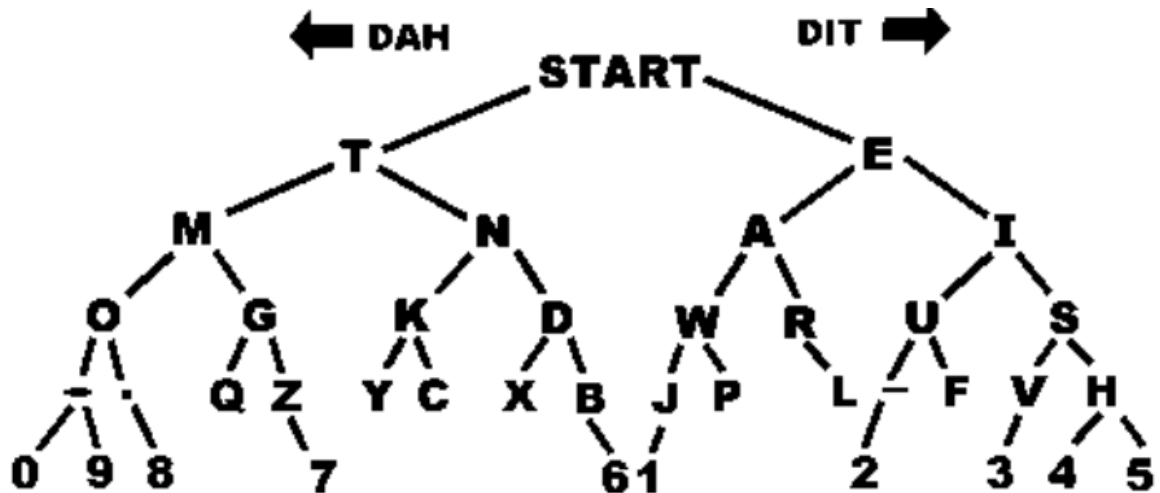
Wishing you good luck

Your lecturer team

1. Test 1: Strong Signal Continuous Wave (CW) and (slow) Morse Code

During the lesson there will be a CW signal on **144.140 MHz** (alternate frequency 144.145 MHz). Tune your receiver to this frequency and select CW. No data decoder is needed.

- Write down the received Morse code and decode it by hand with the following table.



Morse code is still heavily used for cubesat beacons.

Try to get the best signal to noise ratio by adjusting the bandwidth. Start with a bandwidth of 500 Hz.

2. Test 2: Medium strong "real life" signal with data to decode

- Tune your receiver to **144.800 MHz** and select **FM**. Set the bandwidth to 20'000 Hz. Listen until you see a signal on the waterfall diagram and hear the data signal in the loudspeaker. It should sound similar to a demonstrated example. Then do not change anything on the receiver settings.
- Connect the radio audio output to the Virtual Audio Cable (VAC).
- Start the UISS decoder. Verify that
 - you connected the input of UISS to the Virtual Audio Cable (VAC)
 - the selected modem is **VHF AX.25 1200 bd**.

After a short while – as signals are coming in – you will see decoded data.

Your decoded data should look similar to the following example:

```
Fm M0GQS To APMI06 Via MB7UW*,MB7UCC*,WIDE2* <UI pid=F0 Len=57 >[20:47:08]
@071849z5126.27N/00057.83W-WX3in1P1us2.0 U=14.1U, T=38.5C

Fm MB7USB To APW10 Via MB7UCC*,WIDE1*,WIDE2-1 <UI pid=F0 Len=27 >[20:47:14]
@184714h5108.41N/00054.31E-
```

Now you are ready to receive real-time online data from the International Space Station (ISS). The ISS uses exactly the same protocol and data format. Of course you can only receive data from the ISS when it is in sight of your location. You can always check this on www.heavens-above.com.

3. Test 3: Weak beacon Continuous Wave (CW) and Morse Code

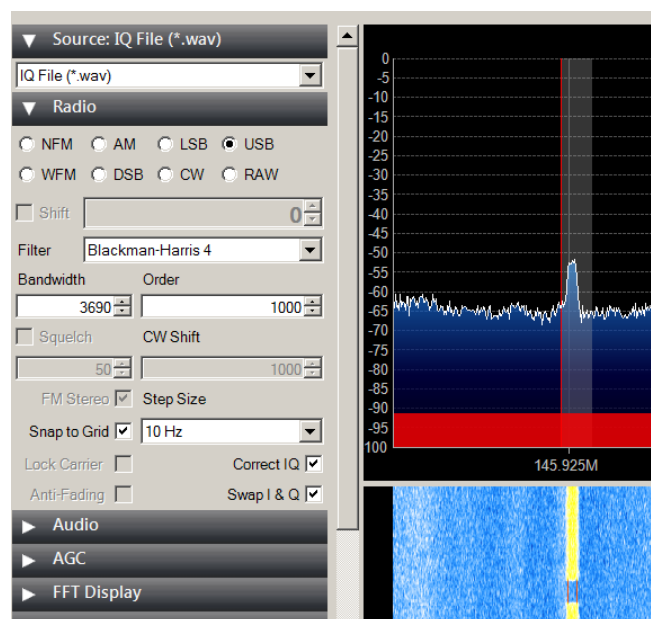
Tune your receiver to **144.4494 MHz** and select **CW**. Set the bandwidth to 500 Hz.

There is a weak signal from the beacon Grenchenberg **HB9HB**. Use a narrow bandwidth. Verify that you really receive the HB9HB beacon. There is another beacon very close to this frequency with a different call sign. Depending on atmospheric conditions (inversion) sometimes you can hear beacons from very far away. We are only interested on hearing the HB9HB beacon. Because the site of our test transmitter is between high buildings, it may be necessary to perform this test from the meadow between our campus and the train station Horw.

If you can hear this beacon transmitter, the sensitivity of your system is sufficient to receive signals from many of the cubesats and other satellites. Satellites, which are easy to receive, are e. g. **AO-73** and AO-85 and of course the **ISS**.

4. Test 4: Decoding of FUNcube-1 telemetry and fitter messages

The following settings in SDR# are necessary to decode the **IQ-Testfile** from the dropbox:



- Decode the file EMrecording3_weak_20131005_161728Z_145942kHz_IQ.wav by the complete signal chain: SDR# -> VAC -> FUNcubeDashboard. Settings: Auto Tune
- **Check** the monitor audio option, so that you can simultaneously decode and listen.
- **Check** that the realtime display of the FUNcubeDashboard is populated.
- **Check** that some fitter messages are decoded. You will be asked about the contents of Fridays fitter messages.

5. Recommendations for additional testing

- Can you verify the predicted directivity of the antenna?
- How far do you have to move from the transmit antenna to be in the far-field?
- What is the difference with and without the amplifier?
- Is there a difference, whether you switch off the amplifier by removing one of the batteries or whether you take the amplifier completely out of the signal chain?
- Try different bandwidth settings? What does this effectuate?
- Design, execute and document additional

6. Satellite signals vs. terrestrial signals

There are many terrestrial signals. Furthermore even very sophisticated and expensive receivers generate annoying internal signals (spurious signals, birdies from mixing products, ...)

How can I be sure, that a signal stems from a satellite?

- Satellite signals are generally weak and they
- Always show a **Doppler effect**, i.e. the frequency changes slowly from high to low and has to be – in your case - compensated for by hand on the VFO (or by computer software).

Change history

version	date	state	changes and remarks	author
1.0	07-09-2016	draft	first version	M. Klaper
1.1	07-09-2016		Added settings for IQ decoding	M. Klaper
1.2	09-09-2016		Added bandwidth recommendations	M. Klaper

Table of contents

1. Test 1: Strong Signal Continuous Wave (CW) and (slow) Morse Code.....	2
2. Test 2: Medium strong "real life" signal with data to decode	2
3. Test 3: Weak beacon signal Continuous Wave (CW) and Morse Code.....	3
4. Test 4: Decoding of FUNCube-1 telemetry and fitter messages	3
5. Recommendations for additional testing.....	4
6. Satellite signals vs. terrestrial signals.....	4