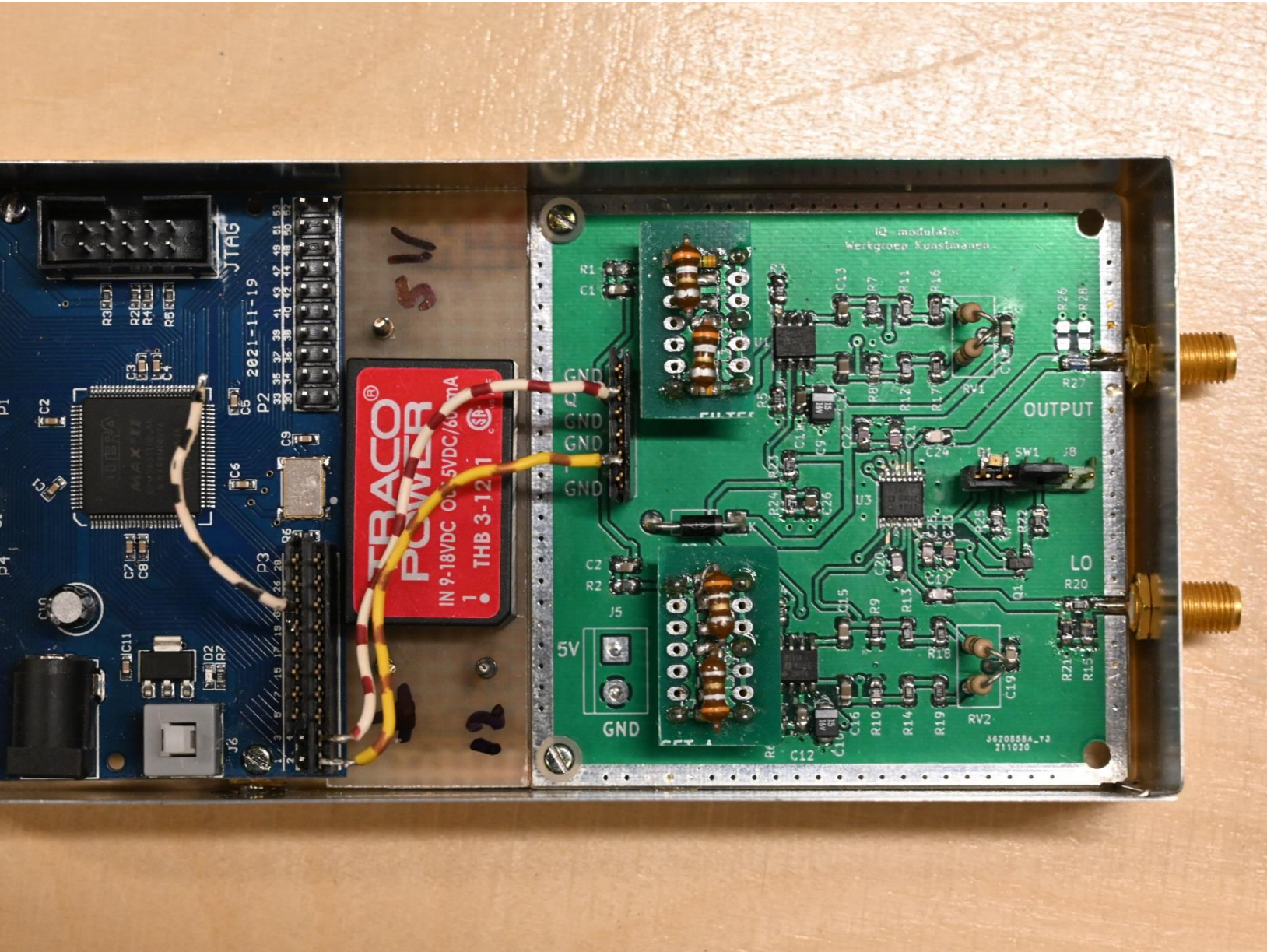




DE KUNSTMAAN

September 2022 - 49th Annual No. 3

Published by the Werkgroep Kunstmanen



This issue includes.

Satellite positioning with Satpy
QPSK Generator in CPLD
X-band receiving stations
and many more

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The next meeting will be on 19 November 2022

Photos

Front page:

Harm de Wit's artificial satellite modulating QPSK at 1700MHz with a CPLD

Inside pages:

All photos and images accompanying the various articles are by the respective authors unless otherwise stated.



DE KUNSTMAAN

Association organ of the Werkgroep Kunstmanen.

The Artificial Moons Working Group aims to promote the observation of artificial moons using Visual, Radio Frequency or other means.

This magazine is published 4 times a year and contains publications in the field of visual and radiographic observations of artificial Earth satellites.

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All internet references accompanying the articles can be found on our website under:
<Weblinks | Links from KM>

Ben Schellekens

Foreword

The renovation of the Nimeto is progressing very well. The previous meetings, during the renovation, were in a big old room. This classroom was accessible via a footbridge across the street. The lift was not always available, so you had to climb a lot of stairs.

How much better is the room we are in now. It is on the ground floor. Accessible through the main entrance, it has moved slightly. On entering, turn right and then the classroom is at the end of the corridor.

There are very spacious desks / work tables with sockets at the sides. There is also a very large TV / monitor that can be connected via an HDMI cable.

What an improvement on the canteen we were in before. If you wanted to present something, everything had to be darkened. You were bothered by other groups having lunch or having to go outside to smoke.

Parking was also possible again. Next to the old canteen, where we also had our antenna set-ups in the past, is a car park.

The only drawback is that the room is noisy. The sound echoes against the bare walls. I don't know if they are going to do anything about that.

This brings me to the next point.

Zoom during the meeting

Because of corona, we were able to continue the meetings online. Now, fortunately, we can meet again and have combined this with participation via zoom.

Speaking close to the microphone is easy for zoom participants to follow. But at the ask around, we don't get it right. We tried different mobiles for the camera and microphone function. Still it is not easy to follow for the zoom participants. Because we also focus on offering the roundtable as well as possible via zoom, the character of the roundtable is lost.

The number of participants via the zoom is also low now because you can now come to the meeting. The informal part of the meetings after the official part is not possible via the zoom at all.

We have therefore decided to stop offering the meetings through the zoom. We can better focus on

offering quality meetings for the members who make the effort to come to Utrecht.

De Kunstmaan

Rob has written a sequel to the QPSK generator in a CPLD. The advantage is that you don't have to sacrifice an FPGA to generate a test signal. His second article is about the third generation of the Meteosat, which is already coming. In preparation for this, test data has already been released. This data can be processed by both Satpy and xrit2pic. His latest article is about satellite positioning. This is needed, among other things, when you want to add land contours to the recording.

Job managed to receive his first pictures from the 8GHz! More on this in this "Kunstmaan".

I myself described what was published in the Dubus and the UKW-berichte. And still managed to receive Syracuse this summer! A description of the reception setup and how the ADF5355 is controlled is in this Art Moon.

Enjoy reading "de Kunstmaan" and see you at the meeting on 12 November or earlier at the Day for the Radio Amateur on 29 October!

Ben Schellekens
Chairman "Werkgroep Kunstmanen"



Meeting Nimeto September

Dear members,

As is well known, a pdf membership is also available. Information where the pdf can be retrieved is in an additional newsletter sent via email to all members.

As it now turns out, there are people who have (inadvertently or not) unsubscribed from the newsletter and therefore do not receive a newsletter containing the link for a newly released "de Kunstmaan".

We are therefore going to split this; the link to a new magazine will be put in a separate newsletter (which will contain no further information besides the link) or email, to which every member will be automatically subscribed. (No action required on your part!)

By the way, it is of course important that we have the correct email address! Unfortunately, this is not always the case.

On the website, you can see to the right whether a new magazine has been released. Normally it is in March, June, September and December. If you have not yet received anything please check the website to see if "de Kunstmaan" has already been sent; if you have not received anything (either pdf or paper) please let me know, e.g. via the website: menu Contact → Contacts → Rob Alblas.

 Werkgroep
Kunstmanen



Laatst verstuurde
"Kunstmaan" (op
29-06-2022):
**DE KUNSTMAAN nr. 2,
2022**

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Volgende bijeenkomst:
**De eerst volgende
bijeenkomst is op 10
september, in het Nimeto
in Utrecht.**

U bent welkom vanaf 10:00
(start "officiële" deel 11:00)

Locatie:

Gebouw: NIMETO
Smijerslaan 2
3572 LP Utrecht (Tuindorp)



POSITIONING SATELLITES WITH SATPY

Rob Alblas

There are several ways to determine the position of a satellite at a given time. For many years, the Kepler elements have been used for this purpose.

With satellite files transmitted via Eumetsat, either via Eumetcast or via the internet, position data is added to those files; this allows Satpy to add precise land contours etc, without the need for separate Kepler elements. With Metop, that data is even in there in two ways:

1. as lon/lat positions (103 points per line of 2048 pixels: from pixel 5 to 2045, i.e. one position for every 20 pixels; intermediate points should then be interpolated)
2. Kepler elements used to calculate position; positions in the scanning direction, i.e. perpendicular to the orbit, must be calculated separately if necessary

Satpy will use the lon/lat positions directly for position determination; the Kepler elements are not used, as far as I know. Data from other satellites, such as NOAA20, as far as I know do not contain Kepler elements, only lon/lat positions.

Older NOAAs, relayed by Eumetsat, do not contain position information at all, and as far as I know cannot be used in Satpy if positions are required in the process. There are also no 'readers' (functions that convert the data into images) for these satellites available in Satpy.

So Kepler elements are not really needed for Satpy. But if a plate needs to be made of a certain part of the Earth, you do need to know when a polar satellite "takes" that part, so that only the relevant files are decoded. For this, Kepler elements are then needed. In the Satpy scripts, Ernst Lobsiger has done this by using Kepler elements in TLE format. If you use recent satellite files then this is not such a problem; you simply fetch the latest Kepler elements from e.g. the Celestrak site. However, if you want to look at data from the past then you also need the Kepler elements around that time. Although the accuracy is not so important here (the Kepler elements are not used for overlays etc., only for a rough estimation of the position), you will sometimes have to use old Kepler elements, which you don't have so readily available.

For Metop, this would not be such a problem because, as mentioned, the Kepler elements are already in the files; it would only be necessary to open a single file of the day in question to extract that data, after which you can calculate the stretch of orbit for that day with sufficient accuracy.

Unfortunately, this cannot be done for other satellites if they do not contain Kepler elements. True, you could extract the lon/lat positions from the files, but then you would have to do that for several files until you got the file with the desired position. That could become a lengthy process. Or you have to try to extrapolate from the positions of one file (which contains several lines so multiple sub-sat positions) the trajectory for the rest of that day, which is not so easy.

Old Kepler elements are available from the site Space-track.org ([1]). Here you can get several Kepler elements per day of all satellites of interest to us, from the launch of the satellite in question until now. Fortunately, this can also be done via commands so that things can be automated. For this site, you need a login and password, but that is easy to do; there is a "Create account" link on the above website.

Once logged in, you can enter a satellite name via tab "ELSET Search", and enter the start and end dates, and a list of Kepler data between those two times will be shown. Incidentally, you can also see the orbits of satellites that are either out of service or broken, e.g. of NOAA13, but even NOAA 1 seems to still haunt uselessly.

Retrieving old Kepler elements in this way is quite a hassle; as mentioned earlier, it can also be done via commands. There are several examples on the site on how to retrieve the desired data, e.g. using wget or curl. For satpy, we want to do that in Python. Python wouldn't be Python if a library wasn't already written for it: 'spacetrack' ([2]) With just a few spacetrack-specific commands, the Kepler data can be retrieved in TLE format:

```
drange = op.inclusive_range(dt1,dt2)
lines = st.tle(object_name=Sat,
iter_lines=True, ) .
    epoch=drange, orderby='TLE_LINE1',
format='tle')
```

The first line defines a time span; dt1 and dt2 can be created with 'standard' commands:

```
dt1=dt.datetime.strptime(Date, '%Y-%m-%d')
dt2=dt1+dt.timedelta(hours=23,minutes=59)
```

'Date' is then e.g. '2020-04-03', dt1 is that day at 00:00. dt2 is the time at the end of the same day.

The second line is structured as follows:

- SAT: satellite name, e.g. Sat='METOP-B'
- epoch: time span as just defined
- format: in this case TLE

The time span between dt1 and dt2 must be large enough to ensure that Kepler's are available herein. 'lines' now contains a number of line pairs; several TLEs may be defined in a day. Of these, we will only use one: the first one in the list.

Using the Python scripts I have on my website ([3]) an example, for METOP-B, day recording: (only the relevant options are shown here)

```
python3 Metop.py -t 20190607 -sat BD -area
euro1 -histtle
```

In this case, a TLE file METOP-B.TLE will be used, so each satellite will have its own TLE file. If a TLE file name is explicitly specified with option -tle, it will be used. So this may then contain orbital data from multiple satellites and multiple days, which is no problem.

Complete handling is now as follows (see fig. 1)

- If historical TLE is needed, add option -histtle to the command
- Using the -t option, the TLE file is searched for the orbit data nearest in time for the specified satellite. So in this case, for satellite METOP-B with time corresponding to 7 June 2019.
- It can be specified how much the time may vary; the default is now 0 days. If no suitable orbit data has been found, it is retrieved from space-track and added to the TLE file. This way, this orbit data is immediately available for next time, without consulting space-track again first.
- The orbit data thus obtained are used to determine the metop files needed for the specified area, in this case 'euro1' (see 'area' option)

If the -histtle option is not specified then everything works as before, so it is assumed that the track data in the available TLE is good enough. To retrieve space-track's TLEs, a login is required, as mentioned above. Name and password should be stored in a separate file 'spacetrack.ini':

```
[configuration]
username = <login-name>
password = <password>
```

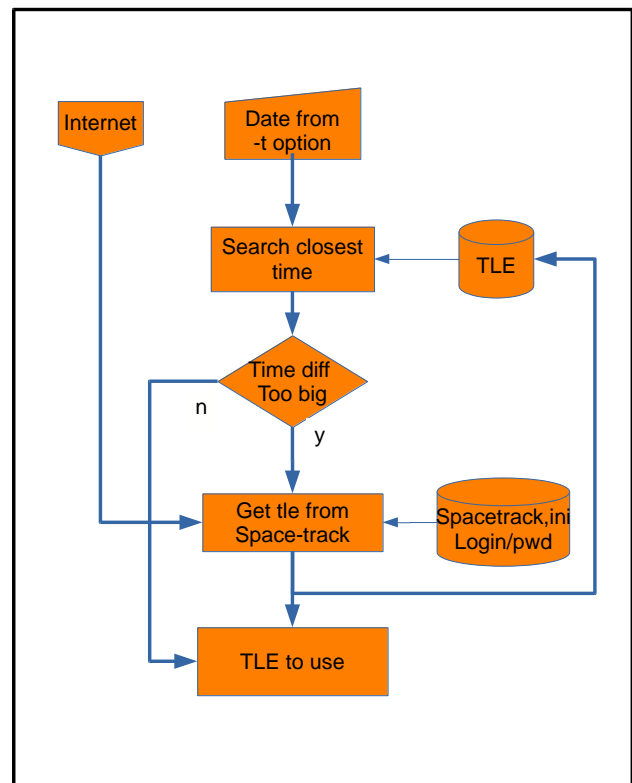


Fig. 1. Determination TLE.

TLE: how much longer?

It was recently announced that the TLE format will be abandoned. The problem with this format is that the NORAD number can only have 5 digits. NOAA 1 of 1970 has No 4793, NOAA19 of 2009 has No 33591 and Metop-C (2018) No 43689 With the large number of satellites to be launched, that 5-digit number will no longer be sufficient. For now, the TLE format will continue to be supported, but if we get above satellite No 99999 then we will have to switch to another format for those satellites. (See [4]) One such format is XML (actually a meta-format; it is used for all sorts of things, including gpx data). It is already available now, including via spacetrack. I have kept it with TLE for now but in due course that will have to be changed. By the way, the numbers in that XML format are the same as what is in the TLE format; ultimately it is intended for trajectory calculation via the SGP4 model.

Here is an example of the old TLE format and the same information in (part of) an XML file.

0 NOAA 20

```

1 43013U 17073A 22207.13069778 .00000010 00000-
0 25443-4 0 9996
2 43013 98.7169 145.0826 0000948 64.0715
296.0558 14.19563126242712

```

```

<body>
  <segment>
    <metadata>
      <OBJECT_NAME>NOAA 20</OBJECT_NAME>
      <OBJECT_ID>2017-073A</OBJECT_ID>
    </metadata>
    <data>
      < meanElements>
        <EPOCH>2022-07-
26T03:08:12.288192</EPOCH>
        <MEAN_MOTION>14.19563126</MEAN_MOTION>
        <ECCENTRICITY>0.00009480</ECCENTRICITY>
        <INCLINATION>98.7169</INCLINATION>

<RA_OF_ASC_NODE>145.0826</RA_OF_ASC_NODE>

<ARG_OF_PERICENTER>64.0715</ARG_OF_PERICENTER>
      <MEAN_ANOMALY>296.0558</MEAN_ANOMALY>
    </meanElements>
    tleParameters>

```

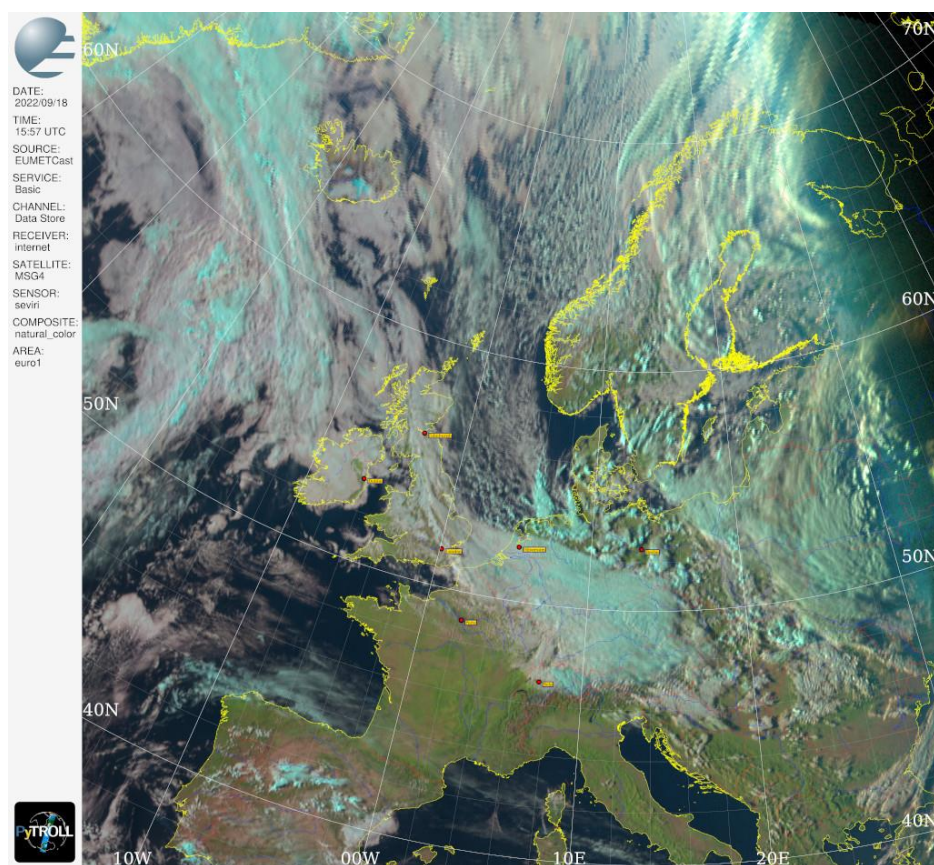
```

.....
<NORAD_CAT_ID>43013</NORAD_CAT_ID>
.....
</tleParameters>
</data>
</segment>
</body>

```

References

- [1] [Site space-track](#)
- [2] [spacetrack with Python](#)
- [3] [Satpy scripts-scripts](#)
- [4] [A New Way to Obtain GP Data](#)



Only with a Raspberry Pi

This record was produced entirely with a Raspberry Pi using (almost exclusively) Python:

- download data from Eumetsat Data Store via the internet (see 'Meteosat without an antenna', "de Kunstmaan" 2020-3, 2020-4 and 2021-1)
- Editing with SatPy

More on this in the next KM.

MY FIRST X-BAND RECEPTION

Job de Haas

As may be evident from several previous articles of mine in “de Kunstmaan”, I have been working for some time on the conditions to receive and automatically track satellites in X-band.

Having finally succeeded in capturing the FengYun 3D's transit, here is a summary of the means I used in the process. And, of course, the experiences so far with those solutions.

The dish

As a dish, I have a newly purchased Laminas OFC-1200 polyester dish. It is a 1.20m offset dish. The purchase was some six years ago and I chose this one in particular because of its relatively low weight: (8kg including mounting brackets).



Fig 1. The dish setup with rotor

Of the dish, I have the manufacturer's parameters and I also measured and calculated it using Paul Wade W1GHZ's method ([1]) and those values matched nicely, so I am confident about that.

The rotor

About the rotor I have already told a bit in a number of articles ([2]). Nevertheless, it still took me quite some time to achieve an accuracy of less than 0.5 degrees. This was not so much due to the measuring accuracy of the encoders, but to all kinds of mechanical effects. What worked well was returning to a position. This succeeded with an accuracy of about ± 0.1 degrees. What worked less well was

that after a command of moving 90 degrees, it sometimes became 91 degrees, depending on the start and end position.

Using a digital spirit level that I mounted in various places on the rotor and dish, I was finally able to determine a reasonably reproducible deviation, especially of the elevation. That deviation is not simple deflection or backlash and varies across the range. I now correct for this in my version of the rotor controller software.

I was able to do the positioning of the azimuth most accurately with the sun. For this, I use a function to plot the received power over a longer time (30 minutes). In *xtrack*, I then set the rotor in the direction where the sun will be in 15 minutes and I also note the azimuth angle associated with it. From then on, the rotor is stationary and I measure the power in the receiver for 30 minutes.

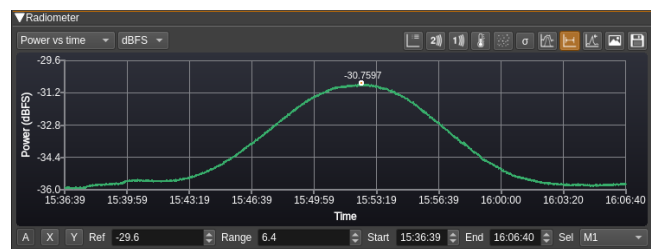


Fig. 2 Evolution of received power from the sun

The gradient then looks like Figure 2. In the program I use for this (*SDRangel* [3]), you can also save this data as a text file, allowing you to determine the time of the maximum even more precisely. Then, with the time you then find, you can look in *xtrack* to see what the azimuth angle associated with that time is. The difference between this angle and the previously noted angle is then the error remaining in the azimuth calibration. You can specify that in *xtrack*, for example, as an extra offset.

The horn

A good feed for an offset dish is a W2IMU 'dual mode' horn ([4]). This horn has two diameters, the actual horn with SMA connector, a reducer and then a wider input. According to initial calculations, an opening diameter of 52mm was good. An outer diameter of 54mm is a standard size so I bought standard reducer from 54 to 28mm. Later I found out that 60mm for my offset dish is a better match. I am still constructing that version.



Fig 3. Horn with amplifiers and conversion stage.

Amplification and conversion

The received signal must then be amplified and converted to a frequency that can be processed by my receiver (a LimeSDR).

Since I still do not have a fully working homebrew LNA with sufficient gain, I now use 2 LNAs purchased via eBay. The first is a MITEQ AFS3-08500960-15-10P-TC-4 at 7800 MHz it has ~32dB gain and ~1.1dB noise figure. The second LNA is an ALN/078-1724-34. That one has about 23dB gain at ~1.6dB noise figure.

The mixer is an active mixer with a built-in doubler for the LO. So with an ADF4351 signal generator at 3.5GHz, I get a conversion of 7GHz down. The gain of the whole chain is 45dB, which matches nicely with the gain of the two LNAs and the 10dB conversion loss the mixer gives.

The output of the mixer goes with a 50ohm coaxial cable of about 10 meters directly to my SDR.

The receiver

As a receiver, I use an SDR. The LimeSDR USB to be precise. This one can receive from 100KHz to 3.8GHz, more than enough for the 500-1500MHz

coming out of the mixer. Unfortunately, the LimeSDR USB is no longer in production.

The LimeSDR itself also has several amplifier stages that can be set precisely by 1 or 3 dB steps. For me, this gives at least another 28 dB or so improvement in SNR in the receiver, so you have to use it.

The maximum sample frequency of the LimeSDR when using USB3 is limited to 61.44MS/s. However, I find when using SDRangel that I then lose samples because the laptop doesn't keep up. Therefore, I usually use 56MS/s as the maximum. The LimeSDR has 12 bit samples, but so far I only used 8 bit to limit file size. With 8 bit, you need about 3.5GB per minute, and if you use 16-bit storage already 7GB per minute. That's already getting very tight on my laptop for daily use.

The decoding

Since we do not yet have a receiver in hardware for the X-band satellites, I had to look for an alternative. Fortunately, there is a very nice software tool in the form of *SatDump* ([5]) that makes this very easy. It is an open source application available via github. Written in C++ and pretty well optimised. On a very fast PC you even seem to be able to decode live, but I haven't tested that. I am currently using version 0.39.

The procedure is first to make a recording via the Baseband Recorder (fig 5 and 6) and save the digital data stream to disk. Then, via the Offline Processing screen (fig 7), decode the data into the various instrument images that are all part of the data stream. These are sometimes many dozens of images depending on the satellite.

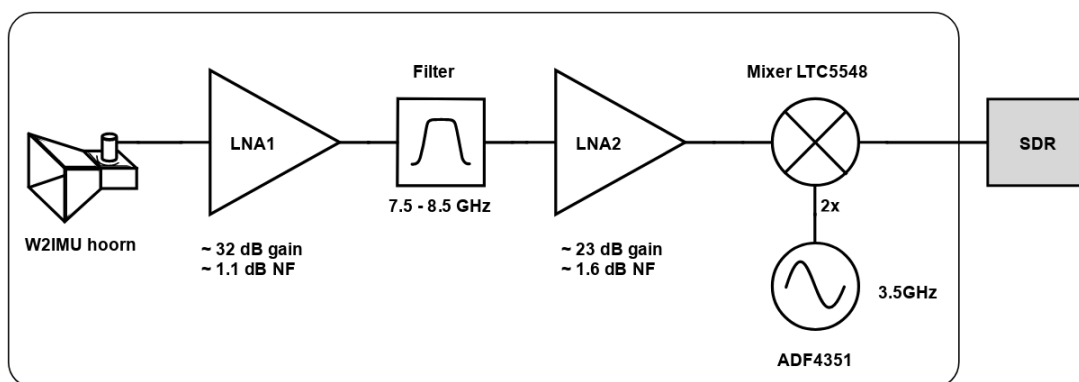


Fig. 4 Schematic representation of the amplifier and conversion stage

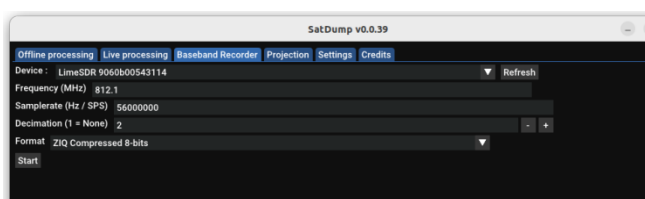


Fig 5. Configuring the Baseband Recorder

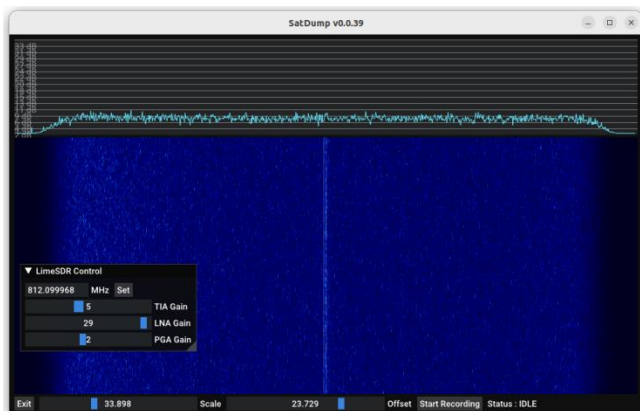


Fig 6. Spectrum/Waterfall and amplifier settings in the Baseband Recorder

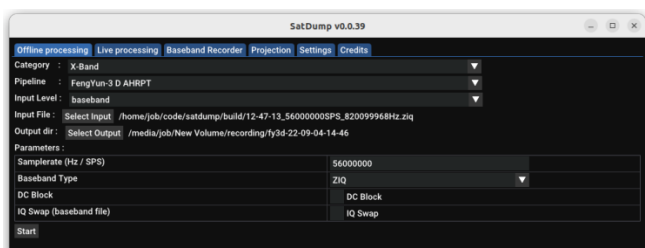


Fig 7. The Offline Processor using FY3D as an example

The images, like the stored data stream, are very large. The image in Fig 8 is the perspective-corrected version and is 116.5MB in size. Image 9 is a full-size part when printed at 300 dpi (dots per inch). Figure 10 is an image taken 3 days later and gives an idea of the level of detail.

Conclusion

The first reception of FengYun 3D is a nice step. It is a strong signal and therefore nice to start with. The other weaker satellites are not yet easy to receive with my current set-up. For that, I will first have to tune the receiver better to my dish and possibly add some additional gain as well.

We also still need to work on weatherproofing the dish, so plenty to do!

References

- [1] [OFFSET-FED PARABOLIC DISH ANTENNAS.](#) Paul Wade
- [2] "de Kunstmaan" June 2021 No. 2 and "de Kunstmaan" March 2022 No. 1
- [3] <https://www.sdrangel.org/>
- [4] http://www.w1ghz.org/QEX/circular_wg.pdf
- [5] <https://github.com/altillimity/SatDump>



Fig 8. The first received MERSI2-RGB-3(24)1-CORRECTED image of 11600x2600 pixels on 20/8/2022 at 14:26

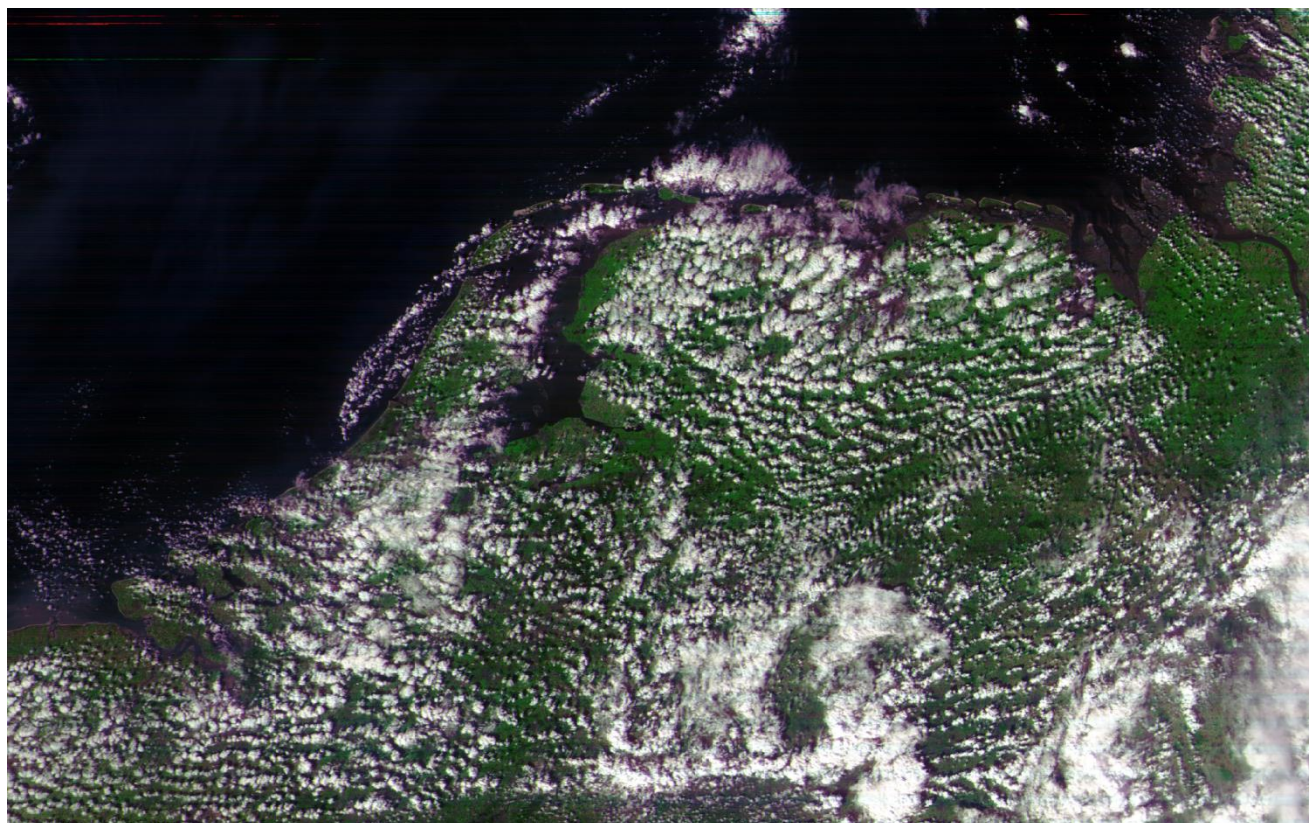


Fig 9. Zoomed-in view of the Netherlands FY3D

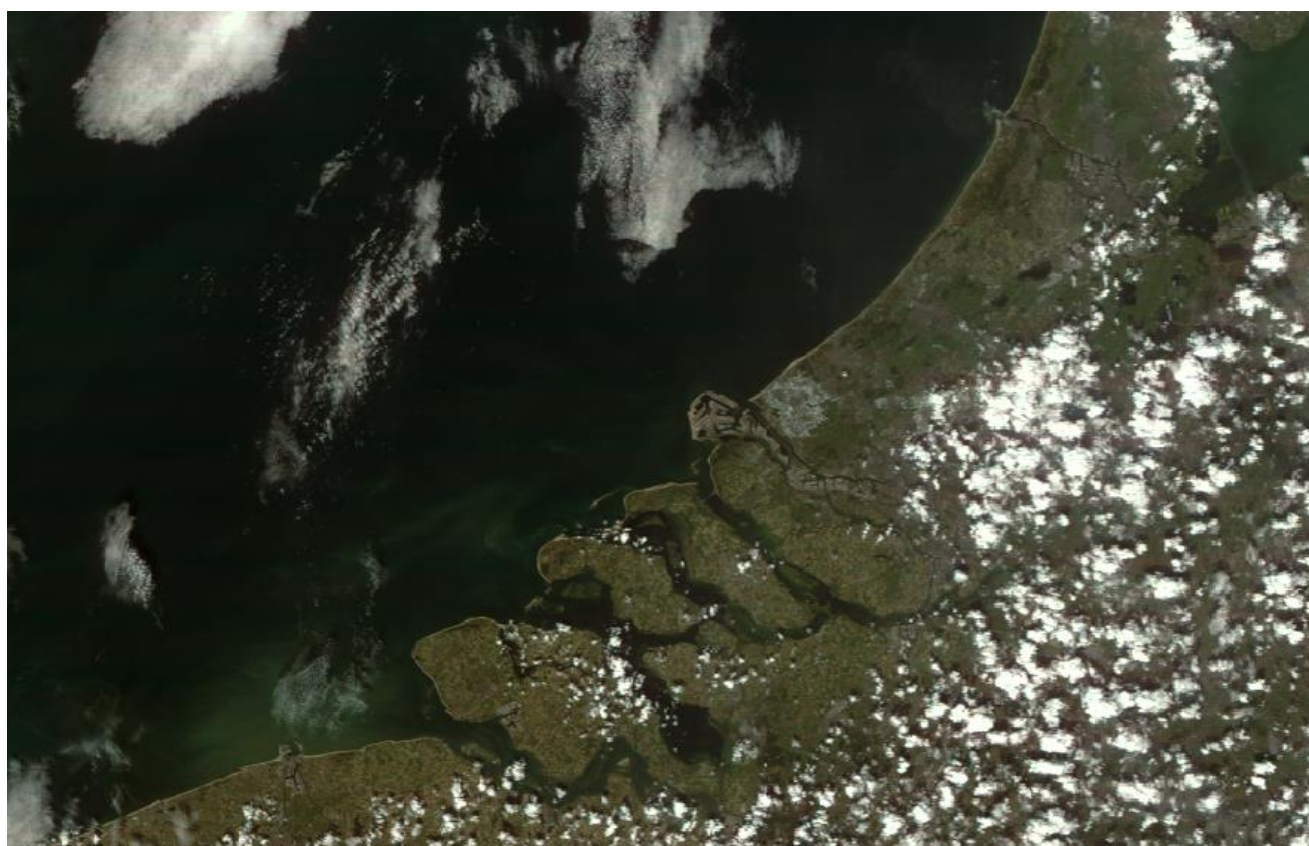


Fig10. Zoomed-in image of western Netherlands, showing recognisably the islands of Zeeland, the Maasvlakte and Westland. Recorded from Fengyun 3D on 23 August 2022 at 15:11.

QPSK GENERATOR IN CPLD

PART 2

Rob Alblas

In the previous KM ([1]), I discussed a QPSK generator that can be programmed into a simple CPLD. I did not then discuss the Quartus software, which can be used to synthesise the VHDL code and program it into the CPLD. Herewith.

For now, I will stick to explaining how to programme the CPLD yourself.

Quartus software

The CPLD used is of the Altera/Intel brand. To program those, you need associated programmes: Quartus. This software is free and easy to install; in part 1 I already gave the link where to find it.

On github ([2]), in addition to the vhd, I also put a bit-file and command-file that make it easy to program the CPLD. The zip-file `qpskgen_upload.zip` contains the following files:

- `qpskgen.pof`, which contains the bit code
- `qpskgen.cdf`, this is a control file
- `qpskgen_upload.sh`, the command used to program the CPLD

There are now 2 ways to programme the CPLD:

- With the Quartus GUI, only the `.pof` file is needed
- Or with a command from a shell.

Via the gui, programming goes as follows: (only the `.pof` file is needed)

- Connect the USB programmer to the CPLD board and a USB input of your computer.
- Also connect 5V to the CPLD board and press the on/off switch. An LED should now light up; a new CPLD may already have a programme on board where another LED will flash.
- Start Quartus, you will get the following screen; see fig. 1.

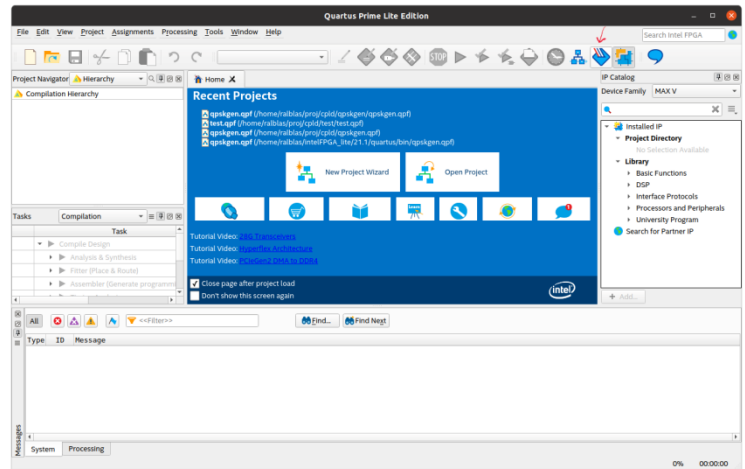


Fig. 1. Start screen

- In the upper-right corner, near the drawn arrow, click the 'Programmer' icon. You will then get a new window, fig. 2:

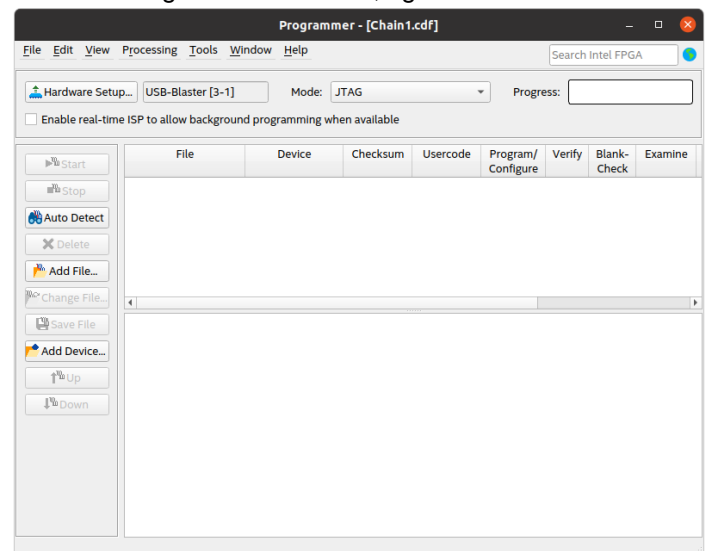


Fig. 2. The 'Programmer' window.

- Click 'Add file' and search your PC for the file `qpskgen.pof`. Click 'Open'.
- Under 'Program/Configure', tick the first button, the rest will go with it.
- Do the same under 'Verify'. See fig. 3.

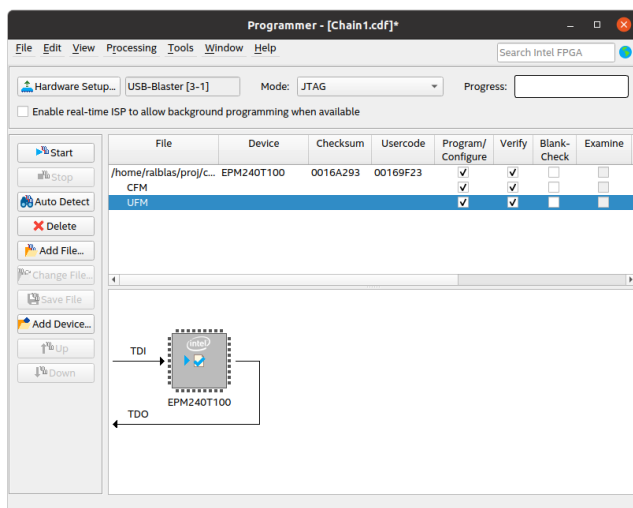


Fig. 3. Ready for programming.

If all goes well then you can now press 'Start' button. The CPLD is programmed and after a few seconds, you will see 100% (Successful) in the upper-right corner at 'Progress:'.

With a command, it goes as follows:

- Connecting CPLD with programmer and power supply.
- Run programme: *qpskgen_upload.sh*. Note: Now both .pof and .cdf file are required. (This script contains the following
- command: `quartus_pgm -c USB-Blaster qpskgen.cdf`)
- Among other things, you will then get the following message rolling across the screen:

```
Info: Command: quartus_pgm -c USB-Blaster
qpskgen.cdf
Info (213045): Using programming cable "USB-
Blaster [3-1]"
Info (213011): Using programming file
./qpskgen.pof with checksum 0x0016A293 for device
EPM240T100@1
Info (209060): Started Programmer operation at
Wed Aug 3 14:34:15 2022
Info (209017): Device 1 contains JTAG ID code
0x020A10DD
Info (209018): Device 1 silicon ID is ALTERA04-0
Info (209044): Erasing MAXII/MAXV configuration
device(s)
Info (209023): Programming device(s)
Info (209021): Performing verification on
device(s)
Info (209011): Successfully performed
operation(s)
Info (209061): Ended Programmer operation at Wed
Aug 3 14:34:19 2022
Info: Quartus Prime Programmer was successful. 0
errors, 0 warnings
```

This completes the programming.

The above was performed under Linux, Ubuntu. I also tried this under Windows-10, but windows had some problems recognising the USB programmer. Apparently, all sorts of things need to be installed again; under Linux, it just works immediately...

References

- [1] QPSK generator in CPLD. "de Kunstmaan", 2022 no. 2, p. 12.
- [2] [Github: qpsk generator](#)



Recording of Fengyun 3D on 23 August 2022 at 15:11 with SatDump. See zoomed-in image in Fig 10 on page 11

ADF5355 WITH AN ARDUINO

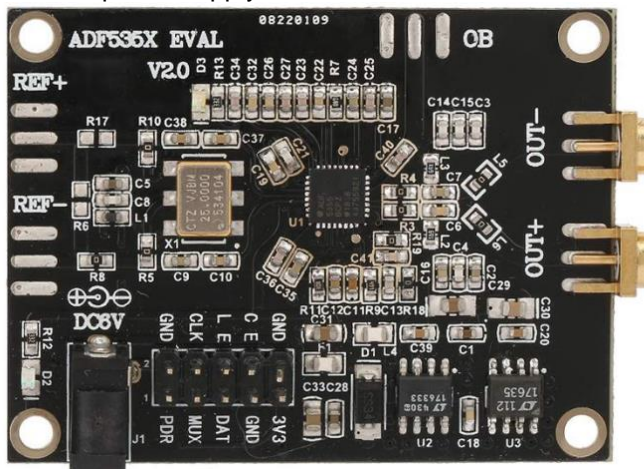
Ben Schellekens

For my 8 GHz downconverter, I use a (probably) Chinese development board with an ADF5355. I bought this some time ago for 90 Euros, these days the price has gone up to 240 Euros due to the chip shortage!

ADF5355

I have already written about the ADF5355 in the June 2021 "Kunstmaan". The VCO runs from 3400 to 6800 MHz and with a doubler you get to the 13.6 GHz range. In the downconverter application, I do not use the doubler. The signal from the connection RFoutA goes to the mixer of the downconverter.

I did make some additions to the development board: an extra power supply board and a 100 MHz VCXO.



The ADF5355 development board.

Power supply print

Since I want to power the ADF5355 with 12V, I used an LM317 regulator that provides the required 6V.

I left the voltage regulators sitting on PCB of the ADF5355 for what they are. These LT1765 and the LT176333 seem to produce a lot of noise anyway. Radio amateur GM8BJF has designed a PCB with the ADM7150 that are very low noise. This might be something for later when the downconverter takes its final shape.

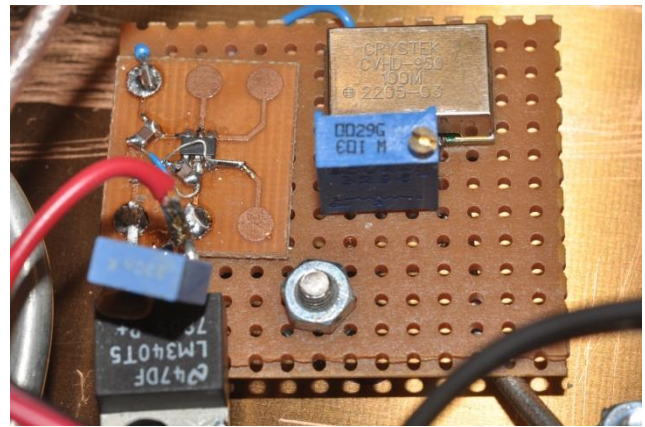
Oscillator

On the development board is a 25 MHz oscillator. In the output signal, you will see multiples of that 25 MHz. Because the bandwidth of the received signals runs from 15 to 60 MHz, this oscillator will still make an unwanted contribution to the noise.

Hence, I replaced the oscillator with Crystek's CVHD-950 100 MHz. This is a so-called "ultra-low phase noise" VCXO. This oscillator can be set to the right frequency with a control voltage. Because of the

Doppler effect (and therefore changed reception frequency), this is not so important for us.

The VCXO needs a supply voltage of 3V3 at a maximum of 25mA. I placed a 3V3 regulator behind a 7805.



The VCXO on hole board. Bottom right you can see a piece of coax to the ADF5355. Top left is the 3V3 regulator on a separate PCB.

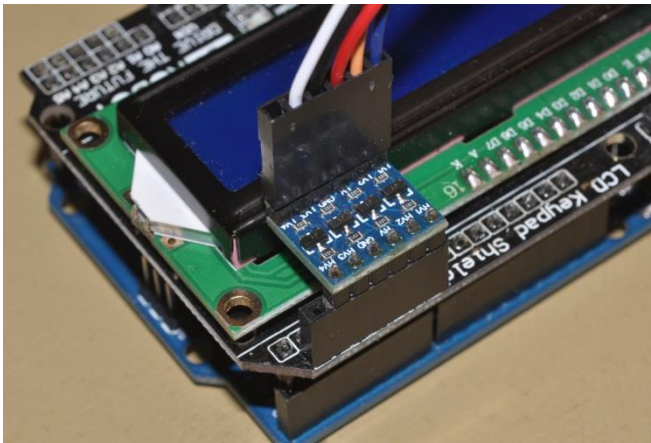
To disable the existing 25 MHz oscillator, you need to remove a 0-Ohm resistor. A coaxial cable I soldered to the REF connector of the development board.

The construction is not ideal. It is probably better to can the oscillator to prevent the 100MHz signal from irradiating the output of the ADF5355.

SPI interface

The ADF5355 does nothing by itself and will have to be programmed via an SPI interface. This interface allows only 3V3 signals. The Arduino provides 5V signals. Without a level shifter, you run a good chance that the ADF5355 will break, it won't work anyway.

The level shifter I bought is suitable for 4 channels and so can be used for I2C or SPI signals to convert them to and from 3V3 and 5V. So they are bidirectional level shifters. For SPI (as here with the ADF5355), a voltage divider would also suffice, but I found that such a hassle to build this with resistors.



The level shifter on the LCD keypad shield

The level shifter needs two supply voltages, the high 5V and the low 3V3 and a (common) ground. Of the four channels, we use only three.

The best thing would be if I could plug the level shifter directly into the Arduino and not have to bother with wires for the power supply. Since the level shifters hardly consume any power, we can use GPIO pins for this and this does not pose any problems for the Arduino either.

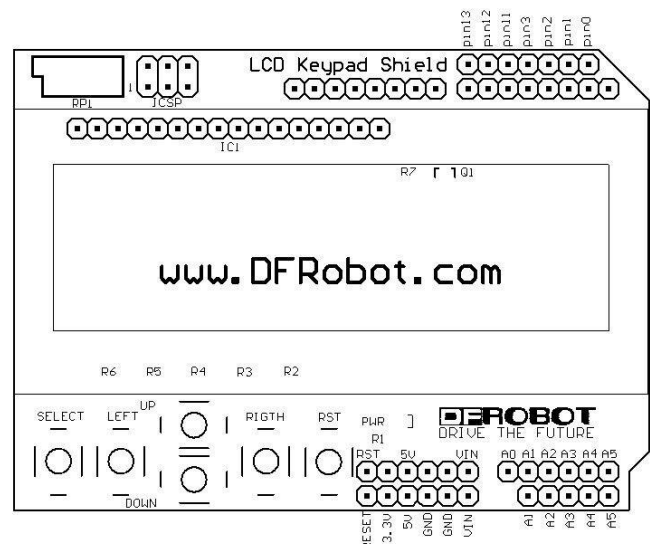
Now putting 5V on an output of the Arduino is no problem. But how do you do this with the GND? You can do that too, by writing a "LOW" to the relevant pin, it will then "sink".

Below is the relevant code:

```
// Power for the level converter
pinMode(11, OUTPUT);
digitalWrite(11, HIGH);
pinMode(3, OUTPUT);
digitalWrite(3, LOW);
```

Arduino code

I chose a fixed centre frequency of 1420MHz. This is the frequency where hydrogen line measurements take place and is a quiet part of the spectrum. It also falls in the middle of the 900 and 1800MHz GSM bands. This means that the VCO has to be set to different frequencies for the different satellites. I use the Arduino "LCD Keypad Shield" for this, which is a combination of an LCD display and some push buttons. Very nicely, there is a corresponding library: <https://github.com/dzindra/LCDKeypad>



The pin layout of the shield. This is not the same for all "LCD keypad" shields!

Unfortunately, we cannot use the built-in SPI hardware. The hardware-matched SPI interface of the Arduino / ATmega328 uses pins 10, 11, 12 and 13 (ChipSelect, DataOut, DataIn, Clock), but the LCD display uses pins 4 to 10, and the analogue pin A0 for the push buttons. And we use pin 11 as the power supply. So there is overlap in pins 10 and 11, which is why I opted for the so-called "bit ganging" of SPI. In this, you go into the programme code to switch the relevant pins on and off. I do this with the function below:

```
void sendCommand(longvalue)
{
    digitalWrite(slaveSelect,LOW); //chip
    select is active low
    delay(1);

    for (int i = nrbits; i >= 0; i--)
    {
        onoff = bitRead(value, i);

        digitalWrite(that,onoff);
        //delay(1);
        digitalWrite(clk,HIGH);
        //delay(1);
        digitalWrite(clk,LOW);
    }

    digitalWrite(slaveSelect,HIGH);
    //release chip, signal end transfer
    delay(1);
}
```



Tailored to the Syracuse

Below is part of code for the push buttons. In the infinite loop, the statement "switch(lcd.buttonBlocking())" checks whether a key has been pressed. This command also includes "debounce", contact denial, ideal if you want to create a menu with the up and down keys. A case-statement is then used to check which key was pressed. See further below.

```
void loop()
{
  switch(lcd.buttonBlocking())
  {
    case KEYPAD_UP:
      if (setsat1 < 6)
        setsat1++;
      break;
    case KEYPAD_DOWN:
```

```
    if(setsat1 > 0)
      setsat1--;
    break;
```

I use the following keys:

UPfor scrolling through the list of satellites
DOWN for scrolling through the list of satellites
SELECT sending the data to the ADF5355
LEFT dividing the output frequency by eight

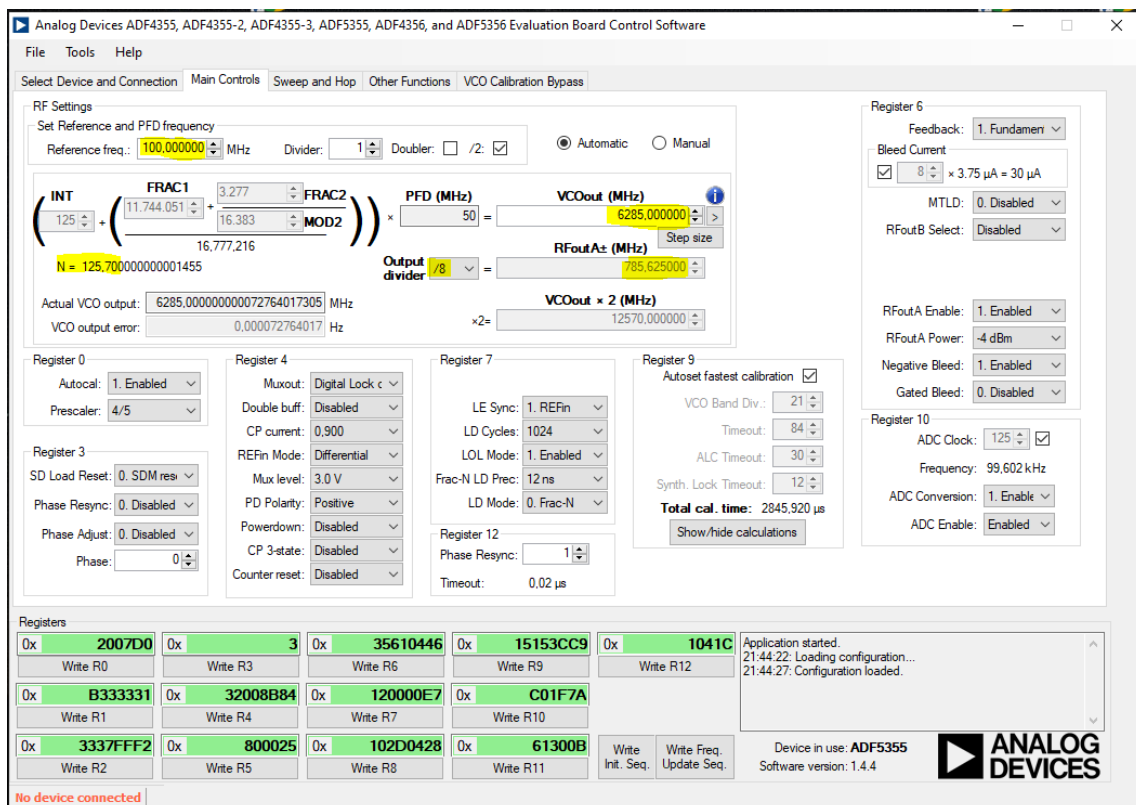
The LEFT switch I want to explain. I can't check if my VCO is doing it because I don't have a spectrum analyser that goes up to 8GHz. However, by temporarily dividing the output frequency by 8, I can see it on my spectrum analyser (which goes up to 1.5GHz) and therefore know that the oscillator is running.

Concluding remarks

The whole thing works satisfactorily. Unfortunately, I have not yet had the opportunity to receive images from an 8GHz satellite.

I think some improvements can be made to the power supply of the ADF5355 to achieve lower phase noise. The phase noise goes down further when in the PLL is not divided by a fraction but by an integer. See image above where N=125.70, better is when N=125.

The full Arduino code is on GitHub: <https://github.com/werkgroep-kunstmanen/LocOscADF5355>.



The settings in Analog Devices' software. The output divider is set to 8. On the output will be 785MHz. The divider factor N = 125.7

MTG IS COMING

Rob Alblas

The first of Meteosat's third generation will be launched this year: MTG-I, the 'imager' (see [1]). A total of four MTGs of the 'imager' type will be launched over the next 10 years. In preparation, Eumetsat has released test data, which can be used to develop and test software. See [2]. The format is hdf5; at MSG it was still HRIT. Both compressed and uncompressed data are available; I assume that eventually the compressed data will be distributed via Eumetcast.

Creating images with (more or less) "real" colours is now also possible; MTG has many more visual channels than MSG: VIS04 (blue), VIS05 (green), VIS06 (red), VIS08, VIS09 (MSG had only VIS006 and VIS008). Incidentally, these are not the exact colours our eyes are sensitive to, so completely "real colours" as you would see from space, it won't be.

Last year, test data had also been released. I have already modified xrit2pic back then so that it can also display MTG data, but for now only the uncompressed data.

Meanwhile, I have played quite a bit with Satpy ([3]). For MTG, a Python script is now also available, see [4]. It also works on compressed data. The usage is identical to the already existing script for MSG; you can specify the desired area and combination of channels.

MTG-I will broadcast a full image of 11136x11136 pixels (visual) or 5568x5568 (infrared) every 10 minutes; that adds up to $6 \times 24 = 144$ images per day, with 16 channels.

From the above site, you can retrieve 144 zip files; test data for a full day all together. It is a matter of retrieving and unzipping one or more files, and then giving the command, e.g:

```
MTGx.py -t 201709201200 -src <path_to_.nc_files> -composite true_color_raw
```

The date indicated here, i.e. 20 September 2017, corresponds to available test dates. The images you

get to see will somehow have been compiled/simulated using data from already existing satellites. See also [5].

One advantage of using xrit2pic is that it is easier to use; on the other hand, with Satpy you have many more options and also get better quality results; for now, the images produced by xrit2pic are uncalibrated.

Some comments and limitations regarding the test data: (see also [5]):

- An earlier set of test data was made available in 2020. This is test data with date 10-4-2017. In this data, a number of channels were exactly the same, including vis_04, vis_05 and vis_06. In the new test data dated 20-9-2017, however, the content is different.
- The resolution of the visual channels is 3712x3712, as in MSG. While the number of pixels in the images suggest the full resolution of 11136x11136, in this test data it consists of blocks of 3x3 identical pixels. The data is actually taken from (among others) MSG and converted to MTG.
- Time interval is 10 min for MTG, 15 min for MSG. The test dates for minute 10 and 20 are identical and derived from minute 15 of MSG. Same for minute 40 and 50, both of which are identical to minute 45 of MSG.
- In the image generated by satpy, you can see that the edge of the globe is not displayed. This is so in the test data; the simulated data does not go beyond 75 degrees from zenith.

References

- [1] [Meteosat third generation](#)
- [2] [Test data](#)
- [3] Weather satellites with SatPy. "de Kunstmaan" 2022, no. 1, p. 19
- [4] [Python scripts for GEO satellitessatellieten](#)
- [5] [MTGTD-360 Spectrally Representative FCI L1C Test Products - Package Description](#)



Fig. 1a. MTG image produced by xrit2pic

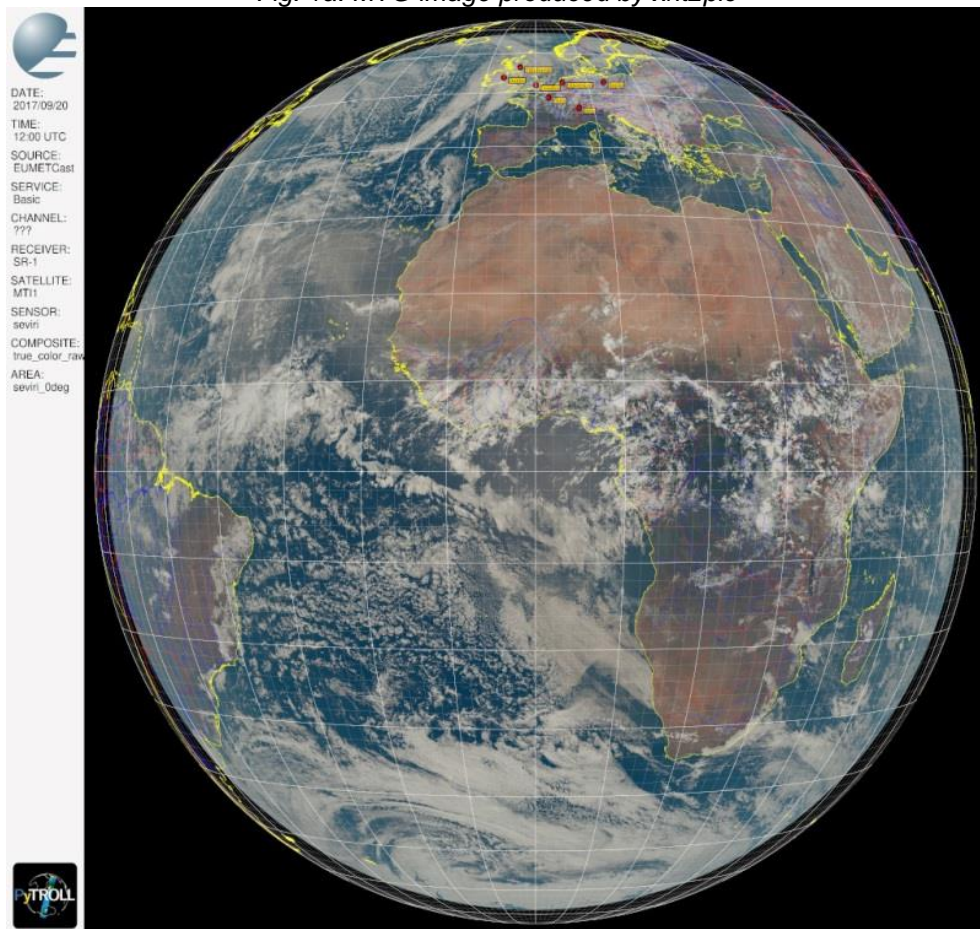


Fig. 1b. MTG image produced by Satpy.

SYRACUSE AT JOB

Ben Schellekens

Introduction

At the May meeting, Harm made a call to get some enthusiasts together and see if we could receive 8 GHz satellite signals. Job was kind enough to make his garden, facing south, available.

In this article, I want to describe my setup and I can reveal that I was able to receive the Syracuse on my spectrum analyser!

No reception

On my part, this still required quite a bit of preparation. I wanted to go to Job only when my receiver/downconverter was working.

Using a homemade signal generator for the 8 GHz, I tested the downconverter and it worked as expected. I was able to test the feedhorn with a directional coupler and determine the correct location of the rear end.

Then you have something on your desk that you think will work. Then put the whole set-up in the garden and see if I could receive anything. As I do not have an aligned antenna motor, aligning the antenna will have to be done by hand. An orbit calculation programme can easily determine when the sun has the same azimuth as the Syracuse. I determined the elevation using the markings on the dish mount.



A 110cm offset dish on a surveying tripod

Many different positions of the dish I tried, but on the spectrum analyser I saw nothing. The signal generator really came in handy. When you switched it on, the signal went everywhere, you didn't have to hold it in front of the dish to see anything. So it was not a problem of the reception system. I suspected that the Syracuse's signal was being blocked by trees. Picked the whole thing up and put it on my balcony, but no improvement there either.

To Job

Job was kind enough to offer his garden for a measurement session. On 10 August, Harm, PeterS and I visited Job's place to try to accommodate the Syracuse. It was one of the hottest days of the year. Fortunately, there were plenty of umbrellas for shade.

Job has his dish on an antenna motor and was able to receive Syracuse with the LimeSDR. My dish could, by sight, be aligned properly.

Why I probably did not see anything at home was because I did not know how to look with the spectrum analyser. The signal is quite narrow-banded and has a low signal level.

But it worked, on the spectrum analyser the signal can be seen. The noise floor is around -91dB and the peak of the signal comes to -77 dB, not bad for a first attempt. The correct location of the rear of the feedhorn is now easily determined.



The Syracuse on the spectrum analyser

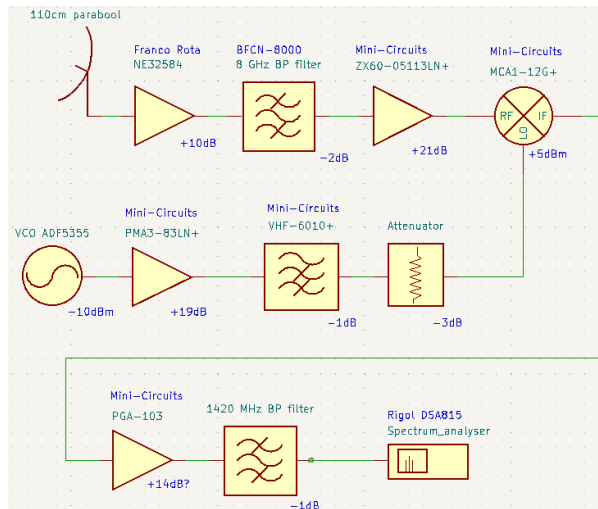
I used the following settings on the spectrum analyser:

A 40MHz bandwidth around 1420MHz. The reference level is at -75dBm, scaling is 2dB. RBW is 100kHz and VBW 1kHz. With these settings, the image refreshes quickly enough for easy adjustment. The amplifier in the spectrum analyser is on and the attenuator is off.

Reception system

My reception system consists of a number of components:

- Dish
- Feedhorn
- LNA by Franco Rota
- 8 GHz Bandpass filter
- LNA from MiniCircuits
- Mixer
- Local oscillator, with amplifier and high-pass filter
- Amplifier
- Interdigital bandpass filter 1420MHz



Offset dish

I use a 110cm offset dish as used for TV reception. I mounted this on a surveying tripod to make the whole thing transportable.

The feedhorn

Hendrik made the W2IMU dual-mode feedhorn from a block of aluminum and aluminum tube. This is a feedhorn without a step baffle for the circular signal.

A piece of Teflon (I was only able to find this on Amazon in Germany) is used to make the signal circular. My main consideration was that this could be manufactured in a short time.



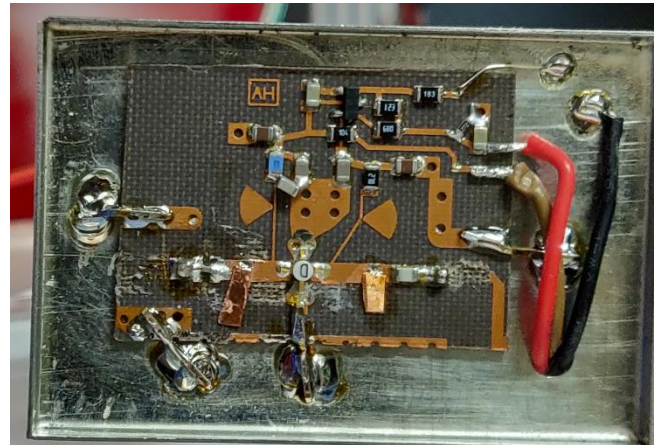
An SMA connector is mounted on the 34mm (external, 26.6mm internal) tube.

The back of the tube is an aluminum disc that you can slide into the ideal position. During my measurements on the workbench with a directional

coupler, I arrived at a distance of 10mm (from tube end) for minimum reflection. On the Syracuse, the disc had to go all the way to the end for optimal results.

LNA by Franco Rota

The LNA is connected to the feedhorn with a short semi-rigid cable; it is Franco Rota's modified PCB, as described in the June 2022 edition of "de Kunstmaan". It delivers a gain of about 10 dB at 0.8dB noise.

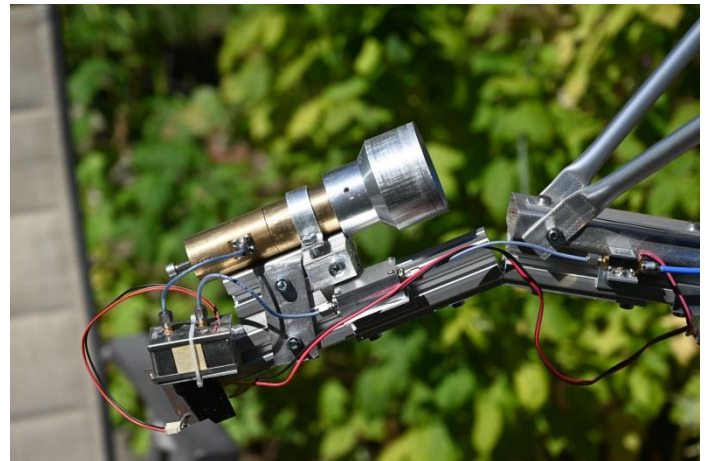


Single-stage LNA from a surplus print

Downconverter

8 GHz Bandpass filter

If there is no bandpass filter then a large part of the frequency spectrum is amplified in the following stages. In the mixer, this then leads to an increase in the noise floor. This filter ensures that only the band we are interested in is amplified. The characteristics of this filter are described in the March 2021 edition of "de Kunstmaan".



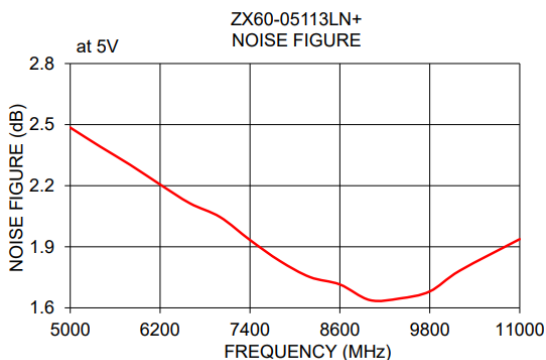
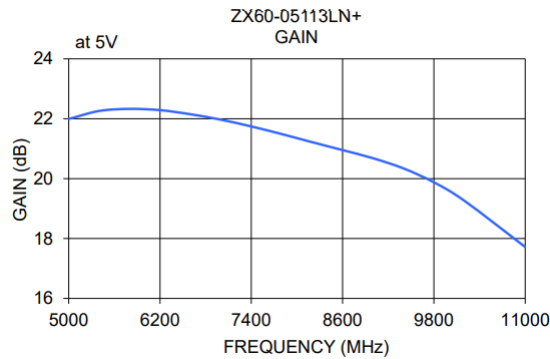
Feedhorn, with LNA, bandpass filter and Mini-Circuits' LNA. The whole thing is mounted on 30x30mm aluminum profile. Very handy if you wish to adjust anything.

LNA from Mini-Circuits

As a second amplifier, I took a ready-made model from Mini-Circuits: ZX60-05113LN+.

This amplifier runs from 5 to 11 GHz and at 8 GHz has a gain of 21 dB at a 1.8dB noise figure. Not ideal,

it cost me a rib, but readily available if you want a lot of gain.



Mixer

As a mixer, I use Mini-Circuits' MCA1-12G+ in a self-milled enclosure.

VCO

As a VCO, I used the ADF5355 on a clone board. This is described in the June 2022 edition of "de Kunstmaan". At -10dBm, the output level is far too low to drive the 7dBm mixer. I used the PMA3-83LN+ as an amplifier. This gives about 19dB of gain around 6800 MHz. The VCO is set to frequency with an Arduino. An article on this later in this Art Moon.

After the amplifier comes a VHF-6010+ high-pass filter. This one is really needed to suppress a lot of clutter. After this filter comes a 3dB attenuator for adjustment at the mixer.

Mid-frequency amplifier

The mixer's output is at 1420 MHz. Behind this, I placed another PGA-103 for additional gain. The 1420MHz interdigital filter did not do much on the spectrum analyser.

Receiver

As a receiver, I use the spectrum analyser DSA815, which runs up to 1.5GHz. Hence also my low centre frequency at 1420 MHz.

Optimisations

Feedhorn

The 34mm tube is now trapped in the aluminum. It is probably better if the whole thing is made of a solid piece of metal.

Furthermore, there is a hole in the tube because I wanted to get started with an N-connector first.



Despite the gap, the feedhorn does work. But it could probably do better.

I am going to make a new feedhorn tube, with a fixed rear end. I am going to make the location of the SMA connector adjustable.

LNA

With both LNAs, I am at a gain of about 27dB. Rather, I would prefer to see this 10dB higher.

Mixer

Maybe by playing with the level of the local oscillator I can do something about the noise level. Now it is 5dBm, slightly too low according to the datasheet. This results in a slightly higher conversion loss

VCO

Choose the frequency so that the divisors do not contain a fraction. The phase noise of the oscillator thus becomes lower.

Another consideration is to have a fixed oscillator frequency. The centre frequency will then become much more broadband. If you assume the Elektro-L2/3 at 7500MHz and the Oceansat-2 at 8300MHz, you end up with a bandwidth of 800MHz.

Mid-frequency amplifier

Is the mid-frequency amplifier even necessary? I will have to test this when I can actually receive images. This also applies to the interdigital filter.

Concluding remarks

Many thanks to Job for making his house available and the refreshments we received!

Now I have to rebuild everything at home and see if I can get the same results. Then make the optimisations. And then anyway, see if I can receive images with my setup. First this will be with SDR and then see if we can also make a receiver in hardware. A long way to go, but the first step has been taken.

UKW-BERICHTE

Ben Schellekens



In addition to the regular sections, six main articles have been published in this year's second UKW Notices.

The first article is by Bernd Kaa and he describes Susumu attenuators as an alternative to homebrew and is a follow-up to his article in the previous UKW-berichte.

Susumu offers attenuators in SMD-built form 0603 and 0402, these attenuators run up to 10 GHz. Using thinner laminate, the 50-Ohm trace width becomes about 0.3mm, this is exactly where these attenuators fit.

He made a measurement of a 3dB attenuator up to 15 GHz. The attenuator was terminated with 10dB attenuators to prevent interference with the measurement cables. He soldered the attenuator upside down to suppress parasitic inductance. Even above 10 GHz, the result is just fine.

When the attenuator is soldered normally, you can see that above 10 GHz the attenuation increases slightly.



Attenuators of Susumu

The attenuators can be bought from Mouser.

The second article is by Olaf Schilperoort and deals with the use of radiating cables. Radiating cables are used indoors, as an alternative to antennas. The advantage is that you can lay them in curves and have predictable reception. An important application, for example, is in metro tunnels. A radiating cable is broadband. So FM, GSM, LTE and 5G signals can be transmitted over the cable. The diameter determines the highest frequency that can be transmitted.

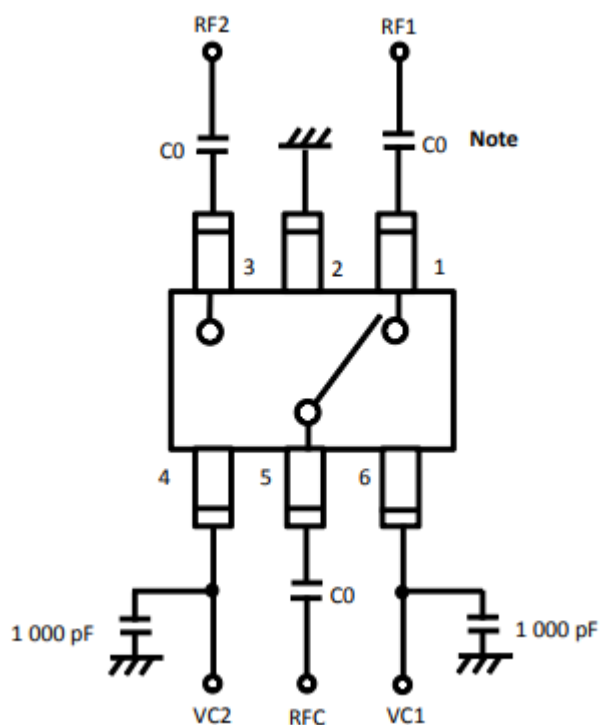


Example of a radiating cable from Eupen.

The third article is by Wolfgang Scheider. He has made an electronic inverter (SPDT, Single Pole Double Throw)suitable for 5W signals up to 5 GHz. This is an alternative to an HF coax relay.

For this, he uses CEL's CG2409M2. The whole thing is mounted on a Rogers circuit board in a milled aluminium case.

He made two prototypes: one on FR4 and the other on Rogers 4350B. As might be expected, attenuation is higher on FR4 at higher frequencies, but isolation (crosstalk) is also higher on FR4. The CG2409M2 can be purchased from Mouser.



Sample diagram from the datasheet for the CG2409M2

The fourth article is by Heiko Leutbecher. He describes how a CATV amplifier suitable for a 75-Ohm environment can be used in a 50-Ohm environment. The advantage is that you then have access to many low-cost components (in the range from 50MHz to 1 GHz) with special properties.

As an example, he takes the BGA3018. This is an 18dB amplifier that goes up to 1006 MHz.

Using a Smith diagram, coils and capacitors are used to make the adjustment. Other MMICs reviewed: MAAM-010373 from Macom and the PGA-122-75+ from Mini-Circuits.

For delivering larger powers, he gives an example of parallel switching of two and of six PGA-122-75+s.

The fifth article is by Henning Weddig and is a follow-up to the first article in the previous UKW-berichte about the TinySA. This is a spectrum analyser the size of a credit card.

The TinySA can also be used as a generator from 100kHz to 350MHz with a level of -76dBm to -6dBm. This is in "low output mode", generating a sine wave. In "high output mode", you get a square wave from 240MHz to 960MHz.

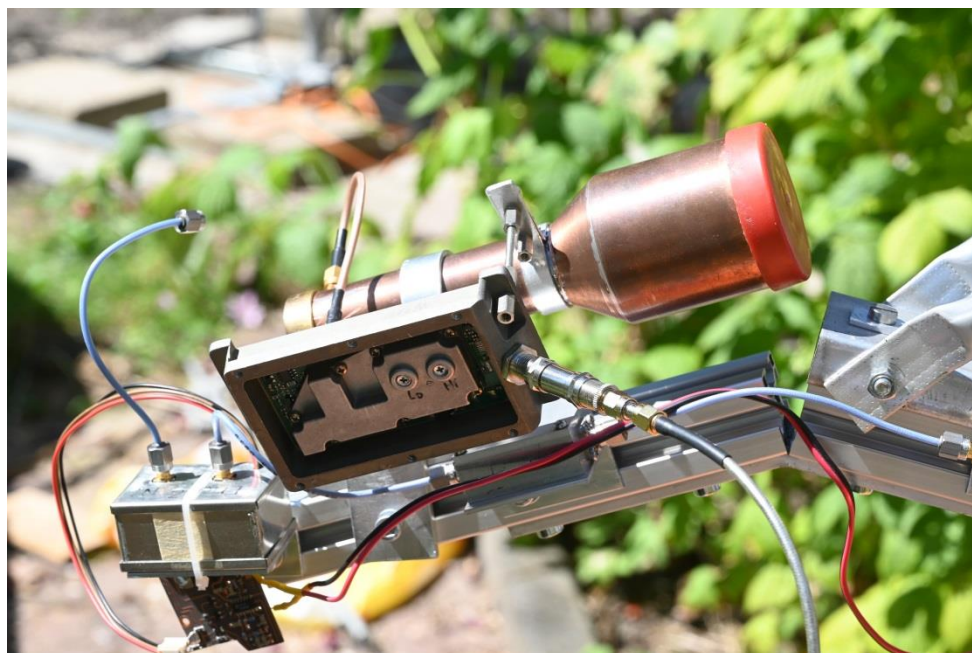
Furthermore, you can also modulate signals in amplitude (AM) or frequency (FM).

The latest article is by Gunthard Kraus. He discusses the use of the Arduino for the radio amateur. There is a brief introduction to the C programming language. In the end, this produces a programme that displays Morse code via an LED.

In the Fundstelle Internet, Gunthard comes up with a nice introduction to mixers and modulators from Analog Devices:

<https://www.analog.com/media/en/training-seminars/tutorials/MT-080.pdf>

Please let me know if you are interested in an article.



Feedhorn from Peter Smits on measurement day. Pictured in front is the modified LNB of which Arne has several in stock. Unfortunately, this setup did not yet give the desired results.

DUBUS NO 3 2022

Ben Schellekens



Novel Feed for QO-100



122 GHz Transceiver

Magazine for Amateur Radio on VHF/UHF and Microwaves

Dubus is a German quarterly magazine and targets radio amateurs with topics on VHF/UHF and microwave. The text is in both German and English.

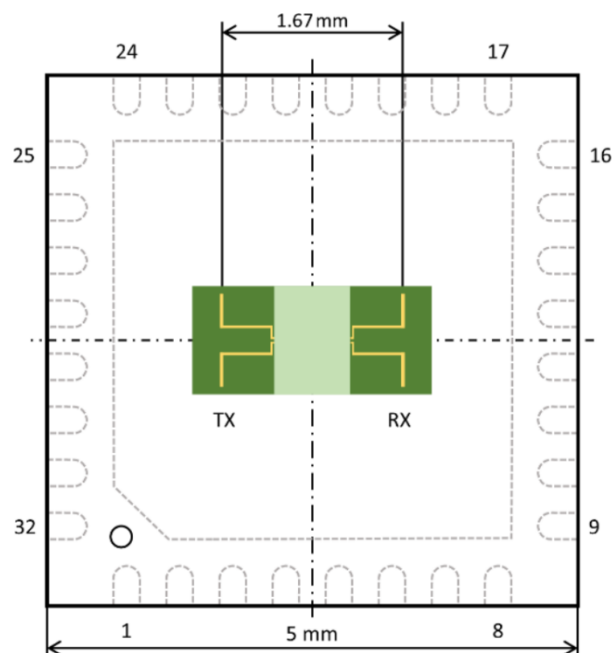
A subscription can only be ordered through the Veron service bureau and runs per calendar year, not very convenient. For the cost, 32 Euro, you don't have to leave it at that. More information at <http://www.dubus.org/>

This third-quarter issue is 132 pages thick.

The first article is by Philipp Prinz who, at the age of 83, looks back on radio amateurism. He has attended many fairs, including: Friedrichshaven, Weinheim and Heelweg, among others. This is how he was active on 76 GHz!

David Minchin has written an update on his article on a 122 GHz transceiver. New parts and part shortages necessitated an update.

The actual transceiver is the chip TRA_120_045 and is used for radar applications, such as measuring distances and speeds. The antennas are already integrated on the chip, how convenient.



The antennas are on the chip. On the front of this Dubus, you can see that another horn is mounted in front of the chip to amplify the signal.

Paul Wade wrote an article on metal plates that allow you to connect corrugated pipe of different sizes anyway.

In the mm frequency range, wave pipe is used. Wavepipe is a metal tube in which radio waves travel. Coaxial cable gives far too many losses.

Wavepipe equipment is unaffordable new. The radio amateur will have to seek refuge at fairs.

For the amateur bands, two or three types of standard waveguide are usable. For the 10-GHz, the following wavepipes are suitable: WR-75, WR-90 and WR-112, with a preference for WR-90.

When you want to join different sizes of corrugated pipe, commercial solutions make the corrugated pipe gradually transition from the old to the new sizes and are therefore relatively long. However, Paul tracked down some adjustment plates and recreated them and took some measurements.



A commercial transition WR-112 to WR-90 from Paternack.

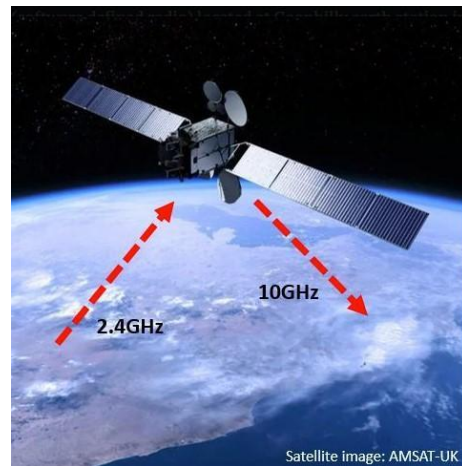
For taking measurements, using a VNA is difficult because he has no calibration equipment. Therefore, he uses a slotted line. Traditionally, these are used with the HP-415 VSWR meters, but these no longer worked for him. Instead of the HP-415, he now uses the HMC662, which is more sensitive than the standard diode detector.

There is a table of dimensions on how to connect different standard corrugated pipes.

Furthermore, he also describes adjustment plates between round tube (circular polarisation) to corrugated pipe. In Dubus No 3, 2015 there was a description of an adaptation plate from 20mm tube to WR-90.

Three Czech authors describe an antenna installation that allows them to use the 10 GHz transponder on the QO-100 satellite. They use a 40cm offset dish combined with a dual-mode horn, based on work by Turrin and Potter. Simulations they do with CST software.

Because the QO-100 transponder is close to satellite TV frequencies, standard LNBS can be used.



The geostationary QO-100 Es'hail-2 satellite

Andy Talbot describes the development of a new beacon. The ADF8346 is used as an I/Q modulator and is fed a -5dBm RF signal from 800 - 2500MHz. The RF signal comes from an ADF4351. The -1000 to +1000Hz I/Q signals are generated with the PIC 16F688.

The last article is by Hans van Alphen who describes his experiences in making the first connections on the 122, 134 and the 241 GHz. At these frequencies, the shape of the satellite dishes must be perfect. Thus, a dish designed for optical use was used.

The 241GHz is achieved with two multipliers of X3 and X6, the input is 13.44GHz.

The Dubus concludes with 30 pages including an aurora report, solar activity and microwave news from Europe, America and Japan.

We don't have the Dubus in the library, but it would certainly be an asset.



Harm, Peter and Job busy measuring during measurement day in August

MEMBERSHIP MEETING REPORT

10 SEPTEMBER 2022

Rob Alblas

1 Opening

There are 12 attendees, and also 3 via zoom. Meanwhile, Nimeto has undergone major renovation; we can use a new classroom today.

Coffee is free, but you must bring your own cup/mug.

2 Adoption of agenda.

No adjustments.

3 Governance matters.

The librarian vacancy has unfortunately not yet been filled. The secretary is also still AI filled.

4 Satellite status

Arne reviews. Harrie receives NOAA15/18/19, Meteor-MN2 and the Metop's. The Fengyun's on L-band are no longer there, Fengyun-3D on X-band is. See further elsewhere in this KM.

5 Any other business

Harm de Wit neatly built in his transmitter. This can be used to make a signal for Metop, Auqa and NOAA20. So this is actually an artificial satellite.

Rob Hollander has 137 MHz quadrifilar antennas he wants to get rid of. If there is no interest it goes to the "metal farmer". There should be some photos in this KM.

Rob Alblas modified the rotor controller so that starting the motors is gradual.

Furthermore, he is working on getting Satpy running on a Raspberry PI, That way a simple 'image' can be made so that installation of a complete satpy environment becomes child's play.

Wim Bravenboer shows a so-called Joywes;, a construction with which you can fix a component on e.g. a PCB. It could be used to help solder SMD components.

Elmar reports that when ordering from e.g. Aliexpress, VAT can be paid right away so there are no surprises later. Rob reports that he had a bad experience with this method; the VAT code, which indicates that VAT has been paid, was put in the address field by the supplier, making the address incorrect (major delay in delivery) and also requiring VAT to be paid. With great difficulty, this was rectified again, but it is something to consider.

Job shows an X-band feed, with which he received FY3-D. He is also working on copper machining to make his own feeds; for this he also uses the roller designed by Peter Smits (see in a previous KM).

Ben shows a test construction with LNAs, mixer, and feed, With this he has received Syracuse, ie, on a spectrum analyser. It is still a "nice-weather construct" though.

Harrie (via zoom) reports that the sound during the round table discussion is very poor. Peter Smits agrees; so this is not going well.

Peter Smits further reports that he is working on measurements of an LNB made by Arne; furthermore, he is in the process of making a second LNB.

There will finally be another DvdRA in Zwolle on 29 October. Ben, Hendrik, Wim, Rob, Job, and maybe Arne will be manning the stand.

6 Presentation:

Ben elaborates a little more on his X-band test setup.

7 Closure

Rob Alblas
secretary AI

Arne van Belle, September 22, 2022

POLAR	APT (MHz)	HRPT (MHz)	X-BAND (MHz)	Remark
NOAA 15	137.620	1702.5		Morning/evening, weak/sync problems
NOAA 18	137.9125	1707.0		Early morning/afternoon
NOAA 19	137.100	1698.0		Afternoon/night
FengYun 3A	no	1704.5		AHRPT 2.80 Msym/s
FengYun 3B	no	no	no	AHRPT 2.80 Msym/s
FengYun 3C	no	1701.3	7780	AHRPT 2.60 Msym/s
FengYun 3D	no	?	7820	RHCP 30MS/s QPSK
FengYun 3E	no	?	7860	RHCP 38.4MS/s QPSK
Metop-B	no	1701.3	7800	Only AHRPT 2.33 Msym/s
Metop-C	no	1701.3	7800	Only AHRPT 2.33 Msym/s
METEOR M N2	137,100 LRPT	1700.0		LRPT/MHRPT
METEOR M N2-2	off(137,900 LRPT)	1700.0	8128	LRPT/MHRPT damaged by meteorite ?
AQUA			8160	RHCP 7.5 Mbps no FEC
TERRA			8212,5	RHCP 7.5 Mbps no FEC
SUOMI NPP(jpss)			7812	RHCP 15 Mbps
NOAA20 (jpss-1)			7812	RHCP 15 MHz FEC ½
ARKTIKA-M1			7865	RHCP BPSK 30.72MS/s
OCEANSAT-2			8300	RHCP 42.4515 Mbps
GEOSTATIONAIR	LRIT/GRB (MHz)	HRIT/GVAR (MHz)	Orbital position/status	
MET-11 (MSG-4)	no	1695.15 HRIT	0 degree, operational	
MET-10	no	1695.15 HRIT	9.5 degree E, RSS	
MET-9	no	1695.15 HRIT	3.5 degree E, standby	
MET-8	no	1695.15 HRIT	41.5° degree E, IODC	
GOES-E (no. 16)	1686.6 GRB	1694.1 HRIT	75.2 degree W via Eumetcast	
GOES-W (no. 17)	1686.6 GRB	1694.1 HRIT	137.2 degree W via Eumetcast	
GOES 14	1691 LRIT	1685.7 GVAR	105 degree W, Backup	
GOES 13 / EWS-G1	1676 SD	1685.7 GVAR	61.5 degree E, Now Space Force	
GOES 15	1691 LRIT	1685.7 GVAR	128 degree W parallel with GOES 17	
Electro-L2	1691 LRIT	1693 HRIT	14.5 Degree W, 7500 MHz & via Eumetcast	
Electro-L3	1691 LRIT	?	76 Degree E, Operational	
MTSAT-1R	1691 LRIT	1687.1 HRIT	140 degree E, Backup for MTSAT2	
MTSAT-2	1691 LRIT	1687.1 HRIT	145 degree E, via Eumetcast	
Himawari-8	no LRIT	no HRIT	140.7 degree E, via HimawariCast	
Himawari-9	no LRIT	no HRIT	140.7 degree E, Backup for 8	
Feng Yun 2G	-	-	99.5 degree E	
Feng Yun 2H	-	-	79 degree E	
Feng Yun 4A	1697 LRIT	1681 HRIT	99.5 degree E, Operational	
Feng Yun 4B	1697 LRIT	1681 HRIT	7500 MHz X-band	
SYRACUSE 3B	Test signal	7705MHz LHCP	Only for test signals 5,2W	



Founded in 1973, the working group aims to:
*Promoting the observation of artificial moons
by visual, radio-frequency and other means*

www.kunstmanen.net

