DE KUNSTMAAN

June 2022 –Volume 49 No.2 Publication of the Kunstmanen Working Group

In this issue amongothers

QPSK in a CPLD
An XYrotor and Arduinorotor driver
LNA designs
and much more

colofon

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The next meeting is on September 10th

photos
Front page:
The XY Rotor by Peter A. Kuiper. See later in this number.

Inside pages: All
photos and images accompanying the various articles are by the relevant authors unless otherwise stated.

werkgroep kunstmanen

DE KUNSTMAAN Association
organ of the Kunstmanen Working Group.

The Werkgroep Kunstmanen aims to promote the observation of artificial moons
by 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 to the articles can be found on our website under:
<Web Links | Left off KM>

van de voorzitter

Ben Schellekens

Physical meeting
It was in Nimeto searching for a room where we could sit. The room where we were in March was not available and we were allowed to choose another room.

Now that is a fact. Because the elevators can only be operated with a special key, we had to climb quite a few stairs.

Finally we were back in school after all these years...

Job taught us how to design an LNA suitable for the 8 GHz on the computer. Free software is available that allows you to do this. Then copy and hope that the result is good. Designing a good LNA is an art in itself.

Job offer
Once again I would like to call on someone to pick up the website and the library. After the renovation of the Nimeto, all moving boxes will have to be unpacked again and put in the cupboards. We will then make a selection of the stuff again. But it would be great if we could show the contents of these cabinets on our website so that more people can benefit from them.

De Kunstmaan
Peter Kuiper has written an article about his DIY rotor control system with stepper motor and planetary deceleration.

Rob has written two articles about a qpsk generator in a CPLD. In combination with Harm's qpsk modulator, you get a nice signal source to adjust qpsk receivers.

Furthermore, Rob has made a gui (a graphical user interface) for the Satpy scripts.

Job has put the presentation he gave about designing an LNA for the 8 GHz in an article.

No technical stories from me, but the annual overview 2021, the report of the GMM and, in the absence of a librarian, an overview of what was in the UKW messages.

If everything goes according to plan, we will install several 8 GHz reception installations at Job in order to be able to do some comparative measurements. At the moment I'm also busy connecting LNA's, mixer and oscillator to receive a 7.8 GHz signal from Syracuse.

More about this in the Kunstmaan of September.

Have fun reading this Kunstmaan and wish everyone a nice summer and hopefully see you in September!

Ben Schellekens
Chairman of the Kunstmanen Working Group

A VIEWER FOR SATPY

Rob Alblas

In the previous KM I described how you can use SatPy to process Eumetcast data into images ([1]). The necessary Python scripts for the various satellites must be started in a command window, with the appropriate arguments.

For automatic processing of data, these scripts are fine, but if you want to look at 'something' manually, a gui can be the answer.

In the previous article I mentioned xrit2pic as a possibility but in the end it turned out to be quite easy to make a simple gui in Python. That fits better in the Satpy environment.

Currently, there are scripts for both geostationary and polar satellites; a gui should be able to handle all of that. The following functionality is needed:

- display the available data, grouped by satellite type, date and time in the form of a list
- selection of one of the lines in the list
- selection of an area to be imaged
- for polar satellites: selection day or night crossing
- selection of an RGB composite
- generating the data
- optionally: display the image using a viewer

Fig. 1 shows a first version of the programme.

In the python script, first enter the desired locations of the raw data at the top, e.g.:
loc_msg='/home/ralblas/data/eumetcast/bas/msg/src'.

A separate directory may be defined for each satellite; the desired directory is selected with a program argument, e.g:
python satpy_selector.py msg

In this way, it is not necessary to enter the entire location at the start of the programme.

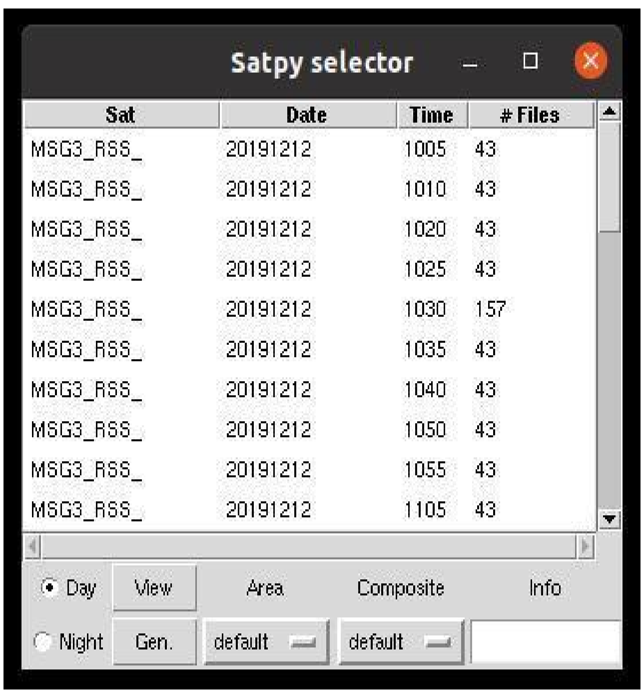
The selector starts and displays the available data as in Fig. 1.

Now select one of the lines and choose an area (under 'Area', now set to 'default') and a composite (under 'Composite').

For polar satellites, "day" or "night" still needs to be selected.

Clicking on 'Gen' starts the right script with the right options, and a jpeg file is generated.

Clicking on 'View' does the same, but now a viewer is started after generation so that the result can be viewed immediately.



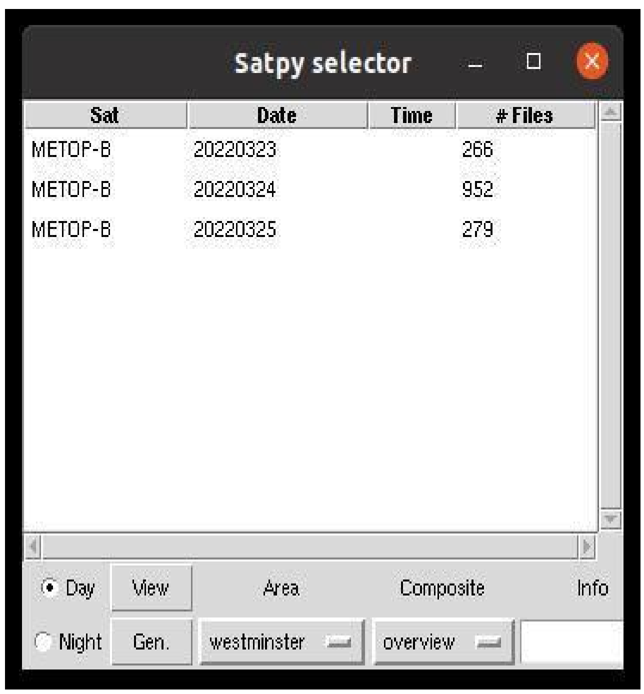


Fig. 1. The selector, on the left an example with geostationary satellites and on the right with polar satellites.

For polar satellites, the 'Time' column remains empty; the time is actually chosen here with the 'day/night' option. Just like that happens with the scripts if you start them yourself.

Note: if the directory contains data from multiple satellites, these will also be displayed; that's no problem! The argument specified when starting the selector is associated only with the name of the directory containing the raw data. Thus, for example, one can store all MSG data in a single directory.

It is even possible to put both geostationary and polar satellites in one directory; the choice of the script is determined by the name of the files and not where they are located. Whether it is desirable to put all the data together is questionable, but for the selector it is no problem.
Fig. 2 shows an overview of the operation of the selector.

Still to be done: Polar satellites also require Kepler data to be able to select the correct area. Currently the TLE file is defined in the scripts, but for older data that file might not suffice.

[1] Weather satellites with SatPy. the Kunstmaan 2022, no. 1, p. 19

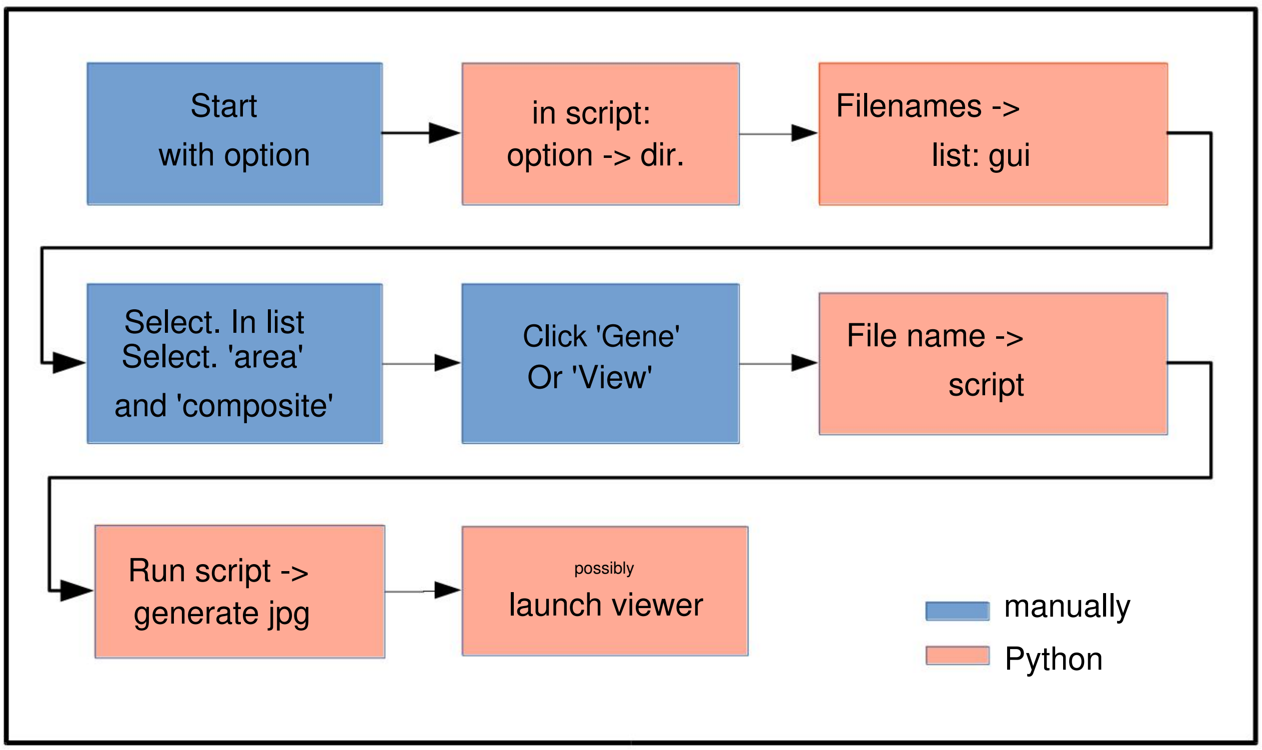


fig. 2. Operation selector

MY X-Y ROTOR SYSTEM

Peter A. Kuiper

It has been several years since Peter Smits and I decided to build an X-Y rotor tracking system to follow polar weather satellites.

Over the years, many articles on this subject have appeared in the Kunstmaan, written by Rob Alblas and Harry van Deursen, among others.

The X-Y system has some advantage over an Azimuth Elevation Tracking system especially at high altitudes.

Peter Smits was the one who started looking for suitable motors. He drew my attention to the fact that there was a firm in Maasdam, which offered three-phase motors with a planetary gearbox for a reasonable price on the Internet. The planetary has a delay of 1:42. We both then bought a number of copies.

After some deliberation, we decided not to use the three-phase motors for our purpose, since that might (at the time) cause problems with their control. For me it was clear that I wanted to use stepper motors, because I had no experience with them.

Description X-Y rotor tracking system
The description below assumes one axis. Everything must therefore be done twice.

The three-phase motor has a 6.35 mm shaft with a gear on it that fits into the planetary gear.

So I had to find a stepper motor with a 6.3 mm output shaft that would fit on the planetary. I found this stepper motor at the firm Stappenmotor.NL, Type 57HS131.7 Nm 1.5Amp., NEMA 23, a bi-polar stepper motor.

A 2 mm hole must be drilled in the stepper motor's shaft for the cotter pin, which secures the gearwheel in front of the planetary.

The stepper motor and the planetary gear connected to it fit exactly into an aluminium tube of 60x60 mm internally (bought at Aluminiumopmaat.NL). The length of the tube is 230 mm.

As it is an X-Y system, the two tubes are connected at right angles to each other with a 10 mm spacer.

welded. This is very precise work, as the aluminium may not warp due to the heat.

The planetary has an output shaft of 12 mm with a keyway. This shaft is too short to run out further. For this reason a shaft with a diameter of 20 mm and a length of approx. 40 mm was made from stainless steel (this can also be aluminium), in which a 12 mm hole was drilled on the lathe up to about half of the shaft. This sleeve/extension is slid over the output shaft of the planetary and secured with two M4 bolts.

An M4 is a so-called socket-head screw with a length of 10 mm. This goes a little further than the keyway of the planetary shaft. (See Fig. 2.)

Fig. 2. Shaft of planetary gear with M4 tapped hole to centre line of shaft.

Therefore, I also tapped the thread in the planetary shaft. I have additionally secured this Allen bolt with Loctite. This is really necessary; in the beginning, during the test phase, I turned the rotor several times by hand to a position and the bolt came loose and there was too much play on the output shaft. The second bolt is a brass one with a flat slotted head. I will later solder the vane for the light locks, 0°-180° stops, onto this. See fig. 3.

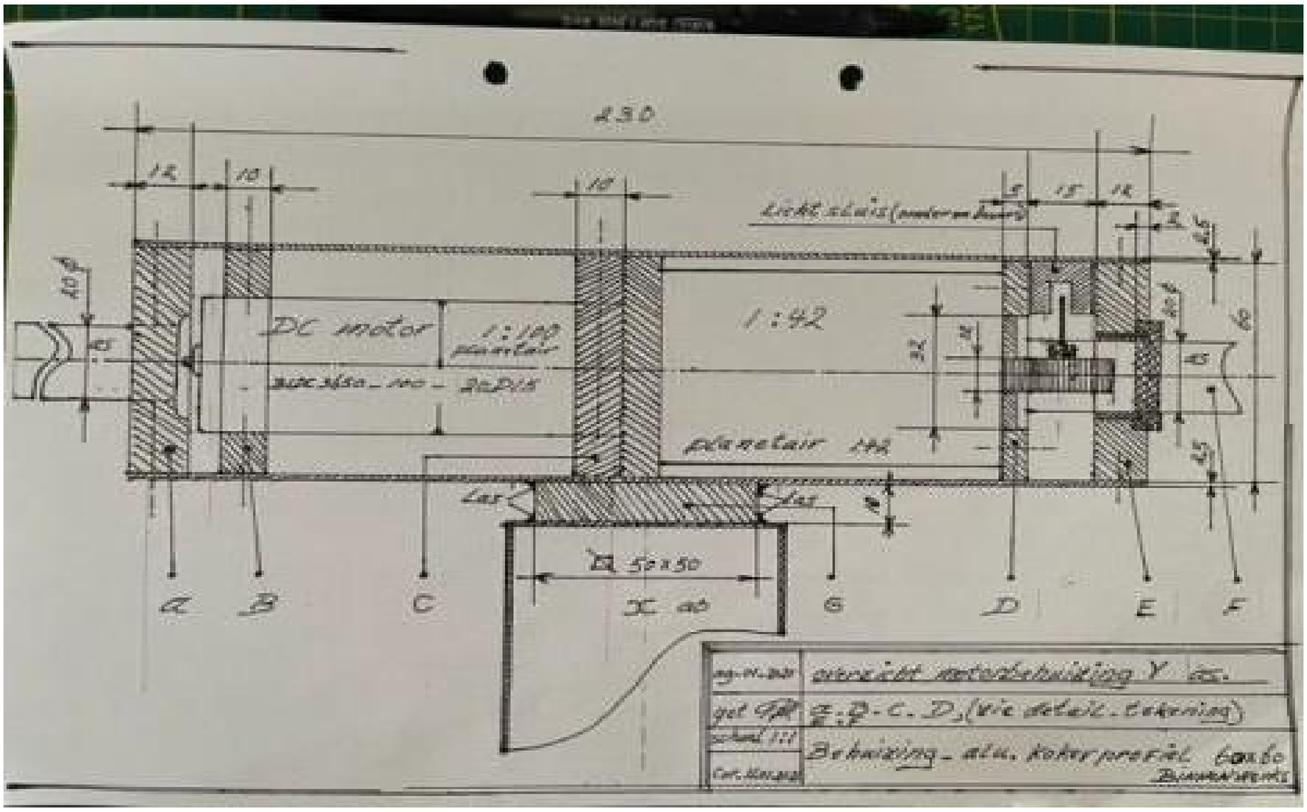


Fig. 1. Sketch of Y axis of rotor.

Fig. 3.Fan soldered to M4 bolt.

The 20 mm output shaft is led out via an aluminium end block measuring 60x60x12 mm, into which a slide bearing fits. On the outside of the block a notch has been turned for an oil seal,

The other end of the tube is also closed off with an aluminium block of 60x60x12 mm, in which a hole has been drilled of 20 mm for the fixed axle. The other end of the tube is also sealed off with an aluminium block measuring 60x60x12 mm, in which a hole has been drilled of 20 mm for the fixed axle. This shaft is secured with 3 M4 socket head screws and fused with Loctite. (See fig. 4.).

What can the installation do?
Bear in mind that in an X-Y system, in my case, the X rotor must also lift the Y rotor. This requires a large unbalanced force. Since my stepper motors are specified with a torque of 1.7 Nm and a planetary gearbox of 1:42, this results in a torque of 1.7 x 42 = 71.4 Nm.

The main advantage of a planetary gearbox is that it has a very high efficiency compared to a worm gear retardation, between
80 and 90%. I am assuming 80%. So on the output shaft I have a force of 57.1 Nm. My 1.20 metre parabola with illuminator, LNA and 1700 mHz interdigital filter together weigh about 4.5 kg.

Balanced, I can indeed lift ± 6 kg. If I move some of the weight further out than 80 cm, think of longer focal lengths and heavier illuminators, then my system is in trouble.

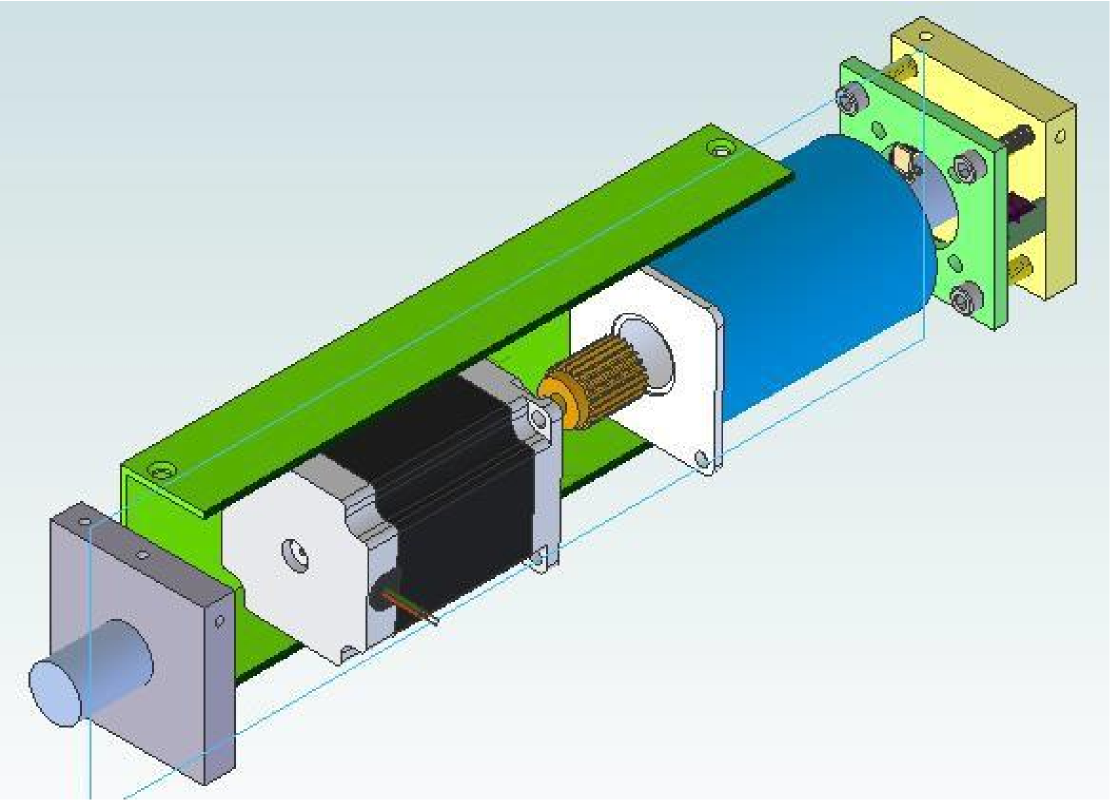


Fig. 4. Construction with motor, planetary gearbox and end blocks.

The electronics
To ensure that the motors stop at the right moment, I have fitted the X and Y axes with light locks of the Sharp GP1A52HR type, a 5V. type, where the light lock has an opening of 3 mm. The locks are mounted at the 0° and the 180° positions. These locks fit, mounted on a piece of small hole print, exactly in the space of 15 mm between planetary and end block. The copper vane, soldered to the M4 brass bolt, rotates through the centre of the locks.

As you never know exactly where 0° and 180° lies during assembly, Rob Alblas has included a parameter in both Xtrack and Wsat with which you can shift the 0° position, as well as the 180° position, by a few degrees.

The motor control
For the stepper motor control I had initially built a stepper motor control board from the Elektor. Unfortunately, the tin under the IC for controlling the motors melted, so that it came loose when the motors stopped working under voltage. A good cooling became so big that I abandoned it.

I then took refuge in a stepper motor driver type MSD-50-5.6, bought from AliExpress.

This driver can handle 128 microsteps, the H-bridges are suitable for 5.6Amp. and the driver has a maximum input voltage of 50V. My installation works on 24V.

As a tracking system, I use both, Xtrack and Wsat, with Wsat being my preferred system. [1]

The software
The software I use was initially written by Harry Arends. Later it was adapted and expanded by Rob Alblas. He has set up this programme as universally as possible (see further on in this Kunstmaan).

This software is now available for stepper motors as well as DC motors and is very reliable. It is very reliable. It should be noted that Peter Smits has tested it for a long time and subjected it to long endurance tests. The program is written for an ATmega 328 architecture and can be loaded into an Arduino Uno or Nano using Arduino software. For the software, see [2].

Cabling
During testing of the system, there appeared to be enormous sharp pulses (spikes) across the cables. Even so bad that when the motor reached the 180° position, for example, the Arduino did not see this and the motor continued to run. I solved this by using double-shielded eight-core patch cable and by grounding all shields at a central point.

Afterword.
With this article, I have tried to give you some insight into what is involved in building a well-functioning X-Y rotor tracking system.
I do not pretend that the article is complete. For example, I am did not address, inter alia, the confirmation of the

aluminium bridge on the Y-axis, to which the parabola is attached, and I have also omitted how the counterweight is mounted on the X-rotor.

However, I can say that my system is many times cheaper than a bulky commercial system and building it has given me a lot of pleasure.

The next step is to set up a similar system for DC motors. The turning work for this has already been completed.

A word of thanks is due to Peter Smits, who did the turning at the time, as well as to Harry Arends, who converted my drawings into 3D images.

Those who want more detailed information can always contact me.

References

[1] tracker software: xtrack, wsat
[2] Rotor controller software.

Fig. 5 Rotor with control

ARDUINO ROTOR CONTROL

Rob Alblas

A lot has been written about rotor systems. I finally wrote a program for Arduino (or other processors) that can be used for both DC and stepper motors and for both X/Y and elevation/azimuth systems. This code (first version based on code by Harry Arends) is available via the working group's github ([1]).

I noticed that there is actually no description yet in "the Art Moon" on how to deal with this code. So here it is.

I will not describe the code in its entirety; a small part of it has already been done in [2]. For the rest, the comments on the code will (hopefully) suffice.
The following motor types are supported:

- DC with speed control via PWM; position feedback via pulses
- DC with only full/half speed; position feedback via pulses
- stepping motors, only feedback from limit switches

With DC motors, it is assumed that there are limit switches so that the motor stops automatically. These limit switches must be bridged with a diode so that the motor can rotate out of its endstop when the polarity is reversed. The limit switches are also used during calibration to determine the reference position. The position is determined after calibration by counting pulses.

With stepper motors, limit switches must be present and connected to the controller. Here there is no feedback; the position is determined after calibration by the number of steps the motor makes, dictated by the controller.

File names
The code consists of a number of files:

- rotorctrl.ino: the main program, containing the well-known 'setup()' and 'loop()' functions
- rotorfuncs.ino: a number of functions such as running an engine to a certain position
- calibrate.ino: functions necessary for calibrating the rotor system
- command.ino: reception of commands via the UART interface
- misc.ino: general functions not directly related to driving motors
- pins.ino: definition of the various pins
- rotorctrl.h: definition of records etc.
- rotor_spec.h: This selects the type of rotor system you are using, the pin numbers etc. etc.

The case is set up in such a way that only rotor_spec.h has to be adapted to the used rotor system; other properties are also defined here. The other files can remain unchanged. If the name 'rotor_spec.h' is to be changed (e.g. to 'rotor_spec_jaeger.h'), the last line in rotorctrl.h must also be changed:
#include "rotor_spec.h"
should then be (in this example)
#include "rotor_spec_jaeger.h"

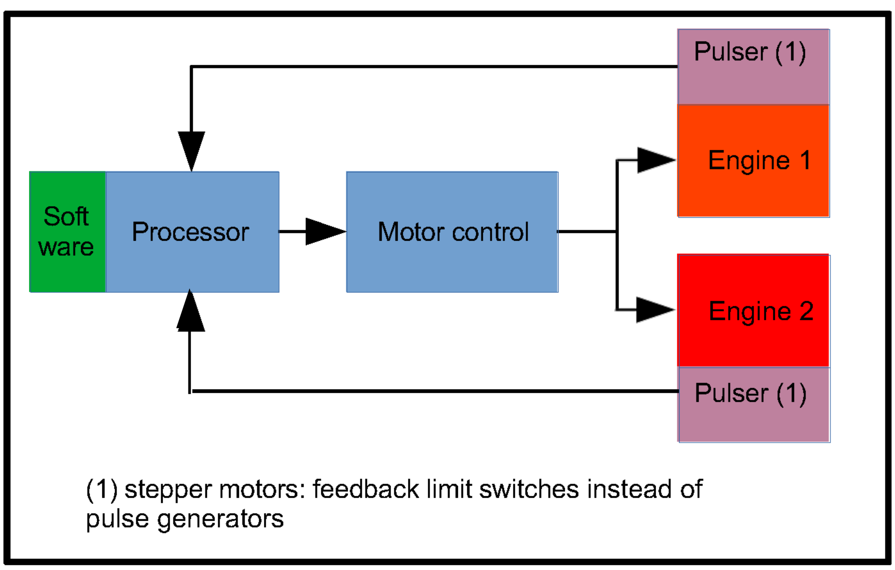


Fig. 1. Overview rotor system.

Adjust rotor_spec.h
The following items may need to be adjusted:

- ROTORTYPE:
  - ROTORTYPE_AE for azimuth/elevation rotor system
  - ROTORTYPE_XY for X/Y rotor system
- ENGINE_TYPE:
  - MOT_DC_PWM (DC motor, PWM speed control)
  - MOT_DC_FIX (DC motor, with control full/half speed via separate pin
  - MOT_STEPPER: stepper motor

- Pinning: the names are preceded by PIN_ and ended by _AX or _AY.

- DC motor: pins for each motor:
  - ROTPLS: input pulses of motor
  - ROTDIR: direction of engine
  - ROTDIN: idem, inverted value of ROTDIR
  - LOWSPD: high when the motor must run at low speed (only for type MOT_DC_FIX). Running at half speed must be solved in the motor control unit.
  - ROTPWM: pulse width modulated output (motor type MOT_DC_PWM) or only on/off (motor type MOT_DC_FIX, in combination with pin LOWSPD)

- Stepper motor: Pins for each motor:
  - ROTDIR: direction of engine
  - ROTPWM: Pulses for stepping motor (no pulse width modulation!)
  - AXEYEnable: switch both motors on/off
  - Endsw1, Endsw2: limit switches on both sides of the direction of rotation

- general:
  - R, G, B for both motors: LED or 3-colour LED (common cathode), indicates progress of calibration

Other variables: for each engine (names are preceded by AX_ and EY_)

- POffset: Offset from limit switch to reference position, in number of pulses or steps
- REFPOS: Position reference in degrees
- STEPS_DEGR: number of steps per 360 degrees

Only for elevation/azimuth systems:

- USE_EASTWEST: 'true' if east/west passage info must be included, see [3]
- FULLRANGE_AZIM: false if azimuth motor cannot rotate over 360 degrees
- SET_AZIM_MIN: azimuth smallest angle, modulo 360
- SET_AZIM_MAX: azimuth greatest

angle For stepper motor only:

- MotorSpeed
- MotorAccel

For DC motors only

- MINSPEED: min. speed in % (see note 1)
- MAXSPEED: max. speed in % (normally 100%)
- L_DEGR_MAXSPEED: error angle above which the motor should run at maximum speed
- H_DEGR_MINSPEED: error angle below which the motor should run at minimum speed
- D_DEGR_STOP: Angle at which the engine should stop. (See note 2.)
- PWMFreq: Frequency of PWM. Too low a frequency can cause an annoying whistling sound.
- MAX_PWM: maximum pulse width; 255=DC 5V. (See note 3.)

For calibration: (see note 4)

- SPD_ENDSW1: speed in % of max. during calibration
- SPD_ENDSW2: if >0: 2nd speed of max. during calibration

Other:

- SWAP_DIR: reverses the direction of both rotors; calibration is then done on the other end stop.
- ROTOR_AX, ROTOR_EY: 'false' or 'true': these can be used to activate or deactivate the rotors. It is possible to operate only one rotor (e.g. for test purposes).
- RELEASE: version no.
- ROT_ID: a code used by wsat and xtrack to recognise the controller. Do not change it.

Notes

1. MINSPEED must be such that the engine still runs even under maximum load.
2. If the motor is turned to 0 degrees error angle, a small amount of overshoot can cause unwanted "swabbing" of the rotor/dish. An angle slightly greater than the resolution (degree per pulse) should be sufficient.
3. PWM cannot always be 100%. Some PWM control boards always need edges to function properly, so then the duty cycle must be < 100%.
4. During calibration, the motor will stop suddenly at the end stop. As it is not clear beforehand when this will happen (the rotor can be in any position), the speed can be reduced so that the stop is not too hard. The second variable can be used to do a double calibration: go to the end stop as fast as possible, then do the last part again at low speed.

References

[1] github working group
[2] Analysis of polar satellite tracking accuracy. de Kunstmaan December 2020, p. 9 ff.
[3] Jaeger rotors for dish control the Art Moon June 2017, p. 12 ff.
[4] Discussion of rotor control. the Artificial Moon June 2020, p. 20

QPSK GENERATOR IN CPLD

Rob Alblas

The weather satellite decoder, realised in a GODIL module ([1]), can decode the incoming data for a satellite and simultaneously generate a test signal. This generator can be used to control a transmitter, which then provides a set for testing the receiver+decoder. Harm de Wit tries to make a test generator for the L- and X-band in this way ([2]). The problem with this setup is that decoder and generator are in the same box. It is better to have a generator completely separate from the decoder hardware, so that transmitter and receiver are completely separated. A second GODIL could provide the solution.

The generator part is not so complex, and can also be realised in a simple CPLD: a Complex Programmable Logic Device. In terms of complexity, a CPLD is somewhere between a PAL (Programmable Logic Array) and an FPGA (Field Programmable Gate Array, as is also found in the GODIL module). The advantage of a CPLD over a GODIL is that it is cheaper and more readily available.

A well-known type of CPLD is the EPM240 from Altera, with 240 LEs (Logic Elements). There are simple PCBs for sale with the CPLD, a voltage stabiliser and a 50 MHz crystal; see fig. 1

Fig. 1. CPLD board connected to a USB programmer.

On the left side of the board you can see the 5V connector, on the right side the programming connector. Above and below, four connectors are connected to the in/outputs of the CPLD (centrally on the board). Furthermore, there is a LED and a power switch present, and a 50 MHz crystal oscillator (at the bottom, between the 2 connectors).

Once programmed, it is just a matter of applying power and it works. Thanks to the crystal oscillator, the generator can be realised without any additional external components. The generators of all satellites that the GODIL decoder can handle do not fit in this CPLD, but the three most important QPSK versions do:

- METOP, 2x 2.3 Mb/s
- Aqua, 2x 7.5 Mb/s
- NOAA20, 2x 15 Mb/s

Software

First, the functionality of the generators must be coded. This is done in VHDL, a language specially designed for describing hardware ([3]). I have taken the same code as I used for the GODIL decoder/generator. Because the crystal has a different frequency (the GODIL has a 49.152 MHz crystal, the CPLD has a 50 MHz crystal), some dividers had to be changed, but that was easy to do.

The VHDL must now be synthesised into something that fits in the CPLD. For this, I used the program Quartus; a light version can be downloaded for free, for both Linux and Windows. ([5])

Also included is the software to control the USB programmer, with which the design can be loaded into the CPLD. See fig. 1. After programming, the programmer is no longer needed.

Fig. 3 shows the connections of the generator; it couldn't be simpler.

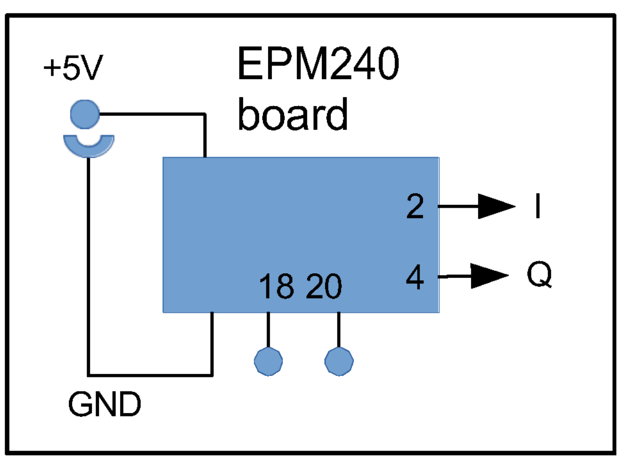


Fig. 3. Connections to the generator.

The various generators can be selected as follows:

pin 18	pin 20	function	bitrate
open	open	METOP	2x 2.3 Mb/s
GND	open	AQUA	2x 7.5 Mb/s
open	GND	NOAA20	2x 15 Mb/s

I tested this generator by connecting it directly to the GODIL decoder. For 15 euro you can get a simple QPSK generator. The module + programmer are available from e.g. AliExpress and hobbycomponents ([4]).

For the software (Quartus) to synthesise and program the code, see [5].

The vhdl is available on github ([6]); qpskgen.vhd is the vhdl, in qpskgen.csv the pinning is defined. Note that the crystal generator on the board is fixed to pin 12 of the CPLD; the remaining pinning can be changed if desired.

I have yet to see how I can publish the synthesised vhdl so that it can be programmed directly into a CPLD, without synthesising first. The USB programmer costs less than 10 euros, so that purchase should not be a problem.

In a next article, I will try to go into more detail about the Quartus software. This kind of hardware can of course also be used nicely for realising other digital circuits, where a processor cannot be used.

References

[1] A new HRPT decoder. de Kunstmaan, 2011 no. 1, no. 2, 2018 no. 3

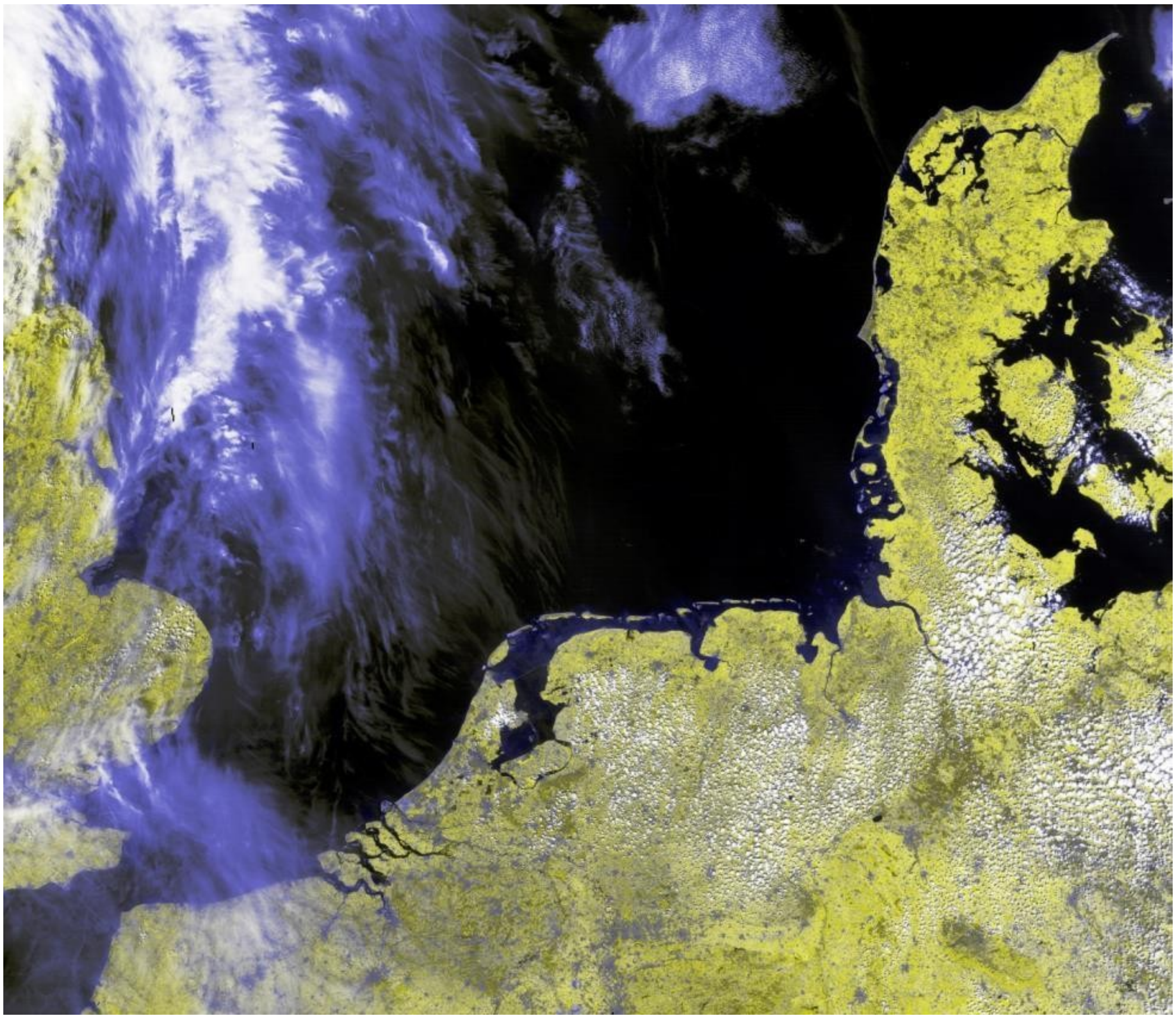
[2] I-Q modulator; de Kunstmaan, December 2021, p. 9

[3] Wiki VHDL

[4] hobby components website with the cpld module

[5] Website Intel with Quartus Lite design software

[6] qpskgenerator code on github



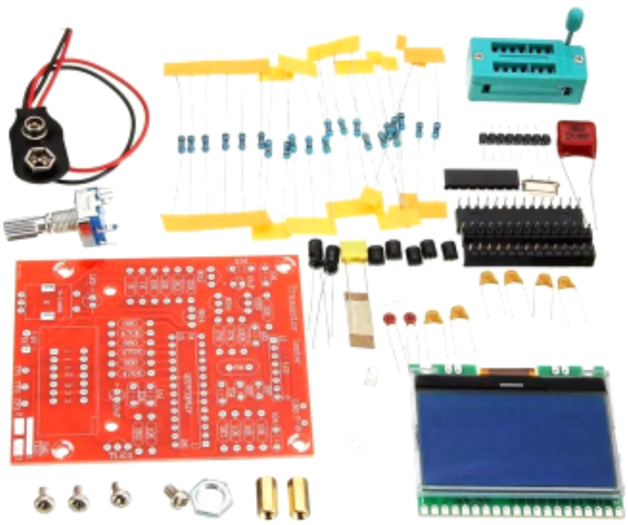
Fred Jansen recording: 16 Jun 2022 AQUA @ 12:38Z - max El 80.9 West. Crop of NW Europe - RGB=221

LCR-TRANSISTOR-AND-MUCH-MORE-TESTER

Fred van den Bosch

Introduction

In Elektron from April '22 there was an article about an LCR tester. Triggered by the enthusiastic story of the author, I also went to Lazada to have a look. It's a bit like AliExpress but very popular, especially in Vietnam. It turned out that there were several different versions of the tester. In the end, I chose this one:



The possibilities are quite extensive as the advertisement indicates:

Features:

- Digital 12864 LCD display, easy to read.
- Can be powered by 9V battery (not included).
- Automatically detects NPN and PNP transistors, N-channel and P-channel MOSFET, JFETs, diodes, inductors, resistors, capacitors, thyristors or other devices.
- Support 2 resistances measurement, also support potentiometer measurement.
- Automatically tests the pins of a component and shows them on the display.
- Measure the gate threshold voltage and the gate capacitance of the MOSFET.
- Measure bipolar transistor current gain and base emitter threshold voltage.
- Short detection time: only 2 seconds. It takes more time for bulk capacitor detection.
- Can be used as signal generator and frequency meter. Various built-in square wave signals from 1Hz-2Mhz are available for selection. It can generate 1-99% PWM (pulse width modulation) signals.

Specifications:

- Power supply: 9V battery (not included)
- Resistance measurement: Max.50MΩ
- Resolution resistance: 0.1Ω
- Capacitance measurement: 25pF~100mF
- Capacitance resolution: 1pF
- Inductance Measurement: 0.01MH~20H
- Screen size: 50mm x 35cm (2" x 1.4")
- PCB Size: 76mm x 63mm (3" x 2.5")

And yes, for a mere €10 and €1.80 for the Perspex casing, all this was neatly delivered to the gate. Although neat? Unfortunately, there appeared to be a crack in the casing. After reporting it, we received a voucher for the amount but did not have to return it. So in the end we just used it.

Mount

What you receive is a bag of loose parts and a circuit board with a few pre-assembled smd parts. Nothing of any description about assembly and operation. Now that I have a new lens in both eyes, I have also lost my microscope eyes. And for this fiddling work, I actually need at least another pair of reading glasses. Fortunately, I still have a set of eye loupes. However, they do not really stay in place. Therefore, just to be sure, I measured each resistor separately with a universal meter (which is exactly what this tester is meant for!) and with the magnifying glass in my hand, I immediately plugged them into the PCB. C's and transistors could be read with the loupe and were also immediately placed on the PCB.

Everything else was right, there was even a C left. Soldering was not easy with all those small surfaces. So, prepared for the worst, I connected the battery and...

...it worked!

To my great surprise and even greater relief, the display showed the battery voltage correctly. In short, it can be done.

I was, however, surprised by the message in the self-test: *"Isolate Probes!"* Help, is there a short somewhere? First, I searched the Internet for a description. And indeed, I found one. [1]. And this one gave the solution (*"the three groups of inputs must be connected before the first test"*), as well as a short description of each function.

Cabinet

Building the whole thing into the box is also quite a challenge. Getting all the protrusions of all the partitions to fall into the right holes without gluing is an ordeal. This is one of the reasons why I used the

I have pulled out the connection to the 9-V battery. There is a space for the battery under the display, but opening everything every time for a fresh one is no fun. So I leave it that way: now I can always choose between battery or mains power without any problems. The crack in the casing is clearly visible at the black wire. Now all I have to do is find a nice button.

Conclusions

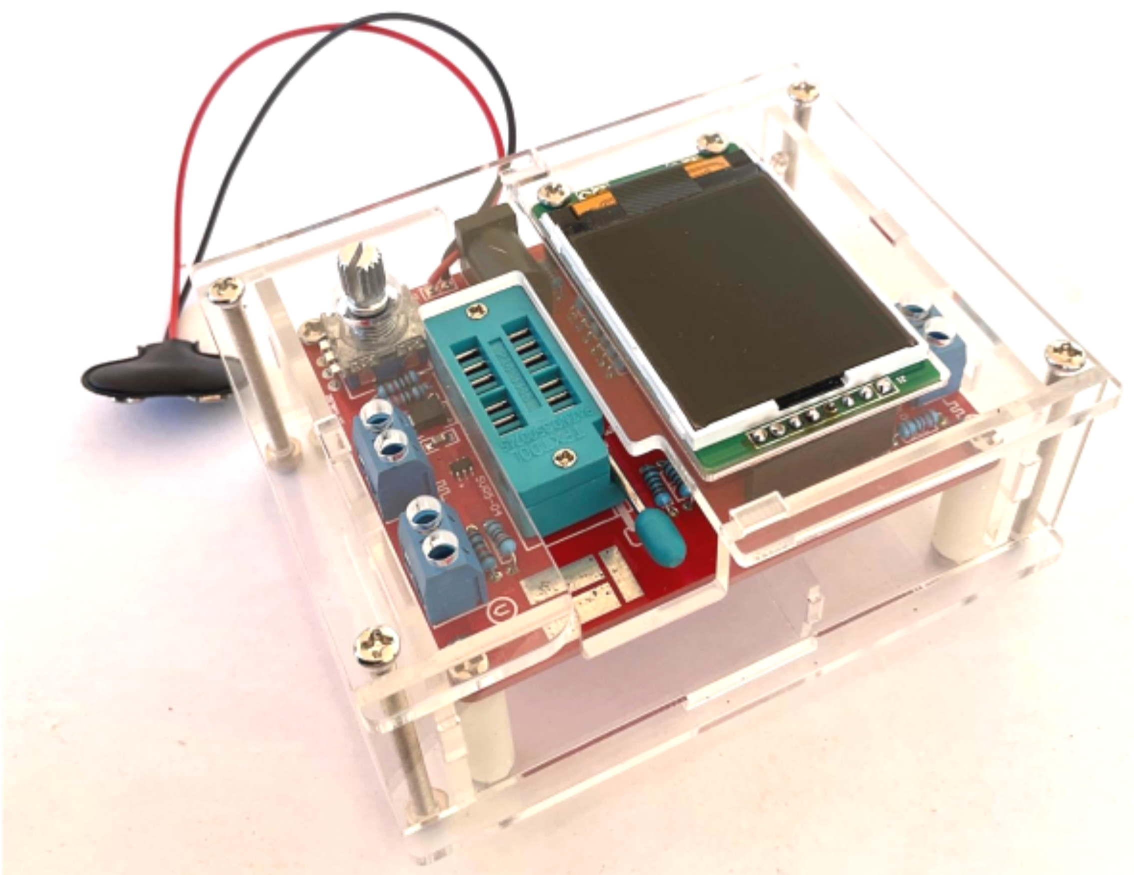
Some quick tests with the remaining C's, some resistors and some transistors convinced me of the good operation. For about €12 you get a component tester with -for me- impressive performance. Plug in any component and the screen tells you what it is, complete with connection details and measured values.

I have made the font colour a little lighter. Just a bit more legible for me.

If you want to see it first: on YouTube you can find several films with examples [2] or even the complete construction [3]. The first film is recommended: with hindsight, I should have watched it myself before building. The second film [3] takes over an hour, of which 45 min. is for editing. Ideal for real beginners, for the workgroup members watching how grass grows.

References (see website)

[1] User Manual
[2] Film about the operation
[3] Film of the assembling process



The fully built tester

LNA DESIGNS

Job de Haas

At the last meeting I gave a lecture [1] about designing a Low Noise Amplifier (LNA) using the simulation program QUCS (Quite Universal Circuit Simulator). In this article, I list that content again.

Design parameters
Designing an amplifier often involves optimizing a number of parameters that describe the behavior that is desired. For an LNA, for example, we can think of this:

- Stability
- Input and output matching
- Noise number
- Reinforcement
- Physical size
- Nutrition

Some of these parameters are more essential than others Stability is always important (unless you're making an oscillator) and with an LNA we want as low a noise figure as possible and that may come at the cost of some gain.

Choice FET
The FET for the LNA is chosen based on a number of references from the world of radio amateurs [2]. The CE3512K2 is still available. Its optimal operating range is 12GHz, but 8GHz is just about feasible. There are few common FETs available for 8GHz.

A FET can be set to run a certain drain current. This is achieved by choosing the voltage at the gate and the drain. The manufacturer provides data on the behavior of the FET at a certain drain current (I_D) and a certain drain-source voltage (V_{DS}). A so-called S-parameter file is available for I_D =10mA and V_{DS} =2V [3]. I myself use a ZABG6004 [4] to set the FETs. This is an IC that can set the bias current of 6 FETs in one solution. These are also used in television LNBs.

Qucs
When designing amplifiers, it is useful to use design tools. Besides several commercial (expensive) simulation packages, there is also an open source simulation package called Quite Universal Circuit Simulator (QUCS). The development of this software has been fraught with hiccups and has resulted in two different versions: Qucs [5] and QucsStudio [6]. Unfortunately, these versions are no longer compatible. QucsStudio only works on Windows. I have worked with a beta version of Qucs on Linux.

You can easily devote several articles to this extensive tool. Fortunately, several people have already done so. An example is the website of Gunthard Kraus [7].

Qucs works with a schema editor and several types of simulators. For LNA designs I use the S-parameter simulator. An example of a schematic is shown in Figure 1.

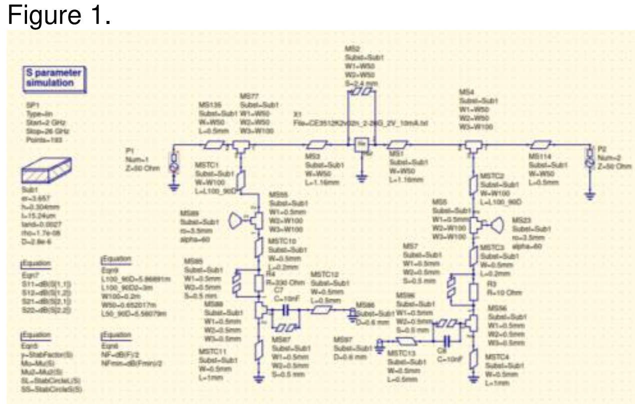


Figure 1. Example diagram in Qucs

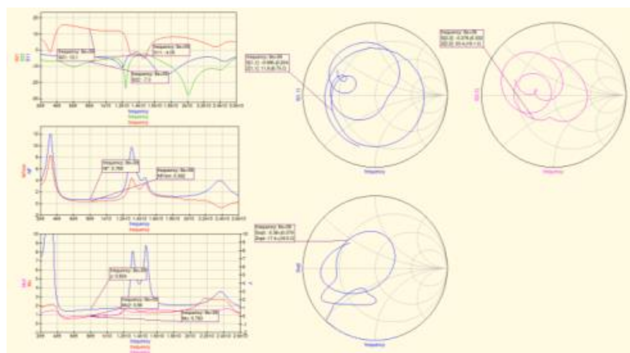


Figure 2 Simulation results in various plots

S-parameter simulation
Simulation of a component for which an S-parameter file is available is straightforward. Place an S-parameter component in the schematic, place an input and output port, and reference the file containing the S-parameter data. See Figure 3.

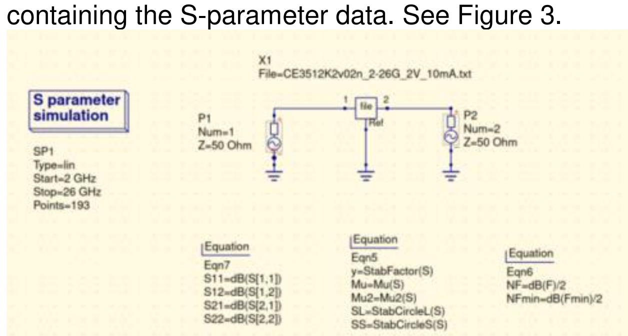
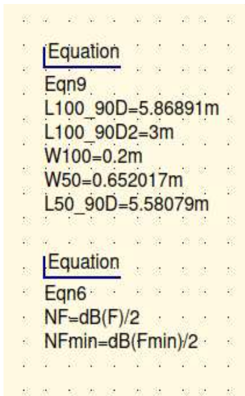


Figure 3 S-parameter simulation.

FET simulation with bias
The next step is to simulate the FET together with the required bias circuits from microstrip on a PCB. First,

a substrate has to be defined. For the LNA, I want to use Rogers 4003C of 12mil (0.304mm). On the Rogers website [8] you can find a tool from which the various substrate parameters can be extracted []. These are the dielectric constant, thickness of metal and laminate, conductivity and surface roughness.



Qucs allows you to define variables through equations which can then be plotted or used as component parameters. Through comparison with other simulators, I discovered that the noise number had to be divided by 2 to match other simulators. I don't know why this is, but I am reasonably confident that this is correct. The trace width for a 50ohm microstrip (W50) can thus also be parameterized via a variable.

To minimize interference from a bias supply, a so-called radial stub is often used. Typical for this is that the track width is high ohm compared to the 50ohm track, the length up to the radial stub is ¼ wavelength of the working frequency and that the radial stub has a diameter that, when simulated, leads to a short circuit at the working frequency. For 8GHz that led to a diameter of 3.5mm in my case.

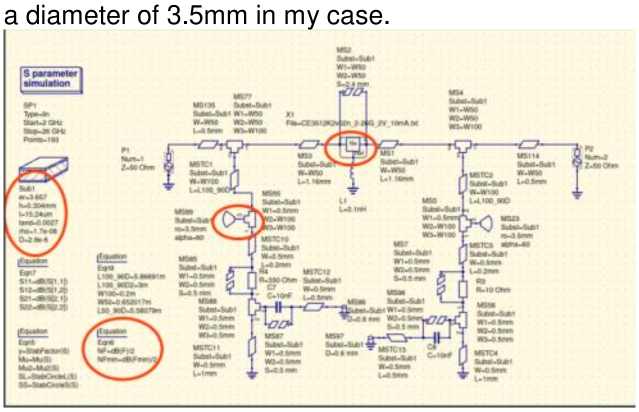


Figure 4 Schematic of bias circuits.

QUCS-RFlayout

A second tool that is very useful when implementing circuits from Qucs on a PCB is QUCS-RFlayout [9]. This allows a schematic consisting of microstrip elements to be converted into a Kicad symbol and then processed and fabricated into a PCB design in Kicad.

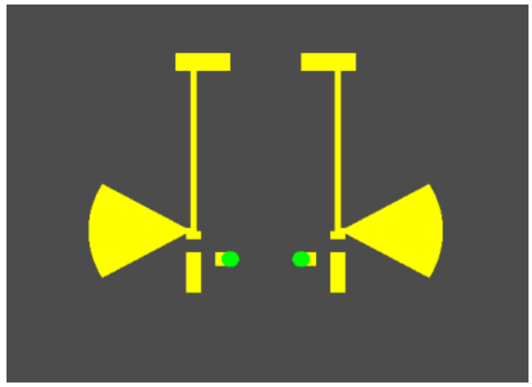


Figure 5 The bias implementation via QUCS-RFlayout

Stability

When positive feedback occurs, an amplifier becomes unstable: oscillation occurs. This often occurs with large amplification: the input is influenced by the large signals at the output. To stabilize the amplification, we want to attenuate it. This can be done over the entire frequency range (with resistors) or in specific areas (with filters). Frequently used solutions are:

- With a series resistor
- With inductance in source
- With filters to reduce gain outside the working area

In Qucs we can plot various stabilization parameters. See figure 6.

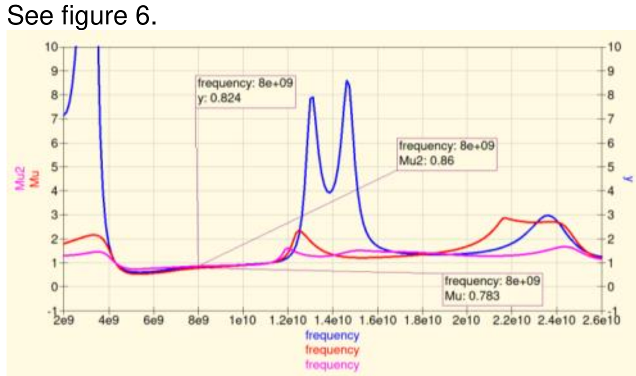


Figure 6 Stabilization parameters

In Figure 6, y is the so-called Rollet factor, where a value greater than 1 indicates stability. Mu and Mu2 are factors that indicate the stability of the input and output. Again, a value greater than 1 indicates stability, but now the value also indicates the degree of stability. This is not the case with the Rollet factor. So based on Mu and Mu2 we can see if it makes sense to make changes to the input or output. Figure 6 shows that the amplifier is not stable between 4GHz and 12GHz.

In practice, we already have a factor that can create stability: inductance at the source of the FET in the form of via's to the ground plane. Additionally, we can include a series resistor to the output.

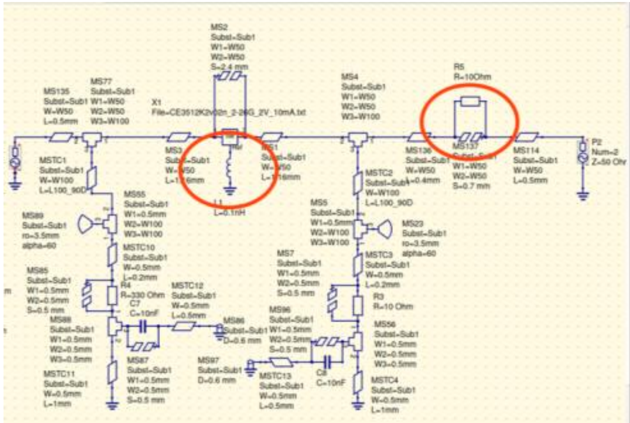


Figure 7 Stability with a series resistor and inductance in the source

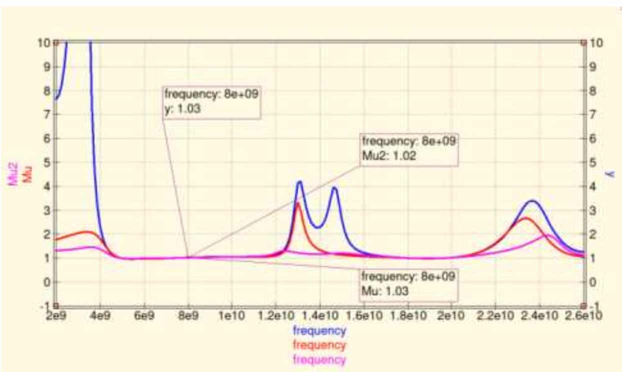


Figure 8 Effect of stabilisation: all values above 1

The simulation shows that with the introduction of 0.1nH source inductance and 10 ohm series resistance a stable situation will arise. If in practice there is instability, the series resistance can be increased. The source inductance is not easy to adjust.

Adjustment at the entrance and exit

The next step in the design process is to ensure optimal matching at the input and output of the amplifier. Normally we design for a matching with maximum energy transfer to 50 ohm on both sides. However, in the case of an LNA this applies mainly to the output.

At the input of the LNA, we have to deal with an antenna and the desire for the lowest possible noise figure. The antenna can have a 50 ohm impedance, but that is not necessary. We could also adapt another impedance. Because we do not know in this case what the antenna impedance is, we keep it to 50 ohm. For the adjustment with minimum noise we do not adjust on S11, but on S_{OPT} . S_{OPT} is a parameter that is provided by the manufacturer and gives the optimal adjustment for the noise figure.

The first step in determining the adjustment is to calculate the S-parameters of the current amplifier.

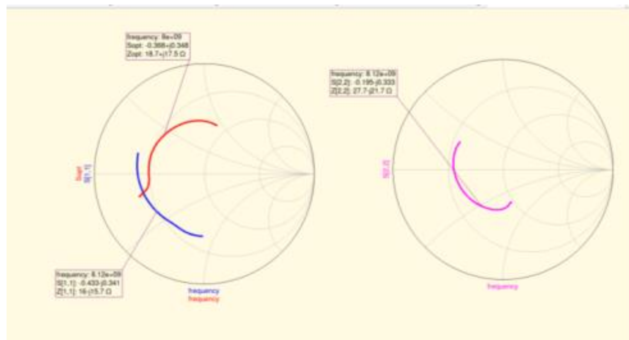


Figure 9 S-parameters for S11, S22 and S_{OPT} without adjustment

We start with the output matching. By opening the context menu of a marker (in this case of S22) we can select "power matching". A design tool is then opened to design a matching circuit. See figure 10.

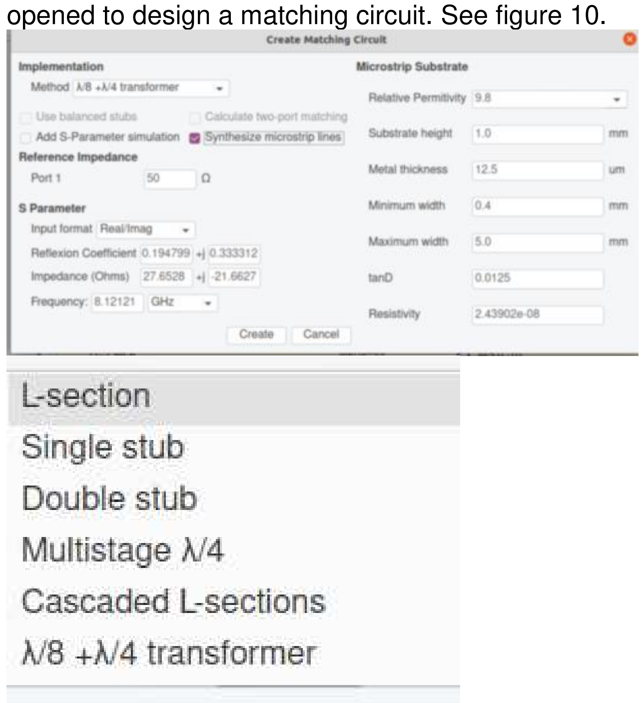


Figure 10 Matching tool showing the options for the matching circuit.

Unfortunately, Qucs does not fill in the correct parameters for the substrate, so we have to copy them by hand each time. In the end, I chose to do the adjustment with λ/8+λ/4 transformer. The tool generates the microstrip lines. Since this is the output, we still need to mirror the circuit. Furthermore, we need to include two transition elements. The result is shown in Figure 11.

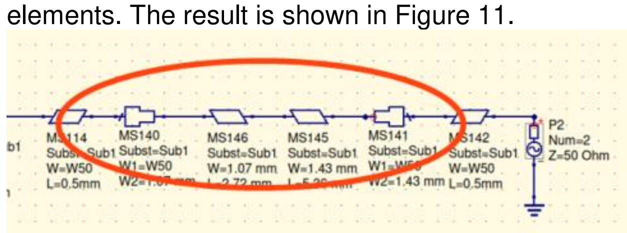


Figure 11 50 ohm adjustment on the output

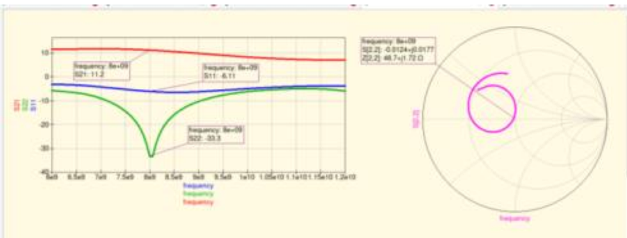


Figure 12 Effect of the adjustment on the output

Any change in the circuit leads to change in the behavior at all ports. So for the adjustment at the input another simulation has to be done. For the input we use the S_{OPT} data to calculate an adjustment.

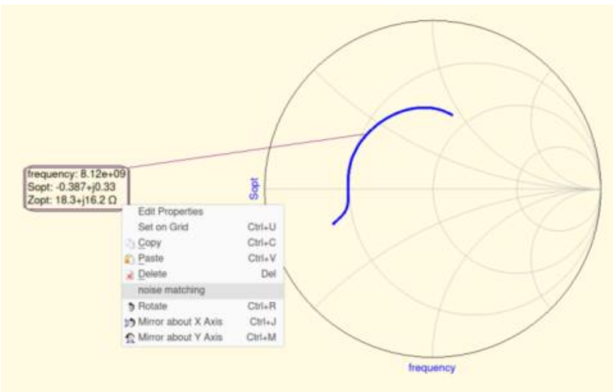


Figure 13 Adjustment for low noise: Noise matching

Figure 13 shows that for the input we can do the adjustment for optimal noise number if we use the SOPT data. Again we make a λ/8+λ/4 transformer.

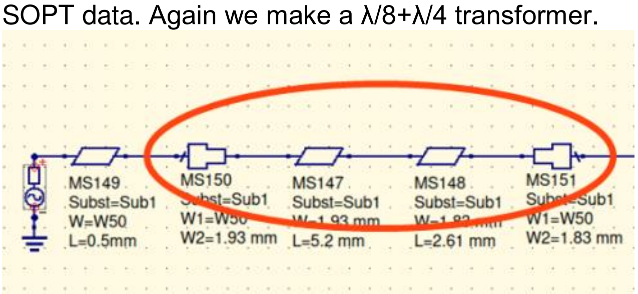


Figure 14 Input for adjustment circuit

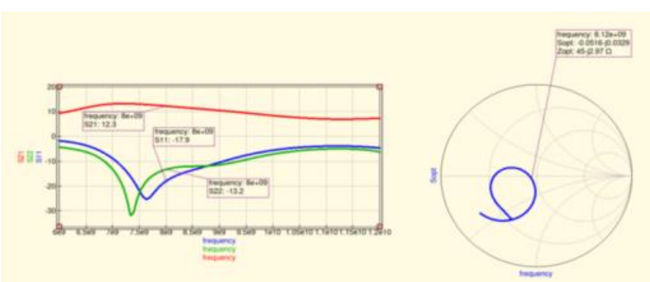


Figure 15 Input and output reflection and reinforcement

In figure 15 we see that the introduction of an adjustment at the input has also caused a shift in the reflection of the output (S22). The calculated adaptation circuit is no longer optimal.

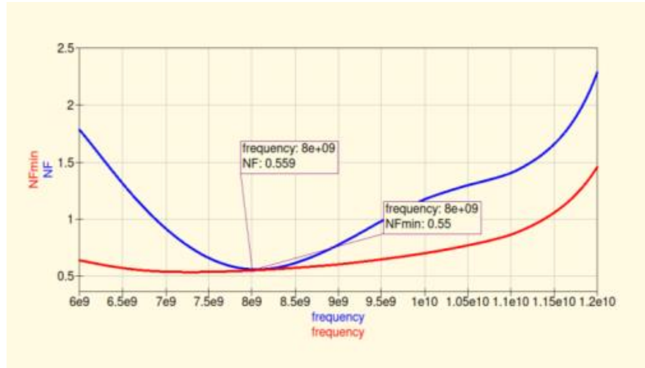


Figure 16 Noise number after optimization. Visible is the optimization at 8GHz

The approach I take here is to now recalculate the output adjustment while at the input the new adjustment circuit remains. Therefore I temporarily disable the output adaptive circuit and recalculate the S-parameters. With these new S-parameters I calculate the output adjustment again. The values are now slightly different than the first time. Next, I calculate the same for the input again, using the new values. After this iteration, both adjustment circuits are good enough. Further iterations do not give any improvement.

The final simulation looks it as in Figure 17.

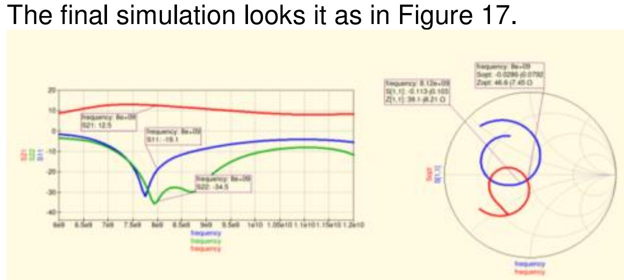


Figure 17 Gain and reflection of the final circuit.

Conclusion

Using the simulation package Qucs, an LNA design can be properly calculated and optimized. Although I have not compared it in detail with professional design programs, I have the impression that it does give a reliable result. Ultimately, deviations in building will probably have more influence than the mathematical limitations of the software.

In a next article I will come back to the further details and the building of an 8GHz LNA.

Links

[1] Presentation 14 May 2022
[2] Comparison of FETs and LNAs
[3] S parameters CE3512K2
[4] ZABG6004 Bias chip
[5] Qucs
[6] QucsStudio
[7] Tutorials with QucsStudio
[8] Rogers Impedance Calculator
[9] QucsRFlayout

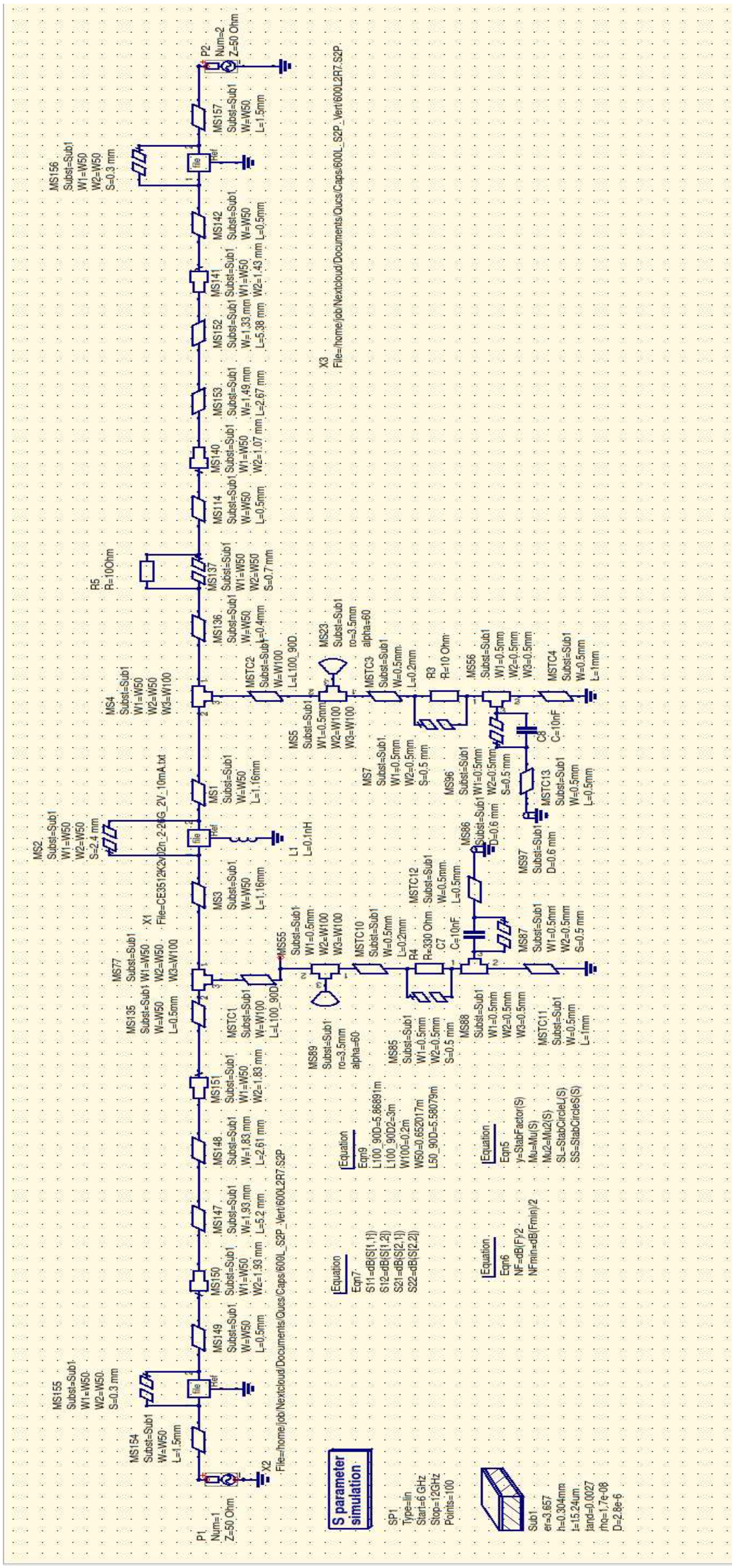


Figure 18 Full circuit with decoupling capacitors

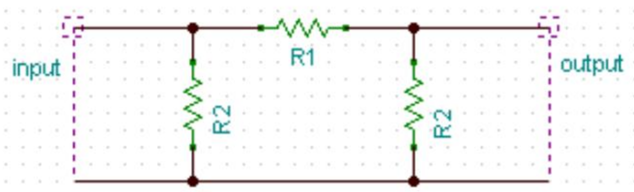
UKW BERICHTE

Ben Schellekens

In addition to the 2021 table of contents, and the regular sections, four main articles have been published in the first UKW messages of this year.

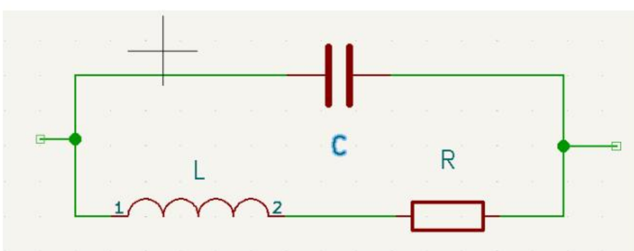
The first article is by Bernd Kaa and he describes DIY attenuators with SMD resistors that run up to the GHz range.

Attenuators are used for example for adjusting the signal level or for impedance adjustments to the inputs and outputs of mixers. A simple 3dB attenuator can be made with three resistors in a pi arrangement.



A 3dB attenuator for an impedance of 50 Ohms. R1 is 18 Ohms and R2 is 300 Ohms.

The problem is that in the GHz range, resistors also have capacitive and inductive components.

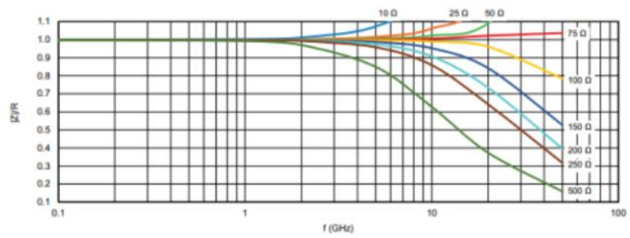


A simple resistor replacement diagram.

These what they call parasitic components depend on the construction shape but also on the resistance value. The smaller the construction shape, the lower the parasitic components.

It turns out that when you mount the resistor so that the resistive layer faces down, the inductance is lower because the signal doesn't have to run along the side and top of the terminal. Above 5 GHz you can already see a difference arise between mounting the resistors upwards or downwards. For example, the 3dB attenuator gives an attenuation of 4.5dB or 9dB at 15 GHz, depending on the mounting of the resistors.

He discusses the impedance curves of Vishay resistors. Resistors below 75 Ohm are inductive in the high frequency range (more than 2 GHz) and above 75 Ohm are capacitive. In another example of a 2.9dB attenuator, the series resistor has been replaced by six 100 Ohm resistors. These are a bit capacitive. It turns out that you then have a fairly flat curve up to 15 GHz.



Impedance curve of Vishay 0402 resistors.

The article shows that by carefully selecting and mounting resistors you can make attenuators well into the GHz range.

Editor's Note: The resistors mentioned in this article are specially designed for high frequencies and are therefore expensive. You can also buy ready-made attenuators that cost 0.33 Euro (eg from Susumu).

The second article is by Alexander Meier and deals with the use of connectors for use at high frequencies. It starts with definitions: male = plug, female = jack, RP = reverse polarity.

Normal SMA connectors and with reverse polarity

The service life is also important. According to the datasheet, a connector can often be plugged in 500 times, with U.FL this is only 30 times. See the datasheet for the exact specifications.

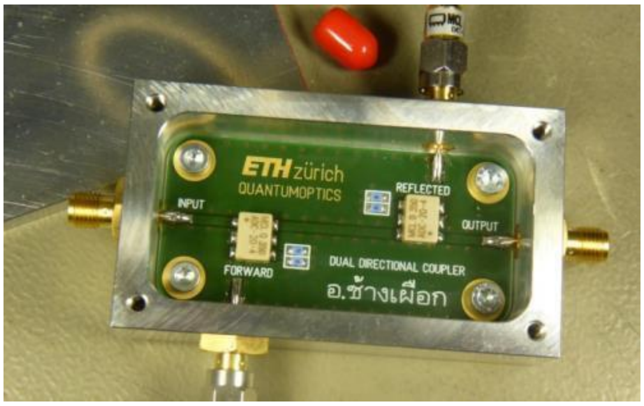
The frequency range depends on the diameter of the connector. For SMA connectors, the maximum frequency is 18 GHz.

Furthermore, there is a distinction in how the connectors connect: screw, bayonet, click, push-pull and slide connection. Screw connectors (N and SMA) must be tightened with a torque spanner.

The material of the connectors consists of: nickel (cheap), bronze, silver, gold and stainless steel.

In many cases, the cable is mounted using a crimp connection.

Wolfgang Schneider describes the construction of a bidirectional coupler for the 23cm band. He uses the ADC-20-4 from Mini Circuits. This coupler is suitable for powers up to 1W.



The directional coupler built by Schneider is similar to this picture

The through-metallised 0.8 mm print is commercially manufactured and a tin can measuring 37x74 mm or an aluminium milled case can be used as the housing.

The last article in this UKW bulletin is by Henning Weddig and he describes the TinySA. This is a spectrum analyser designed by the Dutchman Erik Kaashoek. The format of the spectrum analyser is the size of a credit card. The range runs from 0.1 to 960 MHz and is divided into two areas: 0.1 to 350 MHz and 240 to 960 MHz.

In addition to its function as a spectrum analyser, this device can also serve as a signal source.

The delivery includes the TinySA, two SMA cables, a USB cable and a rod antenna. And this for 65 Euros!

Much information is available on the wiki: https://www.tinysa.org/wiki/

A warning has been issued about the many illegal copies that are on offer on eBay and AliExpress, among others. These perform worse than the original.

The TinySA does not have a tracking generator built in, but with a second TinySA, a tracking generator can be realised. However, this only works for the low band.

This article will be continued in the next UKW-berichte.

ANNUAL REPORT 2021

Ben Schellekens

The two fairs that we have in Rosmalen and Zwolle were cancelled this year.

Meetings

2021 was the second year dedicated to Corona. The meetings in January, March and May were held "digitally". In September and November we were able to meet again at Nimeto.

January meeting
The first meeting was on 9 January and was organised via Zoom. Also present was our member Ed Murashi, hence the meeting was in English.

March meeting
On 13 March, the second meeting was held via Zoom. Job gave a lecture on feeds on the 8 GHz.

Nimeto is going to rebuild
On 1 April, no joke, we were approached by Nimeto's facilities manager with the announcement that Nimeto is going to rebuild. This will start on May 3 in the building where the canteen is located. This renovation will take more than a year. In the canteen where we have our meetings there will be a big hole in the floor so the basement below will get daylight.

The request to us was to empty the four cupboards we have downstairs in the basement and into moving boxes. The stuff goes into storage until the renovation is over. On 21 April Rob, Paul, Job and your chairman went to Nimeto to tidy everything up. Arne joined us later. We threw away a few pieces of equipment, a few boxes went home. But 14! moving boxes went into storage.

May meeting
8 May was a regular meeting via Zoom. We have decided to do the ALV in September as we will hopefully be able to meet again then.

The lecture by Frans, PE1FOT, about 5-10 GHz was fun and informative. As a passionate home builder, he has a wealth of experience. He went deeply into the building of (stripline) filters, doublers and LNAs.

A summary of his presentation was published in the September "Kunstmaan". The presentation itself can be found on our website.

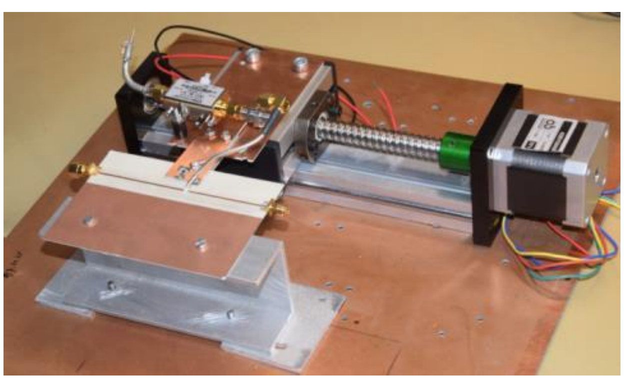
September meeting
On 11 September, we met in a classroom because Nimeto is undergoing renovation. Actually we like this because we are not bothered by other groups.

This meeting is the ALV. A contribution increase has been decided (starting in 2021) for the "paper" members to 28 Euro. The Cash Control Committee, consisting of Rob Hollander and Wim Bravenboer, have checked the figures and found them to be correct. Discharge is granted for the year 2020.

No presentation, but a postponed New Year's reception concluded the meeting.

November meeting
The last meeting of 2021 was again at Nimeto on 13 November. After 10 years of dedication as librarian of our association, Paul Baak stops. We are very grateful to him and miss his articles "From the library".

I myself tried to tell something about measurements on the 8 GHz. The presentation has been incorporated in the article "Self-built slotted line" in the November issue of De Kunstmaan.



De Kunstmaan
Despite all the corona troubles, "de Kunstmaan" was published four times. All copies had 28 pages.

There were some problems with the envelopes. Several times the Kunstmaan arrived soaked at our members. Starting with the March Art Moon, it will be sent in plastic envelopes, this also saves weight and we can publish 28 pages without extra postage.

Arne provided the satellite status, which is included on the last page for easy reference.

Up to and including the September Kunstmaan, Paul wrote "From the Library" and a summary of the UKW reports.

Reports of the meetings were written by Rob.

In the March issue, Rob considers whether the Arduino is suitable for controlling rotors. For example, the pulses of the feedback must be captured, the desired rotor position must be processed and the motors must be controlled. The Arduino can handle this. Furthermore, Rob writes a sequel on how to retrieve Meteosat images with a Raspberry-Pi.

I myself have written a sequel about etching and drilling pcb's. A handy tool is an exposure timer based on an Arduino chip.

In the June issue I compare the official ADF5356 board from Analog Devices with a board from eBay. Furthermore I have been working with surplus-LNB's of RF- microwave. Job helped me with the measurements and the tuning. Eventually we arrived at a noise figure of 0.8dB at 12dB gain. Not bad for 5 Euro! I also give a glimpse of my workplace. You try to cram as much as possible into a small space and it must also remain tidy.

Rob describes new options in xtrack.

Harm starts an article series about his artificial satellite transmitter-on-the-kitchen table. The setup is at the transmit side an ADF4351 RF generator and an AD8346 as IQ modulator to generate a signal at 1700 MHz. The receiver is the existing Meteosat downconverter and the QPSK receiver. The 8 GHz version uses mixers. A special feature is that the signal from the ADF4351 is multiplied by a factor of three using MMICs.

Job describes magnetic encoders as an alternative to pulse counters for determining the position of the dish. The resolution achieved is 0.1 degree. When the magnet is mounted directly on the output shaft you can also read out the absolute position and you do not have to calibrate on a limit switch.

In the September issue of "Kunstmaan", a new rotor control board will be presented on which you can connect separate H-bridges (e.g. L298 modules).

The lecture given by Frans has been published in this Kunstmaan.

I myself got behind the milling machine to make housings for my microwave experiments.

In the December issue of Kunstmaan, a story of mine about the construction of a slotted-line. This is one of the first measuring devices when there were no VNAs yet. Furthermore, I describe the construction of an interdigital filter for the 1420 MHz.

Job describes the ESP32 microcontroller that can be programmed in the Arduino environment. Especially the wireless possibilities of the ESP32 are very attractive. Job uses this microcontroller for his rotor control.

Rob Hollander shows his build QPSK receiver. One housing contains the receiver, decoder and the display for the constellation diagram.

Arne describes the experiences of Jean-Claude who can receive 8 GHz satellites with simple means. An 80cm television satellite dish is sufficient.

The "Digital Kunstmaan"
In addition to the Christmas greeting, it was sent as an advance notice for the meetings and the "Digital Kunst Maan".

Website
Unfortunately, no progress with the new website.

Satellites
In November 2021, the Metop-A was decommissioned. Arktika-m1 was launched on 28 February and the signals can be received.

Attendees at ALV in Nimeto

GENERAL MEETING OF MEMBERS 14 MAY 2022

Ben Schellekens

1. Opening
Welcome to the Annual General Meeting. I apologise for the extremely chaotic meeting. We really didn't know where we could sit. Job went through the whole building to see where we could sit. We have a room, the lighting is old and it is quite dark. We have a monitor. But unfortunately we are on the second floor. Hopefully we will have a decent place in September and that the car park will be available again. We are happy that we can meet here.

Rob was not present due to holidays. The Chairman took over his points.

The chairman has brought along assorted boxes and cigar boxes for those interested. Rob H. had brought some lead with him but had lost it.

2. Explanation of the 2021 figures
These were published in the March Kunstmaan. Last year we made a profit of 232.59 Euros. This has not happened in years. Every year we have made a loss of six or seven hundred euros, but not last year. There are a number of reasons for this: we did not get together. We did not have the costs of Nimeto. On 1 January last year we also started with the Kunstmaan as a pdf, which is financially better. On balance, we lost money on the paper Kunstmaan. Because about 40 per cent of it is in pdf format, that loss is no longer there.

There are no further questions or comments on that.

The KCC has reviewed the figures. Wim Bravenboer: We received the figures from Rob and checked them meticulously. It has all been done perfectly. The KCC approves the cash flow as sent by Rob. There is a signed statement.

The Chairman thanked the KCC for their work. This means that for next year we have to find another volunteer. Wim Bravenboer stops and Harm is then number one in the KCC.

3. Discharge of the management board from liability in respect of its management 2021
Meetings were mainly held via Zoom. "De Kunstmaan" did come out.
There are no objections to granting discharge.

4. Budget and contribution 2022
This was also published in the Kunstmaan. We foresee a small loss. This is because the costs of Nimeto have now been added.

There is money in the coffers. If there are ideas to develop things, there is budget for it, keep this in mind. We don't need to have a piggy bank.

The membership fee remains the same. We do not aim to make a profit. As long as there are no extreme losses, we can keep the contribution the same.

5. Administration
We are still looking for a librarian / webmaster. Paul has stopped. All hands are welcome, also for writing copy. At the very last moment you think: we have succeeded again in filling a Kunstmaan of 28 pages. You are welcome to deliver things, even if it is only a few photos or pen strokes. It is not a problem.

6. Satellite status
Fred Jansen, apologises for not being able to attend. From his email: the FengYun 3B is now officially not active. The Aqua was in safe mode on 31 March and Modis was inactive on 17 April. The Aqua has left the A-train as of January 2022 (comes over for the afternoon, AM). He may then remain active for a number of years. They do not do active runway corrections.

Peter K can receive the new GOES in Curaçao. See further the overview in this Kunstmaan.

Harrie: "The most interesting are the Metop-B and C in the morning and in the afternoon the Meteor N2-2 which is doing fine. There are also two NOAAs. I don't watch those because they come in at inconvenient times."

7. Any other business
There is a discussion about the arrival or non-arrival and delivery time of packages from China

8. Closure
Next meeting in September.

Job is about to give a lecture on QUCS. The chairman wished everyone a good summer.
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satellietstatus

Arne van Belle, June 19 2022

POLAR	APT (MHz)	HRPT (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	off	-
FengYun 3C	no	1701.3	AHRPT 2.60 Msym/s
FengYun 3D	no	7820.0 X-band	MPT 30 Msym/s
FengYun 3E	no	7820.0 X-band	MPT 30 Msym/s
Metop-B	no	1701.3	Only AHRPT 2.33 Msym/s
Metop-C	no	1701.3	Only AHRPT 2.33 Msym/s
METEOR M N2	137.100 LRPT	1700.0	LRPT/MHRPT
METEOR M N2-2	off(137.100 LRPT)	1700.0	LRPT/MHRPT damaged by meteorite ?
NPP	no	7812.0 X-band	HRD 15 Mbps
JPSS-1/NOAA 20	no	7812.0 X-band	HRD 15 Mbps
Arktika M1	no	1697.0 X-band	BPSK 30.72 MS/s, telemetry on 1703 and 7865.0

GEOSTATIONAR	LRIT/GRB (MHz)	(HRIT/GVAR (MHz)	Orbital position/status
MET-11 (MSG-4)	no LRIT	1695.15 HRIT	0 degree, operational
MET-10	no LRIT	1695.15 HRIT	9.5 degree O, RSS
MET-9	no LRIT	1695.15 HRIT	3.5 degree O, standby
MET-8	no LRIT	1695.15 HRIT	41.5° degree O, 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 O, Now Space Force
GOES 15	1691 LRIT	1685,7 GVAR	128 degree W parallel with GOES 17
GOES 18	1686.6 GRB	1694.1 HRIT	89.5 Degree W, drift later to 136.8 W
Elektro-L2	1691 LRIT	1693 HRIT	14.5 Degree W, via Eumetcast
Elektro-L3	LRIT	HRIT	76 Degree O, Operational
MTSAT-1R	1691 LRIT	1687.1 HRIT	140 degree O, Backup voor MTSAT2
MTSAT-2	1691 LRIT	1687.1 HRIT	145 degree O, via Eumetcast
Himawari-8	no LRIT	no HRIT	140.7 degree O, via HimawariCast
Himawari-9	no LRIT	no HRIT	140.7 degree O, Backup for 8
Feng Yun 2E	-	-	86.5 degree O, Backup
Feng Yun 2F	-	-	112.5 degree O, Backup
Feng Yun 2G	-	-	99.5 degree O
Feng Yun 2H	-	-	79 degree O
Feng Yun 4A	1697 LRIT	1681HRIT	99.5 degree O, Operational

The working group wasfounded in 1973and aims to:
Promote the observationof artificial satellitesby means of visual, radiofrequencyand other means

www.kunstmanen.net