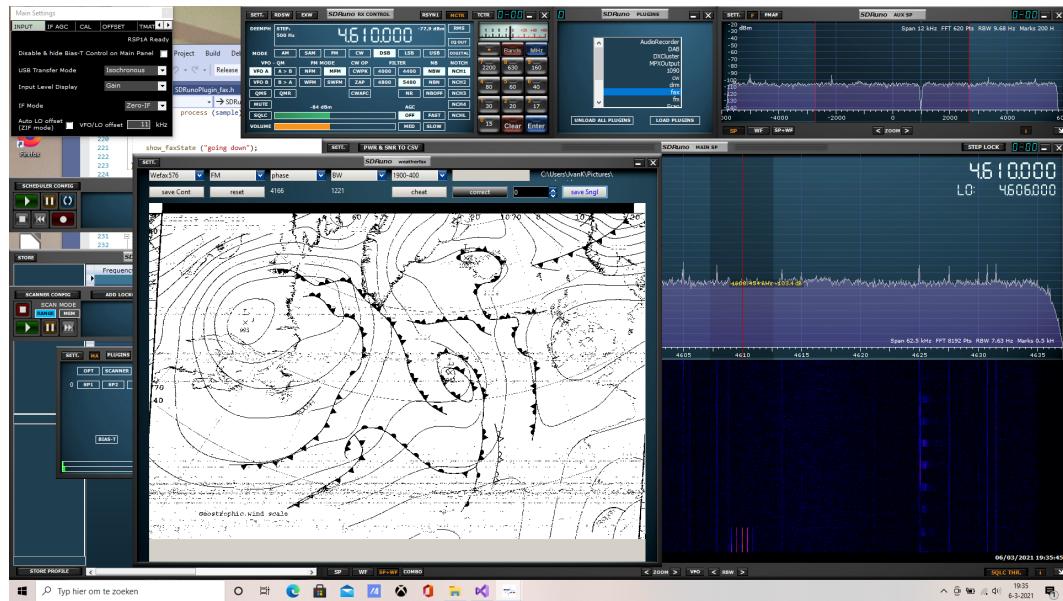


Plugins for the SDRuno environment

user manual

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## 1 Introduction

SDRuno is a platform running under Windows, supporting Software Defined Radio applications with SDRplay devices. SDRuno provides a uniform interface to the different devices (RSP 1A, RSPII, RSPdx, RDSduo).

SDRuno also provides a *standardized* API, an Application Programmers Interface, for *plugins*, i.e. program fragments carrying out some specific tasks, embedded in the SDRuno environment. Plugins use the SDRuno as a "front end", the front end that will take care of device settings, tuning, displaying spectra, (some) filtering and - if needed - decimating the samplerate.

I am not a big supporter of Windows, personally I prefer Linux both as development and execution environment, and in the past years I have written quite some software for running under Linux. One of the software packages written for Linux was a so-called "swradio", i.e. an interface to devices together with a number of decoders, some simple, some more complex. The plugins, described here for use with the SDRuno platform, are (almost) copies of the decoders for my Linux (and Windows) swradio.

The plugins are

- SDRunoPlugin\_cw, a simple decoder for CW transmissions;
- SDRunoPlugin\_cwSkimmer, another decoder for CW transmissions;
- SDRunoPlugin\_psk, a decoder for transmissions in a variety of PSK modes;
- SDRunoPlugin\_rtty, a decoder for transmissions in a variety of RTTY modes;
- SDRunoPlugin\_navtex, a decoder for amtor-B, i.e. navtex, transmissions;
- SDRunoPlugin\_fax, a decoder for weatherfax transmissions;
- SDRunoPlugin\_drm, a decoder for DRM30 transmissions;
- SDRunoPlugin\_ft8, a decoder for FT8 transmissons;
- SDRunoPlugin\_acars, a decoder for acars transmissions;
- SDRunoPlugin\_acars\_M, another plugin for decoding acars transmissions with slightly more functionality;
- SDRunoPlugin\_apt, a *very experimental* plugin for decoding apt transmissions.
- SDRunoPlugin\_wspr, a plugin for decoding and reporting wspr signals.

Navtex transmissions are usually on 518 KHz, weatherfax transmissions in my region on 3588, 4610, 7880 and 8020 KHz. RTTY is still in use for some meteo transmissions, and on amateur bands. Of course cw, psk, rtty and ft8 can be heard/seen in the amateur bands. DRM30 - while not very popular in these regions - can be heard in the 15 and 7 MHz regions. The frequency ranges for both *acars* and *apt* are different, data in these modes is transmitted in the 130 MHz band.

## 2 Why these plugins

Long time ago building a radio from elementary components was fun, with glowing tubes and the soft hissing on switching the radio on. I made quite a few, but again, that is long ago. After retiring I started again, but electronics turned out to be completely different from the electronics in my youth, i.e. no tubes, complex components for which you almost need a microscope to decipher what it is, etc etc, and I let it go soon.

In the early years of my professional life I did a lot of programming (of course computers in the late 60-ties and 70-ties was different. Popular computers had the size one or more large refrigerators, a PDP-8 took 1, a PDP-9 took 3. Later on a PDP-11 arrived with no less than 128 Kbyte, and the summum was a VAX and later an 68000 based systems with 1 Mbyte.

Programming was essentially in assembler, on main frames one could use Fortran, PL/I and Algol, on the mini's there as assembler and forgotten languages like BCPL.

After being retired, I picked up programming again and developed stuff - using Linux as development and application environment. Ever since 2014 I am using SDRplay devices, and when SDRUno matured it seemed interesting to transform a number of decoders - running as separate program or as decoder mode in Linux programs - to plugins for SDRUno.

Since SDRUno (and most likely its successor) are excellent platforms, I developed some more plugins (development still under Linux, then transition to the windows environment for SDRUno).

## 3 Etiquette

The plugins are available for anyone who wants to use it, their sources are available, they are not freeware, however, they are available under a license. The license is the GPL V2 license and it roughly states that the software is provided *as is: the software is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details.*

Since a plugin *is* software, there is always a chance that it contains an error. Of course not all errors show themselves all times, so plugins that run without problem on my W11 system, may cause a problem on another platform. There may be a problem with the installation, there might be some incompatibility between systems, or some unforeseen combination of events, causing the plugin to malfunction.

Experience learns that there are two different styles in the reaction I get when such a thing happens:

- From time to time I get a mail with some (usually unreadable) output and just the text *it does not work*, sometimes even followed by a few "remarks" on the alledged quality of the software.
- most other times I get a mail, reporting issues with a plugin; sometimes the plugin fails to install, sometimes it does not show the expected behaviour, followed by a question for help.

My standard answer on mails of the first category is: *Read the license, stop using the software and ask your money back.*

On mails of the second category I usually respond, and - until now - manage in most cases to solve the issue.

The bottom line being that I am happy to make the software available, no doubt about it. However, if the software does not do what you want or what you expect it to do, read the license before contacting me.

## 4 Installing the plugins

Installing a plugin is simply by placing it in the folder for *community* plugins. While it may differ on different installations, on my W11 system the *community plugins* folder is a subfolder in the folder *Documenten*. Location is determined by installing the SDRUno package, so if unsure, ask the SDRplay people about it.

The SDRUno panel might contain a widget that contains the names of the plugins that can be loaded. The control widget contains a label in the top with the text *plugins*. Touching it will show the Plugins widget. On the picture on the front page the widget showing (some) plugins in in the middle of the top row.

### 4.1 Installing required dll's

Plugins are implemented as *dll*, i.e. *Dynamic Load Libraries*, entities that dynamically can be added to (or removed from) a running program.

Some of the plugins need *additional* *dll*'s for their functioning, these *dll*'s might or might not be installed on your system already. However, to avoid problems it is strongly suggested to install the *dll*'s that are available in the folder *required dll* in the folder C:\Program Files (x86)\SDRplay\SDRUno.

Some of the *dll*'s are required for DRM decoding, some for handling output for ("\*.wav") files and a lot of them for the posting in the wspr plugin

The (current) set of required *dll*'s - available in the folder for required *dll*'s is

```
libfdk-aac-2.dll      libsndfile-1.dll  libssp-0.dll libgcc_s_dw2-1.dll  
libssh2-1.dll         libwinpthread-1.dll libfaad_drm-2.dll
```

## 5 The simple plugins

Plugins for cw decoding, psk decoding, rtty decoding and navtex decoding a relatively simple. They all use the IQ decoder output, i.e. have an input rate of 192000. The drawback is that the main spectrum shows a spectrum with a width of 2MHz, and a signal with a width of, say 100 Hz, is not always easy to identify on such a spectrum.

The main spectrum provides possibilities of zooming in.

### 5.1 CW decoding

#### 5.1.1 introduction

*continuous wave* is one of the most simple ways to encode data, just switch a carrier on or off. The morse alphabet is expressed in *dots*, *dashed* and *spaces*. The duration of a *dash* is (well,

should be) three times that of a *dot*, space between the dashes and dots has the same duration of the dot, and the spacing between letters 3 times, so decoding seems trivial.

The obvious problem is to decide when there is a carrier and when there is only noise. Having done that, decoding is merely a matter of counting samples and deciding what the current element is. Note that in practice the duration of the dash is not exactly 3 times the duration of the dot, so decoding morse code requires some educated guessing.

In spite of the age of the technology, CW decoding is still quite vivid. On 14020 to 14040 KHz it is usually overcrowded with CW signals.

### 5.1.2 The plugin



The plugin (see picture) shows - if possible - decoded text in the top line, the numbers - here 63157 and 48093 - show the guesses for the duration of a *dot* and *space* element (in micro seconds). Ideally they are the same and it is clear that there is a difference in the measurement result.

The computed *number of words per minute* is - given these results - 19, a number shown on the right side of the second line.

The second line shows two more numbers, here 5 and 3, indicating the strength of the signal and the strength of the noise.

The spinbox showing 19 tells the software that the expected number of words per minute is 19, the software sets the limits for guessing the duration of dot and space based on this number.

The bottom line spinboxes set the filter depth and the noise strength values, both used in guessing the border in signal strength between space and data.

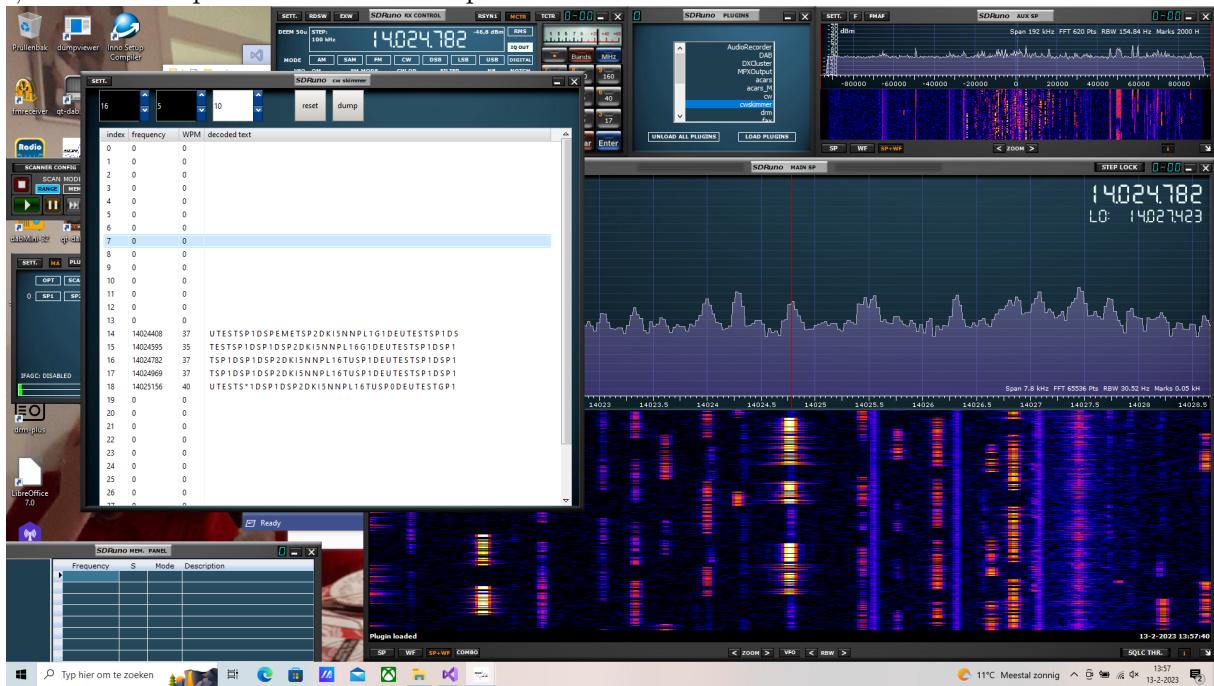
Since tuning to the signal is not always easy, the cw decoder provides a tuning assistant, touching the button *tune* tells the software to compute the spectrum and switch the frequency to the strongest signal in a range of  $2 * 400$  (the number in the spinbox) Hz.

Of course, the main spectrum shown by SDRuno has an excellent zooming facility, making it much easier to tune to the right signal.

### 5.1.3 The cwSkimmer

While the cwDecoder looks at samples in the time domain, the approach in the cwSkimmer is to look in the frequency domain. The samplerate of the incoming samples is 192000, the cwSkimmer computes per two milliseconds, i.e. 500 times a second, a spectrum with 1024 bins. The width per bin is then slightly less than 200 Hz.

In a continuous stream of computed spectra, the signal energy in the bins are measured and duration of space or data is determined. Based on these figures a decoder tries to detect dots, dashes and spaces and tries to map these into text.



The plugin shows the result of a (small) row of bins, the number and place of these bins within a small central part of the spectrum can be selected by the user, using the two spinboxes at the topline. The spinbox top left defines the central bin, the spinbox to the right the number of bins,

The spinbox, here showing the number "10" defines a threshold value for distinguishing between noise and data in the incoming signal.

The buttons *reset* and *dump* have their obvious meaning.

## 5.2 The psk plugin

### 5.2.1 Introduction

psk, i.e. *phase shift keying* is a technique where the data is encoded as shifts in the phase of the signal, with - at least theoretically - a signal with a constant amplitude. For amateur modes, there are two variants, *bpsk* and *qpsk*, standing for *binary* and *quadrature* phase shift keying.

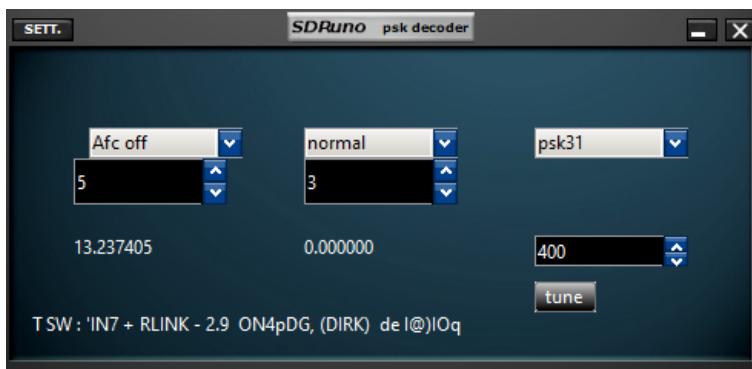
Binary is - obviously - the simplest one, the phase shifts either 0 or 180 degrees. In the quadrature mode phase shift can be 0, 90, 180, 270 degrees. In the binary mode there is one bit per symbol, in quadrature mode 2.

The rate for bpsk is 31.25, variants use the double or 4 times that rate. Qpsk has the same rate.

Decoding is not very difficult, decimate the incoming samplestream to e.g. 500 samples per second, then the duration for a single bit in bpsk (two bits in qpsk) is 16 samples. So, collect 16 samples, such that the first 8 are part of one symbol, and the last 8 are part of the next symbol. Then compute the phase difference between the two parts and send the bit to a procedure that adds it to a sequence of bits for decoding.

The main problem is obviously the tuning, the width of the signal is a few tens of Hz.

### 5.2.2 The plugin



Here the decoded text is shown on the bottom line. The widget has two rows with selectors, the top row shows 3 comboboxes,

- selecting the *Afc*. If tuning is in range, the afc can be used to correct the offset, but do not expect miracles here;
- selecting *normal* or *reverse*, sometimes the encoding of bits wrt to phase and phase change is reversed;
- selecting the *mode*, i.e. bpsk31, qpsk31, bpsk63, etc.

Below these comboboxes there are two spinboxes, the left one for setting the degree of the filtering (note that a high degree of filtering causes averaging in the signal), the next one is a setting for a threshold value (i.e. when is the signal to be considered noise).

As with the cw decoder, a simple form of automated tuning is included, touching the *tune* button instructs the software to tune to the strongest signal within a range, indicated by the spinbox above the button.

## 5.3 The rtty plugin

### 5.3.1 Introduction

RTTY data is transmitted using a frequency shift between a *mark* and a *space* frequency. I.e. as with psk, a continuous carrier is transmitted, with - depending on the baudrate - frequency switches over a given range.

For amateur modes - btw it seems that rtty is less used than e.g. a decade ago - the baudrate is 45 baud, and the distance between mark and space is 170 Hz. The amateurband I am often listening to is around 14080 KHz.

From time to time one finds data transmissions, usually weather related - on non amateur bands on short waves.

Decoding rtty signals is not very difficult, tune in to the frequency in the middle between mark and space and count the durations of the mark and space signals. Since the difference between mark and space frequency is - for amateur modes - 170 Hz, tuning is easier than tuning a psk signal.

### 5.3.2 The plugin



The plugin has 8 control switches, and 4 indicators. The decoded text is shown on the bottom line of the plugin. The controls are

- the *shift*, default set to 170 Hz, however, with a variety of options up to 1200 Hz;
- the *rate*, default set to the amateur rate of 45 baud, but, here as well, showing a variety of options;
- the *bits* per element, default set to 5 as used for common baudot encodings;
- the *stopbits*, default set to 1, as used for common encodings;
- the *parity*, which is usually *none*, but the combobox offers other options;
- the *msb*, i.e. a selection between *msb most significant bit* or *lsb, least significant bit* first;
- the *afc on* or off, the software measures the distance between the tuned frequency and the mark and space frequencies and is able to correct itself (a little);
- *reversed* or not, tells whether or not mark frequency is the higher one or the space frequency.

The small number displays to the left give an indication of the measured frequency offset and the computed baudrate.

## 5.4 The navtex plugin

### 5.4.1 Introduction

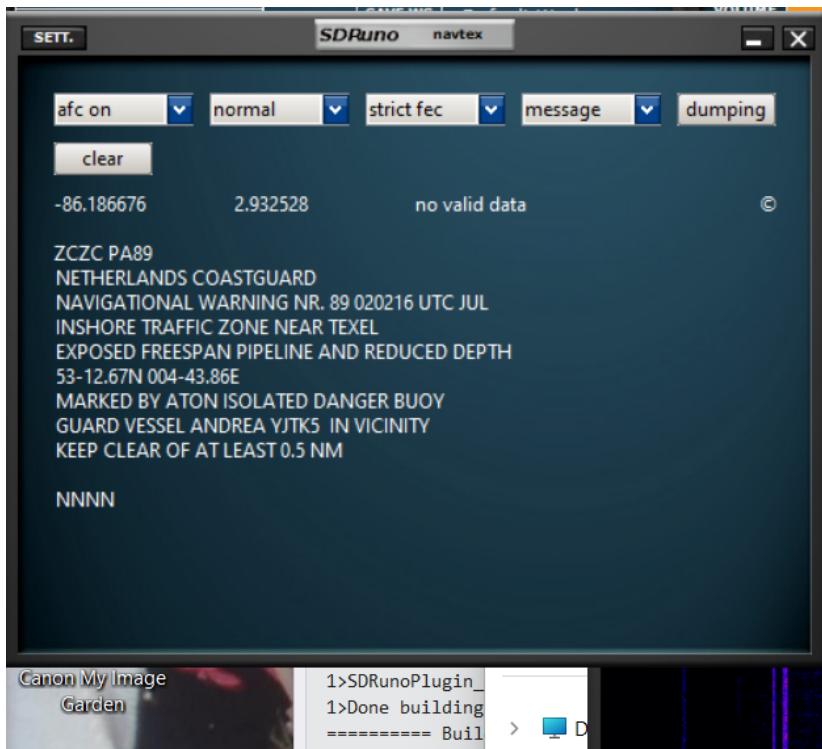
NAVTEX (NAVigational TEleX) is a service for delivery of navigational and meteorological warnings and forecasts, as well as urgent maritime safety information (MSI) to ships.

The transmissions are layered on top of SITOR collective B-mode. SITOR-B is a forward error correcting (FEC) broadcast that uses the CCIR 476 character set. NAVTEX messages are transmitted at 100 baud using FSK modulation with a frequency shift of 170 Hz.

So, other than with common RTTY messages, the text of the message is protected on two levels, a FEC protection on bit level and a (simple) protection on text level by preceding the message with a "ZCZC" prefix.

On the internet one finds a list of coastguard stations that transmit these navigational messages together with the transmission times, see "[https://en.wikipedia.org/wiki/List\\_of\\_Navtex\\_stations](https://en.wikipedia.org/wiki/List_of_Navtex_stations)".

### 5.4.2 The plugin



While not shown in the widget, on starting the plugin it will set the tuned frequency in the SDRUno platform to 518 KHz (of course you can change that to whatever frequency you want).

Other than the previous version, the widget in the current version shows complete messages. The top lines are reserved for the controls, a few comboboxes and buttons and a status label.

- *afc* switch, as with the rtty decoder, a limited form of automatic frequency correction is

possible, of course tuning should already be between the mark and space frequencies;

- *normal* or reverse. The signal is a regular FSK signal, the setting relates to the position of the mark and the space, i.e. which one is the high and which one is the low frequency.
- *strict* or non strict, i.e. with the FEC switched on off, the default setting is the FEC is "on".
- *message*, i.e. protected and checked, or anything that is seen as data. Default is "message" is "on".
- *file* touching this will show a file selection menu. When a file is selected, the navtex messages will be stored in it (i.e. contrary to a previous version, NOT all text). Touching the button when the file is open will close the file.
- *clear*, clear the screen and reset the system.

The two numbers give an indication of the signal quality resp. the computed frequency offset for optimal decoding.

New is a *clear* button on the second line, touching this clears the textfield and resets the state of the decoder, and new is the status field, telling here that currently the incoming data is not valid.

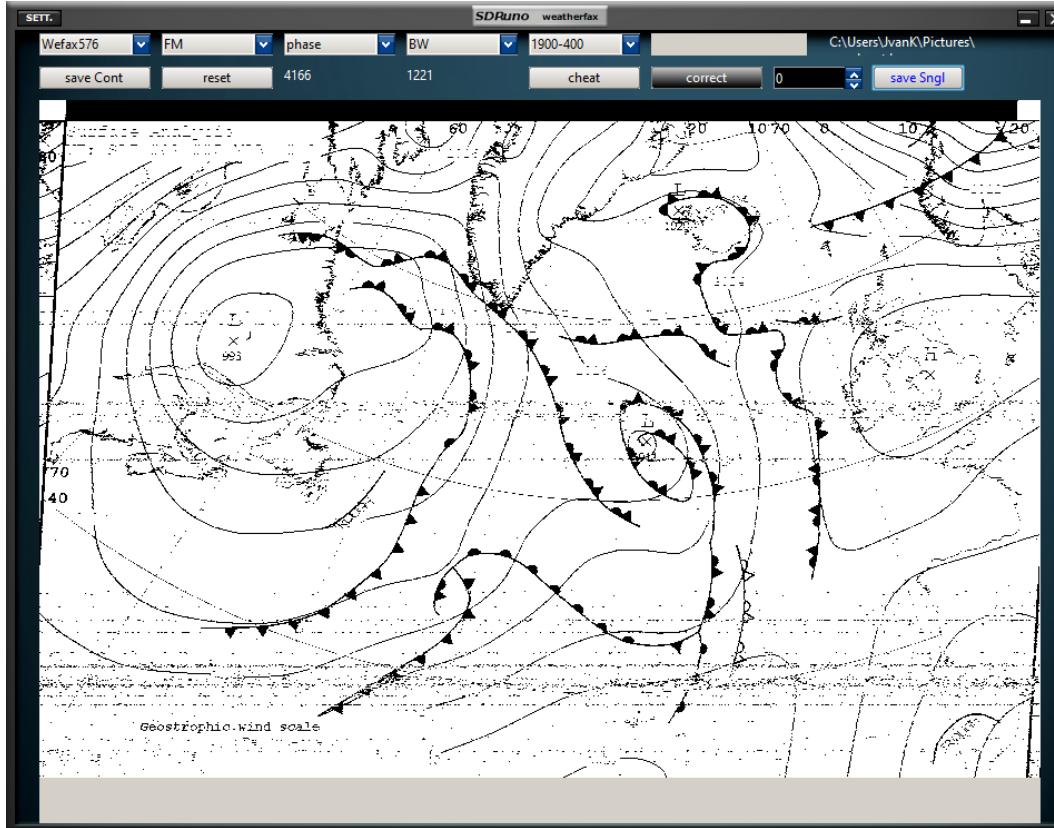
## 6 The weatherfax plugin

### 6.1 introduction

Weatherfax data is still being transmitted on shortwaves, typical frequencies that I receive are 3855 KHz, 4610 KHz, 7880 KHz and 8040 KHz. The encoding of a picture starts with a single tone (for the common Wefax576 mode 300 Hz), followed by a number of lines with white margins left and right, and a black middle. These *synchronization* lines are followed by the lines of the actual picture. At the end of the picture another tone is transmitted, usually 450 Hz.

The picture can be quite lengthy, and since the transmission speed is 2 lines a second, a full transmission of a 1200 line weatherchart takes about 10 minutes.

## 6.2 The widget



The plugin operates in one of a few *states*, on startup the state will be *APTSTART*, after recognizing a start tone the state will be *PHASING*, on successful recognizing the phases and synchronizing, the state will be *ON\_SYNC* and the picture will be decoded. When recognizing an end signal (or after a predefined number of recognized lines) the state will be *FAX\_DONE*.

The widget shows two lines with displays and controls and about 600 lines for the transmitted picture. The size of the picture displayed is *half* the real size, when saving the picture (see the selectors below), the picture in its original format is saved.

The controls and displays on the top line are

- *transport mode*, by default *Wefax576*. Alternatively *Wefax288* can be selected;
- *modulation*, by default FM, alternatively AM can be selected;
- *phase*, the software assumes that the encoding of black and white in the signal is reversed;
- *black and white* or color;
- *1900-400*, with as alternative *1900-450*, tells the deviation of the signal wrt the central frequency. The *1900* number is here meaningless, one should tune to the exact frequency of the transmission rather than tuning with an offset of 1900 Hz.

The top line furthermore contains an indicator for the *state* (not shown here) and - if a file is selected - the (path)name of the file.

The second row contains

- the *save continuous* selector, having enabled this, the software will continuously try to detect pictures and save results into a file;
- the *reset* button, touching this will reset the mode of operation;
- the *cheat* button, which will make the software think that synchronization is achieved, and will set the state to *ON\_SYNC*.
- the *correct* button, which will allow a user to correct the number of samples per line, for which
  - the *correction* value is used.
- the *save single* selector, instructing the software to save the received picture into a file.

The number on the left tells the average frequency of the encoding of the current line, the other number tells the number of the current line.

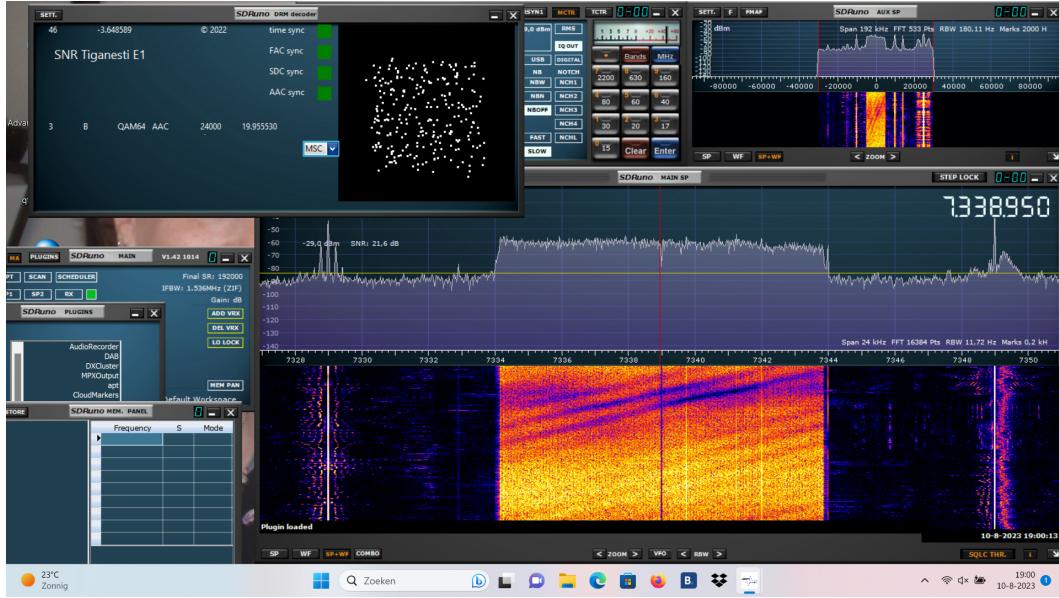
## 7 The DRM plugin

### 7.1 Introduction

DRM, Digital Radio Mondiale, is a type of digital radio that is transmitted on medium and shortwaves. Here in western Europe there are not many transmissions anymore, but some people believe that it has a future.

A DRM transmission fits within the transmission scheme of AM transmissions in short and medium waves. While there are some variations in bandwidth and mode, most transmissions (at least the ones I can receive) are just 10 KHz wide.

A DRM transmission is recognizable on the main spectrum of the SDRUno, rather than a single carrier with some sidebands, one sees about 300 carriers, close to each other, as in the picture. Distance between the carriers is app 45 Hz, and each carrier "carries" part of the transposed data. The major drawback of this type of technique is that tuning must be (almost) perfect, otherwise decoding will be impossible. In case of DRM, a frequency offset of over 23 Hz makes the transmission *unreadable*. Fortunately the transmitted data contain some special markers that will help the decoder to correct frequency.



## 7.2 The plugin



The widget does not provide controls for tuning, if a reasonable signal is found, the software computes the frequency offset continuously and will correct for it. Important in decoding DRM is *synchronization*, there are four steps in synchronization:

- *time sync* tells whether or not the software is able to detect a bitstream looking more or less as a DRM stream;
- *FAC sync* tells whether or not the software is able to decode some data in the input stream, giving information about the structure in the input stream;
- *SDC sync* tells whether or not the software is able to extract information about the encoding of the service(s) in the input stream;
- *AAC sync* tells whether or not the software is able to decode the data of the current service and create audio from it.

The four blocks left of the display on the widget give these indications. As can be expected, green is good, red is not. Successful decoding requires all 4 indicators to be green.

To give an impression on the (quality of the) signal, the current version is equipped with a *constellation display*. The widget has a (single) control, one may choose which constellation is to be shown, the default setting is "MSC". In general the "FAC" (Fast Access Channel) part of the signal - giving the decoder information on the content of the transmission - is encoded as 4QAM signal, i.e. the display ideally shows 4 dots, where each dot is decoded into 2 bits.

The "SDC" (Service Description Channel) part of the signal, i.e. the part containing info on the service(s) carried, is encoded as either 4QAM or 16 QAM. The picture here shows 16QAM, each dot is to be decoded into 3 bits. The actual service data, contained in the so-called "MSC" (Main Service Channel), is encoded as 16QAM or 64QAM, where each dot is to be decoded into 4 bits.

The picture clearly shows that the software "had to think very deep" before being able to map this cloud of dots to audio.

The two numbers top left give an indication of the detected frequency offset (the frequency itself is not shown), the overall offset is obtained by adding these two numbers.

The bottom line tells that the *spectrum* type was 3, i.e. just a 10 Khz wide spectrum, the *mode*, telling how the data is organized, is mode *B*, the data is encoded as QAM64, the audio encoding is plain AAC and the baudrate of the audio output is 24000 baud.

The space between the bottom line on the picture and the bottom of the picture may contain a text message, a message encoded within the audio stream.

## 8 The FT8 plugin

### 8.1 Introduction

FT8 seems to be a quite popular mode, messages are very short, less than 15 seconds and highly structured. In the 20 meter band - my favourite - is the spectrum around frequency 14074 Khz usually overcrowded with the short FT8 messages.

FT8 decoding is essentially based on a - more or less - "intelligent" brute force approach. In a first step an attempt is made to preselect the potential messages using detection of a Costas array that is used for locating the message. In the second step for each of these potentials an LDPC based error detection/recovery mechanism is applied, in a third step the resulting message is subjected to a CRC check. There is no guarantee that all messages in such a message stream are detected and decoded.

The code in the plugin uses parts of the code of the FT4FT8 decoding software of Karlis Goba. Especially the LDPC decoder is a copy of his code, and the copyright to the parts taken or derived from his code are gratefully acknowledged.

## 8.2 The plugin



The picture shows the output, apparently from a transmission around 4.02PM. The messages have a (more or less) standard FT8 format, preceded by 3 columns

- the time of decoding the message;
- a strength indicator (derived from the strength of the costas array);
- the frequency of the message (the accuracy of the frequency obviously depends on the accuracy of the reading from the SDRUno platform, and is expressed in steps of 3 Hz).

The two rows on top of the widget show some controls.

- the spinbox, here set at value 11, sets the number of iterations to be applied in the LDPC decoding. A higher value *may* lead to better decoding results, although values too high will lead to false positives.
- the spinbox with value 3000 sets the searchwidth in Hz, the range around the currently selected frequency where the software will search for FT8 messages;

- the button labeled *file*, when touched will instruct the software to show a file selection menu for storing the results (in plain ASCII), touching the button when a file is open will close the file. The label to the right, here colored green, will change its color to red when a file is open;
- The label wwith text *V2.2* shows the version number of the software;
- the button labeled *preset* will add the currently selected frequency to the list of preset frequencies.

The second row

- the button *reporter*, when touched will activate a handler to transmit the received data to the so-called psk reporter. If successfull the label to the right will color red. Sending data to the reporter will only work is a *callsign* is filled in, the button with that name - when touched - shows a small widget where such a callsign can be entered.
- The combobox showing *14075* tells the currently selected frequency. Elements in this combobox are *preset frequencies*. As mentioned earlier, frequencies can be added to the list of presets. (Obviously, the list will be maintained between invocations of the plugin).
- the button labeled *delete* will delete the last element of the preset list.

## 9 The acars plugins

### 9.1 Introduction

Acars stands for *Aircraft Communications Addressing and Reporting System*, a digital datalink for transmitting short messages between aircraft and ground stations. The plugins decode Acars transmissions in the VHF band (around 130 Mhz).

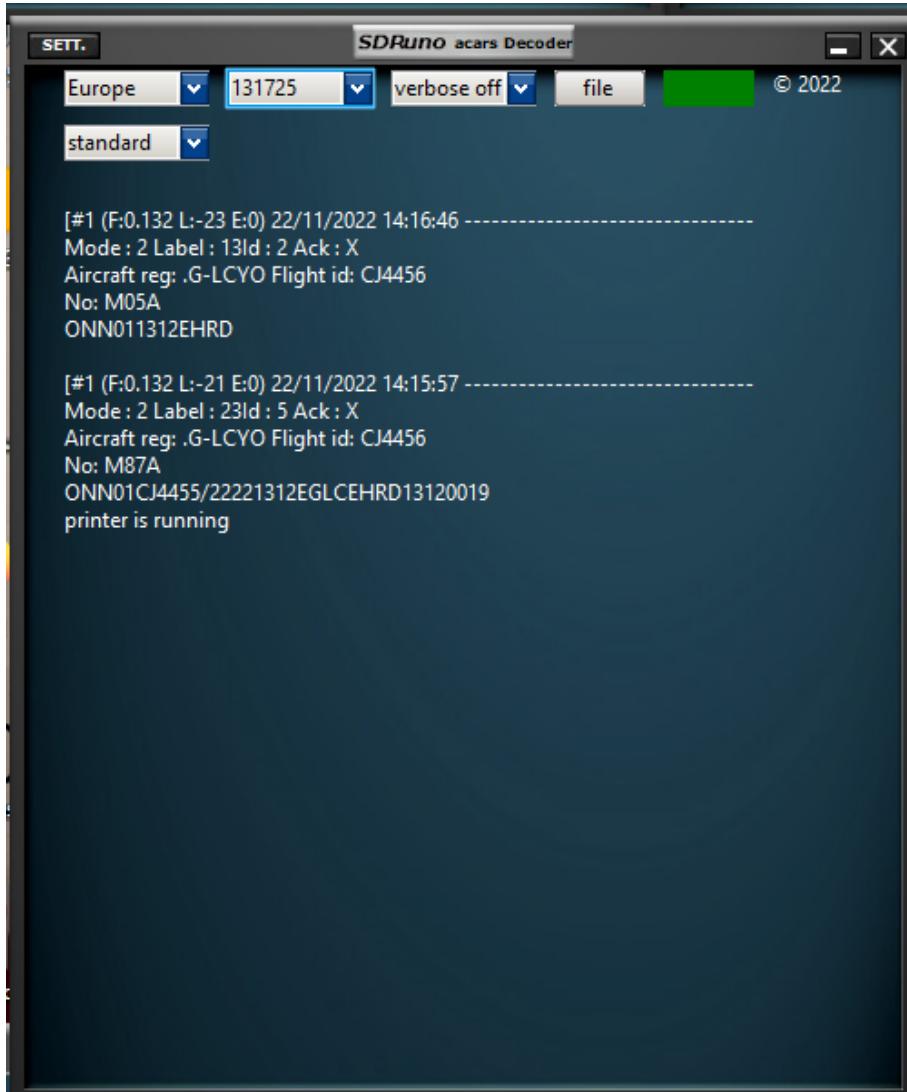
It should be emphasized that the SDRUno plugin for acars decoding uses parts - rewritten though - from the implementation of the Msk decoding and the printer functions from the original acars decoder that was written by Thierry Leconte and his copyrights are acknowledged.

Transmission frequencies for Acars differ from continent to continent, Usually there is a main frequency and some alternative frequencies per continent (or part of it).

There are two versions of the acars plugin, the first one is for decoding data on a single frequency. The second one uses the fact that a frequency range of 2 MHz can be covered by the SDRplay devices and is able to decode data from different frequencies.

Both plugins have selectors for selecting from common acars frequencies.

## 9.2 The acars plugin



Controls for the regular acars plugin are:

- the *continent* selector. Frequencies differ per continent, so the continent selector can be set, selecting a continent will ensure that the frequencies, listed in the the combobox next to the continent selector, are the ones valid for the selected continent.
- the *frequency* selector. This combobox shows the frequencies common for the selected continent. Of course tuning to a different frequency using the SDRUno platform is always possible;
- the *verbose* selector. Setting this selector will create some more details in the output;
- the *file* selector. Touching this selector will instruct the software to show a file selection menu. When a file is selected, all output will also be written to the file. Touching the button when the file is open will close the file. If a file is selected, the label will color red;

- the *standard* selector gives a choice to different forms of output. Standard is displays in the picture, a one line output per message or a monitoring message.

### 9.3 The acars-M plugin



So rather than selecting a continent first and a frequency for transmissions within that continent next, one chooses here a label, and each label represents a continent and a few frequencies used on that continent. For Europe one may choose between Europe-1 and Europe-2, for the US between USA\_1 and USA\_2, furthermore for Australia and Japan.

## 10 The EXPERIMENTAL apt137 plugin

### 10.1 Introduction

As known, there are hundreds of satellites flying over our head, some with somewhat undefined purpose, quite a number watching us or our environment. Three satellites, flying polar circles, transmit pictures, photographs of the earth, on a frequency that is known and with a format that is known. These satellites, the NOAA-15, NOAA-18 and NOAA-19 transmit data in the 137 MHz band and - with some effort - the pictures (photographs) they send downwards can be received.

The photographs are transmitted in an analog form, basically a number of values, one value per color grey, organized in lines, lines with a defined structure, 2 lines per minute.

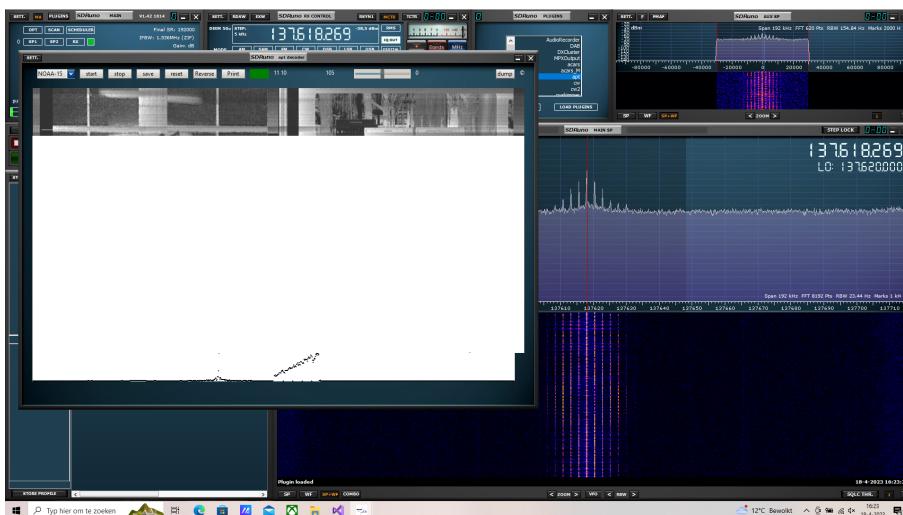
Modulation of the values is first as AM signal on a 2400 Hz carrier, and then FM modulated and transmitted on a frequency specific to the satellite.

Of course there are issues. Satellites fly fast, and their appearance over the horizon is usually limited to at most about 15 minutes. Furthermore, transmission power is very, very low, so one needs a decent antenna for the reception of the signal. Since I am a person with two left hands, I only made a very simple antenna, the one described in

"<http://rfelektronik.se/manuals/Datasheets/DIY%20137MHz%20WX-sat%20V-dipole%20antenna.pdf>".

Although I get a signal, it is pretty weak and the quality of the pictures is not very high. Rather than sitting from time to time in the rain outside aiming my antenna to an assumed azimuth, I developed - based on a decoder made by "Gokberk Yaltirakli" and available under a GNU GPL and using an Adalm Pluto - a simple "transmitter" for fake APT 137 pictures to test the decoder. In that sense the decoder is experimental, I got some data from a satellite, but most of the testing was done with my own generated transmissions. Of course, I'm interested to learn about experiences.

### 10.2 The plugin



A line in an APT picture contains 2080 pixels, since the screen on my laptop has a width of around 2000 pixels, I have the picture reduced on the screen. In "core" the picture has its full size, and saving it (as a bitmap) preserves the full size.

The controls on the top of the widget are:

- the *satelite* selector, when selecting a satellite (either NOAA-15, NOAA-18, or NOAA-19), the plugin will ask the SDRUno platform to switch over to the frequency specific to that satellite;
- the *start* button, touching it will start the actual attempts to decode;
- the *stop* button, touching it will stop de actual decoding attempts, some other operation will only function with decoding switched off;
- the *save* button, when touched will instruct the software to present a file selection menu. After selecting a file, the current picture is saved, as said in the full format as bitmap; Touching the button is a void operation if decoding is "on";
- the *reset* button, when touched will - as the name suggests - reset a number of variables;
- the *reverse* button, when touched will - as the name suggests - reverse the picture. As can be imagined, sometimes the satellite passes the region from north to south, other times from south to north, in which case the picture will be upside down. If decoding is off, the picture will be reversed;
- the *print* button, when touched, will reprint the picture on the screen. This is useful when changing the "grey setting", with the slider.
- the *grey slider* alters the mapping from incoming values to grey values (a little);
- the *dump* button will , when touched, instruct the software to present a file selector, with which a ".wav" file can be selected. If a file is selected, the incoming data, i.e. a samplestream, will be saved after the FM decoding and after converting it to an 11025 Ss single channel stream. The reason is that I found a few decoders on the internet that could decode input after the FM decoding and as single channel streams with lower rates.

The green label on the top line indicates that the software seems to be synchronized, the two numbers to the right tell how many samples from the start of the current buffer the first pixel of the line is found. Since that is computed in two different ways, there are two numbers that should not differ too much.

The number to the right of these 2 numbers, here 105, is the number of the line being written.

## 11 The wspr plugin

wspr is a "whisper" mode, signals are usually pretty weak, and are made up of a few tones, in frequency very close to each other. The bandwidth of the signal is (roughly) 6 Hz, the tones have a frequency shift of about 1.45 Hz. The *duration* of a message is nearly 2 minutes, and messages start (should start) on an even minute.

Decoding wspr signals is pretty tough, happily there is a ready-made set of functions that will do the hard work (wsprd). It must be stressed that the copyrights for those functions

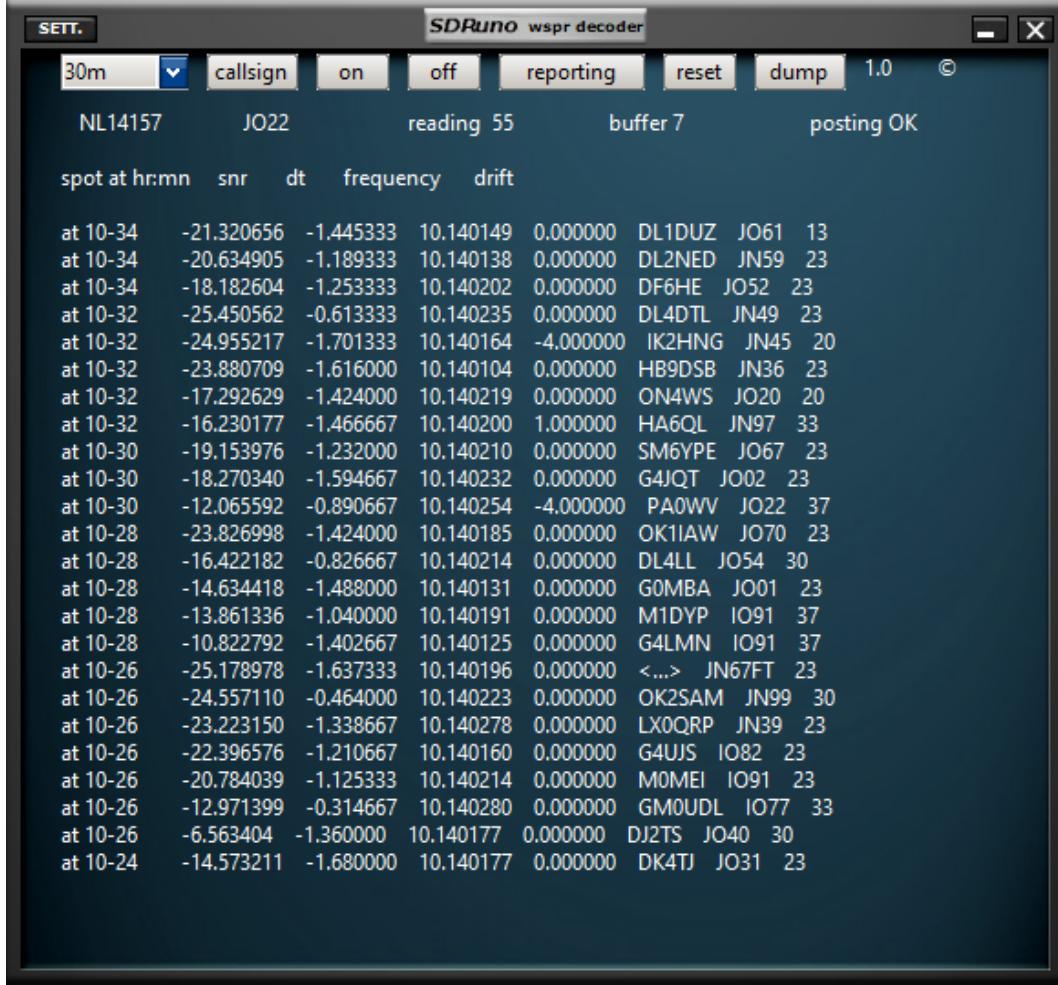
belongs to the developers, **Joe Taylor** and **Steven Franke**. These functions are included integrally in the code of this plugin.

What needs to be done to use that "core" is basically to build a front end that deals with the input device, the frequency selection, some filtering and processing the output.

That is precisely what the SDRUnoPlugin\_wspr does: it functions as a front end for the "core functions" taking care of the input handling, the various settings and the "output".

The output of the plugin is a list with elements describing the signal heard. The last 25 lines of the output appear on the widget, the full output can be written to a file (in .csv format, so it can be read in a formatted way by e.g. OpenOffice or its Windows equivalent. Furthermore, the output can be "posted" to the site of the psk reporter. Precondition is that the software knows your callsign and location, the widget contains a selector with which a callsign and a location can be given.

The plugin will continuously read in messages, and - while the next message is being read in - will try to decode the message and generate output. So, it might happen that subsequent messages contain signals of the same transmitter. To avoid that, a message will only be shown if the caller was not seen for at least 10 minutes.



The screenshot shows a window titled "SDRUno wspr decoder". At the top, there is a menu bar with "SETT." and other options. Below the menu is a toolbar with buttons for "30m", "callsign", "on", "off", "reporting", "reset", "dump", and a numeric value "1.0". There is also a copyright symbol. The main area displays a list of received signals. The first few lines of the list are:

spot at hr:minn	snr	dt	frequency	drift	call	name	lat	lon
at 10-34	-21.320656	-1.445333	10.140149	0.000000	DL1DUZ	JO61	13	
at 10-34	-20.634905	-1.189333	10.140138	0.000000	DL2NED	JN59	23	
at 10-34	-18.182604	-1.253333	10.140202	0.000000	DF6HE	JO52	23	
at 10-32	-25.450562	-0.613333	10.140235	0.000000	DL4DTL	JN49	23	
at 10-32	-24.955217	-1.701333	10.140164	-4.000000	IK2HNG	JN45	20	
at 10-32	-23.880709	-1.616000	10.140104	0.000000	HB9DSB	JN36	23	
at 10-32	-17.292629	-1.424000	10.140219	0.000000	ON4WS	JO20	20	
at 10-32	-16.230177	-1.466667	10.140200	1.000000	HA6QL	JN97	33	
at 10-30	-19.153976	-1.232000	10.140210	0.000000	SM6YPE	JO67	23	
at 10-30	-18.270340	-1.594667	10.140232	0.000000	G4JQT	JO02	23	
at 10-30	-12.065592	-0.890667	10.140254	-4.000000	PA0WV	JO22	37	
at 10-28	-23.826998	-1.424000	10.140185	0.000000	OK1IAW	JO70	23	
at 10-28	-16.422182	-0.826667	10.140214	0.000000	DL4LL	JO54	30	
at 10-28	-14.634418	-1.488000	10.140131	0.000000	GOMBA	JO01	23	
at 10-28	-13.861336	-1.040000	10.140191	0.000000	M1DYP	IO91	37	
at 10-28	-10.822792	-1.402667	10.140125	0.000000	G4LMN	IO91	37	
at 10-26	-25.178978	-1.637333	10.140196	0.000000	<...>	JN67FT	23	
at 10-26	-24.557110	-0.464000	10.140223	0.000000	OK2SAM	JN99	30	
at 10-26	-23.223150	-1.338667	10.140278	0.000000	LX0QRP	JN39	23	
at 10-26	-22.396576	-1.210667	10.140160	0.000000	G4UJS	IO82	23	
at 10-26	-20.784039	-1.125333	10.140214	0.000000	M0MEI	IO91	23	
at 10-26	-12.971399	-0.314667	10.140280	0.000000	GM0UDL	IO77	33	
at 10-26	-6.563404	-1.360000	10.140177	0.000000	DJ2TS	JO40	30	
at 10-24	-14.573211	-1.680000	10.140177	0.000000	DK4TJ	JO31	23	

(It shows that my antenna equipment is "limited", the messages seen are all from neighbouring locations).

## 11.1 Installing the plugin

Installing the plugin is simple, just copy the dll file to the folder for the community plugins.

## 11.2 The plugin



Op top of the weidget there are two lines, the top one contains all selectors, the second one labels that tell about the status of the processing of the widget.

- The *frequency selector*. The combobox contains a list of the frequencies, known for wspr frequencies, the default is the frequency in the 20m band. While a frequency may be selected at any time, the software will delay the actual effectuation until the current message is completely read. One exception, in the waiting time on startup (which may last for nearly 2 minutes), attempts to set or change the frequency using the band selector will be obeyed immediately. The setting in the picture here is the wspr frequency in the 30 m band.
- The *callsign selector*, when touched, will show a small menu where a callsign and a location can be entered. The callsign and location will be kept between invocations of the plugin. (Note that if no callsign and location are entered, the plugin will never post the results.)
- *subtraction* on or off. If a message is decoded, genereting the signal the message should have had and subtracting that from the incoming signal may help in decoding other messages in this buffer;
- switching *quick mode* on or off. Quick mode is - as the name suggests - a mode where some tests are done less rigourously;
- *reportmode button*, indicates whether or not the results should be uploaded. Switching the report "on" will start a module that tries to connect to the psk reporter site and - if successfull - will take care of the posting;
- the *reset button*, with the obvious semantics;
- A *dump file button* for the results shown. On touching, a file menu is shown. The received messages will be saved in the selected file in a format that can be displayed by e.g. OpenOffice (or obviously, its Windows equivalent).
- a label telling the version number (here 1.0);
- a copyright symbol.

The second line

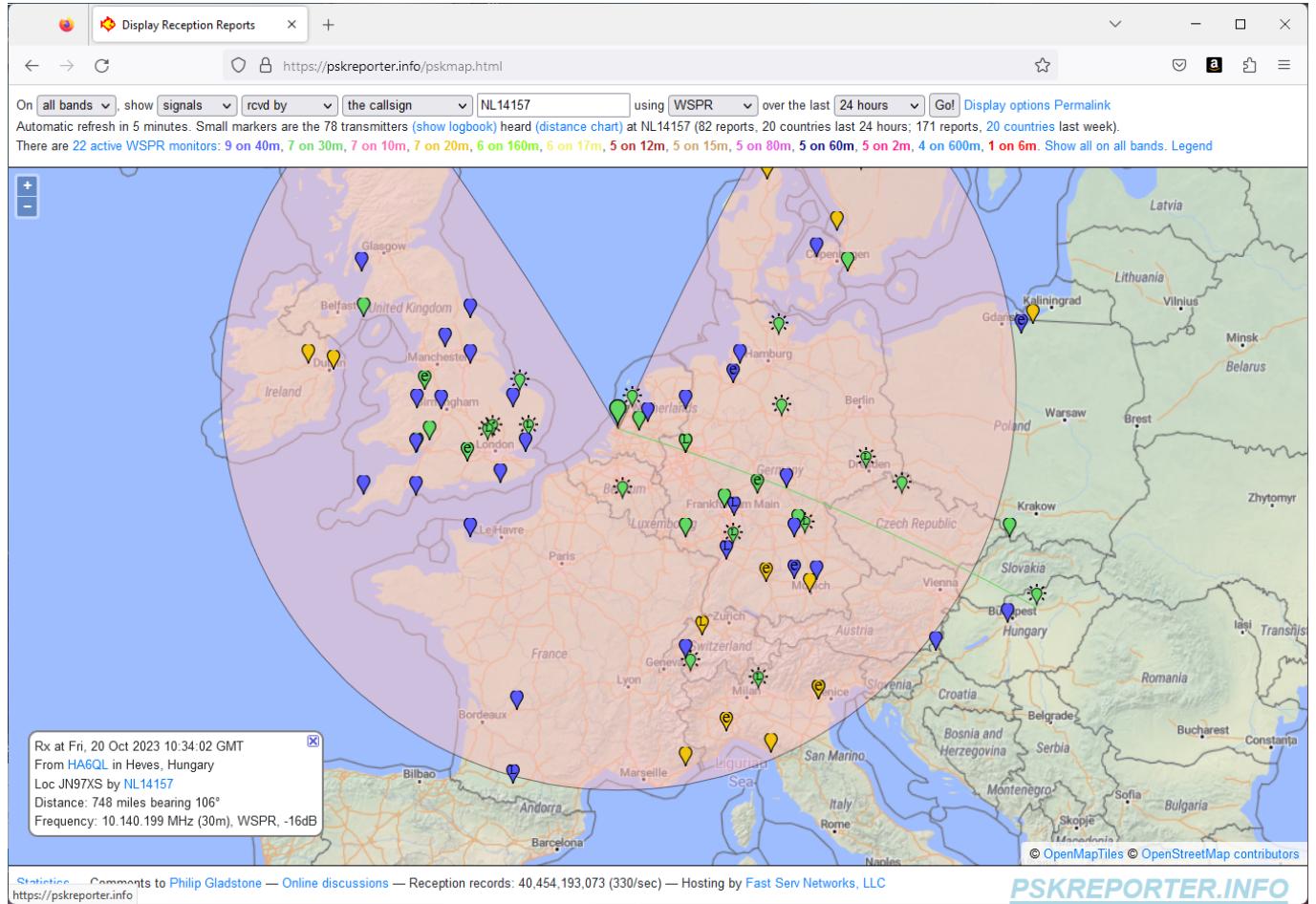
- the *callsign* of this receiver station;
- the *locator* of the receiver station;
- the *counter*. WSPR transmissions start on even minutes, so when starting the plugin there is usually a waiting time (that may run to up to almost 2 minutes), and when the transmission is on, during just about 115 seconds data is transmitted. The label tells the seconds to wait or the seconds the software is reading the current transmission. The picture shows that it was taken when 55 out of 115 seconds was passed when reading;
- A label for *status messages*, usually telling the number of cycles passed. The picture shows that the 7-th buffer was processed, so now the program is reading for the 10-th cycle;
- A label for telling the *status of printing and posting* the results. If *reporting* is selected, the first message indicates whether or not a connection could be made to the pskreporter site. If posting succeeds, the message *posting OK* is shown.

Kolomtype:

	Standaard	Standaard	Standaard	Standaard	Standaard	Standaard	Standaard	Standaard	Standaard	Standaard
1										
2	snr	dr	freq	drift	call	loc	power		Thu Oct 19 13:32:10 2023	
3										
4	at 11-32	-15.035252	-0.293333	14.097164	0.000000	IZ3WXD	JN55	27		
5	at 11-32	-19.899557	0.645333	14.097123	0.000000	OK2SAM	JN99	30		
6	at 11-34	-5.834878	-0.400000	14.097100	0.000000	HA6QL	JN97	33		
7	at 11-34	-15.359796	-1.104000	14.097072	0.000000	HB9PVI	JN37	23		
8	at 11-34	-29.170626	4.037333	14.097016	0.000000	OH8RO	KP25	23		
9	at 11-36	-17.106005	-0.208000	14.097032	0.000000	E17JR	I063	23		
10	at 11-36	-18.293562	-0.485333	14.096992	0.000000	IZ3WEQ	JN55	30		
11	at 11-36	-19.173397	-0.101333	14.097049	0.000000	SM6YPE	J067	23		
12	at 11-36	-21.053486	-0.080000	14.097027	0.000000	SP2LNY	J094	17		
13	at 11-36	-23.183554	-0.101333	14.096990	0.000000	E18KG	I063	23		
14	at 11-40	8.208358	-0.080000	14.097078	0.000000	IK5BNG	JN54	37		
15	at 11-40	-21.014339	-0.122667	14.097054	0.000000	DL7MPQ	JN58	30		
16	at 11-40	-22.837818	-0.378667	14.096997	0.000000	4Z4TJ	KM71	37		
17	at 11-42	-10.679616	-1.680000	14.097088	0.000000	HB9BAX	JN36	30		
18	at 11-44	-18.482115	-0.400000	14.097100	0.000000	OZ1IPH	J047	13		
19	at 11-44	-19.222992	-0.592000	14.097092	0.000000	HB9DSB	JN36	23		
20	at 11-44	-20.045301	-0.378667	14.097020	0.000000	IZ3WXD	JN55	27		
21	at 11-46	-23.498032	-0.165333	14.097033	0.000000	SA7RST	J078	23		
22	at 11-46	-28.788517	-0.336000	14.097194	1.000000	IU1FIG	JN44	20		
23	at 11-48	-15.261477	-0.186667	10.140151	0.000000	HB9AE	JN36	23		
24	at 11-48	-23.139955	0.981333	10.140129	0.000000					

### 11.3 The pskreporter

Similar to e.g. the FT8 plugin, this wspr plugin is able to send data of the received messages to the psk reporter. This reporter displays on a map the location of the "monitor" as well as the location of all transmitters from which a message is received. The map below shows an example.



## 12 The Gnu GPL

As mentioned before, the software is available under a GPL V2. Since I am using ideas and some code parts of other software that is available under this or a similar license, GPL V2 is the license for all my software.

Roughly speaking it means:

- the software - including the sources - are available *as is*, no guarantee on the correctness of usefulness is given, but anyone can see for itself whether the software is useful for one's own purposes or not. Being available *as is* obviously implies that I am not obliged to react on comments or questions for modifications or additions. It also means I am not responsible for the effects of using the software: while not foreseen, if the software ruins your computer, do not blame me;
- You are (always) invited to remove errors, both real and alledged errors, to add functions or to use parts of the software for your own software. However, you should make the modified software available under the same license. Of course, if you just keep the software for yourself, no one else will see it, however, if you make your software available , you

should provide the sources and - obviously - acknowledge the copyrights of the provider. As an example, the error correcting facility and the actual wspr decoding software are included in these plugins and the providers of these parts (both parts are included as slightly modified sources) keep having the copyrights of the providers.

## 13 Acknowledgements

In the development of the plugins - they are open source - abundant use is made of other, existing, open source libraries. As an example, in different plugins FFT transforms are made, For FFT processing the *kiss\_fft* library is used *Copyright (c) 2003-2010, Mark Borgerding. All rights reserved.*

The DRM plugin uses the *libfdk* for translating the AAC segments into PCM samples, for equalizing the signal it uses the *Eigen3 library*, and the equalizer itself is based on code found in *diorama*.

The FT8 plugin uses parts of the code of the FT4FT8 decoding software of *Karlis Goba*, in particular the LDPC decoder is (almost) a copy of his code.

The acars plugins use code fragments (and ideas) by *Thierry Leconte*.

The core functions of the wspr decoder are developed by *Joe taylor* and *Steven Franke* and some elements of the structure, processing in the front end, especially the posting of the results, is based on *rtlsrd-wsprd*, *WSPR daemon for RTL receivers Copyright (C) 2016-2021, Guenael Jouchet (VA2GKA)*.

All copyrights are gratefully acknowledged.