Manual to the
Weather Satellite Receiver
R2FU

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Read the manual carefully before using the receiver.

1. Introduction

With the R2FU you get a receiver which is designed for the reception of polar orbiting weather satellites which transmit in the 137MHz band, mainly those of the American NOAA series. In addition it is possible with a suitable converter to receive the geostationary satellites like Meteosat which transmits on 1.7GHz (note: European Meteosat quit its WEFAX transmissions, however in America and Pacific area the GOES satellites are still active).

Matched IF filters and a highly linear demodulator provide optimal image quality, even with weak signals. Thanks to the excellent receiver noise figure an additional pre-amplifier is not necessary in most cases.

Thanks to the scan mode it is easy to find the satellites even without satellite tracking software.

An AFC circuit compensates for the Doppler frequency shift of the satellite.

A novel feature which no other low-cost sat-receiver is providing yet, is the ability to use two antennas simultaneously in diversity mode. This gives images virtually without any signal dropout during the pass even with simple antenna configurations.

The R2FU is an improved version of the R2FX. Main difference is the USB 2.0 interface that became necessary since most modern PCs don't have a serial interface any more.

Above that the receiver comprises a highly selective crystal IF filter and an improved RF fronted which was taken from the much more expensive R2ZX. This provides a much better ability to receive the satellite signals in presence of strong signals in the same band. The feature is in particular useful in countries like UK where pager services operate close to the satellite frequencies.

2. Safety precautions

The receiver complies to the national and European requirements for electromagnetic compatibility. The reception of weather transmissions is free for everybody in most countries.

Technical modifications of the receiver by the user invalidates the guarantee. There is no liability for damage caused to the receiver which is due to disregarding the contents of this manual. Also there is no liability for incidental or indirect damages arising from that.

The receiver should be powered only by the USB interface of the PC or with a well filtered 5 VoltDC voltage from a USB power supply. Voltages which exceed this value can damage the device. See chapter 9 for further information about suitable power supplies.

3. Included items

- 2m-receiver R2FU
- 3.5mm connector cable
- Mini-USB interface cable
- User Manual
- CD-ROM with configuration software for the R2FU and freeware versions of common image decoder software.

4. Preparing for use

Connect the R2FU to the USB interface of a PC. The receiver does not have an on-off switch. It starts immediately when it is powered. First all LEDS on the front panel light up. After one second at least a red and a yellow LED remain lit.

If you have a Windows PC and if there is already a FTDI driver installed the receiver is ready to use. Otherwise there will be a message from the OS "new hardware found". Insert the R2FU CD-ROM and install the driver from there.

The receiver needs the USB interface only for configuration. For pure satellite reception a USB mains adapter like those which are commonly used for mobile telephone charger is sufficient.

5. Operation with a PC

The receiver provides an adjustable audio signal of up to 1V$_{PP}$. To get an image out of this signal it must be processed. In general this is done by the PC.

Connect the 3.5mm connector of the receiver to the line input of the sound card. You can use mono or stereo connectors. In the latter case the signal comes out only at the centre pin (right channel). The sound card of the PC in most cases has the same connector so that a one-to-one cable fits best.

Some Notebook or Netbook-PCs have only a microphone input rather than a line input. In that case the output voltage of the receiver in the default configuration is too high. Use the R2FConfig tool (see chapter 11) to reduce the level to an appropriate value.

You can check if there is a signal at the output if you plug a headphone in the AF socket. If no satellite is in range you will hear random noise. A satellite becomes noticeable by a rhythmic chirp. You can find audio samples of the satellite signals on the CD-ROM.

Meanwhile there are plenty of public domain and shareware programs available which supports APT reception. See the appendix for more information.

6. Connecting to an antenna

The receiver has two 50Ω BNC connectors for the antenna. Since the satellites are working in the 2m-band in general all 2m-antennas are suitable. The satellites are in 600 – 800km orbits above the Earth and provide reasonably strong signals. This means that you will not need a directional antenna. The best solution is an omni-directional antenna. This makes antenna tracking superfluous.

However due to multipath propagation of the satellite signals (e.g. due to reflections from walls or ground) there are often signal drop-outs which you can see as noisy stripes on the picture. With the diversity circuit the receiver automatically selects that antenna which provides the better signal quality. So if you connect two antennas e.g. a vertical and a horizontal dipole it is very likely that you will not get any signal drop-out during the whole pass. The two LEDs marked with A1 and A2 indicate which of the antennas is currently in use. This mode is called diversity operation. In factory default it is disabled (see chapter 11).

You should pay attention to the feed line of the antenna. The cable should not be too thin or too long. For distances up to 20m R58 is fine. Up to 60m RG213 can be used. For longer distances an additional pre-amplifier directly mounted at the antenna may be necessary. DC supply of a remote pre-amplifier is supported by the receiver (see chapter 10).

7. How to select the frequency

The receiver includes 6 memory channels. Channels 1 to 5 are pre-programmed with the currently used satellite frequencies. Channel 6 was provided for operation with 1.6GHz converters for geostationary satellites which mostly are not operational any more today. However there are other interesting satellites on the 137MHz band which could be stored here. Please see the table for the channel allocation.

- Channel 1: 137,100 MHz   NOAA18
- Channel 2: 137,400 MHz   Okean, SICH1M
- Channel 3: 137,500 MHz   NOAA12, NOAA15
- Channel 4: 137,620 MHz   NOAA17
- Channel 5: 137,9125 MHz   NOAA19*
- Channel 6: 134,000 MHz   (WEFAX down-converter)

* The NOAA19 channel on 137.9125MHz does not fit into the 10kHz channel spacing of the receiver. This is not a problem though since the AFC (Automatic Frequency Control) has a tuning range of ±7.5kHz. You simply tune the receiver on 137.910MHz and the AFC easily cares for the 2.5kHz offset.

By pressing the key labelled **SELECT** you can proceed cyclically from one channel to the next. For each channel there is a corresponding LED on the front panel.

Holding the switch down for more than 2 seconds sets the receiver into scan mode. Only channels 1 to 5 are scanned. If there is a sufficiently strong signal the receiver will lock onto that channel. If the signal vanishes the scan mode is resumed after a latency time of 5 seconds.

In particular in urban areas it can sometimes happen that there is a noise level that exceeds the scan threshold. This will cause the receiver to stick on the disturbed channel. Therefore it is possible to adjust the threshold level to an appropriate value (see chapters 10 and 11).

Pressing the key again for a short time stops the scan mode.

Some satellite decoder software controls the receiving frequency of the R2FU. As soon as a frequency adjust command is issued by the PC the red channel LEDs go off.

8. Displaying the signal strength

On the front panel you will see four green LEDs which indicate the level of the received signal. The table below shows the relationship between RF input power and the numbers of active LEDs. As soon as the first LED is on the signal strength is sufficient for most decoders to provide a good picture quality. With the second LED on the pictures will be almost free of noise.

LEDs	RF input power	RF input voltage
1	-120 dBm	0,22µV
2	-110 dBm	0,71µV
3	-100 dBm	2,2µV
4	-90 dBm	7,1µV

You can read the effective RSSI value with 7 bits resolution from the interface (see chapters 10 and 11). The RSSI value is directly proportional to the logarithm of the input level over a dynamic range of about 60dB.

9. Power supply

Typically the receiver is supplied through the USB interface of the PC. The receiver has a current consumption of about 70mA. To save power sometimes you may want to track the satellites without having the PC running. In that case you can use a 5 Volts USB power supply or even four AA batteries at the USB port and a solid state audio recorder connected to the AF output.

10. Pre-amplifier supply

If you want to use a pre-amplifier with the receiver you can supply it through the coax cable connected to antenna port 1. The supply must be activated by a command via the USB interface. Then the 5V will be active to this port. The current is limited by a 500mA fuse.

Please notice that the commonly used pre-amplifiers that need 12V will not work. A 5 Volts compliant pre-amplifier is necessary. An appropriate device is available from the supplier of the receiver.

11. Remote control

The USB interface allows users to control a number of functions of the receiver. You can re-program the memory channels, control the receive frequency or read an RSSI value. On the CD-ROM which

comes with the R2FU there is software "R2FConfig" for the communication with the receiver. See the next chapter for a detailed description.

If you want to use the functions on non-Windows systems or from other applications there follows a detailed programming guide below. Since the communication is performed through a virtual COM port you can use the commands with any terminal software that communicates over the serial interface like Hyperterm which comes with Microsoft Windows.

The (virtual) baud rate is 1200 bps, 8 data bits, 1 or 2 stop bit, no parity, no flow control. Each character you type on the keyboard will be echoed. The commands comprise a single character only or with the addition of one or two parameters. Editing the entries e.g. with backspace is not possible. If you make a typo just press RETURN and start again. All entries are stored and will remain after switching the receiver off.

Syntax

Cxyyy With this sequence you store a new frequency. C is the character C on the keyboard (ASCII code 43h or 63h). x is the channel number and runs from 0 to 6. The numbers 1 to 6 correspond to the memory channels 1 to 6. Entering a frequency on the virtual channel 0 causes the receiver to jump to that frequency immediately without saving it to any memory location. This is a way to make a fast programmed scan from the PC (e.g. the Wxtolmg software uses this command). When a C0yyy frequency is entered the channels LEDs will be switched off.

yyy is the 3-digit frequency value starting with the 1MHz digit and having 10kHz resolution. I.e. 750 means 137.500MHz or 791 is the code for 137.910 MHz. 999 is the highest value and sets the receiver to 139,990MHz. The lower limit is 400 which means 134.000 MHz.

Dx The command **D** controls the antenna diversity mode. If x is 0 it is off, with 1 it is on. **In delivery condition the antenna diversity is off.**

H All who operate the receiver "by hand" from a terminal software get a short help text with **H.**

Lxx This is the command to control the AF output level of the receiver. The value of xx ranges from 00 to 31 (leading zeros must be entered). The value corresponds approximately with the RMS voltage in 10mV steps. E.g. L02 is 20mV and is good for the MIC input of the sound card. L31 means 310mV (about $1V_{pp}$) and is sufficient for almost every LINE input.

M This command will respond with the frequency allocation table and some other parameters. The output is self-explanatory.

Px With this command you can switch the supply voltage for an external pre-amplifier. x=1 means on, x=0 means off. Only pre-amps can be used which work with 5 Volts.

Q If the receiver is in diversity mode you will get the RSSI value for both antennas.

R The receiver returns the current RSSI value. This value is a measure for the received signal strength. It ranges from 40 with no signal to an upper limit of approximately 130. The absolute value does not mean much, however the slope is well defined and is related accurately to the logarithm of the input power (see chapter 8).

Sx S and a number of 1 to 6 sets the receiver to the corresponding memory channel.

Txx With **Txx** the threshold value where the scanner stops is defined. *xx* is an integer number between 00 and 99 and corresponds to the value you get with the **R** command. Reasonable values are between 50 and 80. The initial value is 61. This function is useful if you operate the receiver in environments where RF noise exists which otherwise would cause the scanner to stop.

V After entry of **V** the receiver responds with the version number of the firmware and the series number of the particular unit.

11. R2FX-Config

The software "R2FConfig" reads and programs the parameter memory of the receiver. It works with all Windows versions from Win98 to Windows 7. No installation is necessary. Copy the program in any folder you want or just start it even from CD.
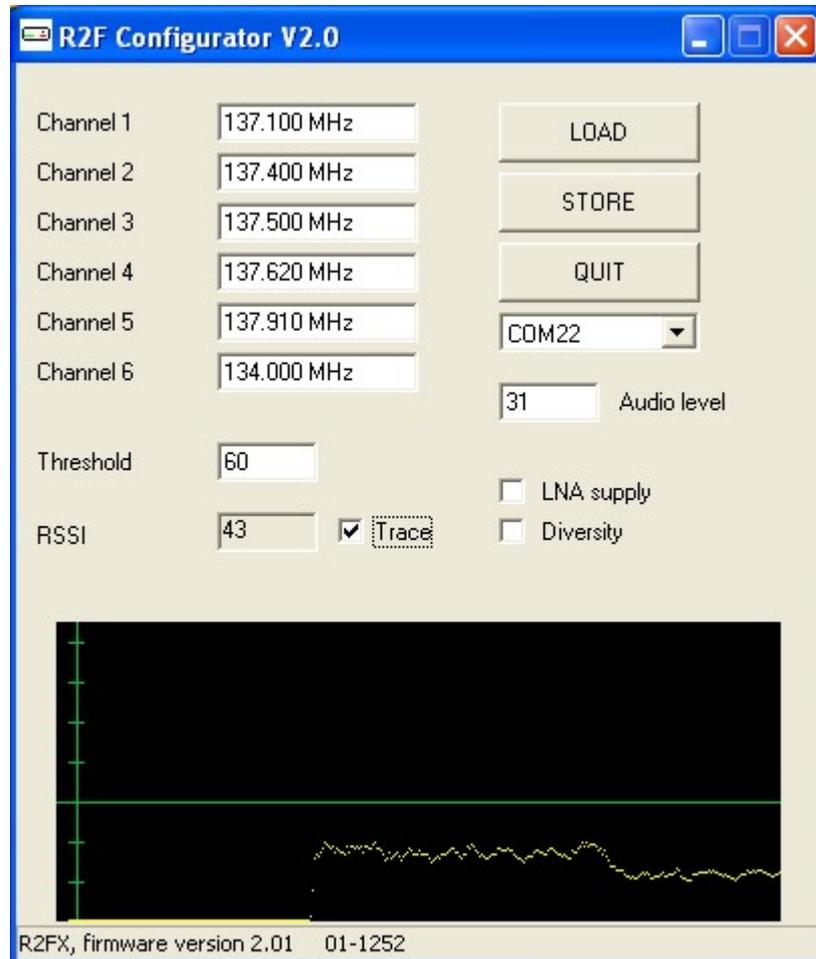
Operation

On the picture above you see the program window. The lower half with the RSSI curve is off at the start. After starting first click into the selector window on the right and choose the COM port to which the receiver is connected. Unfortunately Windows often comes up with new numbers for the same unit so that you probably have to try a little bit if you have a number of choices. Of course the receiver must be connected to the PC.

Click the LOAD button to download the current parameters from the receiver. After a second you see the programmed frequencies in the windows "Channel 1" to "Channel 6". The "Threshold" window shows the RSSI value above which the receiver stops scanning. The window below displays the current RSSI value (Radio Signal Strength Indicator). This is a relative measure of the receiver input level. The status line at the bottom of the window shows the firmware version of the receiver.

The window "Audio level" and the checkbox "Diversity" appears only with receiver firmware versions of 1.9 and above. With this version you can control these parameters by software. The range of the audio level is between 0 and 31 and corresponds to the output voltage in 10mV steps (e.g. 31 = 310mV$_{RMS}$).

If the Diversity box is checked the antenna diversity mode is active.

From firmware version 2.0 on, there is the checkbox LNA supply. If it is checked there is 5 Volts DC on antenna port 1 to supply external pre-amplifiers.

You can modify all values except that of RSSI. That means, you can enter the value in the particular window. Valid frequencies are 134.000 to 139.990 MHz in 10kHz steps and threshold numbers from 0 to 99. By clicking the STORE button the values will be transferred into the receiver memory. This can take a couple of seconds.

If you click the "Trace" checkbox the RSSI value continuously updates once a second. Another windows open where you see a RSSI diagram over a time of 5 minutes. This is useful to monitor the signal strength of a satellite pass or to see if there is any interference on the channel. The horizontal green line is the scan threshold.

12. RESET

If you want the receiver to restore all settings to the initial delivery values you must switch on the device while pressing the *SELECT*-button. Keep the key pressed until the green lamps extinguish.

13. First steps

Receiving weather satellites is not as easy as watching TV. If it does not work first time you will surely succeed with some patience. Currently there are 4 satellites which you can hear regularly: NOAA15, NOAA17, NOAA18 and NOAA19.

The satellites do not process the images in any way. They just show that what they see below on the ground. All orbits cross the poles. While the earth rotates below they scan the surface trace by trace. Each satellite sees each point on the earth twice every day. Since the previous and the following segment of the traces are overlapping this means for an observer on the ground that he can receive at least six passes of each satellite per day.

In average one revolution of a satellite takes 100 minutes from which you can receive it at most for 16 minutes. Seen from Middle Europe the image covers an area from North Africa to Iceland. NOAA15 and 19 appear in the morning and in the evening whereas NOAA 17 and 18 are visible around noon and midnight.

Good passes are those where the elevation is high so that the signal is strong and the visible area is large. In particular in winter the morning and evening passes fall partly into darkness as do the midnight passes. This means that in winter the good passes become rare, from 24 possible you get good pictures perhaps from 4. In summer however there are plenty of good pictures.

For initial testing you can put the receiver into scan mode for a couple of hours. The chance is very high that you will receive one or more more passes from a NOAA satellite. If you are not sure if the signal you receive is a satellite you can connect a stereo headphone to the audio connector of the receiver, set the level to 31 and listen for the signal. The satellites send a rhythmical chirp. You can compare it with the WAV files in the sample folder of the CD-ROM.

The best way to collect good passes is to use some software for satellite contact prediction. You find plenty of them on the internet. Also WxtoImg on the R2FX CD-ROM provides a very simple prediction routine. It is important that you use current Kepler elements. Kepler parameters are the orbit data of the satellites and should be updated at least every 4 weeks. Many programs update automatically from the internet. You will find the data also at www.space-track.org.

14. Technical data

Frequency range	134 ... 138 MHz
Channel spacing	10kHz
IF bandwidth	30kHz
Number of channels	total 6, 5 of them scanable
Sensitivity	0,22µV at 20dB S/S+N (SINAD/CCITT)
AF output voltage	10 – 300mV$_{rms}$, adjustable
Distortion at 1kHz AF	<1%
AFC-pulling range	±7.5kHz
Supply voltage	5V, 100mA max. (from the PC or an USB power supply)
Size	113x85x31mm

User interface	Key for channel selection
	4 LEDs for signal strength
	6 LEDs for channel display
	2 LEDs for antenna switch
Connectors	Antenna (2x 50Ω ,BNC)
	AF-Output (300mV$_{rms}$)
	USB 2.0 interface

15. Appendix

Software for decoding satellite transmissions:

- APT-Decoder, open source program for APT decoding with a countless number of features. Very active community. Free download: http://www.poes-waether.com

- SATSIGNAL, Offline-decoder, i.e. you store the satellite pass as WAV-files and the decoding follows later. Excellent picture quality. Free download: http://www.satsignal.net/

- WXtoImg, excellent weather satellite signal to image converter for Windows, Linux and MacOS www.wxtoimg.com

Kepler elements:

- The latest Kepler elements for the tracking software: http://www.space-track.org

General:

- Good sites for everything concerning picture transmission: www.hffax.de and www.geo-web.org.uk.

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