# "Malachite- DSP" Radio Receiver



## R6DAN (Vladimir Gordienko), R6DCY (Vadim Burlakov),

## RX9CIM (Georgy Yatsuk)

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## Linuxslate.com 2020

Manually translated with extensive help from Google Translate. Minor Formatting
Cleanup.

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# 1. General information

The receiver was developed with the participation of: RX9CIM (idea, DSP , general scheme), R6DAN ( GUI and control), R6DCY (refinement of the circuit, wiring, design) and dadigor - Igor Naumenko (active participation in the discussion of solutions).

Key Features :

1 ) The radio is built according to the SDR principle - the functionality is determined by the loaded software

2) Frequency range - from 50 kHz to 250 MHz, from 400 MHz to 2 GHz

3 ) Types of analog modulations : AM, SSB , NFM , WFM

4 ) Functionality : variable filter width, adaptive squelch , threshold squelch , Noise Blanker, AGC, Equalizer

5)An inespensive, but functional MSI001 chip is used

6 ) Applied powerful STM32H743 with a clock frequency of 480 MHz

7 ) 3.5-inch display with touchscreen

8 ) Built-in UHF

9 ) Controls - 2 encoders with buttons and a touchscreen

10) Powered from internal battery or USB, whith USB charging. The capacity of the built-in battery is at least 1500mA/h.

11 ) Power consumption - 300mA when listening with headphones.

12 ) Reception with a built-in telescopic or external antenna. For improved HF reception with a telescopic antenna, there is an additional board , which contains:

- source and repeater with switching elements;

- attenuator, adjustable in the range of 0-30dB with a step of 1dB;

- 4 filters: LPF 500kHz, bandpass filter 500-1500kHz, bandpass filter 1500-4500kHz, HPF 4500kHz

The board is built into the standard receiver design.

13 ) USB connection to a computer with the ability to transfer SAT, IQ and audio.

14 ) 160 kHz span with scalability

15 ) Sensitivity: -0.3 mV at frequencies up to 1 GHz

16 ) Selectivity: about 85 dB due to the characteristics of the  MSI001 chip

17 ) Aluminum chassis

18 ) Display backlight control

19) Antenna socket type: SMA

20 ) Receiver dimensions:120x88x39mm

**Project status - available for self-assembly.**

**Commercial distribution without the consent of the authors - is prohibited.**

**After the first firmware activation of the receiver is required, for this you need to flash the receiver, turn it on and send malahit _ sdr @ rambler by e-mail . ru the code shown on the screen, then enter the response code received in response.**

Receiver schematic is at the link :

https://rx9cim.ucoz.ru/load/malakhit_dsp/fajly/skhema_i_bom/9-1-0-46

The firmware can be found at the fillowing link:

https://rx9cim.ucoz.ru/load/malakhit_dsp/8

Instructions:

https://rx9cim.ucoz.ru/load/malakhit_dsp/fajly/instrukcija_malakhit_dsp/9-1-0-48

CAT uses the Kenwood TS-480 protocol . Driver for USB SAT connection - https://rx9cim.ucoz.ru/load/drajver_sat_dlja_usb/1-1-0-41

Recommendations for self-assembly.

When using a metal case, it is recommended to ensure contact of the touchscreen with metal. Otherwise, some instances of touches may not work correctly.

The first time you turn on the receiver, you will need to activate the firmware.

A code will appear on the screen in the upper part, which must be sent by e-mail to malahit_activation@rambler.ru. In response from this mailbox, you will be sent a response code which must be entered using the upper encoder and its buttons.

After completing the entry, press the button of the lower encoder . If everything is entered correctly, the receiver will enter the main operating mode.

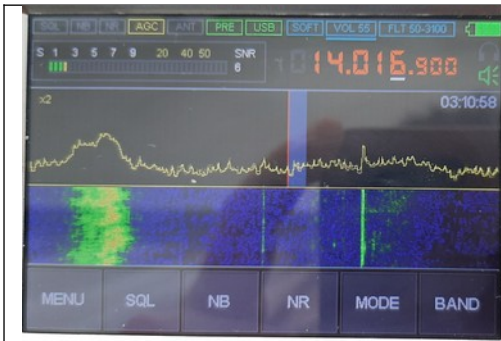## 2. Appearance of the Receiver, Controls and Structural Elements

Main controls and Structural Elements:

| | |
|---|---|
|  | LEFT button controls the power. Located on the side cover |
|  | Headphone Jac |
|  | LED charging indicator |
|  | Socket for connecting USB charger and PC |
|  | Encoder 2 and. To control volume, filter, and equalizer settings |
|  | Encoder 1. For frequency control, and audio output |

| | |
|---|---|
|  | Display and touchscreen |
|  | SMA antenna connector |

## 3. Turn the receiver on and off
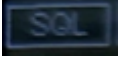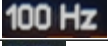
The receiver is turned on by briefly pressing the power control button. Switching off is carried out by long pressing the power control button until the display goes out.

## 4. User Interface
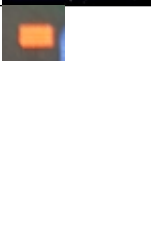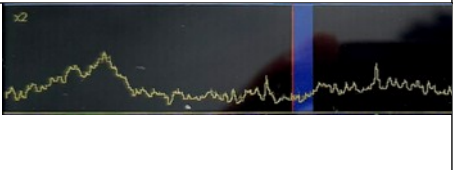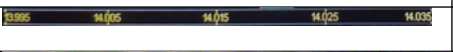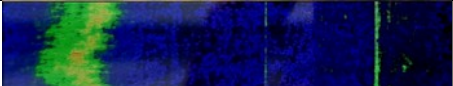
The main receiver window looks like this:

## 4.1 Main Screen Indicators

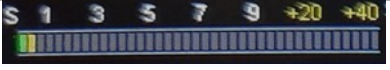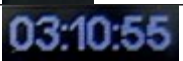| Indicator | Function |
|---|---|
| | Battery Indicator |
| FLT 50-3100 | Filter frequency characteristics: The first number is the lower frequency, second number - high frequency |
| VOL 55 | Volume Level |
| AGC 20 | AGC Level |
| USB | Modulation Type |
| PRE | UHF green means "on", gray means "off". |
| ANT | Indicator of the selected antenna for HF . It is intended for use with an additional receiver board. Gray indicates 50 ohm input, green indicates Hi - Z |
| AGC | AGC status  - Yellow indicates on, gray indicates off. |
| NR | Adaptive Squelch Status  - Green  indicates on, gray indicates off. |
| NB | Noise Blanker Status  - Red indicates on, gray indicates off. |
| SQL | Squelch Status - Red indicates on, gray indicates off. |
| | Selected audio output indicator — Headphones, Speaker, or Both. |
| 14.019.400 | The current receiving frequency. Clicking on this area will enter the direct frequency input mode. |
| 100 Hz | Current Tuning  step |
| SNR 5 | Signal to noise ratio indicator |
| S 1 3 5 7 9 +20 +40 | Signal level indicator. When you click on this area, you enter / exit the HARD (Settings) menu. |
| x2 | Spectrum analyzer magnification indicator |
| 03:10:55 | Current Time |

| | | |
|---|---|---|
| MENU | | Menu button for setting operating parameters |
| SQL | | Button to enable / disable the Squelch |
| NB | | Button to enable / disable the Noise Blanker |
| NR | | KButton to enable / disable the Adaptive Squelch |
| MODE | | Button for selecting the type of demodulation |
| BAND | | Button for selecting memories and frequency range |
| | | Receiver settings saving indicator. Appears when the receiver settings are changed. When the settings are saved, it turns green and disappears. |
| | | Spectrum analyzer window |
| 13.995   14.005   14.015   14.025   14.035 | | Frequency scale |
| | | Waterfall window |

## 4.2 Main Menu

Most of the settings are changed through the menu tabs.

By clicking on the menu button, a list will open:
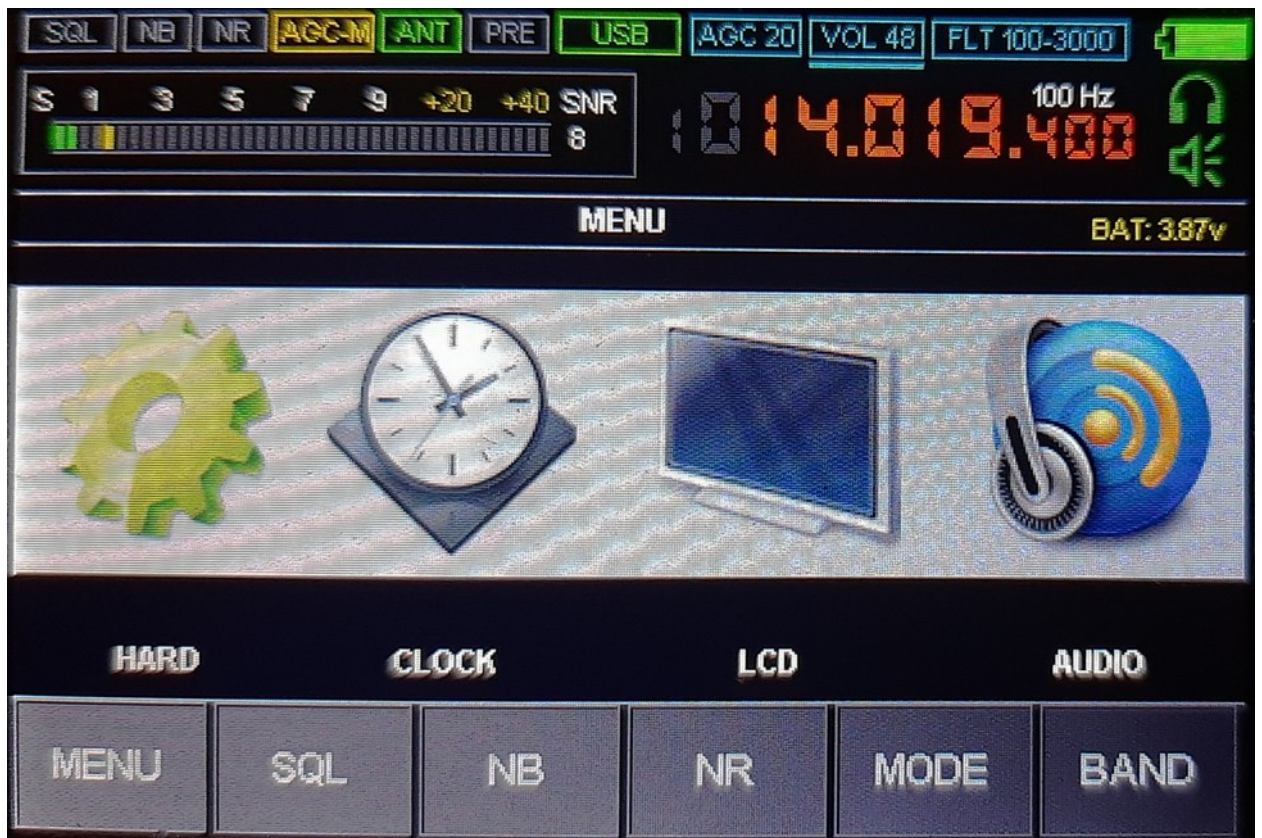
To exit the Main, press the encoder 2 button , or tap the Menu button.

## 4.3 HARD Menu

Entering the HARD (Settings) menu is possible through entering the Main menu, then pressing on the word HARD. A more efficient entry is also possible - by clicking on the area of the S-meter. Exiting the HARD menu is carried out by pressing the Menu button , or by pressing the S-meter area.
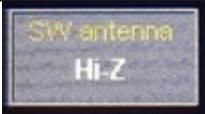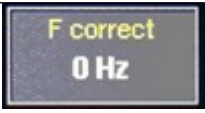
Moving through the menu items is carried out with the help of encoder 2. The selection of the menu item is carried out with the help of the encoder 2 button. Parameters are changed by rotating encoder 2.

Exit the HARD menu to the general menu by pressing the MENU button again. Exit to the main screen of the receiver operation cam be done by pressing encoder button 1.

Options in the HARD menu:

| Perameter | Description |
|---|---|
| | Reverse direction of encoder 1.<br><br>The parameter is changed (toggled) by clicking on this indicator. |
| | Reverse direction of encoder 2.<br><br>The parameter is changed (toggled) by clicking on this indicator. |
| | Battery voltage monitoring function.<br><br>Standard - The receiver will be turned off automatically when the |

| | |
|---|---|
| | supply voltage drops to 3.3V.<br><br>LOW - The receiver will continue to work when the supply voltage drops.<br><br>The parameter is changed by clicking on this indicator. |
| **SW antenna**<br>**Hi-Z** | The Input impedance of the receiver at ANT.<br><br>50 Ohm - for "large" antennas<br><br>Hi-Z - for short antennas such as telescopic antennas.<br><br>Affected only if option is installed.<br><br>The parameter is changed by clicking on this indicator. |
| **PREAMP**<br>**Disable** | Turns on and off the built-in UHF preamp. The parameter is changed by clicking on this indicator. |
| **ATT**<br>**0 dB** | Input RF attenuator value.<br><br>Affected only if option is installed.<br><br>Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |
| **RF GAIN**<br>**20** | RF Gain. Adjusts the amplification of the quadrature wideband mixer in the MSI001. Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |
| **LNA / MIX1 GR**<br>**Disable** | Gain reduction. Adjusts the gain of the mixer or UHF composition of the MSI001. Disable means maximum gain (No attenuation), Enable means less gain. The parameter is changed (toggled) by clicking on this indicator. |
| **MIX / MIX2 GR**<br>**Disable** | Gain reduction. Responsible for amplifying mixers or UHF as part of the MSI001. Disable means maximum gain (No Attenuation), Enable means less gain. The parameter is changed (toggled) by clicking on this indicator. |
| **F correct**<br>**0 Hz** | Receive frequency error correction in Hz. Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |
| **FFT ave**<br>**84** | Spectrum analyzer FFT averaging speed. Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |

| | |
|---|---|
| FFT scale 50 | Spectrum Analyzer Display Range. |
| FFT color YELLOW | Spectrum analyzer line color. Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |
| WFM stereo Disable | Enables / disables stereo reception in WFM mode. The parameter is changed (toggled) by clicking on this indicator. |

## 4.4 CLOCK Menu



Designed to set the clock. The setting is carried out using encoder 2 and its button. To save the value of the set time, press and hold the encoder button 2 until a sound signal is heard.

Exit to the Main menu list by pressing the MENU button. Exit to the main screen of the receiver by pressing encoder button 1.
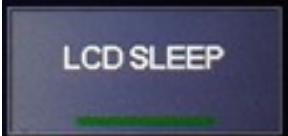
## 4.5  LCD Menu



Moving through the menu items is carried out by clicking on the touchscreen. Parameters are changed with encoder button 2.

Exit from the menu to the Main menu list by pressing the MENU button. Exit to the main screen of the receiver by pressing encoder button 1.

Parameters in the LCD menu:

| Parameter | Function |
|---|---|
| BRIGHTNEES MIN 20 | The minimum value for display brightness. The brightness will be reduced to this value after the Reduction time. Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |
| BRIGHTNEES MAX 20 | The maximum display brightness value. Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |
| REDUCTION TIME 30 sec | The time since the last use of the controls, after which the backlight brightness will be dimmed. Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |

| | |
|---|---|
| SLEEP TIME 60 sec | The time since the last use of the controls, after which the display will be turned off, after the backlight brightness has decreased. The parameter is active only when the LCD SLEEP function is enabled. Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |
| LCD SLEEP | Determines whether to turn off the display or only dim the backlight. |
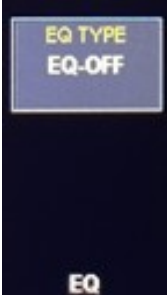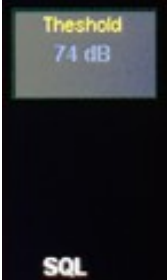
## 4.6  Audio Menu



Параметры в меню Audio:

| Perameter | Function |
|---|---|

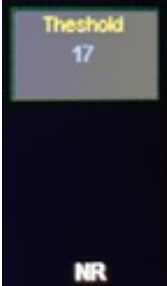| | | |
|---|---|---|
| Threshold 2.0 / Config 2 / NB | | Noise Blanker Settings:<br><br>• Threshold - response threshold relative to the average signal level;<br><br>• Config - settings for the Noise Blanker operating mode<br><br>Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |
| AGC LIM 75 dB / AGC GAIN 20 dB / AGC MODE MIDDLE / AGC | | AGC settings:<br><br>- AGC LIM - maximum output sound level<br><br>- AGC GAIN - amplification of the signal level in the AGC loop. When AGC is off, this indicator is responsible for the manual gain value.<br><br>- AGC MODE - AGC operation mode: OFF, FAST, MIDDLE, SLOW, LONG<br><br>Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |
| EQ TYPE EQ-OFF / EQ | | Equalizer type.<br><br>Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |
| Threshold 17 / NR | | Adaptive squelch threshold.<br><br>Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |
| Threshold 74 dB / SQL | | The threshold of the threshold squelch.<br><br>Parameter change is carried out by pressing this indicator and subsequent rotation of encoder 2. |

## 5. Updating the Software

Firmware updates are possible depending on the revision of the STM32 processor:

- For revision of the Y processor, the firmware is possible only with the use of the STLink programmer;

- For revision V of the processor, the firmware can be updated either by using the programmer or by connecting to a personal computer (PC).

The processor revision must be determined by visual inspection as shown in the figure:



The processor revision is highlighted in red in the figure.

Preparing to download software in DFU mode:

Before downloading, you need to install the DfuSe program. You can download it on the ST website at the link https://www.st.com/en/development-tools/stsw-stm32080.html#getsoftware-scroll                                                    or http://rx9cim.ucoz.ru/load/programma_proshivki_stm32_v_dfu_rezhime/1- 1-0-39.
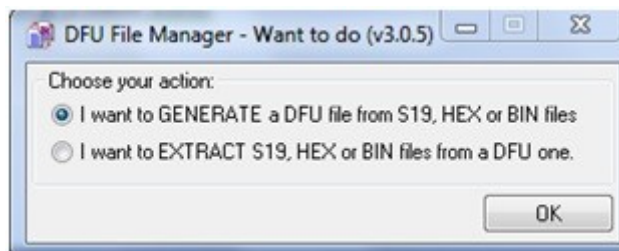
The last link contains an archive, it must be unpacked before use. The Bin folder contains utilities that are required:
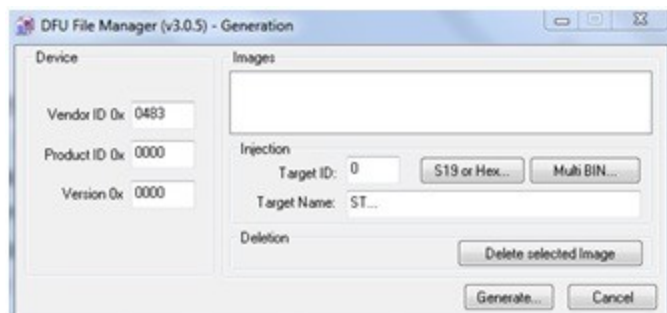
- Dfu file manager;

- DfuSeDemo.

Run DfuFileMgr. In the window that opens, select the settings in accordance with the picture:



Click OK. A window will open:



Click on the "S19 or Hex" button, find and select the firmware file Reciever_msi001hex. Press the button "Generate ...". The program will suggest a location to save the file with the .dfu extension. We indicate the desired file name and indicate the path for saving. A message like this will appear:
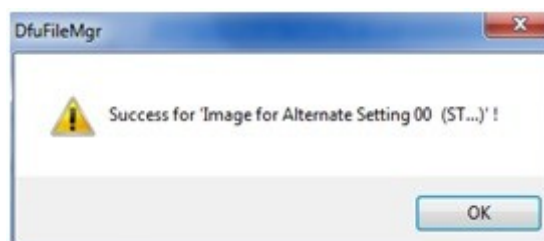
1) If the radio is being flashed for the first time (does not contain the installed firmware), then you must:

- completely de-energize the receiver;

- solder jumpers JP1 and JP3 on the printed circuit board;

- go to step 3.

2) If the radio receiver contains a previously preinstalled firmware, then you must:

- turn off the radio using the existing button;

- hold down the encoder responsible for adjusting the volume;

- go to step 3.

3) connect the radio to the PC via USB. On a radio receiver with a previously installed firmware, press the power button and release the encoder responsible for adjusting the volume;
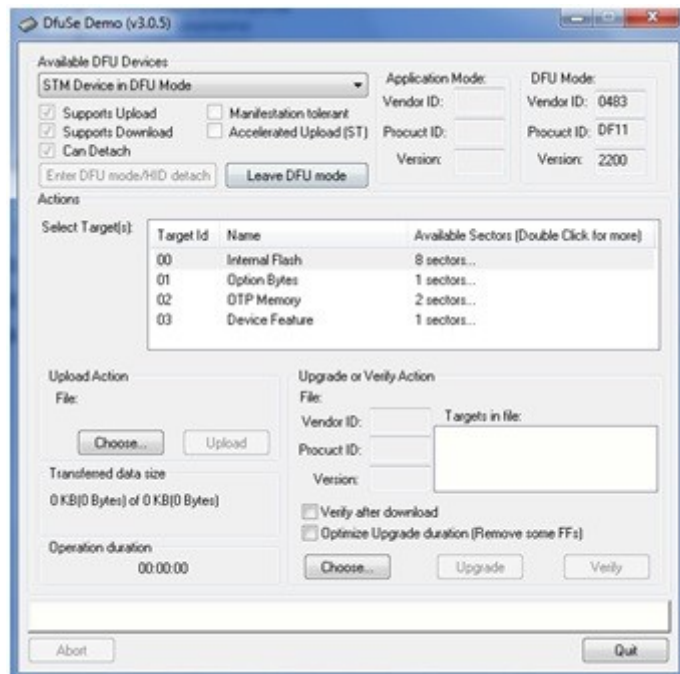
A device of the type should appear in the list of PC USB devices:
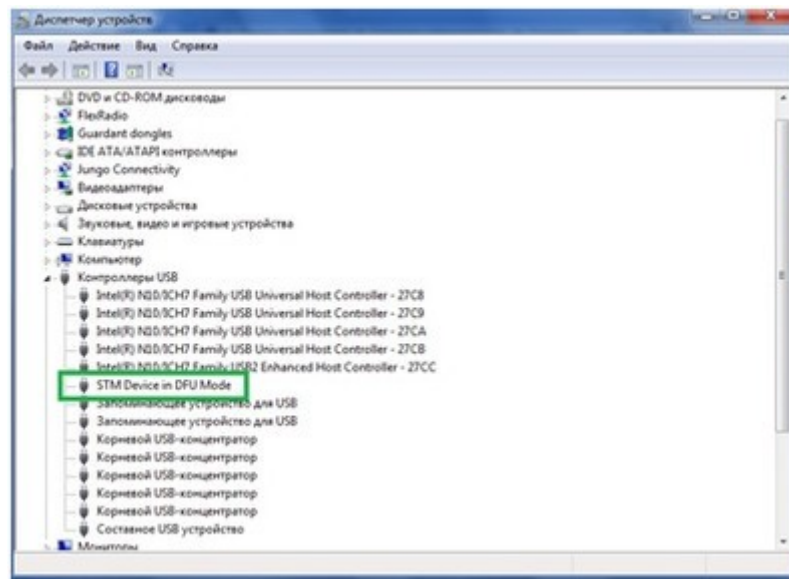


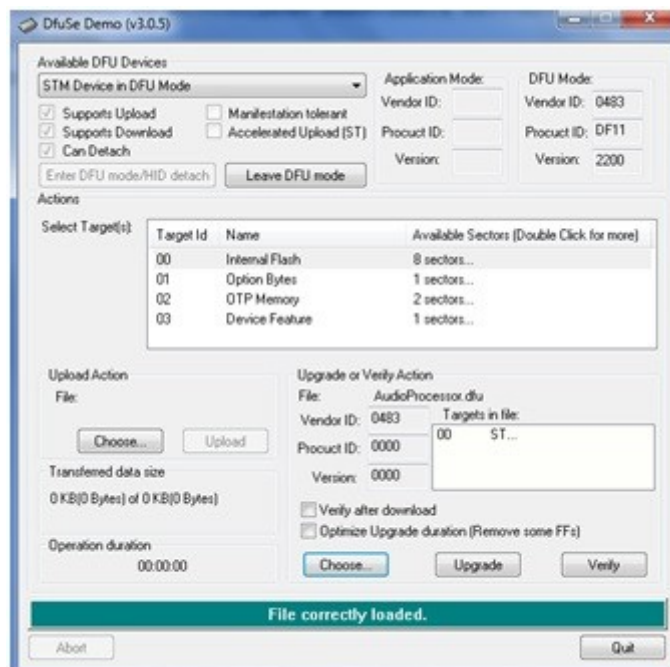If this device is marked as undefined (with a yellow triangle), then you need to automatically search for drivers on your computer in the DfuSe Demo program folder.

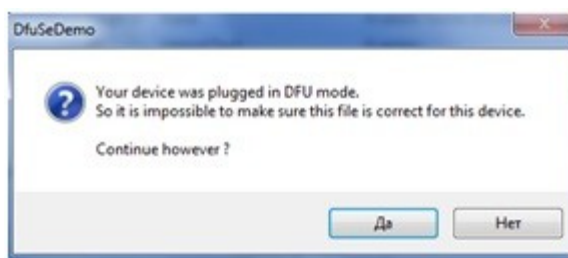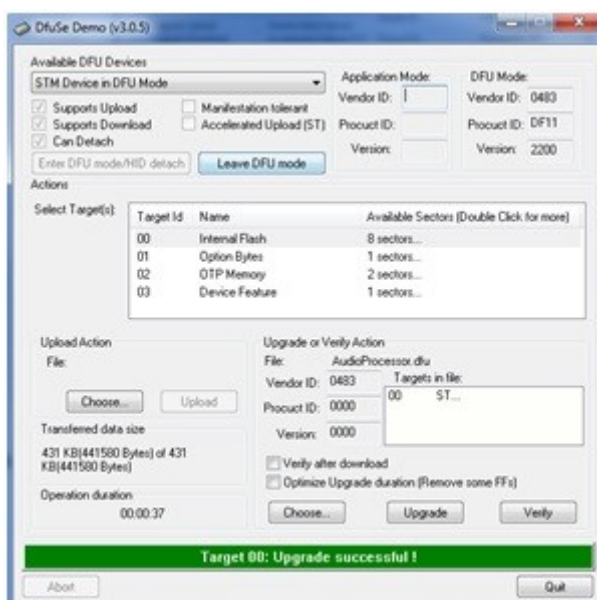Next, you need to run the DfuSe Demo program. The following window will open:

Press the button "Choose…" and select the previously prepared file with the extension .dfu. The window is converted to the form:



Press the "Upgrade" button. A view window will pop up:

Click "Yes". The software update process starts. We are waiting for the window to transform to the following form:



**Be sure to press "Leave DFU mode", then "Quit".** All Software is loaded!

If the "Leave DFU mode" button was not pressed, and the DfuSe Demo program was closed, then the receiver must be completely powered off, including disconnecting the battery. Then re-connect the battery back.

If the radio receiver was flashed for the first time, then turn off the power supply and remove the JP1 and JP3 jumpers.

<u>– This Page Not Part of Original Manual --</u>

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