

Dongle Performance in Observations of Jupiter and the Sun
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Purpose of the Evaluation

The intent of the evaluation of the plug in dongle (software defined radio) was to see if it was viable for Jupiter and solar observations. It was hoped that this inexpensive unit would provide a low cost spectrograph to supplement the Radio JOVE single frequency receivers. Other amateur radio astronomers would also benefit.

The Jove receiver has a bandwidth of 7 kHz and can be tuned over a 300 kHz frequency range centered on 20.1 MHz. Using SkyPipe the Jove receiver simply displays the amplitude of bursts at the frequency it is tuned to. The dongle, when used with RSS software can display activity over a 3.2 MHz wide frequency band in the range of 25 - 1750 MHz.

There are other, more expensive, dongles available to the community, however, we chose to start with the least expensive as a starting point.

The Dongle

These units are based on the RT820 (R820T2) tuner IC made by Rafael Micro. As such, they have a frequency capability from approximately 25MHz-1750MHz (different models have slightly different frequency spans). These units plug directly into the USB port of a computer. During this evaluation, I had no test equipment available to measure specifics with this unit. The evaluation is based on visual observations only. The specific dongle under evaluation is the unit sold by NooElec (<http://www.nooelec.com>) NESDR Mini 2 SDR & DVB-T USB Stick (RTL2832 + R820T2). The cost as of this writing is \$24.99. This particular dongle, according to NooElec, has better specifications than the standard "off the shelf" dongle. I chose to purchase the extruded metal case (\$14.95) for it to possibly shield it from RF interference. This turned out not be necessary. I did do a visual comparison with an "off the shelf" dongle and did see a difference although I would have to say the differences were minor.

The Software

It will be necessary to download a specific set of (free) software to make the dongle function as a spectrograph. Step-by-step installation instructions are provided in the full article on the [SUG website](#). It must be noted here that at the time of this writing, the software (Radio Sky Spectrograph) available by Jim Sky (Radio Sky Publishing) was used. It has, however continues to evolve and newer versions are constantly being developed. So check with Radio Sky Publishing for the latest versions and updated capability.

The Computer

Two different computers were tried for this test. The first was a Toshiba Intel Core i3 CPU M370 2.4 GHz Dual core processor with 4 GB RAM running Win7 Home Edition. The second was a Dell Inspiron 1150 Celeron Mobile Pentium processor CPU 2.60 GHz 1.25 GB RAM running WinXP Home Edition.

The only successful computer used in this evaluation was the Toshiba laptop. The Dell Inspiron 1150 laptop was simply not fast enough to be effective. The display was extremely slow and sporadic. I couldn't get consistently good spectra data from it. There might be a computer running XP with a much faster processor and more memory, so it might be feasible. I don't have access to a computer like that so the results with the Dell laptop were disappointing. This sets limits on the type of processor and processor speeds necessary for the dongle to function as a reliable spectrograph platform.

The set up and settings

The first test of the unit was with the standard Radio JOVE dipoles fed from a multi-coupler from Dick Flagg. From the multi-coupler, a short run of RG8X (Belden) was fed into an 18 db filter/amplifier, also built by Dick Flagg, then through a KAY attenuator set at 8 db. The purpose of the filter/amplifier was to overcome the 10 db loss of the NooElec Ham It Up v1.2 - RF Upconverter. The new version of RSS extends the range of the RTL+R820T below the usual 24 MHz limit without an upconverter or hardware modification. Using a 2.04 MSPS rate, it is possible to see signals down to about 15 MHz, but many people have reported going much lower. Without the need of the upconverter, the filter/amp was also no longer needed. A feature of Radio Sky Spectrograph software is called RTL-Bridge. It is used to allow the RSS software to talk to the dongle. Various settings in RTL_Bridge were tried. The stated specifications of the dongle are optimized at 2.4 Mega Samples per Second (MSPS set in RTL_Bridge) however I did experiment with the full capability of 3.2 MSPS. This resulted in a fall off at the top and bottom edges of the bandwidth as seen in Figure 1. With the most current version of RSS, the following settings seemed to result in the best performance.

Center Freq.	FFT Average	FFT Size	Gain	Sample Rate	Data Scale
20.1 MHz	25	256	49.6	2.4 MSPS	4

Once producing a spectrum, it will be necessary to adjust the Color Offset and Gain in RSS to produce the desired display. For these tests, in RSS, under Color, I selected the color file AJ4CO-Rainbow.

The Observations

Figure 1 is the results from the February 28, 2015 Io-B storm observed with the dongle. The configuration is in the chart. The amp/filter and KAY attenuator were in line before the dongle. Faraday lanes are clearly visible as well as modulation lanes.

Center Freq.	FFT Average	FFT Size	Gain	Sample Rate	Data Scale
20.1 MHz	25	256	38.6	3.2 MSPS	20

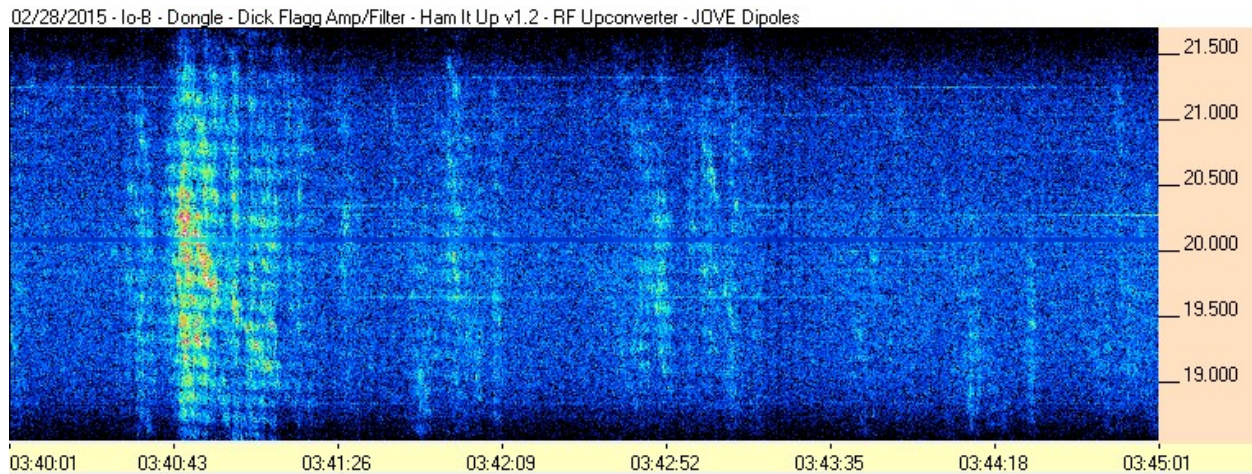


Figure 1. Results from the February 28, 2015 Io-B storm.

Figure 2 is the results from the March 7, 2015 Io-B storm. S-bursts were seen with the dongle. The configuration is in the chart. The amp/filter and KAY attenuator were in line before the dongle.

Center Freq.	FFT Average	FFT Size	Gain	Sample Rate	Data Scale
20.1 MHz	25	256	38.6	3.2 MSPS	20

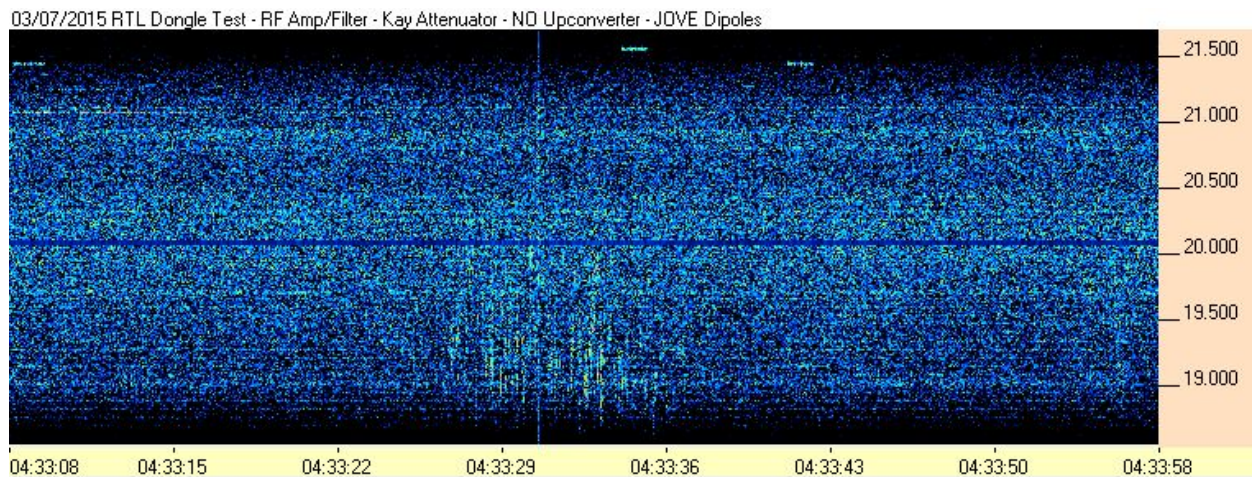


Figure 2. Results from the March 7, 2015 Io-B storm.

Figure 3 demonstrates a solar burst seen with the dongle on May 15, 2015. The configuration of the dongle is in the chart. There was no amp/filter or KAY attenuator in line with the dongle.

Center Freq.	FFT Average	FFT Size	Gain	Sample Rate	Data Scale
20.1 MHz	25	256	49.6	2.4 MSPS	3

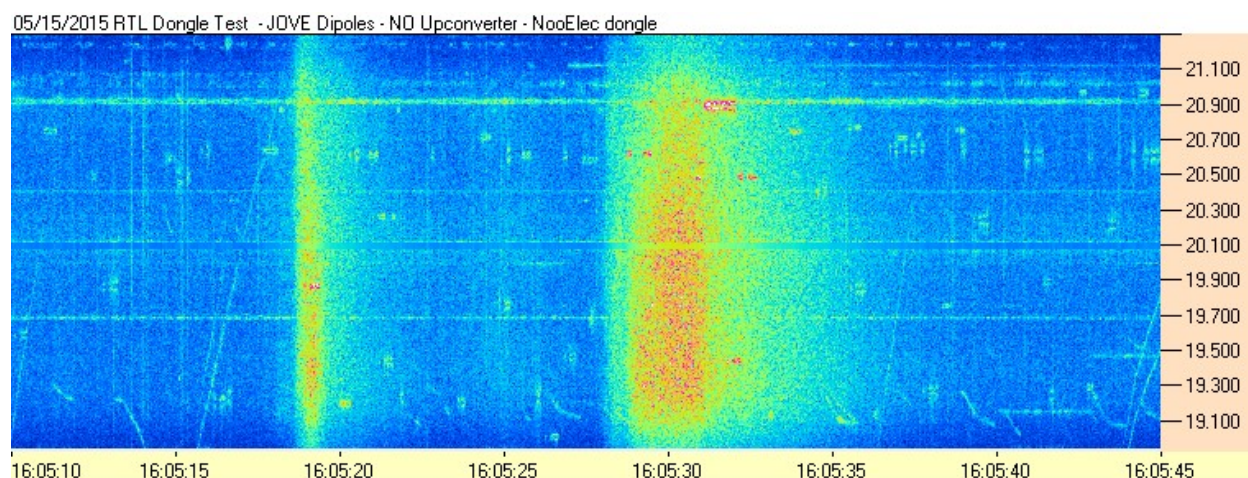


Figure 3. A solar burst seen with the dongle on May 15, 2015.

Unsolved Problems

It seems that the filtering in the dongle is lacking. During the daytime, strong sweepers often show a mirror image we believe is aliasing (Figure 4). Sweepers move from low to high frequency. You can see the “mirror” image here moving from high frequency to low.

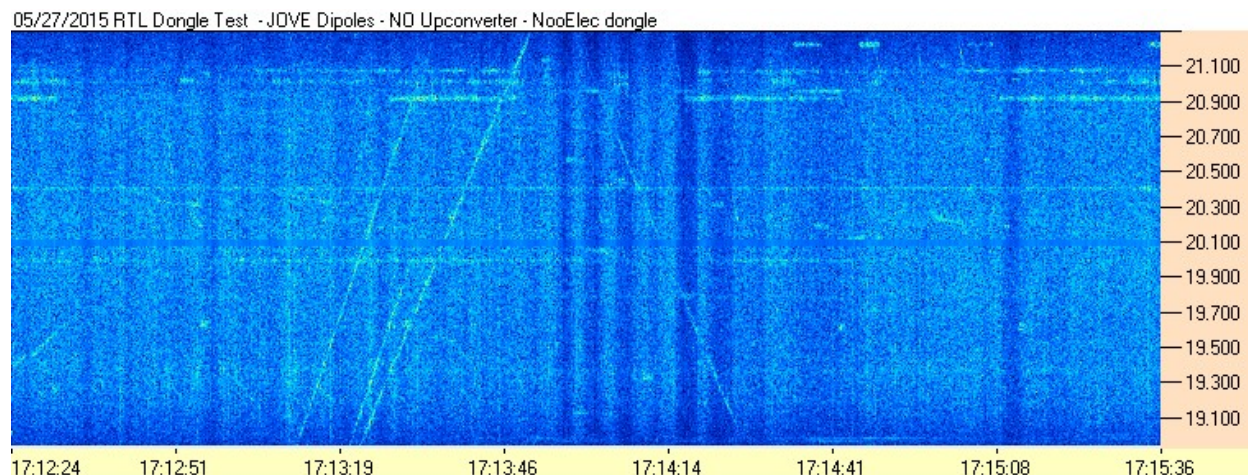


Figure 4. Strong sweepers often show a mirror image we believe is anti-aliasing.

Another problem is, if there is Jupiter activity above or below 2.4 MHz window you have the dongle set to, you won't see it.

Conclusion

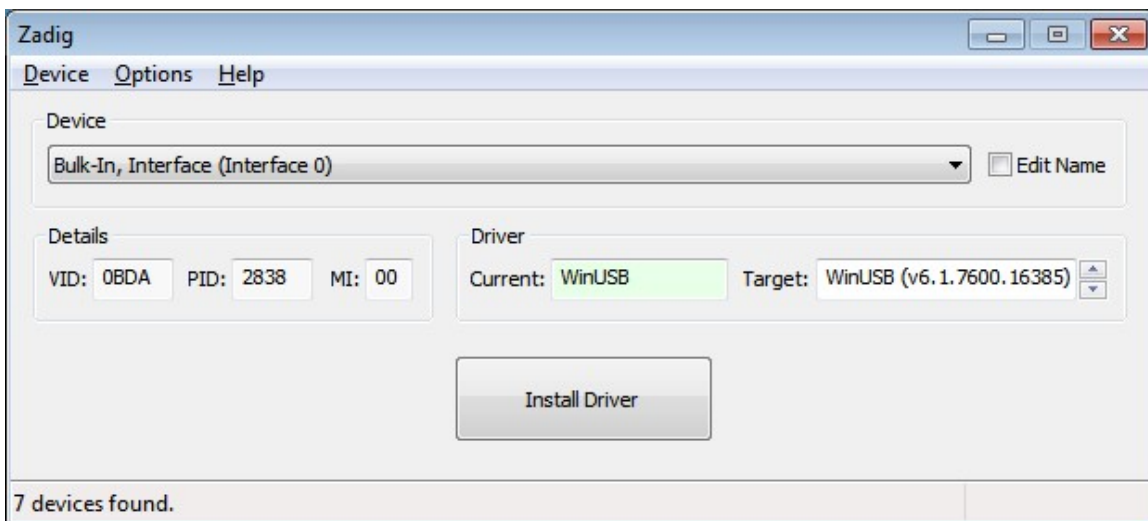
The tests confirm that the dongle is a viable spectrograph for Jupiter and the sun. Advances in technology have made less expensive Software Defined Radios and the dongle useful for Jupiter and solar observations. There is currently testing underway by the Spectrograph Users Group with a more advanced dongle called the AirSpy being distributed by the software developer, SDR#. Airspy (<http://www.sdrsharp.com/>) is an advanced open-source software defined radio receiver with the highest dynamic range in its price range. Its advertised frequency span is continuous from 24 - 1800 MHz with the ability to show a 10 MHz bandwidth, making it more ideal for Jupiter observations. It is possible that the same RSS software that allows the dongle to work at lower frequencies will permit the AirSpy to work at those frequencies also.

Installing the dongle Software defined Radio.

This must be done in the proper sequence otherwise this won't work and you'll be disappointed.

The steps outlined below were valid as of this writing. Typically software is constantly under development so newer versions are undoubtedly available.

1. Download the program Zadig (<http://zadig.akeo.ie/>). Right click this file and select "Run as administrator" if using **Windows Vista/7/8**. (There is a new version that is Windows 10 compatible)
2. In Zadig, go to "Options->List All Devices" and make sure this option is checked.
3. Select "Bulk-In, Interface (Interface 0)" from the drop down list. Ensure that WinUSB is selected in the box next to where it says Driver. (Note on some PCs you may see something like RTL2832UHIDIR or RTL2832U instead of the bulk in interface. This is also a valid selection). (Do not select "USB Receiver (Interface 0)" however).



4. Click Install Driver. You might get a warning that the publisher cannot be verified, but just accept it by clicking on Install this driver software anyway. This will install the drivers necessary to run the dongle as a software defined radio. Note that you may need to run zadig.exe again if you move the dongle to another USB port, or want to use two or more dongles together.
5. Make sure the antenna is plugged into the dongle.
6. Download the RSS software and install it. (<http://radiosky.com/spec/Spectrograph.exe>). Make sure it is version 2.4.21 or later. If not, once installed, download and install the update (http://radiosky.com/spec/Spectrograph_Update_2_4_21.exe) or later.
7. Set up RSS for the dongle under "Options → Radio → RTL dongle receiver"

8. In the RSS folder, run the program "RTL_Bridge.exe". I created a desktop shortcut for this program to facilitate running it when I need it.
9. Make sure that the correct dongle is selected in RTL_Bridge. Most likely you'll be using the RT820 (default) hardware.
10. With RTL_Bridge running (Figure 5), click on "Run rtl_tcp". A DOS window will open and begin displaying information.
11. If the window looks like the one below (Figure 6) and it has a display with similar information, your dongle is now communicating with RTL_Bridge.
12. Minimize the DOS window but DO NOT CLOSE it.
13. Click on the button, "Connect to IQ Server"
14. If the "Draw" button is checked (default) you should see a spectrum of signals displayed in the bottom of the green window (Figure 5).
15. With RSS properly configured for the dongle (Step 5), start RSS. A spectrum should begin being displayed. If not, you may need to close all the windows, reboot the computer and repeat Step 4, rebooting when you're done.
16. Once running and displaying a spectrum, you can make whatever changes you want in RTL_Bridge such as gain and center frequency. Once a change is made, make sure you click the button, "Update".
17. If for any reason you unplug the dongle, it may be necessary to close everything and restart RTL_Bridge and rtl_tcp. If it's working, you're back in business. If not, try rebooting the computer and restart RTL_Bridge and rtl_tcp. If it's still not working, it may be necessary to repeat Step 4.

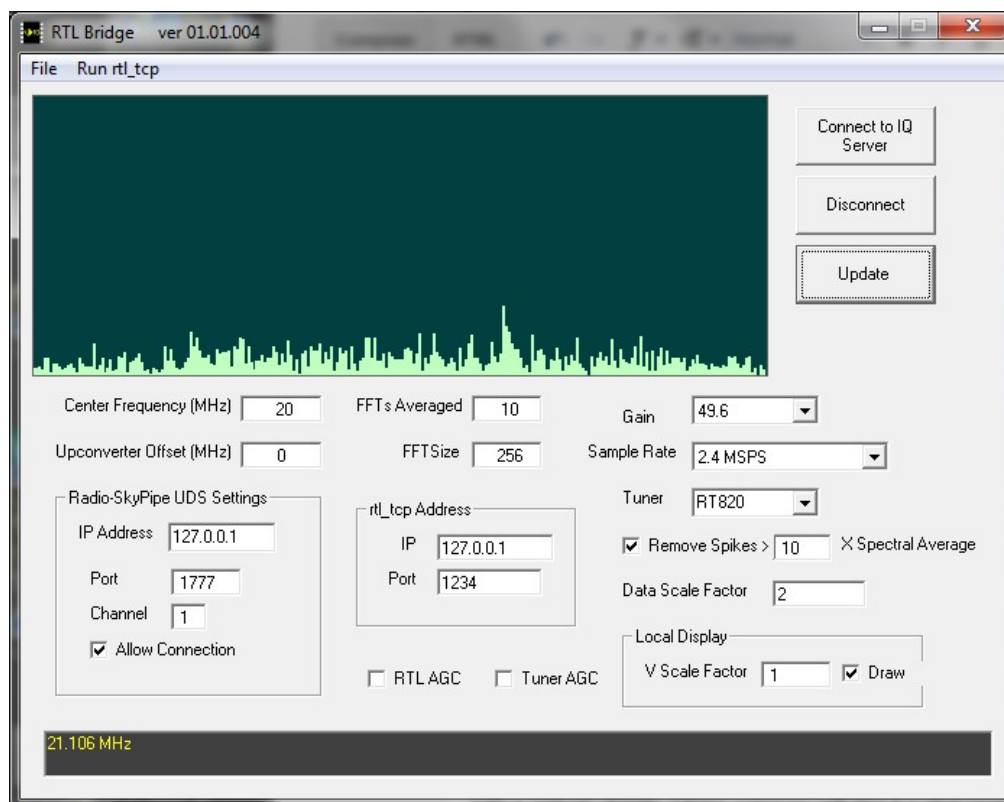


Figure 5. RTL Bridge window

```
C:\windows\system32\cmd.exe

C:\Program Files (x86)\Spectrograph>rtl-sdr-release\x32\rtl_tcp.exe -s2400000 -g
29 -f201000000
Found 1 device(s).
Found Rafael Micro R820T tuner
Using Generic RTL2832U OEM
Tuned to 201000000 Hz.
Tuner gain set to 29.000000 dB.
listening...
Use the device argument 'rtl_tcp=127.0.0.1:1234' in OsmoSDR (gr-osmosdr) source
to receive samples in GRC and control rtl_tcp parameters (frequency, gain, ...).
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Figure 6. rtl_tcp window.