SDR 101 Ham Radio University 2021

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About N2RJ

Licensed 1997 - Trinidad and Tobago

Licensed 2001 - Brooklyn NY USA

Occupation: IT systems engineering team lead

Ham radio has nurtured my gift of technical curiosity and has enabled me to learn tech and engineering. My ham radio Elmers were Tony Lee-Mack, 9Y4AL (teacher), and Steve Mendelsohn, W2ML.

I got involved in ham radio in school, through the influence of a teacher.

I am proud to help and serve the amateur radio community as a director of ARRL and district chair for YLRL.

Note on radios

- I am a Flex radio user, but that does not mean that these techniques cannot be applied to other radios. I will be mostly talking about my experiences, and showing how I operate on the FlexRadio platform
- This talk is not specifically endorsed nor sponsored by any radio manufacturer

My radio story

- I’ve enjoyed DXing ever since I was a child - SWLing, listening to different countries, cultures but most importantly enjoying “radio for radio’s sake”
- I have learned so much
  - About my station
  - About propagation
  - About the world

Other things I’ve done/do

- Emcomm/ARES
  - Primarily in an urban environment
- Homebrew/kits
- Drones/sUAS
- Contesting
- Ragchews

What is an SDR?

- An SDR replaces some or all of the components of an analog radio with software
- Specifically RF components
  - Detector
  - Modulator
- Direct Sampling takes the RF out of the air and converts it to digital bits
- “Baseband” SDRs take RF downconverted to baseband
  - I/Q signals

Today’s SDR landscape

Software defined radios are the new kid on the block but in reality they’ve been around for a while now.

What is different is adoption. We find the mainstream radio manufacturers adopting Direct Sampling SDR technology, and the “boutique” ones going mainstream.

The tipping point has been reached. SDR is mainstream.

What can an SDR offer
you?

1. Visibility - SEE the spectrum
2. Performance - the best performing radios today are typically SDRs.
3. Integration - everything can talk to everything
4. Remote operation - SDRs enable you to be there, even when you are not.

Visibility

See the spectrum

Visibility

This one is straightforward. SDRs typically have sophisticated band scopes. They can show you what is happening well beyond what you can hear.

Visibility with decoding

SDRs can also feed entire bands and multiple bands to decode popular modes.

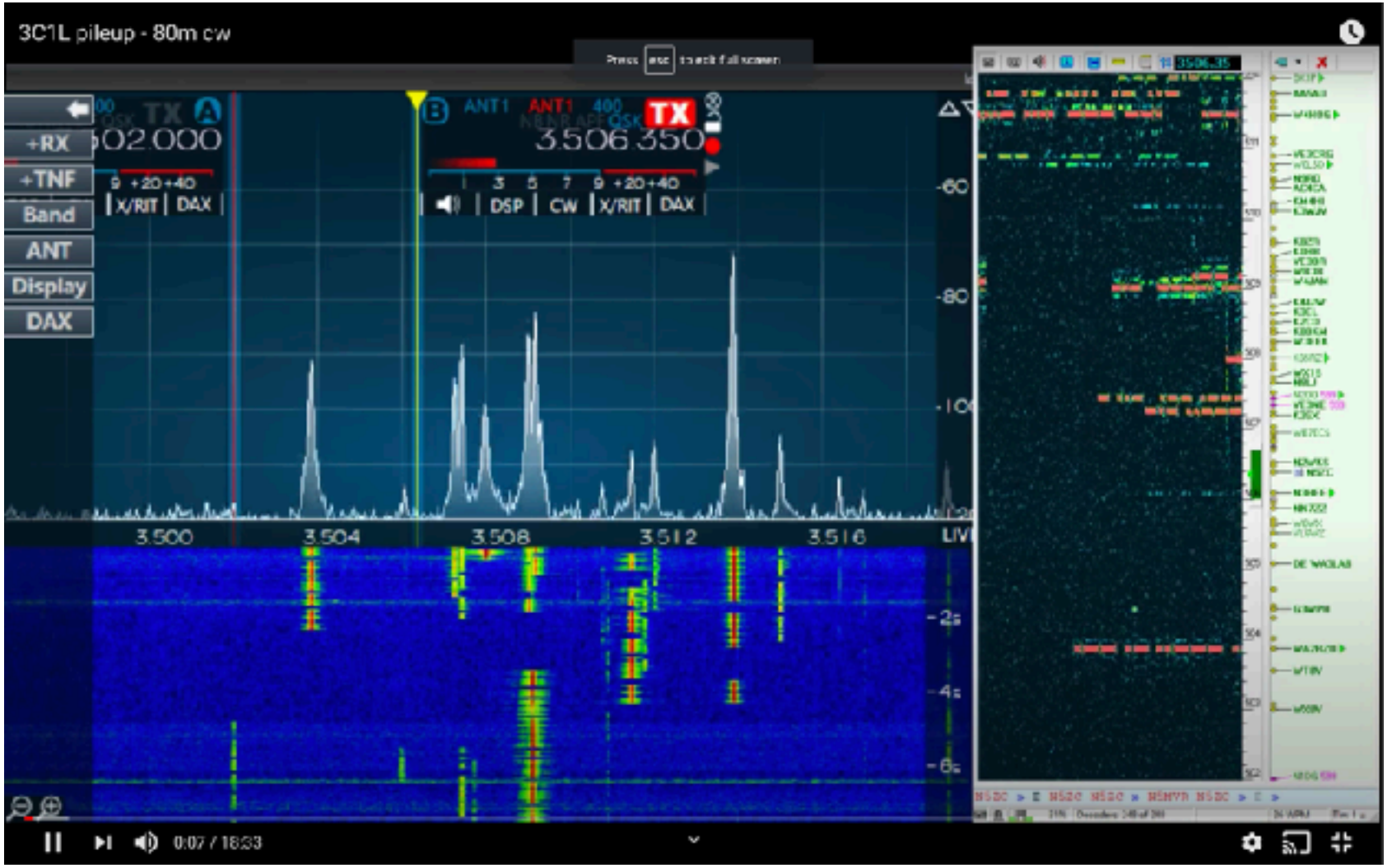
Today we can decode Morse code and digital modes.

Visibility with overlays

Some SDRs offer the ability to overlay information on the panadapter display. This can be fed from a DX telnet cluster or other information source.

This can enable point and click or point and tap DXing

A practical application for DXing



Visibility for Emcomm

- Scout out clear spots
- See who is interfering
- Filters including TNF

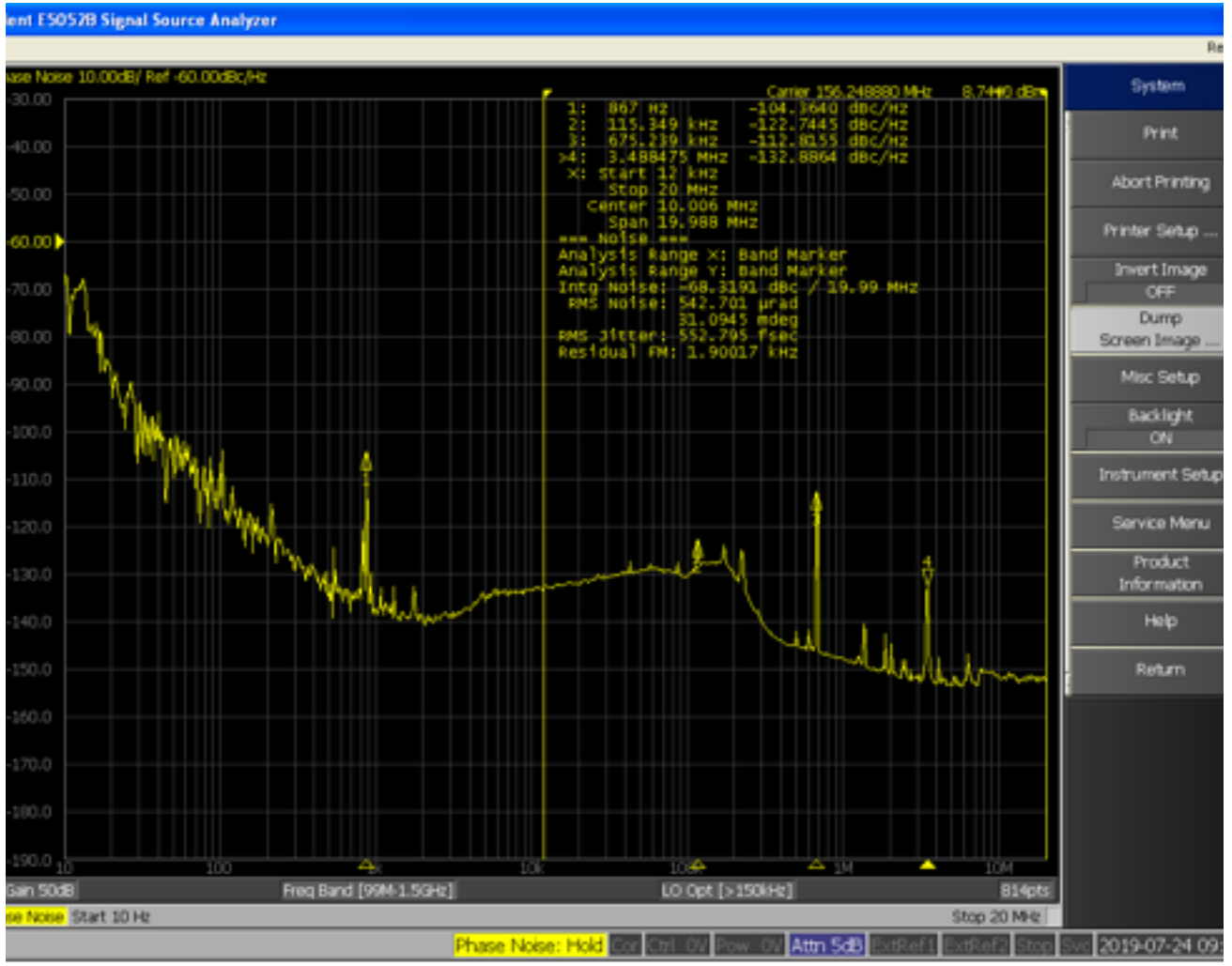
Performance

When you place signals in the analog domain, they are affected adversely by environmental factors in our electrically noisy world.

When signals are in the digital domain, they are isolated from these environmental factors.

Therefore you will find that things like noise floor and dynamic range are substantially better on an SDR

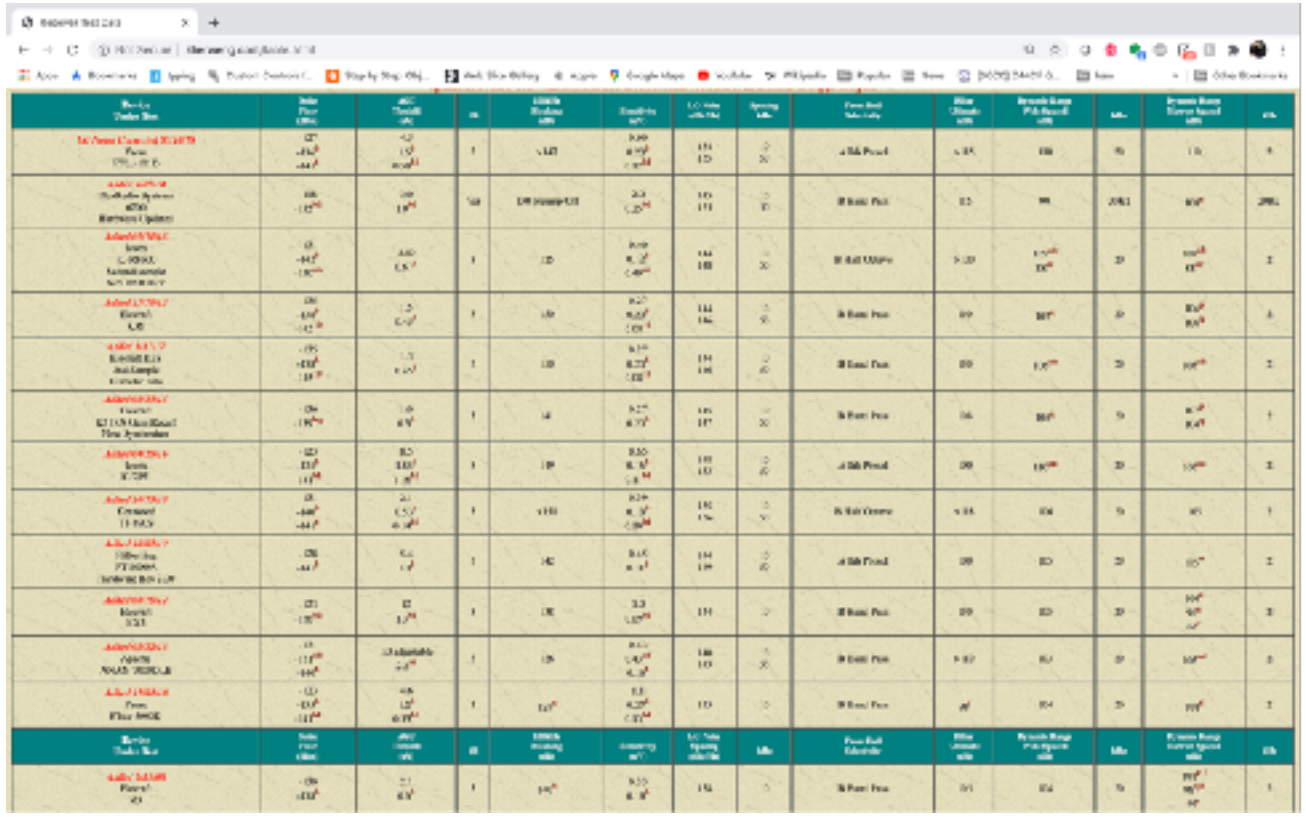
Additionally, with direct sampling SDRs you will find that less reliance on analog mixers means less phase noise.



Performance

Rob Sherwood, NC0B has been doing tests of receivers (and now transmitters) for a long time. His rankings are generally considered to be the metric that the community looks for their receivers to be measured by. You can see that a good number of the top performers are SDRs. But as with anything, there are caveats.

In particular, receivers are measured for their ability to pick out weaker signals interspersed between smaller ones. However, anything above 80-90dB 3rd order dynamic range is more of a numbers game



Performance - ARRL Lab tests

ARRL lab also tests SDRs, with generally high performance as well.

ARRL has developed the metric called “RMDR” or "Reciprocal Mixing Dynamic Range" which also measures the ability to hear weak signals among adjacent strong ones.

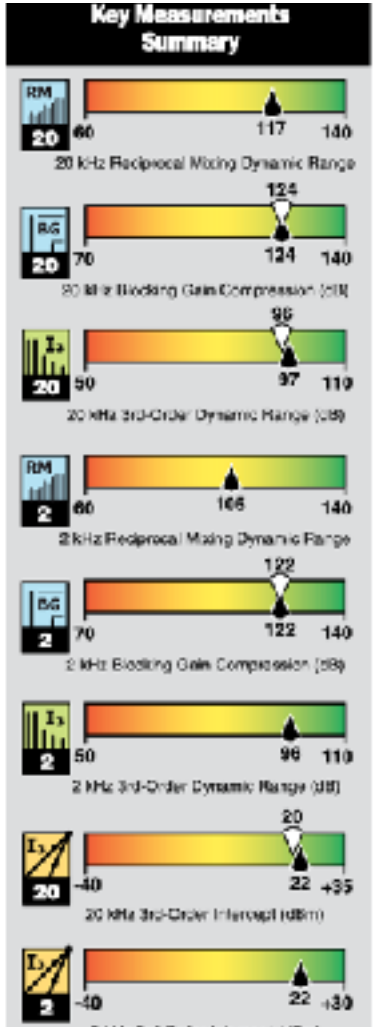


Table 1
Apache Labs ANAN-100D, serial number 32186

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency coverage: Receive, 0.01 – 55 MHz; transmit, 160 – 6 meter amateur bands.	Receive, 0.100 – 61.440 MHz; transmit, as specified.
Power requirement: Not specified.	At 13.8 V dc: transmit, 15 A (typical); receive, 2.1 A. Operation confirmed at 11.7 V dc (≥85 W RF output).
Modes of operation: SSB, CW, AM, Digital, RTTY, FM.	As specified.
Receiver	**Receiver Dynamic Testing**
Minimum discernible signal (MDS): –138 dBm.	Noise floor (MDS), 500 Hz DSP BW: 0.137 MHz –130 dBm 0.475 MHz –130 dBm 1.8 MHz –135 dBm 3.5 MHz –135 dBm 14 MHz –136 dBm 50 MHz –144 dBm
Noise figure: Not specified.	14 MHz, 12 dB; 50 MHz, 3 dB.
Spectral sensitivity: Not specified.	100 kHz screen bandwidth: panadapter, –135 dBm; waterfall, –142 dBm.
AM sensitivity: Not specified.	10 dB (S+N)/N, 1 kHz, 30% modulation, 6 kHz DSP BW: 1.8 MHz 1.16 µV 3.99 MHz 1.16 µV 50.4 MHz 0.56 µV
FM sensitivity: Not specified.	29 MHz, 0.47 µV; 52 MHz, 0.20 µV.
Blocking gain compression dynamic range: Not specified.	Blocking gain compression dynamic range, 500 Hz DSP BW: 20 kHz offset / 2 kHz offset 3.5 MHz 124 dB / 124/122 dB 14 MHz 124 dB / 124/122 dB 50 MHz 116 dB / 116/116 dB
Reciprocal mixing dynamic range: Not specified.	14 MHz, 20/2 kHz offset: 117/110/105 dB.

ARRL Lab Two-Tone IMD Testing* (500 Hz DSP bandwidth)

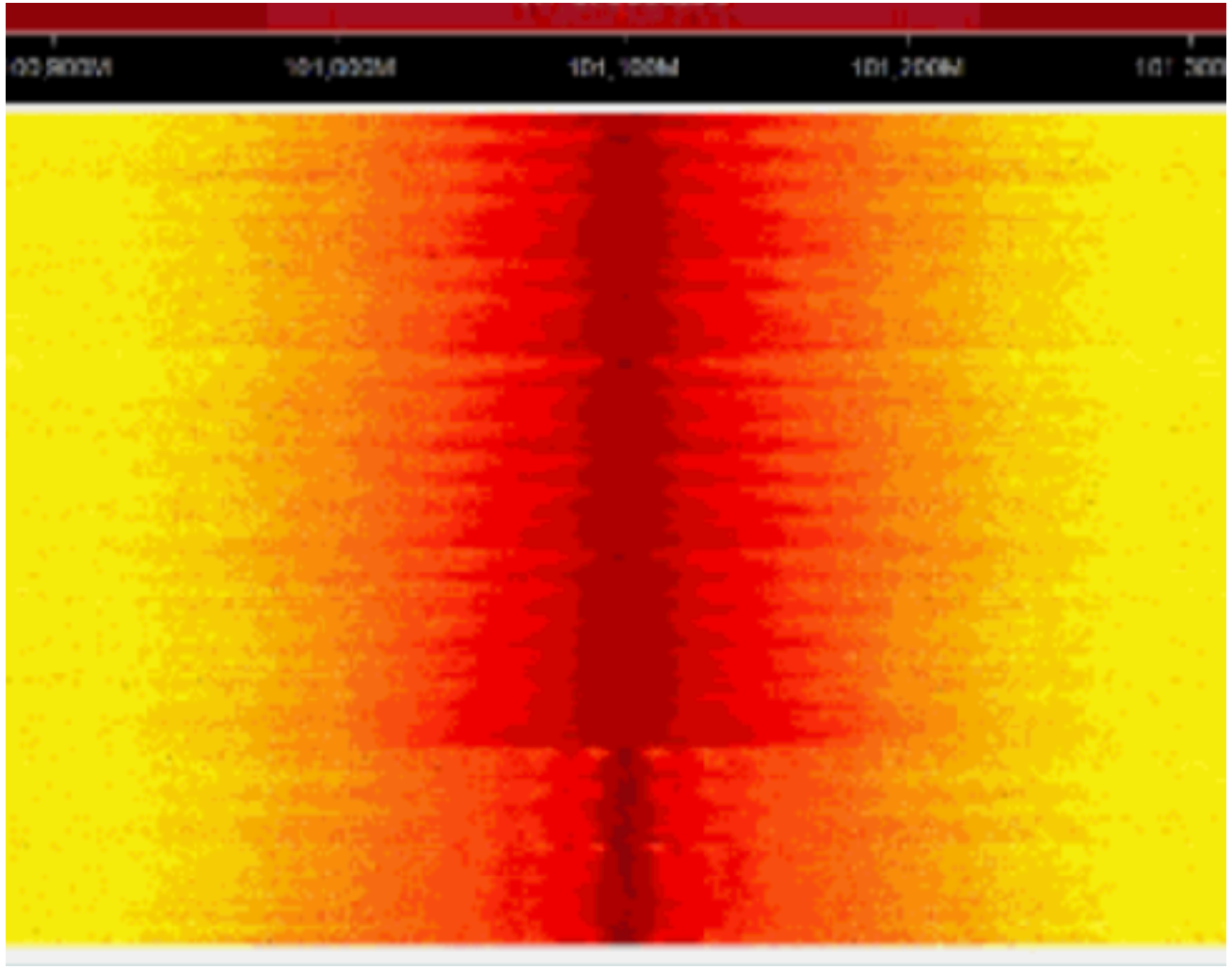
Band	Spacing	Measured IMD Level	Input Level	Measured IMD DR**	Calculated IP3
3.5 MHz	20 kHz	–135 dBm –97 dBm	–30 dBm –19 dBm	96 dB	+9 dBm +20 dBm
14 MHz	20 kHz	–135 dBm	–38 dBm	97 dB	+11 dBm

Caveat - dynamic range

An SDR can suffer from overload pretty quickly. This is why the top performers generally have analog filters before the ADC.

Clipping in the analog world isn't as nearly as bad as in the digital world. Once you reach the top in digital, you are at the top. There is no wiggle room.

Some traditional radio manufacturers have the SDR after a traditional front-end to mitigate this.



Integration

The connected shack

Integration and the connected shack

Today the average ham station is not just a radio and a paper logbook. Today's ham shack is centered around the radio AND the computer. Not just for digital modes but for logging, contesting and automation.

A lot of this can be "blamed" on the rise of WSJT, but also things were trending in that direction anyway.

Software such as N1MM+, DXLog and others are best used with a connection to the radio. Software defined radio implementations tend to be rich in connections.

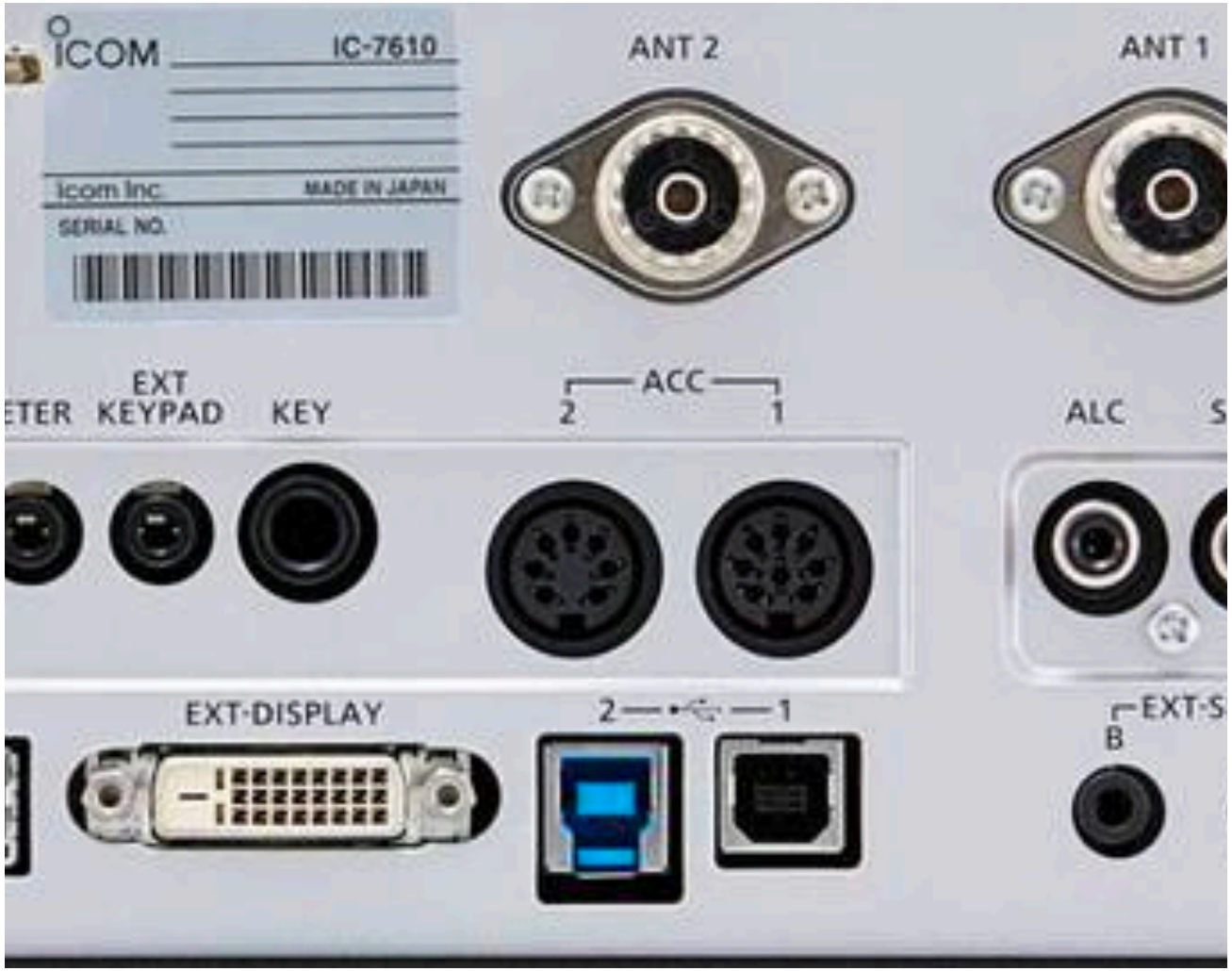
Why Integration matters

- Concentrate on the mission
- Once you get one software application working you can easily get others working
- Winlinkers already know this, but it’s not intuitive unless you get into it!
- I’ll be giving the full treatment to system integration at QSO Today ham radio expo in March 2021

Integration - less wiring

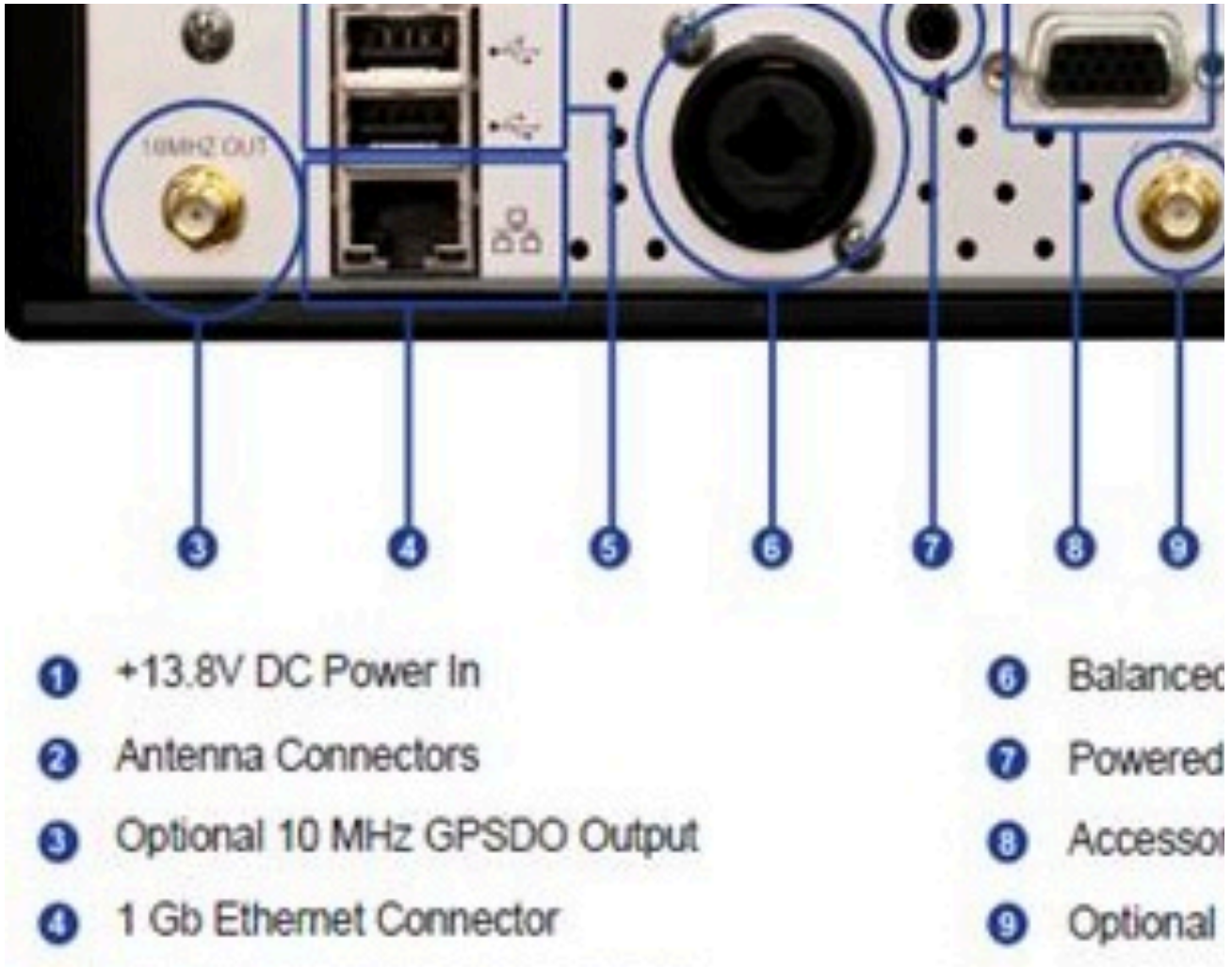
Better Integration also means less wiring. This can increase reliability and offer greater capability to integrate, even over the Internet.

Many radios today, SDR and non SDR come with USB connections that carry many signals on one bus.



Ethernet ports

Many SDR radios today, especially computer controlled ones come with an ethernet port. This can enable less cable clutter and remote operation.



Remote operation

When your world is your shack

No human being can be everywhere at once

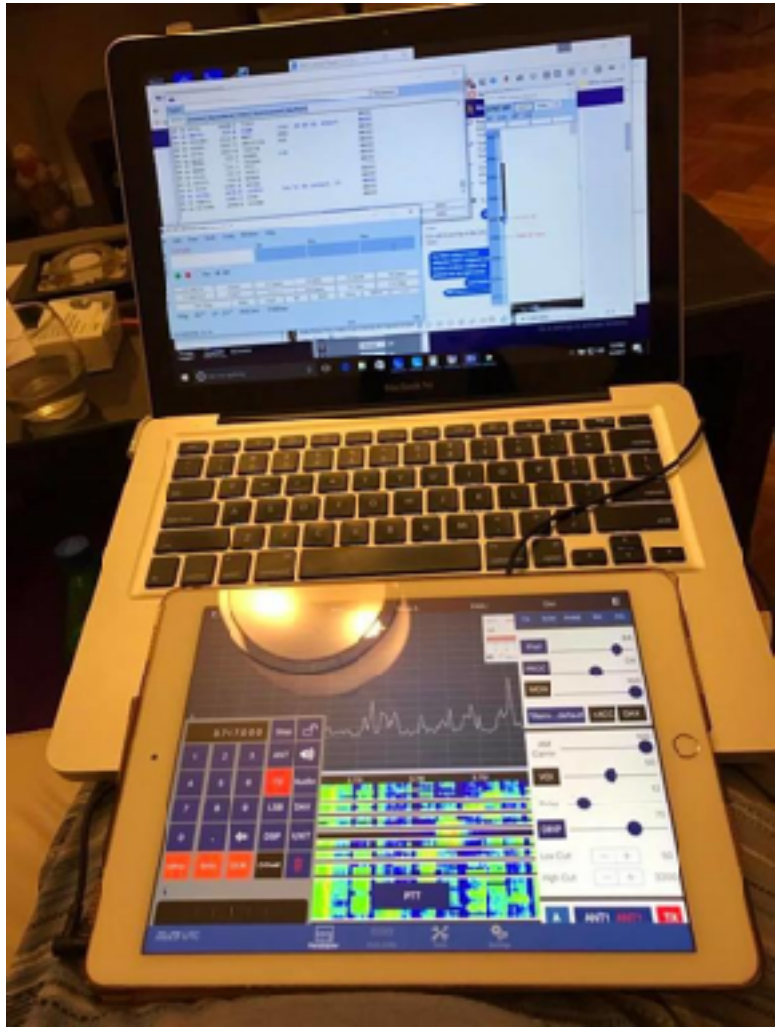
- My life does not revolve among ham radio. I have family and other commitments.
- However, I still manage to work rare ones and fill up my logbook with DX, and put pretty plaques on the wall. How can this be?

Remote operation for Emcomm

- Good location for radio, bad for operators
  - Radio on mountaintop, operators in city
- Solution: Remote operation
- Share radios with your crew
- Operate NCS easily with a powerful station
- The internet becomes your STL (Broadcasters know!)

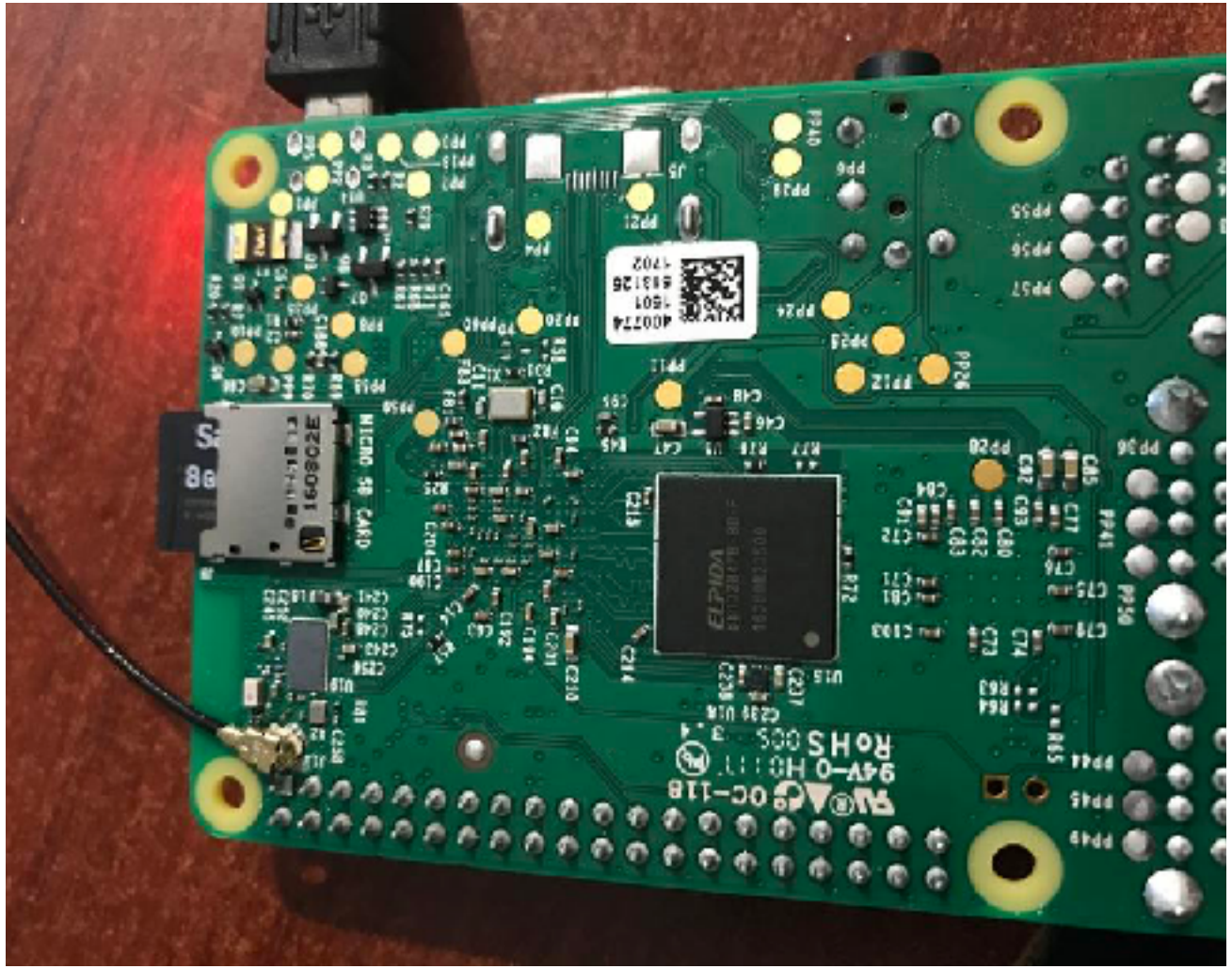
Remote operation

- Remote operation of your own station is a powerful tool to keep on the air even when you are away from home.
- Several solutions to this exist - some turnkey, some not so turnkey
- When the radio is software defined it is a lot easier, as these radios are based on data rather than analog signals, so they can be sent anywhere



More tools of the trade

- WSPR for propagation analysis (learn when band opens and closes at your location)
- FT8 for crude (but effective) propagation analysis



What can you get for $1?

Nothing!

But you can get a functional SDR receiver for $21

Softrock is the grandaddy of cheap SDR

Needs a PC sound card but it works rather well.

Can be used for CW skimmer and monitoring of the band

Commercial solutions

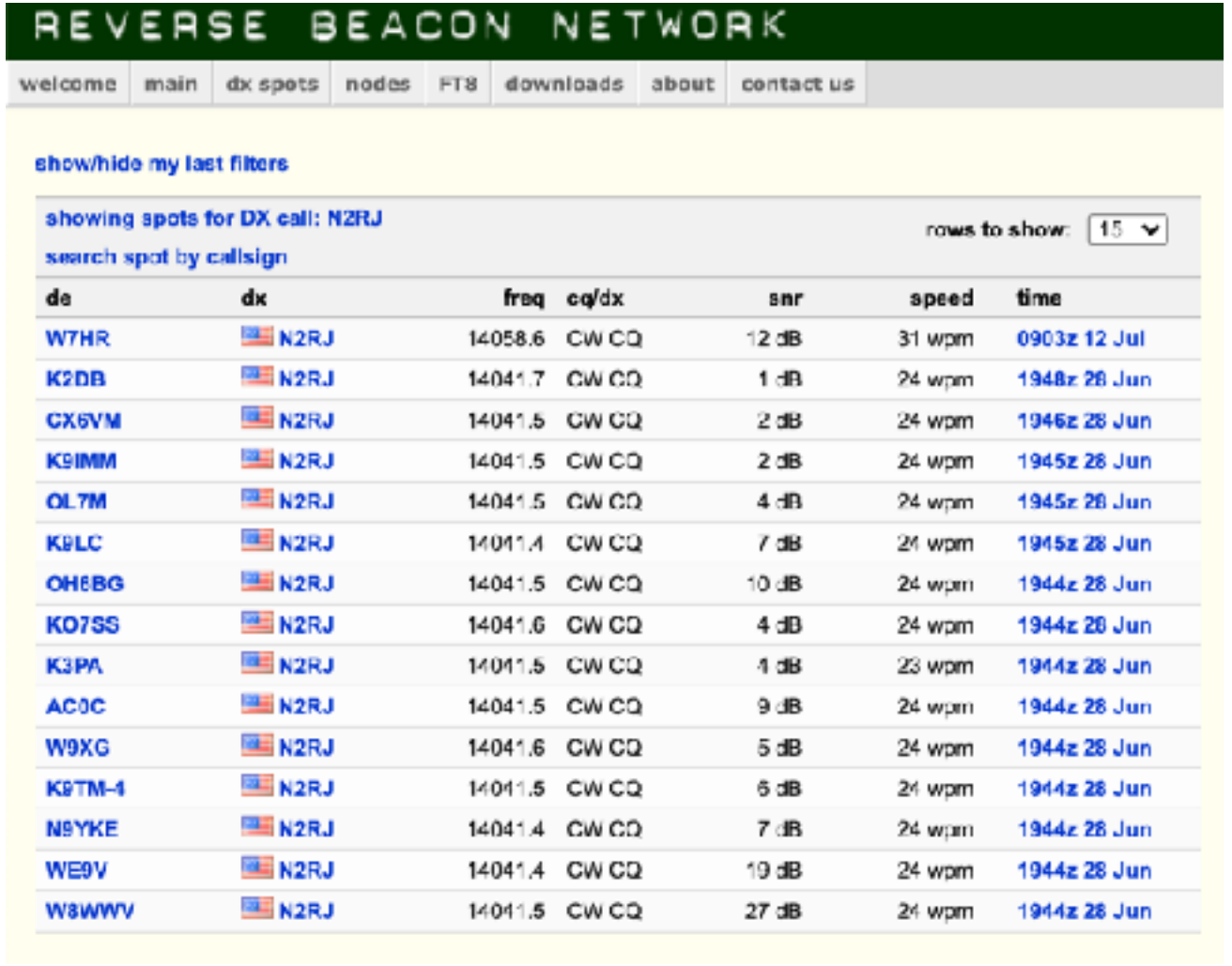
These are based on RTL-SDR

Are you getting out?

See how well you get out with internet connected SDRs.

Send a few CQs and then go to reversebeacon.net and see how you are being heard, and where.

This is a good way to see how your station compares to your peers…



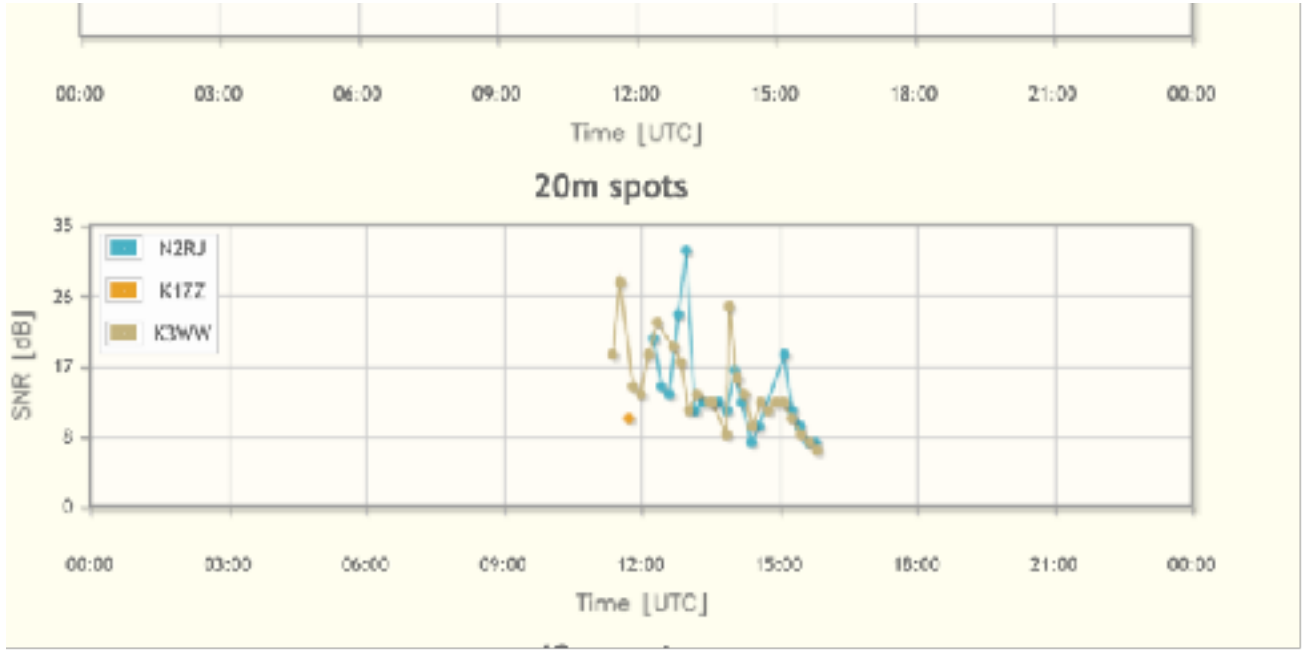
de	dx	freq	cq/dx	snr	speed	time
W7HR	N2RJ	14058.6	CW CQ	12 dB	31 wpm	0903z 12 Jul
K2DB	N2RJ	14041.7	CW CQ	1 dB	24 wpm	1948z 28 Jun
CX5VM	N2RJ	14041.5	CW CQ	2 dB	24 wpm	1946z 28 Jun
K9IMM	N2RJ	14041.5	CW CQ	2 dB	24 wpm	1945z 28 Jun
OL7M	N2RJ	14041.5	CW CQ	4 dB	24 wpm	1945z 28 Jun
K9LC	N2RJ	14041.4	CW CQ	7 dB	24 wpm	1945z 28 Jun
OH6BG	N2RJ	14041.5	CW CQ	10 dB	24 wpm	1944z 28 Jun
KO7SS	N2RJ	14041.6	CW CQ	4 dB	24 wpm	1944z 28 Jun
K3PA	N2RJ	14041.5	CW CQ	1 dB	23 wpm	1944z 28 Jun
AC0C	N2RJ	14041.5	CW CQ	9 dB	24 wpm	1944z 28 Jun
W9XG	N2RJ	14041.6	CW CQ	5 dB	24 wpm	1944z 28 Jun
K9TM-1	N2RJ	14041.5	CW CQ	6 dB	24 wpm	1944z 28 Jun
N9YKE	N2RJ	14041.4	CW CQ	7 dB	24 wpm	1944z 28 Jun
WE9V	N2RJ	14041.4	CW CQ	19 dB	24 wpm	1944z 28 Jun
W8WWV	N2RJ	14041.5	CW CQ	27 dB	24 wpm	1944z 28 Jun

Whose (signal) is bigger?

A neat little tool can tell you.

www.reversebeacon.net/analysis

Choose a spotter, and then enter callsigns.
Plot them on a graph.



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Questions?