

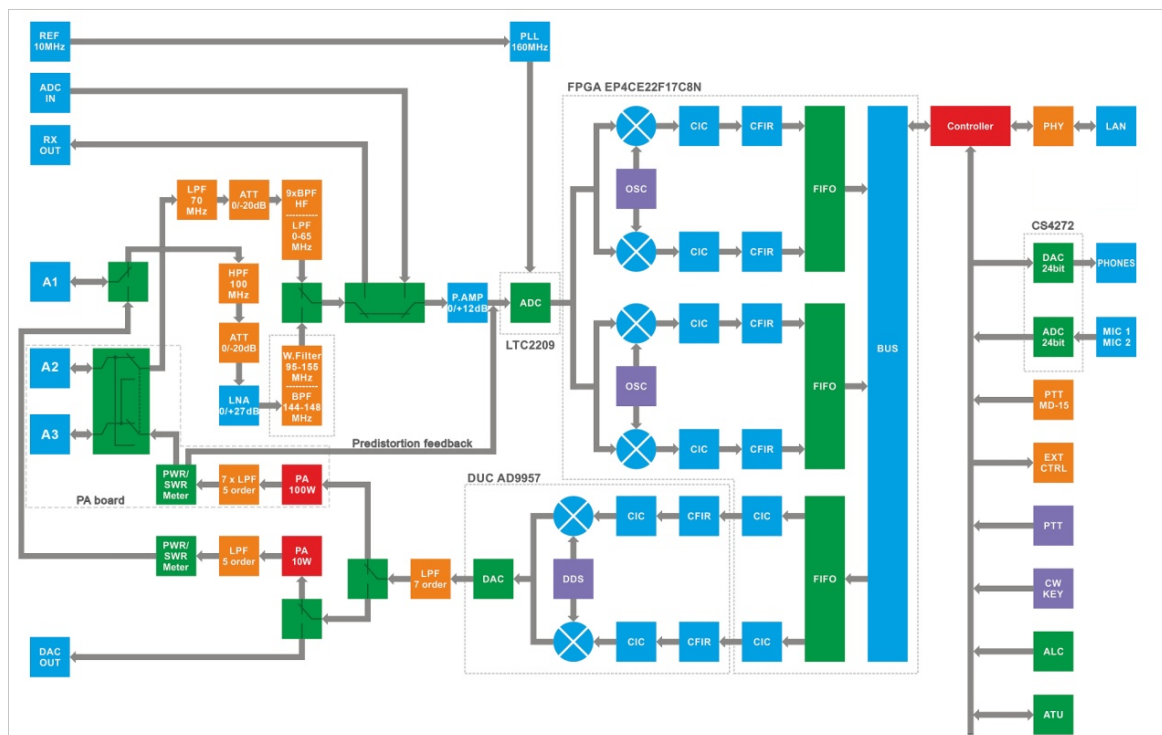
SunSDR2 DX - Test Report



Based on the popular SDR transceiver SunSDR2 Pro, the manufacturer Expert Electronics offers the "SunSDR2 DX". This transceiver operates as a direct-sampling Software Defined Radio (SDR) with a high-resolution 16Bit A/D converter (LTC 2209), at a sampling rate of 160 MS/s. All amateur radio bands from 160 to 6m (0.09...65MHz) as well as the 2m VHF band (95...148MHz) are supported. The transmit power is 100W on shortwave, 50W on 6m and 7W on 2m. Changes compared to the SunSDR-Pro concern the filters. A new high-pass filter from 100 MHz is built in, which leads to a better sensitivity on VHF. For HF, 9 individual, optimized band-pass filters or a single low-pass filter from 65 MHz are available. This combination is complemented by an additional low-pass filter from 70 MHz, which improves the dynamic range on shortwave (HF) and 6m.

The transmitter is designed to be completely independent of the receiver with its own quadrature oscillator, allowing flexible half or full duplex operation. Together with the ExpertSDR2/3 software, two independent main receivers and two independent sub-receivers in the same band range are possible. Furthermore, the display of a wide spectrum of up to 80 MHz is possible.

The SunSDR2 DX is controlled via an Ethernet cable, which is connected either directly to a PC or to the DSL router in the home network. With the help of the new ExpertSDR3 software and a "cloud" provided free of charge by EE, the SunSDR2 DX can be easily operated worldwide from the Internet. Complicated port forwarding and DynDNS are now a matter of the past.



Block diagram SunSDR2 DX

Installation

At first, download the software "ExpertSDR2_SunSDR2DX" from <https://eesdr.com/en/software-en/expertsdr3-en> and install it on a PC (Windows 10 32/64bit, Linux und macOS) and then connect the SunSDR2 DX to the PC via an Ethernet cable (**Fig. 1**). For the PC to recognize the transceiver its IP address must be changed.

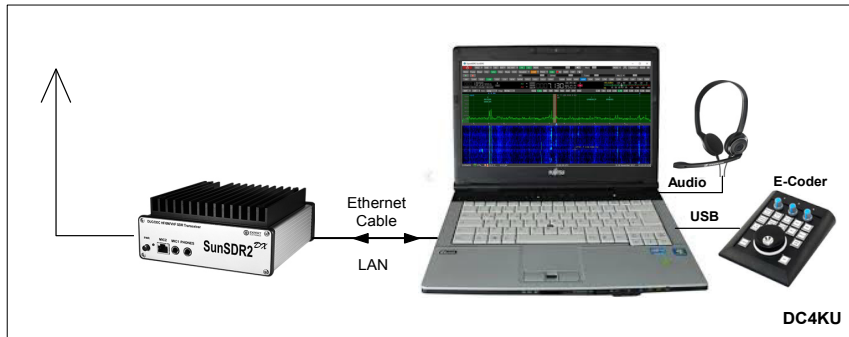


Figure 1: SunSDR-DX in direct connection with a PC

To do this, go to *Network and Sharing Centre -> Change Adapter Settings -> Ethernet -> Internet Protocol, Version 4 (TCP/IPv4)* and set the IPv4 address of the PC from "Obtain IP address automatically" to e.g. 192.168.16.50 (1...199) and save it (**Fig. 2**). After changing the address, the SunSDR2 DX is recognized by the PC and the software can be started. The connection to a single PC is now complete (**Fig. 3**).

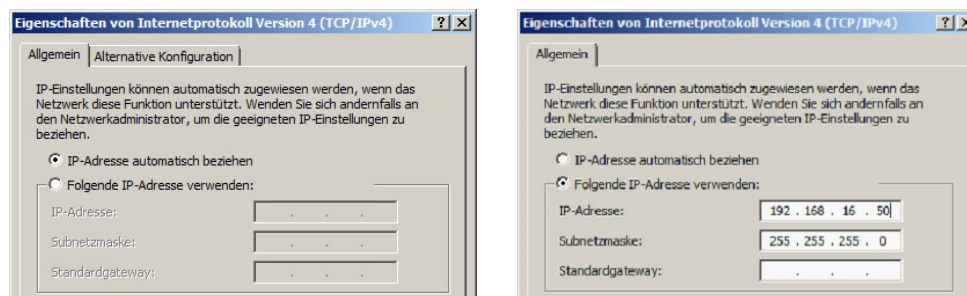


Figure 2: Setting the IP-Address in the PC

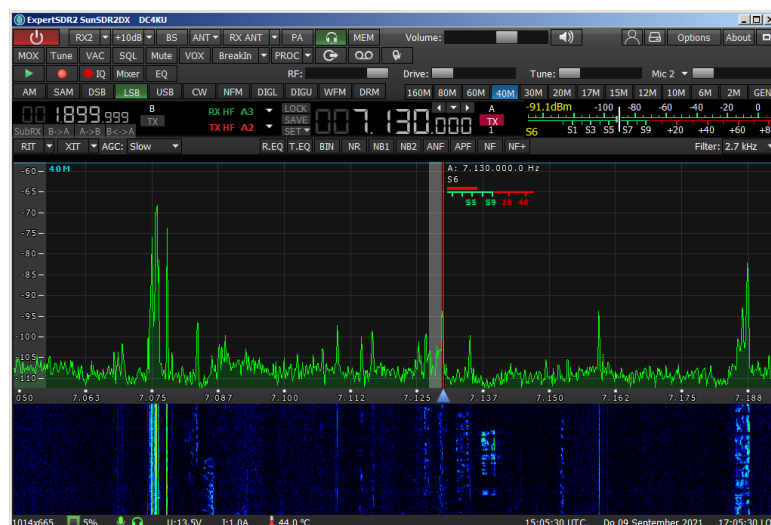


Figure 3: Display of the SunSDR2 DX under ExpertSDR2_SunSDR2DX

To enable remote control of the SunSDR2 DX from other PCs in the home network, it must be connected to the home DSL router (**Fig. 4**). To do this, enter a free IP address of the router in the

menu under *Options* -> *Expert* -> "*Set IP Address*", e.g. 192.168.178.**120** and save this with Write -> OK. If the preset "Port 50001" is already being used by the router for another application, enter a free port here, e.g. Port **50071**. Then switch off the SunSDR2 DX, disconnect it from the power supply and connect the Ethernet cable to the router as shown in **Fig. 4**.

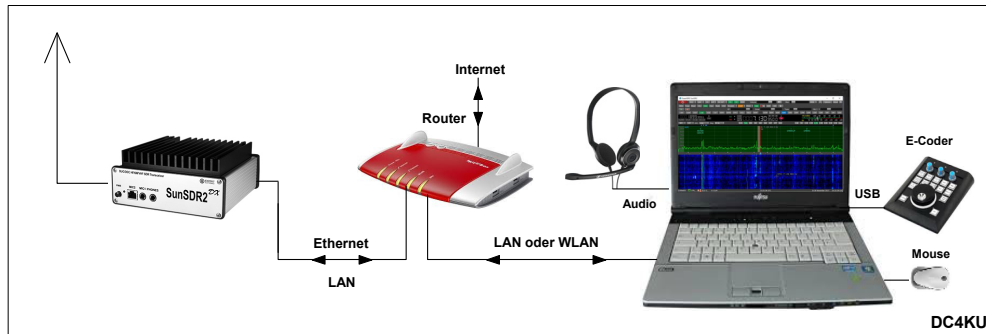


Figure 4: SunSDR2 DX connected to the home network

After switching on the transceiver again, it automatically connects to the router within a few seconds (**Fig. 5**). After restarting the software, the new SDR address and the new SDR port of the SunSDR2 DX can be seen under Options: **192.168.178.120:50071**. The SunSDR2 DX is now connected to the home network and can be reached from all PCs on which the ExpertSDR2_SunSDR2DX software has been installed.

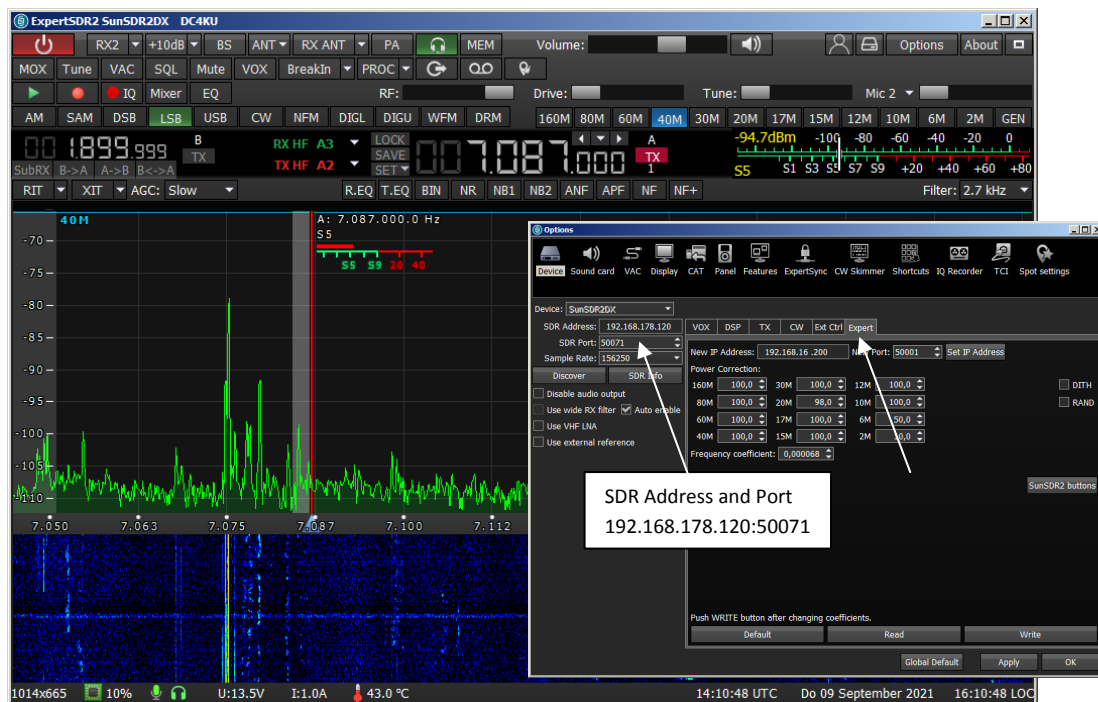


Figure 5: SunSDR2 DX started with its correct IP- and port-settings

Remote control via internet

For remote control via the Internet, a server/client connection is required (**Fig. 6**). Any PC in the home network can act as a server PC. Download the software ExpertRS (Remote Server) and ExpertRC (Remote Client) from <https://eesdr.com/en/software-en/expertremote-en> and install them on the Server- and Client-PC (**Fig. 6**). Open "ExpertRS" on the Server-PC (**Fig. 7**) and enter 50071 under SDR Port and click on Search. The server of the SunSDR2 DX is now activated and on stand-by for a connection. The program can then be closed again, but the server remains open in the

background.

In order for the transmission to the Internet to work, the Server-PC needs a "Port Forwarding". To do this, open the router, go to *Internet -> Release* and release ports 50071 to 50073 (data and audio) on the Server-PC via TCP and UDP. Then open "ExpertRC" on the Client-PC, select *Options -> Device* and enter the public IPv4 address of the router and the port of the SunSDR2 DX, in the example: 92.36.144.213:50071 (**Fig. 8**).

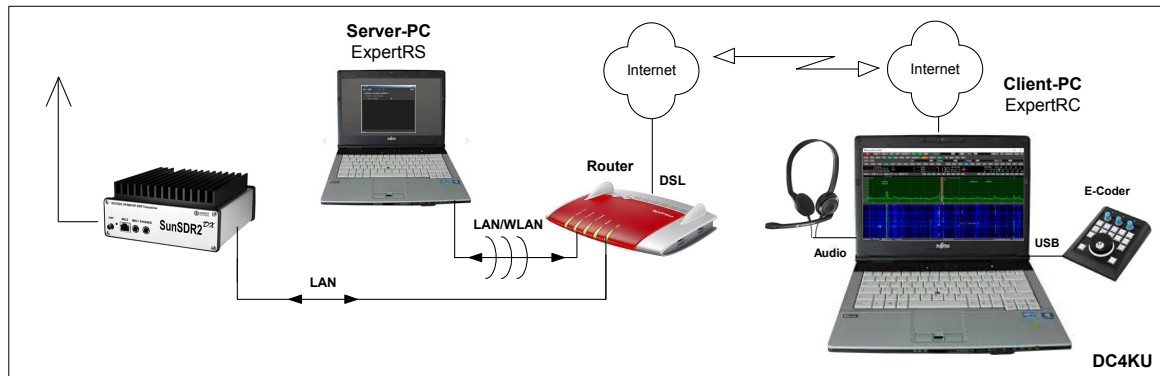


Figure 6: SunSDR2 DX on the internet

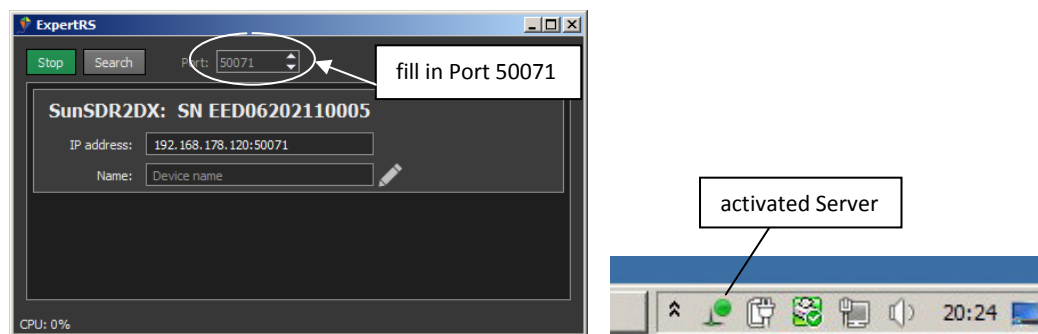


Figure 7: ExpertRS started (left) and server marked at the bottom of the PC screen (right)

Finally, the SunSDR2 DX can be remotely controlled from anywhere in the world via the Internet (**Fig. 8**). The access works under LAN, WLAN and LTE (3G, 5G) with a selectable traffic from 70kbit/s to over 1Mbit/s and a sample rate from 39062 to 312500Hz.



Figure 8: After entering the URL, the SunSDR2 DX can be reached worldwide via the Internet.

ExpertSDR3

Shortly ago, Expert Electronics introduced a new software under the name ExpertSDR3, which works according to a completely new concept (<https://eesdr.com/en/software-en/expertsdr3-en>). After installing and starting the software, a menu opens in which all radios within the home network are listed, in the example a SunSDR2 Pro and SunSDR2DX (**Fig. 9, left**). After selecting one of the radios via "Start", it opens and can be operated (**Fig. 9, right**). If necessary, all radios can be opened and remote-controlled on different frequencies at the same time.

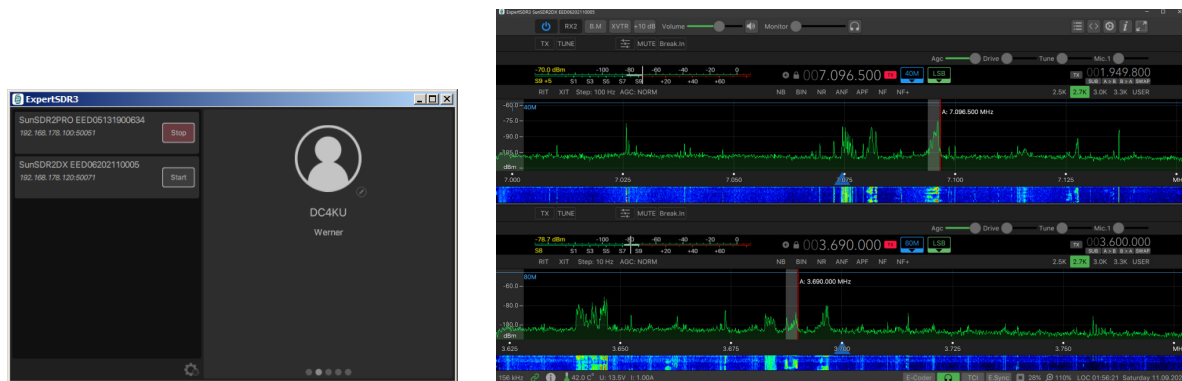


Figure 9: List of available radios (left) and Start of the SunSDR2 DX (right).

A special feature - which is not offered by any other manufacturer - is the remote control of the radios via a "cloud", which Expert Electronics provides free of charge. Here, server and client PCs are connected via a cloud-server (**Fig. 10**). Port-Forwarding and DynDNS are no longer necessary!

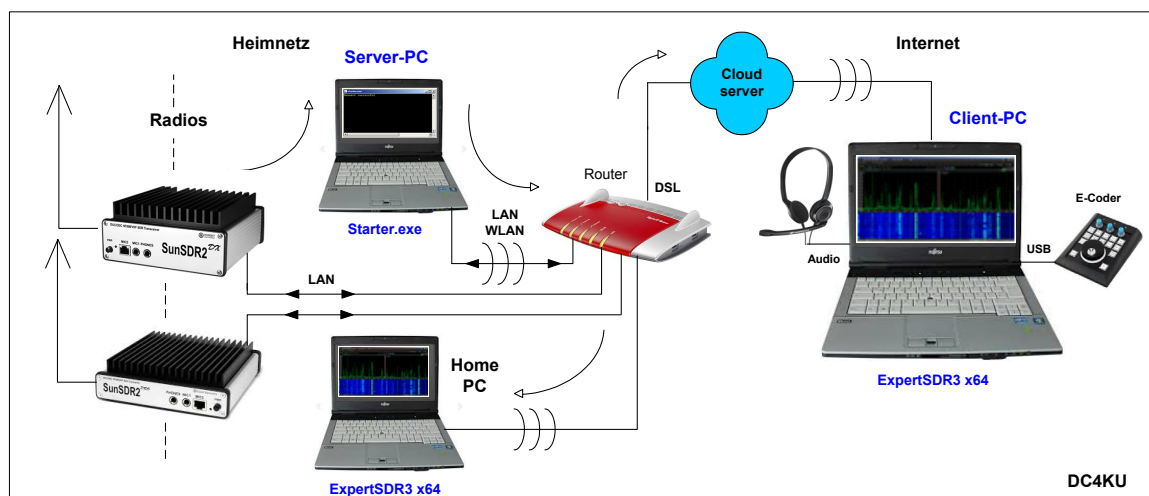


Figure 10: Remote control of all radios and via a cloud

First, register with the EE Cloud (**Fig. 11**). To do this, open the URL <https://cloud.eesdr.com:5450/reg.html> and enter an email address and password in the Cloud menu. The successful registration is then confirmed by Expert Electronics by email, which must be reconfirmed for security reasons.

Then download the file "Starter_Win64" from <https://eesdr.com/en/software-en/expertsdr3-en> on to the Server-PC and open it. Under Starter_Win64 -> 20210702 you will find the file **config.json**. Open it with a text editor and enter the email address and the password of your cloud under "email" and "Secret" and save it. After double-clicking on "starter.exe", the message "Connect Successful" appears on the screen (**Fig. 12**), which means that all radios in the home network are connected to the Cloud. That's all!

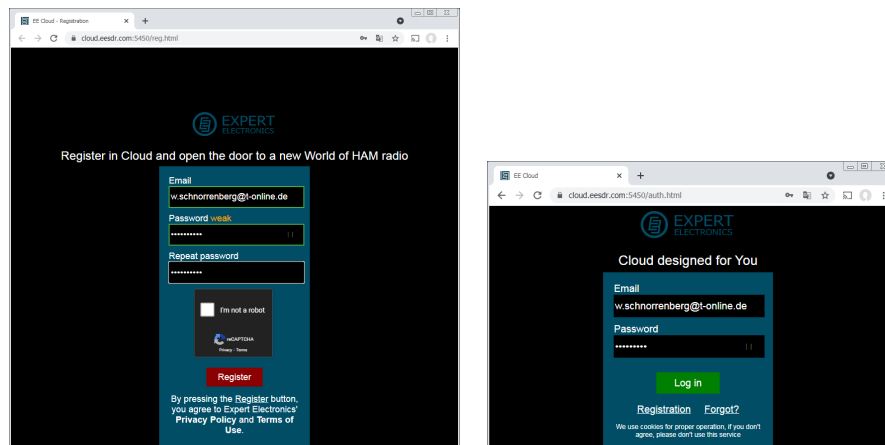


Figure 11: Registering at the EE-Cloud by email and password (left) and Log In (right).

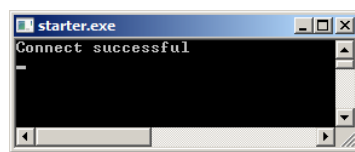


Figure 12: Successful connection

Now there are two ways to connect server with client: Either via Web-Browser or via ExpertSDR3.

a) After entering the URL <https://cloud.eesdr.com:5450.auth.html> in a browser (Opera), all radios connected to the cloud are displayed in a menu and can be started via "Connect" (**Fig. 13, left**). Since the connection works via the WEB, Smartphones or Tablets can also be used as clients.

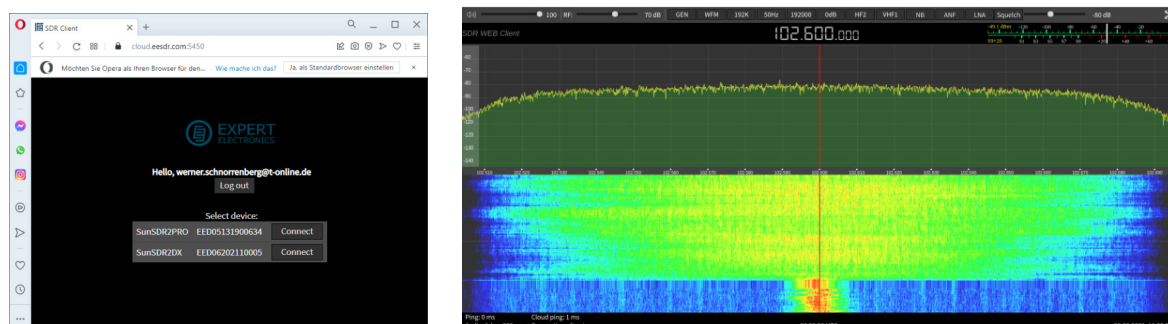


Figure 13: Radio opened via a Web-Browser on PC or Smartphone/Tablet

b) After starting the software ExpertSDR3 on the client PC, a menu also opens in which the URL, e-mail address and password of the cloud are entered (**Fig. 14, left**). After clicking on "Login", all available radios appear again, which can be started after clicking on "Start".

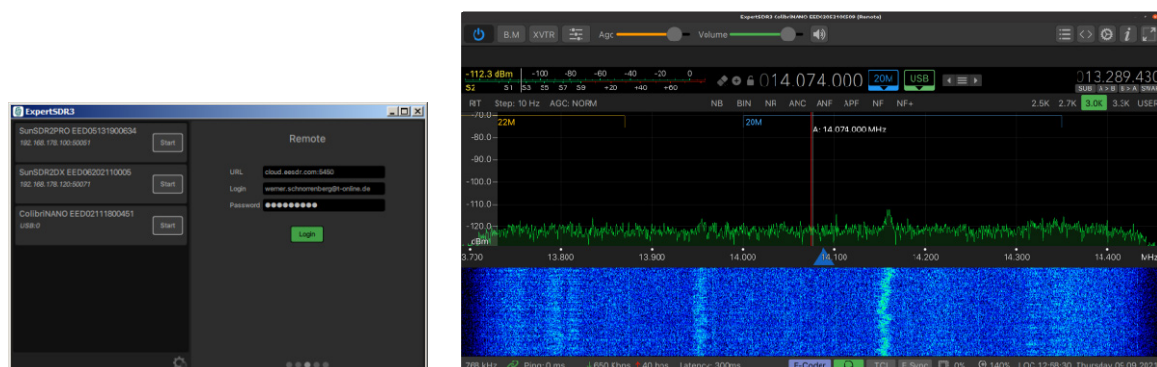


Figure 14: Radio opened via the Software ExpertSDR3_x64

The ExpertSDR3 software opens up so many new possibilities that a detailed description of its features would go beyond the scope of this article. I will reserve that for a later report.

RF measurements at the receiver

Sensitivity (MDS) and Noise Figure (NF)

To measure the sensitivity of the receiver, an RF-Generator is tuned to the frequency of the receiver (CW) and its level is reduced until the demodulated AF signal at the loudspeaker output (800Hz) is only 3dB higher than the basic noise level of the receiver. I use a broadband AC voltmeter with dB scaling as a measuring device for the noise increase at the AF output. **Table 1** shows the determined sensitivity (dBm) on the individual bands, with and without +10dB preamplifier, and **Table 2** the noise figure (dB).

Settings: CW 500Hz, AGC off, Dith/Rand off, use wide filter on, 145MHz with VHF LNA

MDS	3,6MHz	14,1MHz	28,1MHz	50,1MHz	145MHz
Gain +10dB	-133dBm	-133dBm	-133dBm	-128dBm	-144dBm
Gain 0dB	-121dBm	-121dBm	-121dBm	-119dBm	-

Table 1: Sensitivity (MDS) in dBm

With the noise limit of -174dBm/Hz, the noise figure (NF) is calculated as follows
 Noise Figure = MDS - Noise Limit - 10logB = MDS + 147dB, with B=500Hz

Noise Figure	3,6MHz	14,1MHz	28,1MHz	50,1MHz	145MHz
Gain +10dB	14dB	14dB	14dB	19dB	3dB
Gain 0dB	26dB	26dB	26dB	28dB	-

Table 2: Noise Figure in dB

S-Meter and dBm Display

The SunSDR2 DX displays the signal level on a scale from S1 to S9 +80dB, as well as in "dBm". To check the dBm-accuracy, the RF signal of a calibrated signal generator is fed in at 14.2 MHz from S1 to S9+60dB (from -122dBm to -13dBm) and compared with the displayed value of the SunSDR2 DX.

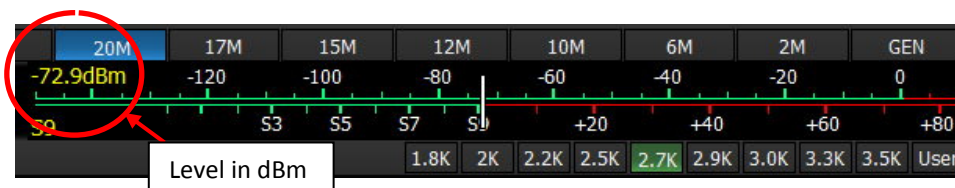


Figure 15: S-Meter and dBm display

Settings: Frequency 14.2MHz, SSB, B=2.7 kHz, Preamp On

Input Level dBm	-121	-115	-109	-103	-97	-91	-85	-79	-73	-63	-53	-43	-33	-23	-13
S-Meter Level	S1	S2	S3	S4	S5	S6	S7	S8	S9	S9+10	S9+20	S9+30	S9+40	S9+50	S9+60
Displayed Level dBm	-120.9	-115.3	-109.4	-102.8	-96.9	-91.0	-85.1	-80.6	-72.9	-62.8	-53.1	-42.8	-32.7	-2.8	-12.8

Table 3: Accuracy of S-Meter and dBm indication over a dynamic range of 108dB, from S1 to S9 +60

The level measurement accuracy in "dBm" of the 16-bit SunSDR2 DX is exceptionally good and is not comparable with any other receiver I know. The maximum error is +/- 0.5 dB over a range of 110 dB. With this extremely high accuracy, the SunSDR2 DX can also be used as a spectrum analyzer or as a measuring receiver.

Sideband Noise and Reciprocal Mixing Dynamic Range

Sideband noise (SBN) and Reciprocal Mixing Dynamic Range (RMDR) are among the most important characteristics of a receiver (**Fig. 16, 17**). In direct sampling SDRs, SBN is mainly caused by time jittering of the ADC clock and in analogue receivers by frequency jittering of the heterodyne oscillator. Small signals near larger signals can be masked by sideband noise, causing the receiver to lose sensitivity and dynamic range. The loss of dynamic range is called "Reciprocal Mixing Dynamic Range (RMDR)". Therefore: The higher the RMDR and the smaller the SBN, the better the receiver.

The SBN measurement is made with a low-noise OCXO at 14.2454MHz. The level of the OCXO is increased at a distance of 1 to 10 kHz from the receiving frequency until the background noise (SBN) increases by 3dB. From this, SBN and RMDR are calculated as follows

$$\text{SBN} = \text{Pi} - \text{MDS} + 10\log B$$

with Pi= input level, B=500Hz and MDS = -133dBm/500Hz

and

$$\text{RMDR} = \text{Pi} - \text{MDS}$$

Delta f kHz	Pi dBm	SBN dBc/Hz	RMDR dB
1	-38	-120	95
2	-16	-138	111
3	-15	-141	114
4	-14	-144	117
5	-13	-146	119

Table 4: SBN and RMDR at carrier spacing from of up to 5 kHz



Figure 16: Visible receiver sideband noise at Pi = -10dBm (S9 +63dBm)

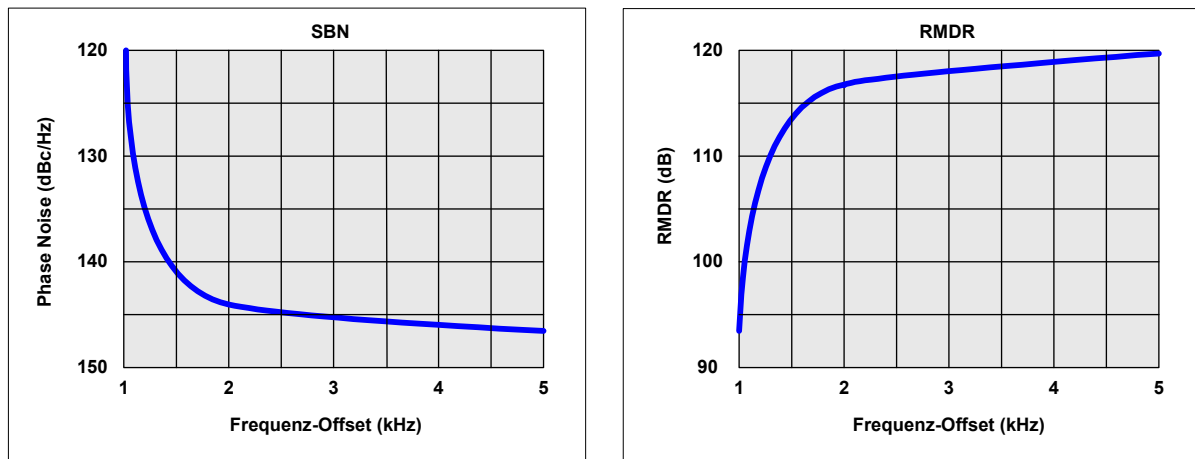


Figure 17: Phase noise and RMDR curves

Intermodulation 3rd order, DR3

To test DR3 (Dynamic Range 3rd order), the receiver is driven with two RF signals of equal magnitude and the 3rd order intermodulation products at $2f_1 - f_2$ and $2f_2 - f_1$ are measured simultaneously. Therefore the level (Pi) of the 2-tone signal is gradually increased and the resulting 3rd order intermodulation is noted, up to the limitation of the receiver (**Fig. 19**). The DR3 is calculated to

$$\text{DR3} = P_i - \text{MDS}.$$

In difference to analog receivers, the IMD3 interference products of direct sampling SDRs do not increase with signal magnification at triple speed, but remain near the noise floor and only increase massively shortly before limiting the ADC. The highest distortion-free dynamic range therefore occurs at maximum gain of the ADC, in the so-called sweet spot. With +10dB pre-amplification and switched on BP-Filters the SunSDR2 DX develops its best dynamics. At a level of $P_i = 2 \times -25\text{dBm}$ ($2 \times \text{S9} + 48\text{dB}$) the largest DR3 of $-25\text{dBm} - (-131\text{dBm}) = 106\text{dB}$ (sweet spot) is produced (**Fig. 18**). With further signal enlargement the ADC then comes into its limitation (clipping).

Settings: $f_1 = 14.100\text{MHz}$, $f_2 = 14.102\text{MHz}$, CW, B=500Hz, Preamp on, Dither/Random on

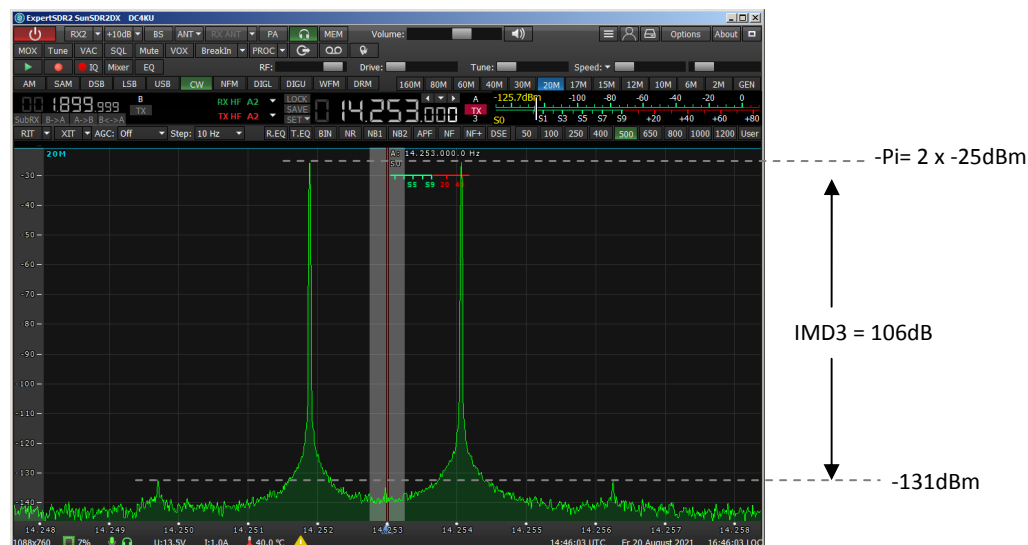


Bild 18: Maximaler IMD3-Abstand, kurz vor Clipping: 106dB

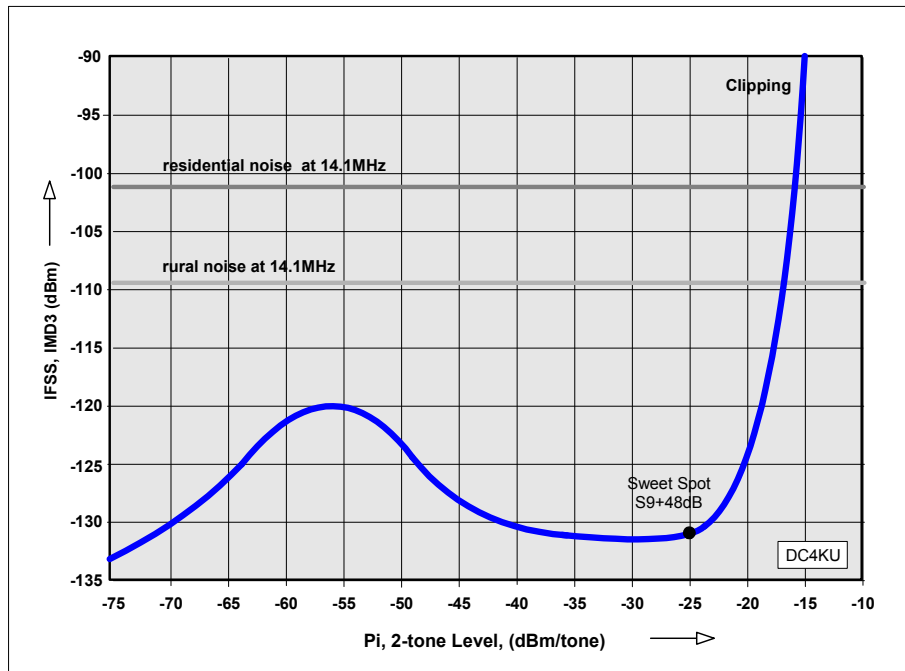


Figure 19: IMD3 curve as a function of a 2-tone signal, with BP-Filter (standard) and HF LP-Filter (0-65MHz)

With a DR3 of 106dB the SunSDR2 DX reaches a very good dynamic range (**Fig. 19**). Better results are only achieved by analogue receivers with an extremely powerful mixer in the front end. In course of intermodulation it is only important that the produced intermodulation of the receiver does not exceed the size of the residential- or rural-noise, which indicate the noise floor of the receiver with the antenna connected.

Intermodulation 2nd order, DR2

The IM 2nd order is also measured with two CW signals, which are in a larger frequency distance to each other, at $f_1 = 6.1\text{MHz}$ and $f_2 = 8.1\text{MHz}$. The IMD2 product falls exactly in the 20m band, at $f_1 + f_2 = 14.2\text{MHz}$. The levels (P_i) of f_1 and f_2 are increased until the unwanted IMD2 product appears at 14.2 MHz with +3dB above the noise. For the SunSDR2 DX, this occurred at $P_i = -25\text{dBm}$ (S9 +48dB) (**Figure 20**). The maximum dynamic range 2nd order (DR2) then corresponds to the difference of the injected signal level (P_i) to the noise level (MDS) of the receiver.

$$\text{DR2} = P_i - \text{MDS} = -25\text{dBm} - (-130\text{dBm}) = 105\text{dB}$$

Settings: $f_1=6,1\text{MHz}$, $f_2=8,1\text{MHz}$, $f_{\text{DR2}}=14,2\text{MHz}$, CW, B=500Hz, Gain=+10dB/0dB, Dith/Rand on

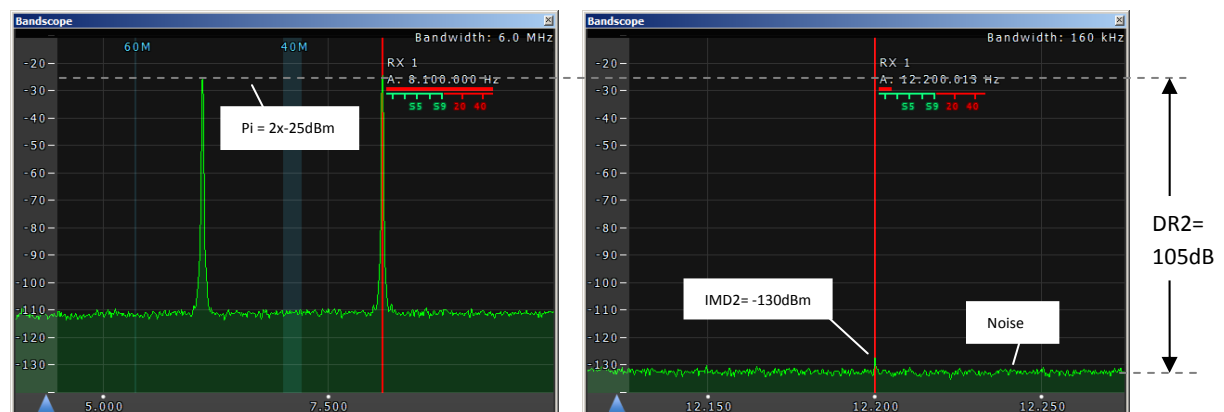


Figure 20: DR2 measurement via "Bandscope" (spectrum analyzer) display

Gain	MDS	Pi	DR2
0dB	-123 dBm	-15 dBm	108 dB
+10dB	-130 dBm	-25 dBm	105 dB

Table 5: Dynamic range 2nd order (DR2), $f_1=6.1\text{MHz}$, $f_2=8.1\text{MHz}$

The +10dB preamplifier of the SunSDR2DX offers a strong signal immunity and produces nearly no detectable intermodulation, as shown in **Table 5**. With +10dB pre-amplification the DR2 decreases only by 3dB, from 108dB to 105dB.

Note on intermodulation

The RF input of the SunSDR2 DX is protected by a series of BP filters (9 in total) by default. If required, only a 65MHz low-pass filter can be connected via the "use wide RX Filter: on" setting. But then it should be noted that the receiver is no longer protected against large signals. **Fig. 21** shows the IMD2 measurement via the 65 MHz LP filter. In addition to the two input signals $f_1 = 6.1\text{MHz}$ and $f_2 = 8.1\text{MHz}$ the IM interference products at $2 \times f_1 = 12.2\text{MHz}$ and $f_1 + f_2 = 14.2\text{MHz}$ are clearly visible. If the BP filter is switched on in the 20m band (as it should be), the selection of the filter causes a strong attenuation of f_1 and f_2 , so that the two IM products disappear in the noise (**Fig. 22**).

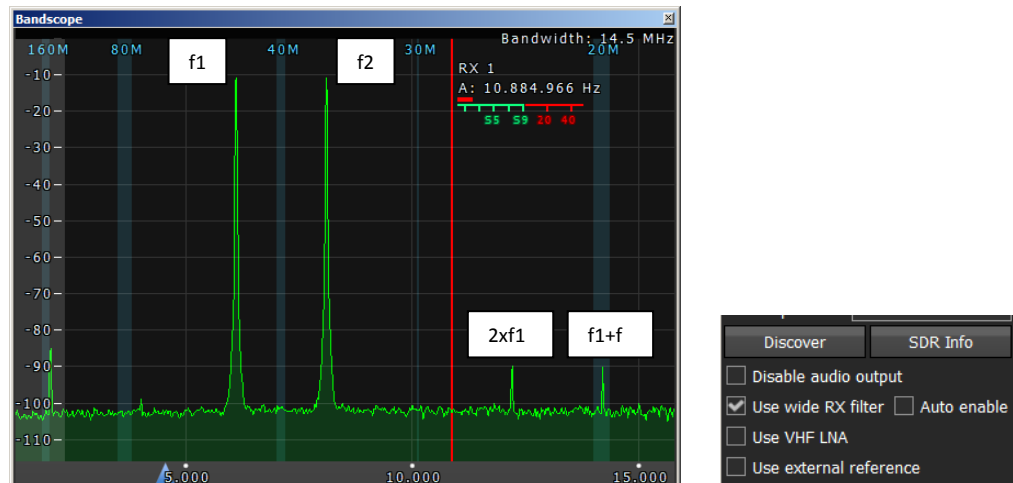


Figure 21: Intermodulation caused by broadband input

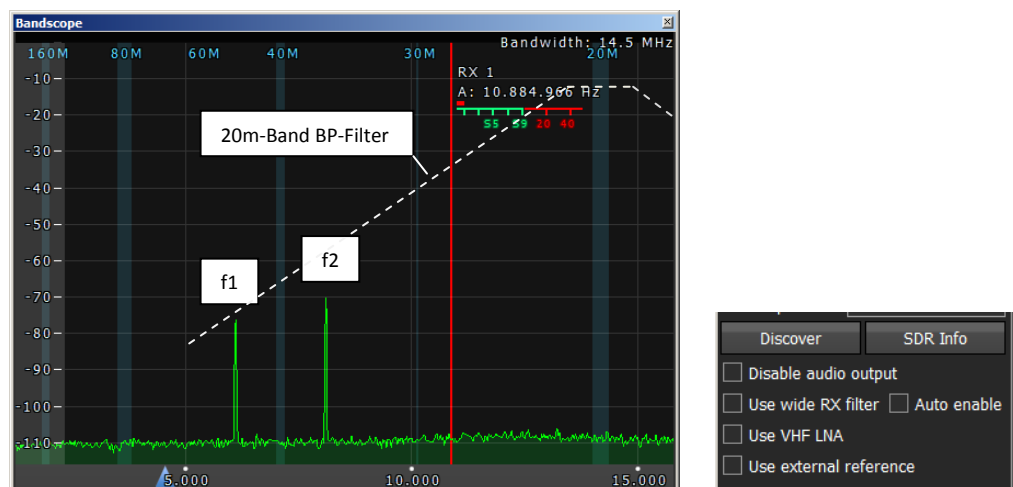


Figure 22: No intermodulation due to bandpass filter in 20m band

Noise Power Ratio (NPR)

An NPR measurement can be used to determine the strong signal immunity of a receiver. The input of the receiver is no longer driven with individual CW signals, but with white noise of constant power.

Fig. 23 shows the test setup consisting of a noise generator (0-100 MHz), bandpass filter, notch filter and attenuator and **Fig. 24** the resulting noise spectrum on the screen of a spectrum analyzer.

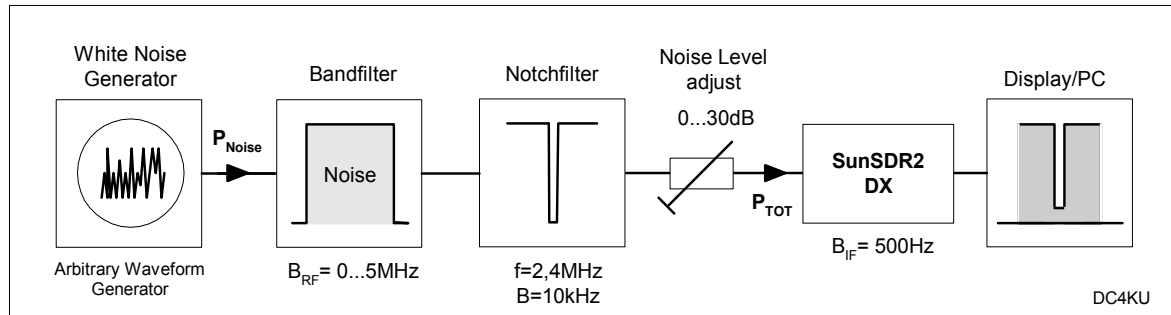


Figure 23: NPR measuring station

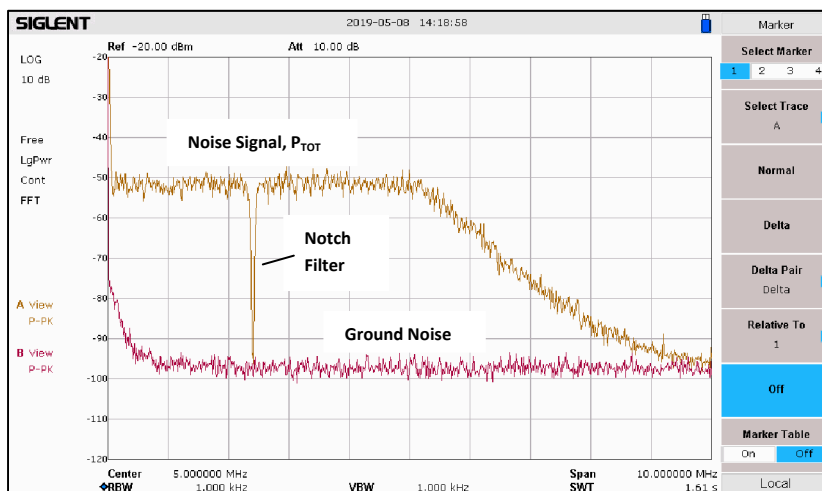


Figure 24: Noise spectrum with notch filter at the input of the receiver

The notch filter has the task of eliminating the noise at one point, in the example at $f=2.4\text{MHz}$. The receiver is adjusted to the centre of the notch filter (2.4MHz) and receives only its basic noise of $-121\text{dBm}/500\text{Hz}$ at this point. Then the applied noise is increased until the ADC is close to its limit. This can be seen by a 3dB noise rise in the base of the notch filter. At this point, the resulting intermodulation reaches the receiver's limit sensitivity and the difference of applied noise power (P_{TOT}) to the background noise level (MDS) corresponds to the NPR.

For the SunSDR2 DX, this occurs at a P_{TOT} noise level of $-5\text{dBm}/5\text{MHz}$ noise bandwidth.

From this, its NPR is calculated as

$$\text{NPR} = P_{\text{TOT}} - \text{BWR} - \text{MDS} = -5\text{dBm} - 10\log 5000\text{kHz}/500\text{Hz} - (-121\text{dBm}) = 76\text{dB}$$

with:

P_{TOT} = Noise power (in the example related to a bandwidth BRF of 5MHz).

BWR (Bandwidth Ratio) = $10\log \text{BRF}/\text{BIF} = 10\log 5000\text{kHz}/500\text{Hz} = 40\text{dB}$

BRF = noise bandwidth of the generator (in the example 5MHz)

BIF = Noise bandwidth of the receiver (in the example 500Hz)

MDS = -121dBm , noise floor of the receiver with Wide RX filter On

The NPR can be read directly from the spectrum display of the SunSDR2 DX, it is 76dB with a noise power of $P_{TOT} = -5\text{dBm}/5\text{MHz}$ (**Fig. 25**). For NPR measurements, no limiting bandpass filters should be connected in front of the receiver, because otherwise there is a risk that not the entire noise spectrum reaches the input of the ADC. Therefore, I activate *Wide RX-Filter On* under *Options -> Device*, which means that only a 65MHz LP filter is connected in front of the receiver.

Settings: B=500Hz, Preamp off, Dither & Random off, Wide RX-Filter on

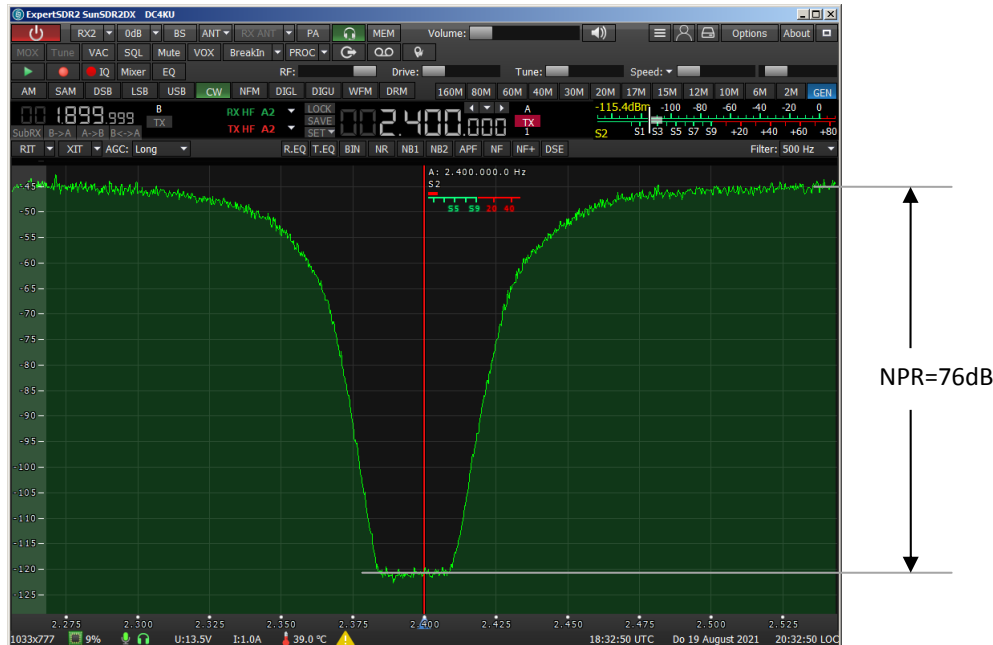


Figure 25: Noise Power Ratio

An NPR of 76dB proves the large signal strength of the SunSDR2 DX; simple SDR's usually only achieve an NPR of 40 to 50dB.

Wide Band Scope

In the operating mode "BS" (Wide Band Scope), the SunSDR2 DX opens an additional screen in which the entire spectrum from 0 to 80MHz is displayed. If you now switch off the bandpass filters of the receiver via the setting "Use Wide RX Filter: on", you will see the entire, unfiltered spectrum from 0 to 80MHz (Fig. 26). In this way it can be estimated well, which signals in which size the connected antenna delivers from 0 to 80 MHz at all. In the example, the strongest signals appear at about 7MHz with about -45dBm (S9 +30dB) and some interfering signals at 40, 50, 60 and 70MHz.

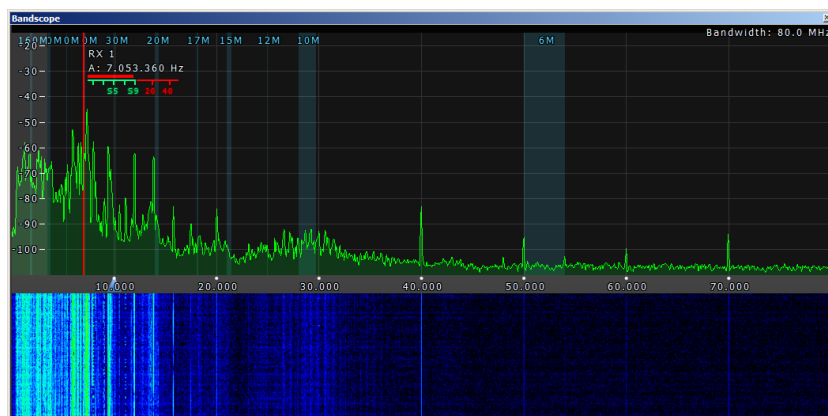


Figure 26: Display of the spectrum from 0-80MHz via "Wide Band Scope".

If you reduce the span to e.g. 2-13MHz (**Fig. 27, left**) and switch the BP filters on again (use Wide RX filter: off), you can see the selective effect of the now reconnected BP filter in the 40m band (**Fig. 27, right**). In this way, the effect of all BP filters in the frequency range can be checked. Frequency, deviation and level can be freely selected, similar to a spectrum analyzer.

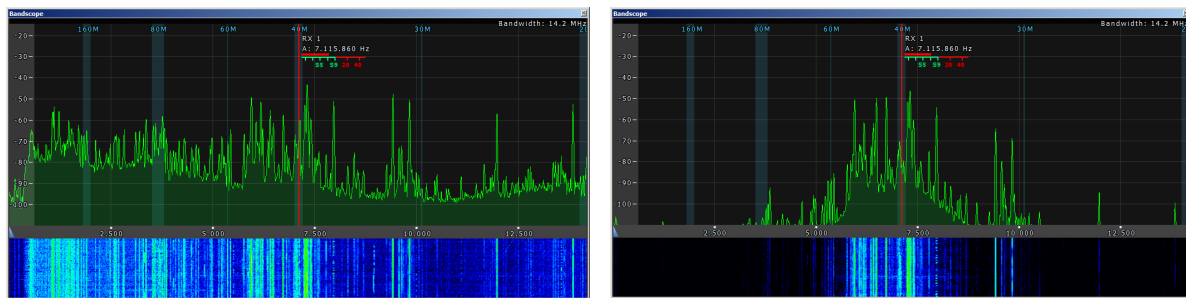


Figure 27: Spectrum in the 40m band without BP filter (left) and with BP filter (right)

Noise Filter

Another very useful function is the noise filters that can be activated. These are notch filters that can be placed anywhere in the spectrum to suppress interfering frequencies. If, for example, I have arranged a QSO on 3793 kHz (**Fig. 28**) and a small, whistling signal in the background disturbs me exactly there, I can suppress it completely and easily with a notch filter. The filters can be set so narrow that they do not interfere with the modulation signal. A total of up to 8 notch filters can be selected, each with a selectable notch bandwidth of 50Hz to 5kHz, which can be placed anywhere in the spectrum.

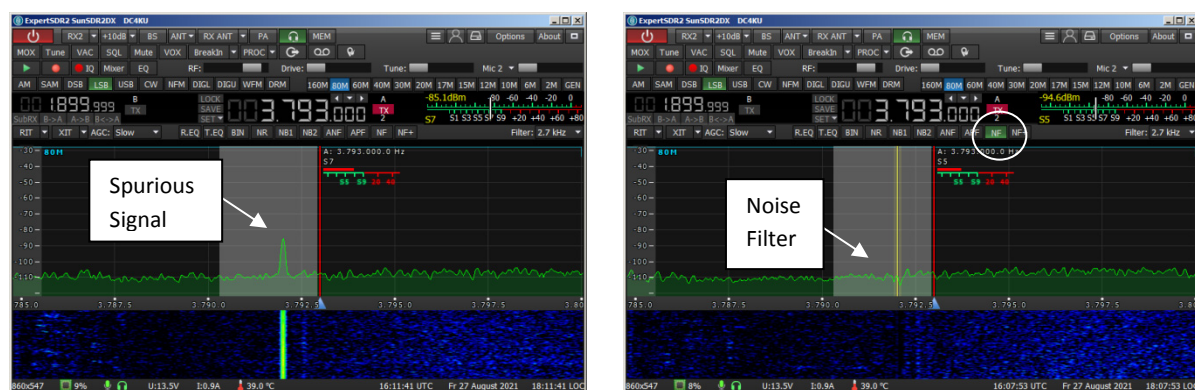


Figure 28: Suppression of unwanted signals in the spectrum by noise filters (notch filters)

RF measurements at the transmitter

RF output power

In this measurement, the RF output of the transceiver is connected to a calibrated spectrum analyzer via a 50dB attenuator and the maximum RF output power (Watt) is determined in CW mode (RTTY) on the frequencies 3.6, 14.1, 28.3, 50 and 145MHz.

Settings: RTTY, power supply +13.8VDC

Frequenz	3,6 MHz	7,1 MHz	14,1 MHz	28,3 MHz	50 MHz	145 MHz
P _{OUT}	107 Watt	107 Watt	110 Watt	119 Watt	75 Watt	8 Watt

Table 6: Max. RF output power

Intermodulation of the transmitter

In this test, a 2-tone signal ($f_1=700\text{Hz}$, $f_2=1500\text{Hz}$) is fed into the microphone input of the SunSDR2 DX and the transmitter is adjusted to maximum output power. The total power P_{OUT} of e.g. 100W is now distributed with 50W each (-3dB) to both signals and reaches a peak power of 100Watt PEP. The resulting spectrum shows not only the two user signals (f_1 , f_2) but also the unwanted intermodulation products of the transmitter, whereby the IMD3 products usually have the highest amplitude.

At maximum output power the distance between the IMD3 products and the user signals should not be less than 25dBc (according to ITU-R Rec. SM.326-7 standard -25 dBc worst-case) and the higher order products should drop in level relatively quickly. **Figure 29** shows the intermodulation of the transmitter in the 20m band and **Table 7** shows the IMD3 results at 3.6, 14.1, 28.3, 52 and 145MHz.

Settings: 20m band, 2-tone signal 700/1500 Hz with equal amplitudes, PEP = 100W

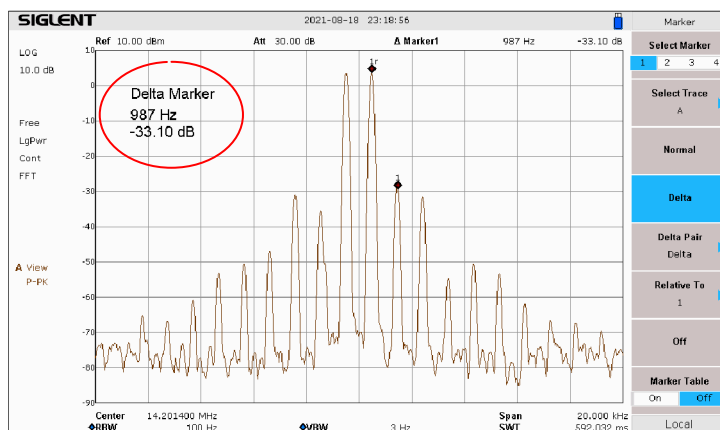


Figure 29: Transmitter intermodulation in the 20m band, 100Watt PEP, IMD3=33dBc

Frequenz	3,6 MHz	14,1 MHz	28,3 MHz	52 MHz	145 MHz
IMD3	31 dBc	33 dBc	30 dBc	30 dBc	30 dBc

Table 7: IMD3 distances at max. power on the individual bands

Even more realistically, the intermodulation can be determined with white noise. Instead of the 2-tone signal, white noise is fed into the microphone input (**Fig. 30**). The result is an almost rectangular noise envelope that corresponds to the bandwidth of the selected resolution filter, in the example $B=2.7\text{ kHz}$ (SSB).

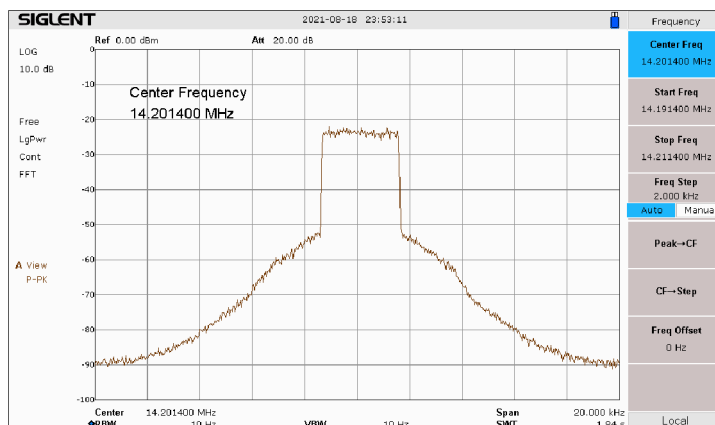


Figure 30: IMD determination with white noise, $B=2.7\text{ kHz}$

Theoretically, the two edges should slope steeply downwards to the noise floor, but in practice, of course they do not. From about -30dBc the first IMD products appear, but their levels decrease

relatively quickly as the frequency increases and decreases. In the noise spectrum, no individual spectral lines are now visible, but only a cumulative spectrum consisting of a virtually endless number of IMD products. For this reason, an IMD measurement with noise is in principle more true to reality than with only 2 signals. However, the procedure is also hard and strict, similar to an NPR measurement, and this is probably why most manufacturers do not publish it in their data sheets. The course of the noise spectrum also gives a good indication of the distance at which another station could be placed without being disturbed.

Transmitter Sideband Noise (TX-SBN)

Transmitters also generate sideband noise, but this is hardly detected in "normal" operation if the stations are far away from each other. However, if the radios are close together, such as during a field day, a transmitter with strong sideband noise may "noise out" (desensitize) nearby receivers (**Fig. 31**). This has nothing to do with "blocking" and additional filters at the receiver's input do not improve the situation (**5**).

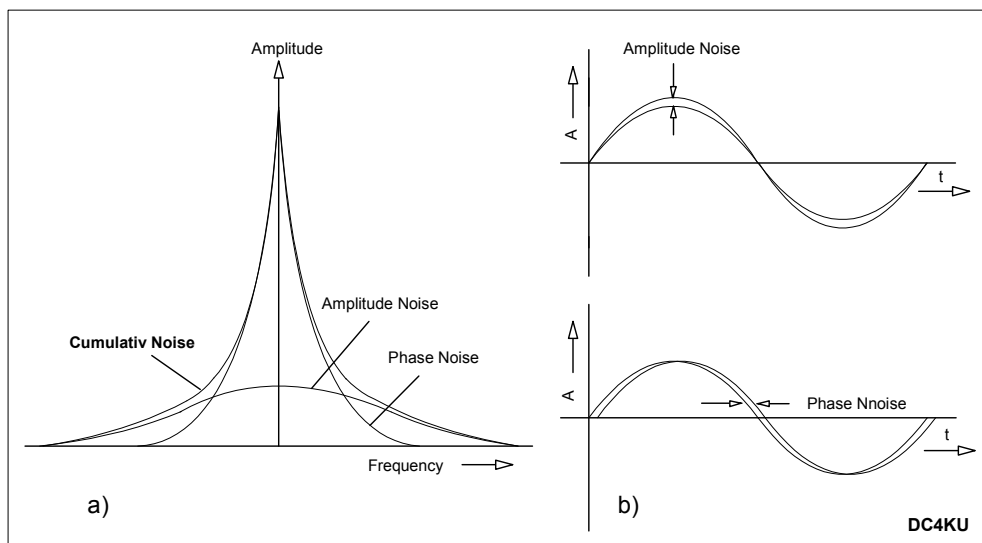


Figure 31: Phase- and amplitude noise in the a) frequency domain and b) time Domain

Although receiver and transmitter are controlled by the same oscillator, transmitters often produce an unacceptably high sideband noise. The reason is usually an (unwanted) AM modulation of the transmitted signal, which is superimposed on the phase noise. The resulting cumulative noise (AM+FM) is often higher and more broadband than just the phase noise.

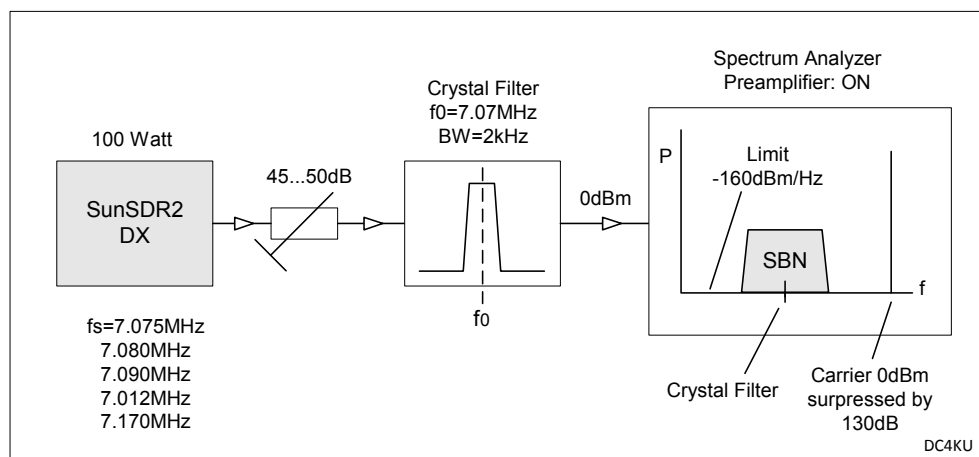


Figure 32: Measurement setup for SBN measurements on transmitters

Measuring the sideband noise of a transmitter is basically done in exactly the same way as the SBN measurement on an oscillator. The transmitter is set at frequency intervals of +5 to +100 kHz to the centre frequency of a narrowband and steep-edged crystal filter (7.070MHz, +/-1kHz) and the resulting sideband noise in the pass band of the filter is measured with a spectrum analyzer (**Fig. 32**). First, the 100Watt transmit signal (CW) must be attenuated to 1mW (0dBm) with an attenuator so that the connected spectrum analyzer is not overdriven. In addition, the 7.07MHz crystal filter blocks the transmit signal from an offset of 5 kHz by approx. 80dB, so that the transmit signal is attenuated by a total of 130dB. Only in the pass band of the crystal filter the noise is transmitted without attenuation. Now the analyzer can be set to its highest sensitivity of -160dBm/Hz, with 0dB RF attenuation and +20dB RF preamplifier switched on. Then the SBN of the transmitter can be determined at intervals of 5 to 100 kHz (1MHz) from the transmit frequency. As an example, **Fig. 33** shows the SBN result at a distance of 10 kHz from the carrier and **Table 8** shows the measurement results at distances up to 100 kHz.

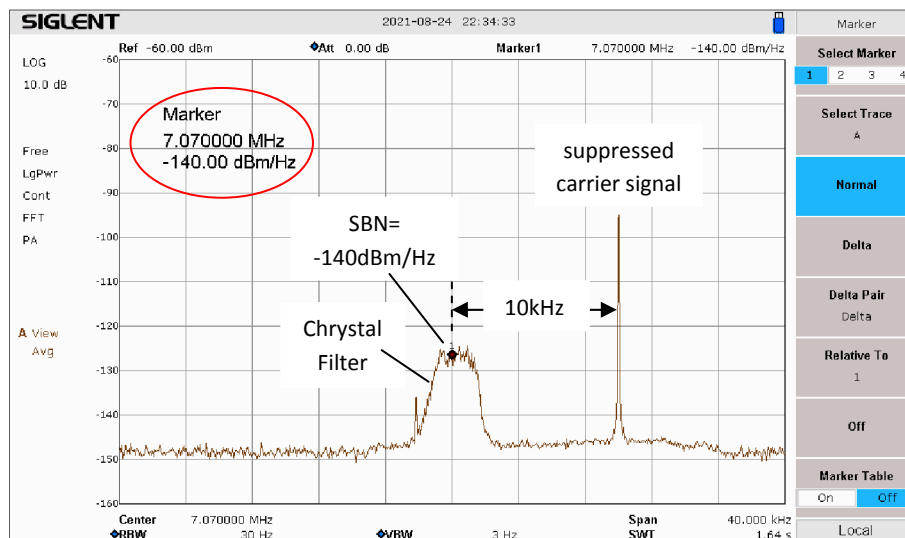


Figure 33: TX-SBN in 10 kHz offset to carrier, SBN = -140dBm/Hz

Offset (kHz)	5	10	20	50	100
SBN (dBm/Hz)	-136	-140	-142	-142	-143

Table 8: Cumulative SBN (AM + FM) of the transmitter at a distance of 5...100k Hz from the carrier

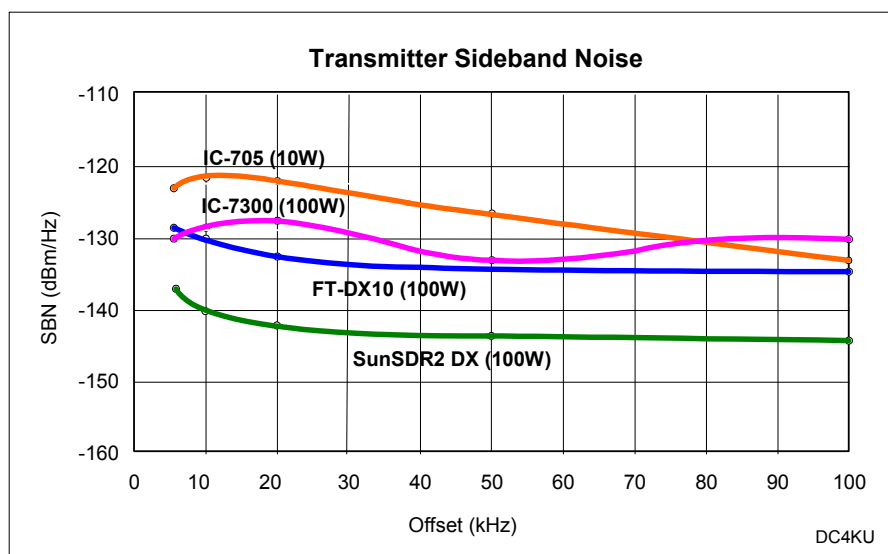


Figure 34: Transmitter composite noise at 7.1 MHz of the IC-705, IC-7300, FT-DX10 and SunSDR2 DX

With an SBN of only -140dBm/Hz at a distance of 10 kHz from the carrier, the noise of the transmitter is so small that the SunSDR2 DX can easily be used at Field Days without disturbing other stations by its sideband noise. **Fig. 34** shows the cumulative TX-SBN of some modern transceivers.

Transceiver data

The characteristic values of some modern transceivers are shown in **Table 9**. It should be noted that the FT-DX10 is a hybrid transceiver (analogue mixer and digital IF), but the SunSDR2 DX (16bit), IC-705 (14bit) and IC 7300 (14bit) are direct sampling SDRs.

	Receiver, 14.1MHz				Transmitter, 14.1MHz	
	MDS Preamp on	RMDR Offset 2kHz	IMD3 Delta f = 2kHz	NPR	IMD3 700/1500Hz	TX-SBN Delta f = 20kHz
FTDX-10	-134 dBm	116 dB	110 dBc	78 dB	27 dBc	-132 dBm/Hz
SunSDR2 DX	-133 dBm	111 dB	106 dBc	76 dB	33 dBc	-142 dBm/Hz
IC-7300	-133 dBm	106 dB	99 dBc	76 dB	36 dBc	-127 dBm/Hz
IC-705	-134 dBm	109 dB	98 dBc	76 dB	36 dBc	-122 dBm/Hz

Table 9: Characteristic values of different transceivers

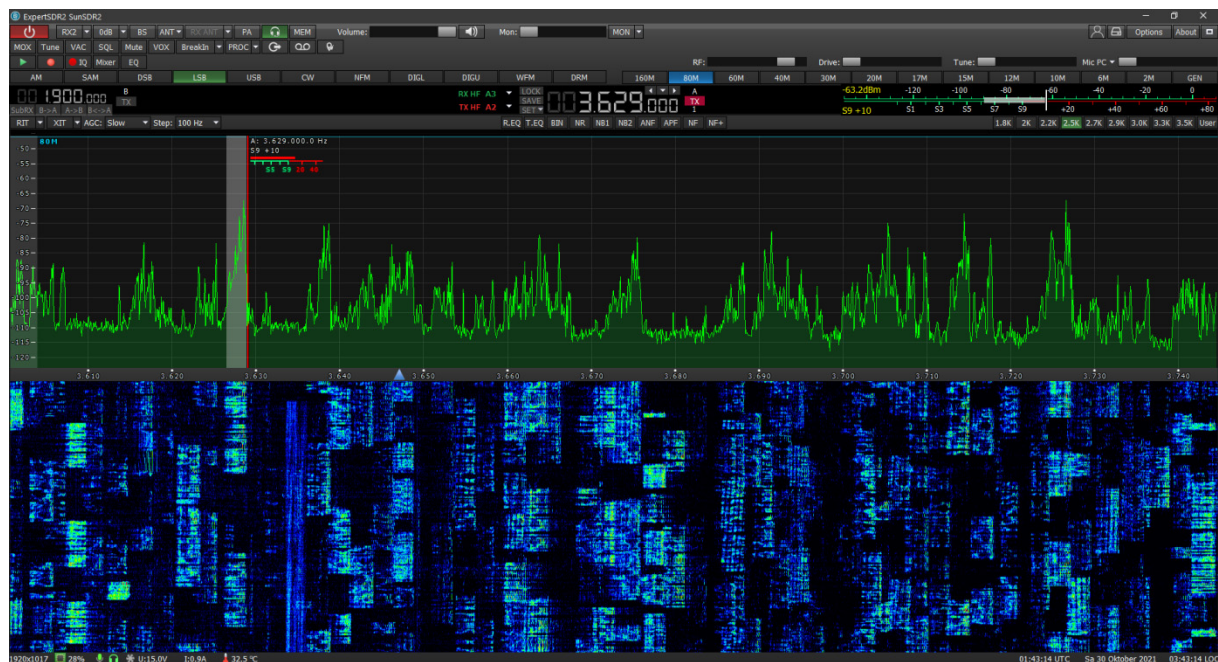


Figure 35: SunSDR2 on 80m during a contest

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Literature

(1) Expert Remote System, User Manual

https://eesdr.com/images/Document/Expert%20Remote%20system_ENG.pdf

(2) SunSDR2DX, HF/50MHz/VHF-Transceiver, User Manual

https://eesdr.com/images/Document/SunSDR2_DX/SunSDR2_DX_User_Manual_ENG.pdf

(3) Expert SDR3 Software

<https://eesdr.com/en/software-en/expertsdr3-en>

(4) Noise Power Ratio (NPR) Testing of HF Receivers

https://www.ab4oj.com/test/docs/npr_test.pdf

(5) Seitenbandrauschen von Sendern

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