# IC-705 - TEST

The IC-705 is a compact and lightweight transceiver for QRP applications and an addition to the ICOM SDR series IC-7300, IC-7610 and IC 9700.

The main features of the IC-705:
- Frequency 30 kHz - 146MHz, 430 - 440MHz
- Direct scanning SDR from 30 kHz to 28MHz, Super heterodyne from 28MHz to 440MHz
- Power supply via built-in LI-Ion battery or power supply unit
- Power 10W with 13.8V DC power supply and 5W with Li-Ion battery
- Operating modes D-STAR DV, SSB, CW, AM and FM
- 4.3-inch touch screen display with spectrum and waterfall display
- Bluetooth and WLAN
- Network server integrated, suitable for ICOM Remote Control RS-BA1
- GPS antenna and logger function
- Full range of D-Star functions

The operation of the IC-705 is described in detail in the ICOM manuals and in the internet (Google) you can already find some videos. A detailed description was published in the German Funkamateur 10-2020. In the following the IC-705 is tested in its most important HF characteristics and its remote control via the Icom software RS-BA1.

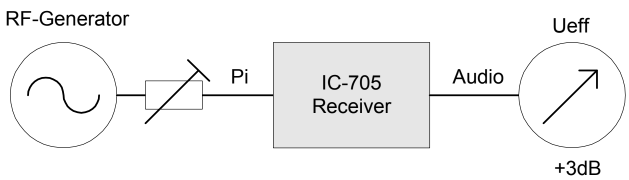


**Figure 1: Test setup for determining the sensitivity**

Starting at -140dBm, the signal is increased until the AF output voltage at the voltmeter rises by 1.414 (20logU2/U1) = 3dB (41%). The overlay tone is set to about 1 kHz. The sensitivity (MDS) of the receiver then corresponds to the input power (Pi).

| | 3,6MHz | 14,1MHz | 28,1MHz | 51MHz | 145MHz | 435MHz |
|---|---|---|---|---|---|---|
| **P.AMP off** | -124dBm | -124dBm | -123dBm | -120dBm | -124dBm | -123dBm |
| **P.AMP 1 ON** | -134dBm | -133dBm | -131dBm | -129dBm | - | - |
| **P.AMP 2 ON** | -135dBm | -134dBm | -133dBm | -132dBm | - | - |
| **P.AMP ON** | - | - | - | | -137dBm | -137dBm |

**Table 1: Sensitivity (MDS) in dBm at BW = 2.4 kHz (SSB)**

P.AMP 1/2 can be connected upstream in the frequency range up to 50MHz, P.AMP at 144MHz and 430MHz. If a bandwidth (BW) of 500Hz (CW) is selected for the sensitivity measurement, the sensitivity improves by the amount of approx. 10 lg2.4kHz/0.5kHz = 7dB.

**Sideband Noise (SBN) and Reciprocal Mixing (RMDR)**

Sideband noise and reciprocal mixing are important criteria for the qualitative assessment of a receiver. Strong SBN of the receiver can "cover" a small signal next to a strong signal and thus make a sensitive receiver "deaf". When the A/D converter is sampled, the sideband noise of the clock generator mixes with the received signal (reciprocal mixing) and can thus lead to blocking of the receiver. Despite sufficient selection, small signals near strong signals can be covered by the phase noise of the clock generator. The sideband noise of the clock generator should be as low as possible. Sideband noise is measured in power/bandwidth (dBm/Hz) is specified.

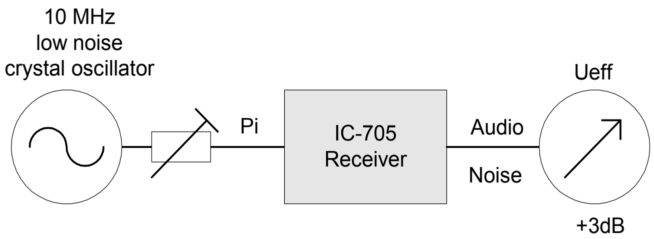


**Figure 2: Setup for RMDR and SBN measurement**

To measure the SBN, the same measurement setup as for the sensitivity measurement is used and the "3dB method" is applied again. The only difference to the sensitivity measurement is that now an extremely low-noise test signal must be used. The SBN of the test oscillator used must be at least 10dB better in all frequency intervals than that of the receiver under test. Otherwise the SBN of the test oscillator and not that of the receiver is measured, because reciprocal mixing works in both directions. As quasi noise-free test signal I use a 10MHz OCXO from KVG with an SBN of -164dBc/Hz in1kHz distance to the carrier.

The receiving frequency is first set to fe = +/-1kHz of 10MHz and the signal level is increased until the noise at the AF output has increased by 3dB (desensitization). In the example this is done at Pe =-23dBm. The SBN level thus reaches the value of the background noise (MDS) of -131dBm/500Hz. This means that a noise-free input signal of Pi=-23dBm desensitizes the sensitivity of the receiver by 3dB at 1 kHz carrier spacing.

This results in an RMDR (Reciprocal Mixing Dynamic Range) of

**RMDR = Pi - MDS = -23dBm - (-131dBm) = 108dB**

and a SBN (Phase Noise) of

**SBN = - (RMDR + 10logB) = - (108dB + 10log500Hz) = - 135dbc/Hz** in a distance of 1kHz

The SBN is then measured at greater spacing to the carrier and the results are plotted graphically **(Figure 3 and Table 2)**. The SBN can be measured until the ADC is limited (OVF). With IC-705 it happens Pi = -8dBm. The rule: The smaller the SBN and the larger the RMDR, the better the receiver.

Result: The RMDR and SBN are good and correspond to the values of the IC-7300.

***Settings IC-705: fe= 10MHz +/-Offset, ATT off, P.AMP off, BW=500Hz, CW***

| Offset kHz | Pi dBm | RMDR dB | SBN dBc/Hz |
|---|---|---|---|
| **1** | -23 | 108 | -135 |
| **2** | **-22** | **109** | **-136** |
| **3** | -22 | 109 | -136 |
| **5** | -21 | 110 | -137 |
| **10** | -18 | 113 | -140 |
| **20** | -16 | 115 | -142 |
| **30** | -14 | 117 | -144 |
| **40** | -12 | 119 | -146 |
| **50** | -10 | 121 | -148 |
| **100** | -8 | 123 | -150 |
| **ADC-Clip** | - | - | - |

**Table 2: RMDR and SBN (Phase Noise) as a function of offset and Pi**

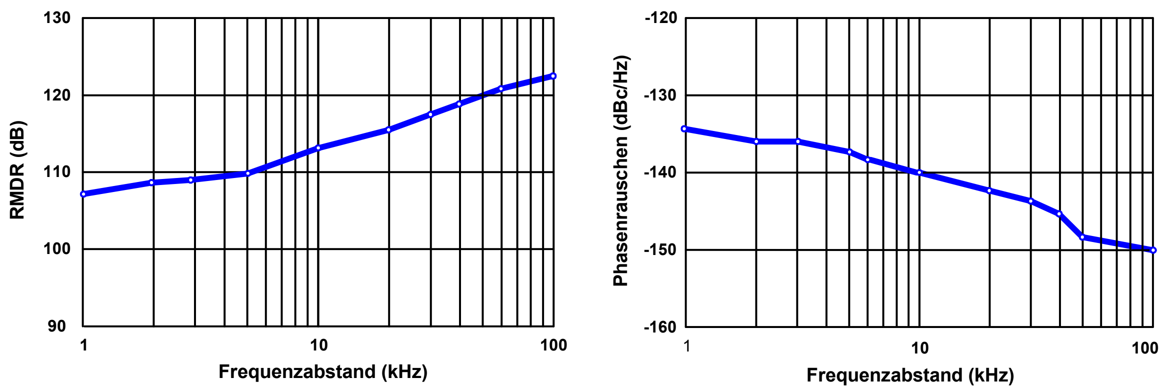


**Figure 3: RMDR and phase noise at a distance of 1kHz to 100kHz from the carrier**

### Intermodulation (IMD3)

To determine the intermodulation strength (IMD3), an HF 2-tone signal is used. Two equally sized RF signals with a frequency spacing of 2kHz from each other (e.g. f1=7.050MHz, f2 = 7.052MHz) are applied to the RF input of the receiver and their levels are increased until unwanted IMD3 disturbances occur at 2xf1-f2 and 2xf2-f1 which are equal to the receiver background noise (S+N)/N =2, i.e. exactly 3dB above the background noise. The difference between input level (Pi) and noise floor (MDS) then results in the IM-free dynamic range of the receiver. This value is also called IFSS (Interference Free Signal Strength).

The IMD3 curve of the IC-705 is shown in **Fig. 5**. The first interference product at f1-2f2 and f2-2f1 appears at Pi = 2x-32dBm (S9+41dB). Then the intermodulation increases strongly at first, up to a level of -114dBm and decreases again when the level increases further. This "humpy" IMD3 behavior is typical for an ADC. At Pi = 2x-22dBm the IC-705 reaches its maximum distortion-free dynamic range of -131dBm - (-22dBm) = 109dB! But this value is only reached in one point, at the sweet spot! With further signal increase the ADC gets into its saturation.
Much more important is the level range from -30dBm to -20dBm. Here the ADC reaches its most unfavorable range, with intermodulation of up to 16dB above the receiver's background noise (MDS). But the resulting IMD3 is unproblematic because it is still far below the noise of the HF receiving antenna. As an example the rural- and urban noise at 14MHz are drawn as lines. As long as the IMD3 does not exceed these lines, there are no problems, because IMD3-products are not visible (audible).

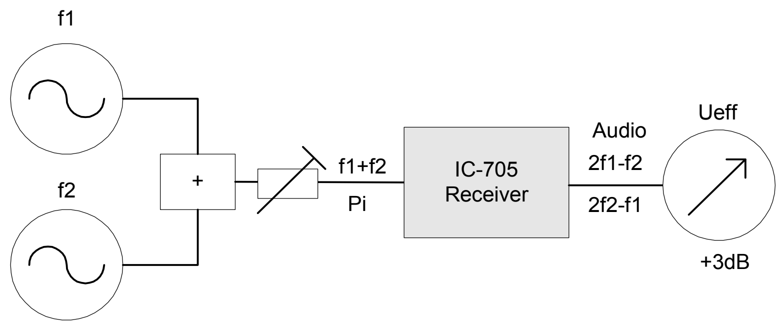


**Figure 4: Test setup for IND3 measurement**

***Settings IC-705: ATT off, P.AMP off, BW=500Hz, CW***

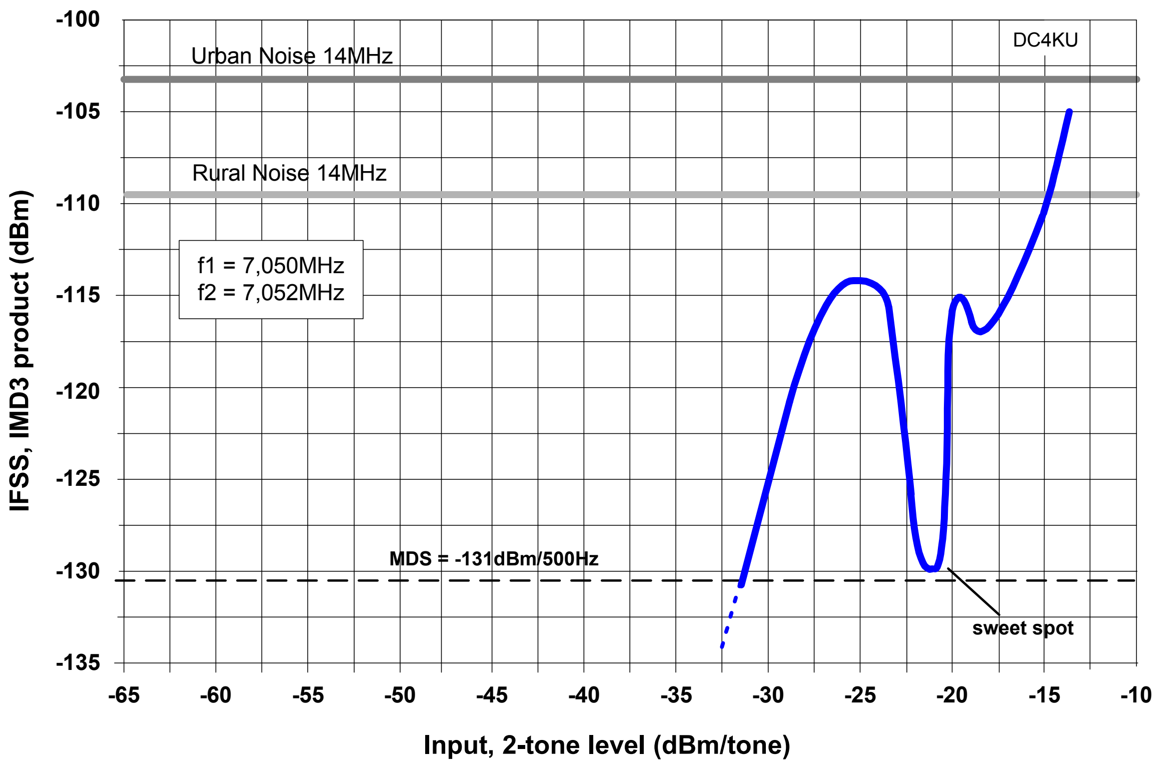


**Figure 5: IMD3 curve of the IC-705**

Note: For correct IMD3 measurement, the HF 2-tone generator used must itself have an IMD3 distance greater than 110dBc. If the 2-tone generator does not achieve this, the sweet spot could not be measured at a distance of 110dB.

Result: The intermodulation of the receiver is far below the Urban- or Rural- Noise (20m-Band) until shortly before its limitation and therefore does not appear disturbing.

## Noise Power Ratio (NPR)

During the NPR measurement, the receiver is loaded with a white noise signal over a defined bandwidth. A narrow-band notch filter completely suppresses the noise at one point so that the receiver no longer receives a noise signal at this point and operates with its normal sensitivity. During the NPR measurement, the noise signal is increased until a small signal increase above the background noise is also apparent in the base of the notch filter and a noise rise of 3dB is produced at the AF output. The ADC of the receiver is thus shortly before it's clipping. The difference between the input noise power (PTOT) and the sensitivity (MDS) then correspond to the Noise Power Ratio (NPR).

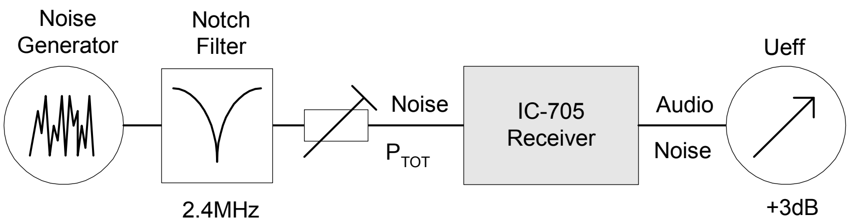


**Figure 6: NPR measurement setup**

With an injected noise level of -14dBm and a noise bandwidth of 0 to 4MHz the IC-705 is close to its limit, which is also indicated by a flickering OVF (overflow) message on the screen. With a sensitivity of -131dBm/500 Hz this results in a Noise Power Ratio of

**NPR = $P_{TOT}$ - 10lg noise bandwidth/resolution bandwidth (BW) - MDS**

**NPR = -14dBm - 10lg4MHz/500Hz - 131dBm = 78dB**

***Settings IC-705: ATT off, P.AMP off, BW=500Hz, CW***

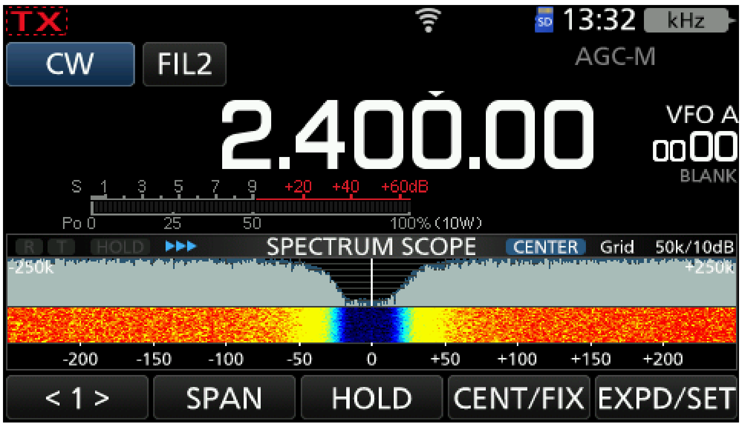


**Bild 7: NPR-Spektrum im Display des IC-705**

| Frequency | Notchfilter | Noise-Bandwidth | RB | MDS | $P_{TOT}$ | NPR |
|---|---|---|---|---|---|---|
| **2.4MHz** | 2.4MHz | 0-4MHz | 500Hz | -131dBm | -14dBm | **78dB** |
| **9MHz** | 9MHz | 0-10MHz | 500Hz | -130dBm | -11dBm | **76dB** |
| **21MHz** | * | 0-22MHz | 500Hz | -130dBm | -9dBm | **75dB** |
| **50MHz** | * | 0-55MHz | 500Hz | -127dBm | -5dBm | **72dB** |

**Table 3: NPR at different frequencies * NPR determination via the OVF indicator**

Result:
In the direction of higher frequencies the NPR becomes smaller, which is due to the wider HF BP filters. The BP filters do not produce any additional IM and the NPR is similarly good as the IC-7300.

# Transmitter

## RF output power

To determine the RF output power, a 1 kHz sinusoidal signal is applied to the microphone input and the RF output power (Pa) is measured via a 40 dB dummy load. For the measurements, the IC-705 was supplied by a 13.8V power supply.

***Settings IC-705: SSB 2.4kHz, RF Power 100%, supply 13.8VDC, Attenuation 40dB***

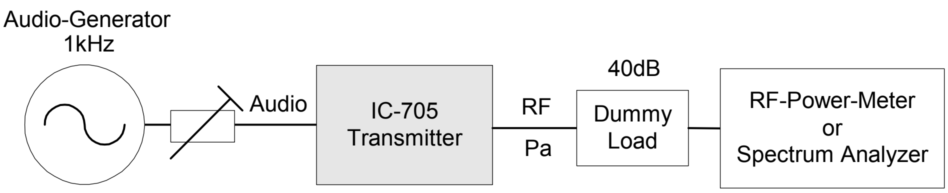


**Figure 8: Power measurement with a CW signal**

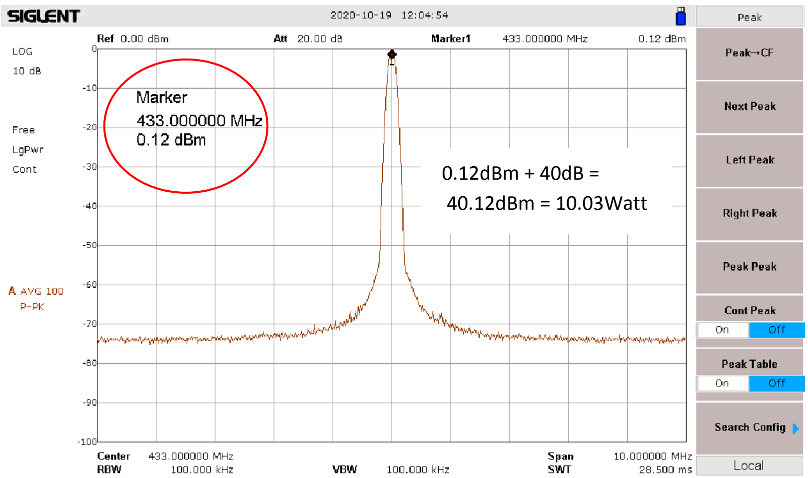


**Figure 9: Maximum RF output power of a CW signal at 433 MHz**

| Frequency | $P_{a\,max}$ |
|---|---|
| 3,6 MHz | 10,8 W |
| 14,1 MHz | 11,1 W |
| 21,2 MHz | 10,9 W |
| 50 MHz | 10,7 W |
| 145 MHz | 10,7 W |
| 433 MHz | 10,3 W |

**Table 4: Maximum RF output power of IC-705 at different frequencies (with ext. power supply)**

## Dynamic, Intermodulation

For measure the intermodulation of the RF output stage, connect the microphone input to a low-frequency 2-tone generator (f1=700Hz, f2=1500Hz) and adjust the microphone voltage so that the transmitter reaches its maximum PEP output power. Please note: Since the transmitter is driven with two equally sized, closely adjacent AF signals, a beat occurs where the signals add or cancel each other out **(Fig. 10)**.
At a PEP output power of 10W, the two sinus signals are therefore 6dB below the peak power of 10W (**Fig. 12**).

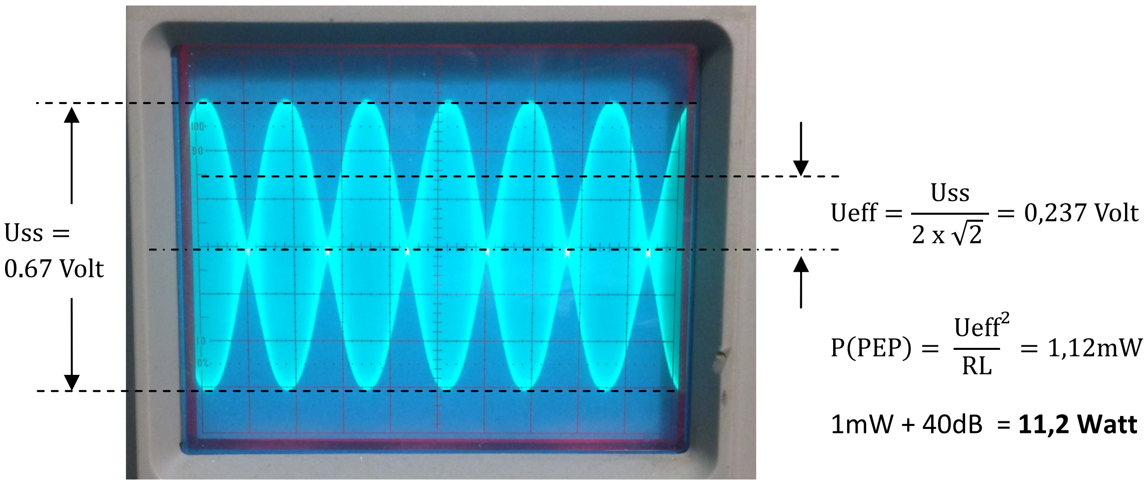


**Figure 10: Measurement of the power of a HF 2-tone signal in the time domain at 14.1MHz**

***Settings IC-705: Modulation with 2-tone signal at 700Hz +1500Hz, SSB, BW= 2.4kHz, RF power 100%, supply 13.8VDC, attenuation dummy load 40dB***

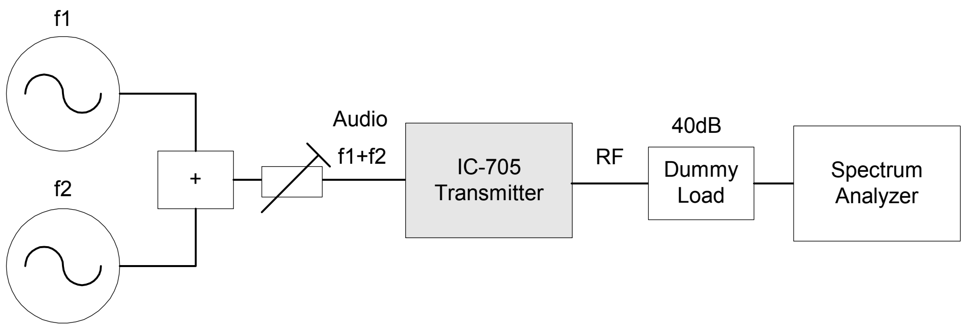


**Figure 11: Transmitter IMD**

| **Frequenz** | **3,6 MHz** | **14,1 MHz** | **50 MHz** | **145 MHz** | **435 MHz** |
|---|---|---|---|---|---|
| **PEP-Leistung** | 10,8Watt | 11,1Watt | 10,7Watt | 10,7Watt | 10,3Watt |
| **IMD3-Abstand** | **35dBc** | **36dBc** | **33dBc** | **30dBc** | **32dBc** |

**Table 5: IM3 measurement results**

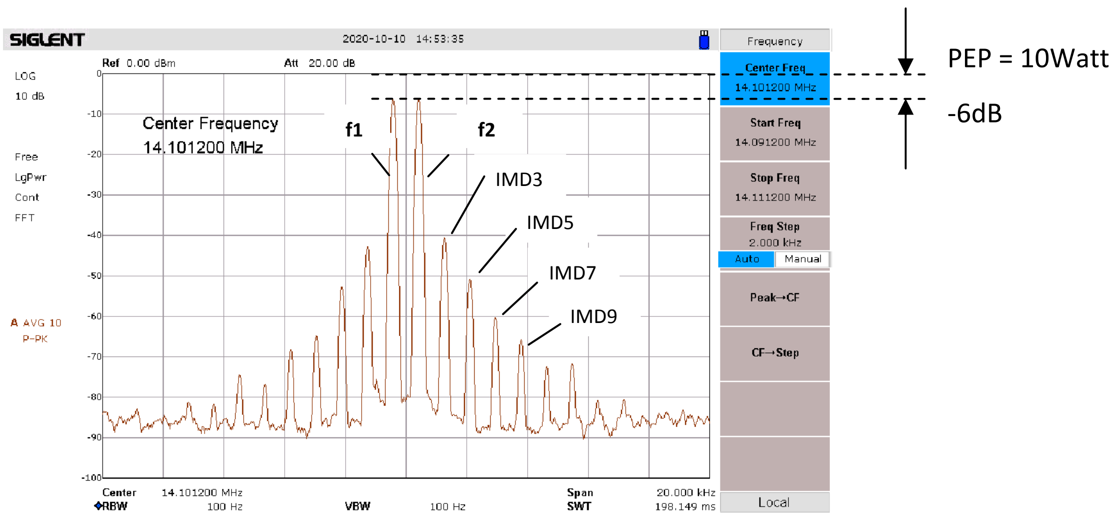


**Figure 12: 14.1MHz: IMD3=35dBc**

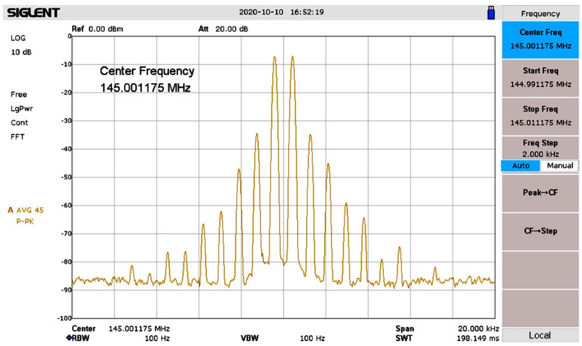


**Figure 13: 145MHz, IMD3=30dBc**

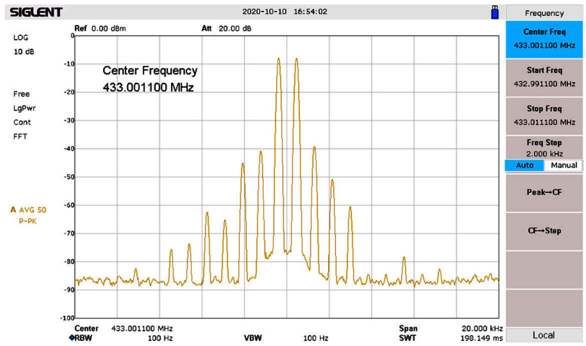


**Figure 14: 433MHz, IMD3=32dBc**

Result:
At full scale the IMD3 distortions are suppressed by >30dBc. The other IM products drop off quickly and adjacent channels are not disturbed.

## IC-705 Remote Control

### Settings on the IC-705

The IC-705 has a built-in server and a WLAN interface, which simplifies the connection to the RS-BA1 remote control software **(1)**. First, the IC-705 must be connected to the home WLAN router via WLAN. To do it go to Menu -> Set to WLAN and switch WLAN to ON. Then go to Connection Settings -> Access Pont and select the access point of the WLAN router. Enter the password of your router and the IC-705 will connect to the WLAN router. The DHCP address of the IC-705 appears in the display **(Fig. 15)**, write it down!

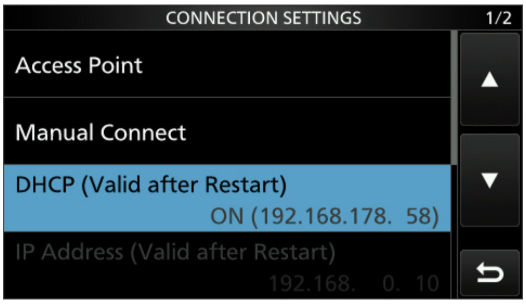


**Figure 15: DHCP address of the IC-705: 192.168.178.58**

Further settings on IC-705:
- WLAN Set -> Connect Settings -> DHCP: ON
- WLAN Set -> Network Name -> Network Name (e.g. DC4KU705)
- WLAN Set -> Remote Settings -> Network Control: ON
- WLAN Set -> Remote Settings -> Internet Access Line: FTTH
- WLAN Set -> Remote Settings -> Network USER1 -> Network User1 ID -> (e.g. user1), Network User1 Password (e.g. user0001)
- WLAN Set -> Remote Settings -> Network User 1 -> Network User 1 -> Administrator: YES

### Settings on the PC

After installing the software **RS-BA1 Ver2.20** on a PC or notebook (Windows 10), two icons appear on the screen. Via "Icom Remote Utility" the connection between IC-705 and PC is configured and "RS-BA1 Remote Control" is the actual operating software.


**Figure 16: RS-BA1 Remote Control and Icom Remote Utility**

Start *Icom Remote Utility* and select *Setup Wizard*. Four available options appear, select "Setup for a Remote PC (A radio with a Server function)" **(Figure 17)**. Then enter the *Network Name* (e.g. DC4KU705) and the *User ID* and *Password* -> e.g. user1 and e.g. user0001. After clicking *Next*, RS-BA1 will search the network for the server, which may take a few seconds and then reports *Add Completed*.

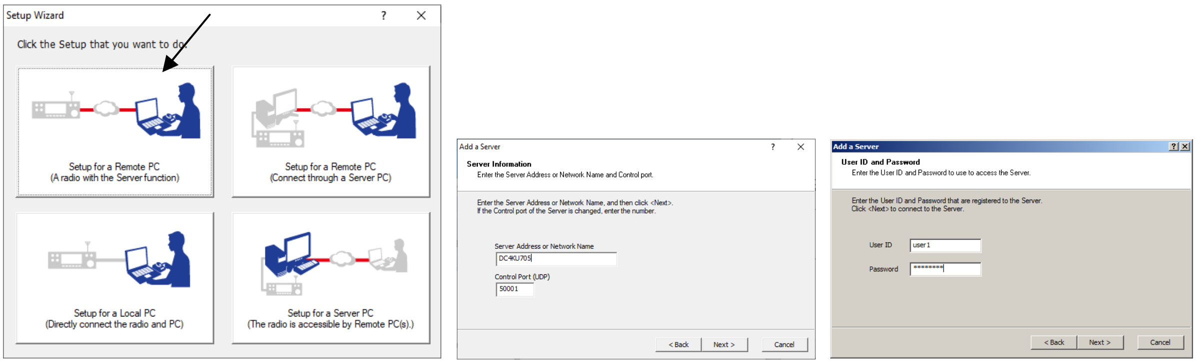


**Figure 17: Select Setup Wizard and fill in Server Address, User ID and Password**

After clicking on Finish, the Icom Remote Utility opens again and under Radio-List appears << Connected >> **(Fig. 18)**. In the loudspeaker of the PC is ready to hear a noise, so the audio connection works already!

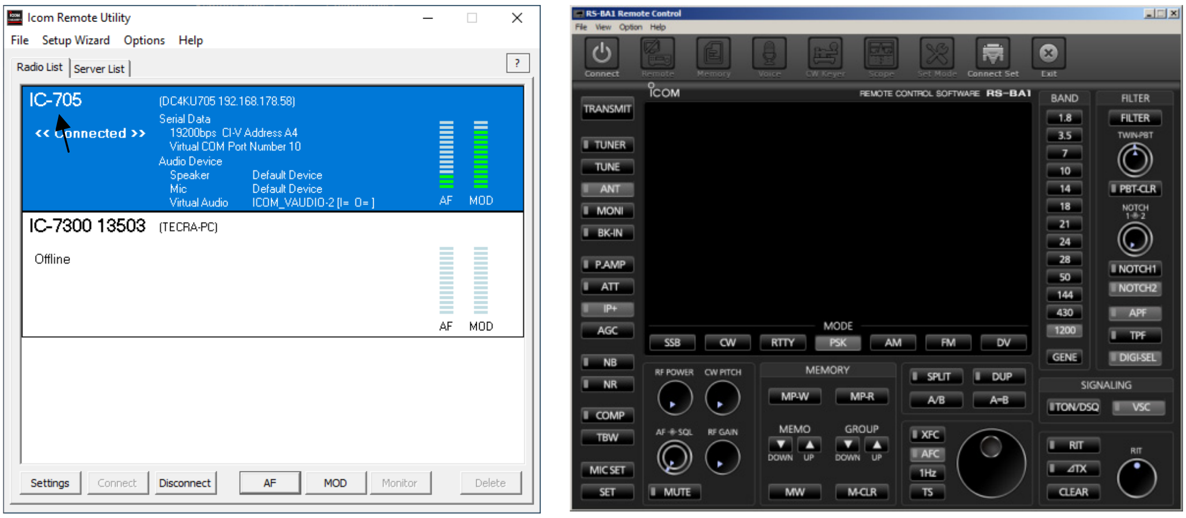


**Figure 18: IC-705 Radio-List (left) and RS-BA1 open (right)**

Then press "Connect" at RS-BA1 and the display of the IC-705 opens **(Fig. 19)**. The transceiver can now be adjusted on all frequencies and modes from the PC.


**Figure 19: RS-BA1 with IC-705 started on the PC**

## Connection to the Internet

For remote control via the Internet, it is only a small step. In the router, under Network (DC4KU705) -> Shares, the ports 50001 to 50003 must be forwarded **(Fig.20)** and the IP address is no longer the DHCP of the IC-705 (see Figure 15) but the "public IPv4 address" of the router. This address can be found in the router under Internet -> Online Monitor, in my case it is 91.36.146.84. Then open Icom Remote Utility -> Server List and enter the IPv4 address of the router under Address **(Fig. 21)**.

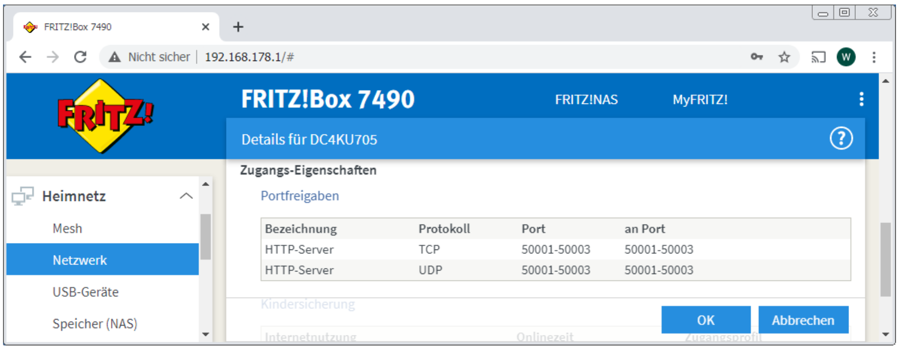


**Figure 20: Setting Port Forwarding in Router**

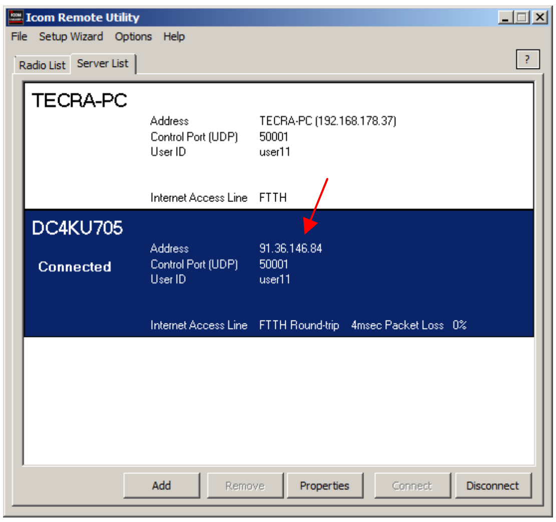


**Figure 21: Enter the "public IPv4 address" of the router into the IC-705 server**

After starting RS-BA Remote Control, the user interface of the IC-705 opens after a few seconds and the transceiver can be operated worldwide over the Internet. The transmission rate is 50...100kbits and with a fast internet connection the latency time is low.

I would like to thank "WiMo Antennen und Elektronik GmbH" for the loan of the IC-705.

Werner Schnorrenberg
DC4KU
19.10.2020, Rev. 28.10.2020, 08.11.2020

**Literatur**

(1) Installation der Icom-Fernsteuersoftware RS-BA1
DC4KU, FUNKAMATEUR 2/2020

(2) Vorstellung des Icom IC-705, WiMo 2000
Ekkehard Plicht, DF4OR
https://www.youtube.com/watch?v=8Hl62KcNR7c

(3) IC-705 Basis Betriebsanleitung, ICOM
https://www.icomeurope.com/wp-content/uploads/2020/08/IC-705_IM_GER_Basic_0_20200804.pdf

(4) IC-705 Advanced Manual (English), ICOM
https://www.icomjapan.com/support/manual/3063/

(5) RS-BA1 Version 2 Instruction Manual (English), ICOM
https://www.icomjapan.com/support/manual/3063/

(6) IC-705, Firmware Download auf Version 1.12
https://www.icomjapan.com/support/firmware_driver/3119/

(7) RS-BA1 Version 2, update auf Version 2.20
https://www.icomjapan.com/support/firmware_driver/3059/