# Why small QRP radio?

**Ultimate in portability**. Grab and go! Laptop, USB cable, radio and telescoping antenna. That's it. Instant Winlink kit. It is a fun little (expensive) radio.

Icom IC-705 is rated 10 watts output and features HF, VHF, UHF. Direct sampling (conversion of signal to digital) of RF up to 25 MHz. Data mode includes built-in "soundcard" interface for digital modes. Built-in GPS, D-Star digital voice, bluetooth and wifi. Snap-on battery. BNC connector; can even use walkie-talkie antenna. Spectrum display adjustable up to +/- 250 kilohertz.

Efficient on battery; takes about 200 milliamps on receive whereas Icom IC-7300 takes about one amp on receive.

# Other QRP radios

Lab599 "Discovery TX500". Russian made HF SDR. Extremely robust with bomb-proof, foolproof and waterproof connectors. The lowest power consumption of any of them; 100 milliamps on receive.

Elecraft KX2 and KX3: The market leaders of HF QRP radios. Perfect for CW operations where you backpack the radio. No built-in panadapter (spectrum display) or digital modes. Receive current 150-190 milliamps.

Xiegu G90: Chinese made HF SDR. Considerably less expensive. You can buy three of these for the price of IC-705. 20 watts transmit. Rated 500 milliamps on receive. Includes built-in tuner.

# About SDR

**Software defined radio** is poorly defined. It basically means that some part of the radio (or all of it) is performed by mathematical computation in a chip rather than by tuned circuits and filters. Enormous variation exists in how "fine" is the sampling and computation to detect small signals in the presence of strong signals as well as how much of the radio spectrum is actually processed digitally, the "window" of spectrum, versus how much is processed conventionally by conventional superheterodyne techniques.

These factors largely explain why one SDR costs ten times another.

**ADC: Analog to Digital Converter.**

All signals eventually arrive at the ADC. Because of the **Nyquist Theorem**, It must sample the signal voltage at least twice the frequency of the highest frequency it sees. This is its **sample rate** and usually stated in terms of **megasamples per second**.

The other factor is **sample size** how many bits per sample? 8 bits (poor) 14 bits (excellent). This governs the dynamic range; how sensitive is the radio to a weak signal in the presence nearby strong signals.

https://qrpblog.com/2019/09/icom-ic-705-considerations-on-rx-power-draw-wild-guesses-ahead/

Intermediate Frequencies and Bandwidth

For the 2 meter and 70 cm bands, ICOM IC-705 uses conventional heterodyne (mixer) techniques to shift this band into the frequency range where the ADC can sample (digitize) it.

Once shifted it is then processed by the ADC and Floating Point Gate Array (FPGA) same as HF signals.

# IC-705:  Where is the antenna tuner?

There isn't one, not built-in anyway. There's so much stuff packed in this radio they leave it up to you whether you want or need a tuner.

When you have only 10 watts, you want a well-tuned antenna, a resonant antenna.  If the antenna is not resonant and you use a tuner, you lose power in the tuner, and in the feedline.

The IC-7300 has a built-in tuner, but it is not designed to accommodate antennas with over 3:1 SWR.  I rarely use the IC-7300 built-in tuner.

External tuners have a much greater ability to deal with random wire antennas.

# Comparing IC-7300 to IC-705 Distance

FT8 Test using IC-705 at **10 watts**, then IC-7300 at **40 watts**.

Each doubling of power is 3db.
Consequently, 6db or 1 "S" Unit between radios.

Essentially identical coverage revealed by **PSK Reporter**

IC-705 great for CW, digital modes.  Less impressive on SSB.
Good also for local 2 meter and 70 cm communications; Winlink.

# Comparing IC-7300 to IC-705

Power Supply variation to Real Power Output:

**IC-705**: Driver stage regulated at 5 volts. Final stage straight off the battery. Battery voltage variation affects only the final stage and turns out to be nearly linear (18% increase in voltage, 20% increase in power out)

**IC-7300**: Driver stage **and** final stage use battery voltage. This makes it exceptionally dependent on battery voltage. At 12.3 volts battery, 27 percent dial, measured **4 watts**. Boost to 13.8 volts, now measuring **16 watts**. A 1.5 volt boost quadrupled the power!

# Comparing IC-7300 to IC-705

Final Amplifier Stage:

**IC-705**: Single MOSFET, Class A amplifier feeds toroid transformer then through bandpass filters to antenna. Basically, it is the IC-7300 driver stage.

**IC-7300**: Dual MOSFETS, Class B, push-pull, then bandpass filters, optionally a tuner, to antenna.

# Benefit of digital audio interface

Traditional digital modes involve a computer then a Terminal Node Controller (TNC) to format data and then convert data to **analog audio frequencies** which are fed to the **microphone** input of a radio.

Consequently, it gets converted, mixed, attenuated, amplified, shaped, pre-emphasized, compressed, mixed again.

It's a wonder that it works at all.  Often it doesn't.

**Software Defined Radio skips the analog audio completely!**

A computer generates and formats data, a "software TNC" converts formatted data into a stream of bytes sent over USB (universal serial bus) to the radio. This data is then simply multiplied (modulates) the stream of data representing the carrier frequency. No mixing, compressing, pre-emphasizing, amplifying or attenuating.

In theory it could even be much wider in bandwidth than 3 KHz since no actual audio filtering exists.

# SDR enables high complexity signals

The FCC regulates **symbol rate** but not symbol complexity.

Morse code is simple on-off, data rate is less than symbol (dit) rate.

Packet Radio uses two tones, Frequency Shift Keying, bit rate is the same as symbol rate and uses the entire audio bandwidth for a single data stream.

PSK31 is narrow bandwidth but still bit rate is same as symbol rate.

Olivia (a digital mode) can use 16 tones, one at a time, but 1-out-of-16 reveals 4 bits of data. Consequently the data rate is four times the symbol rate, which can be very slow and thus noise resistant.

# SDR enables high complexity signals

Vara FM uses up to 58 audio carriers that collectively occupy a single voice channel bandwidth.  Each of these audio carriers are modulated by a thing called OFDM (Orthogonal frequency-division multiplexing).

https://en.wikipedia.org/wiki/Orthogonal_frequency-division_multiplexing

"Channel equalization is simplified because OFDM may be viewed as using many slowly modulated narrowband signals rather than one rapidly modulated wideband signal. "

# Excess audio or RF drive

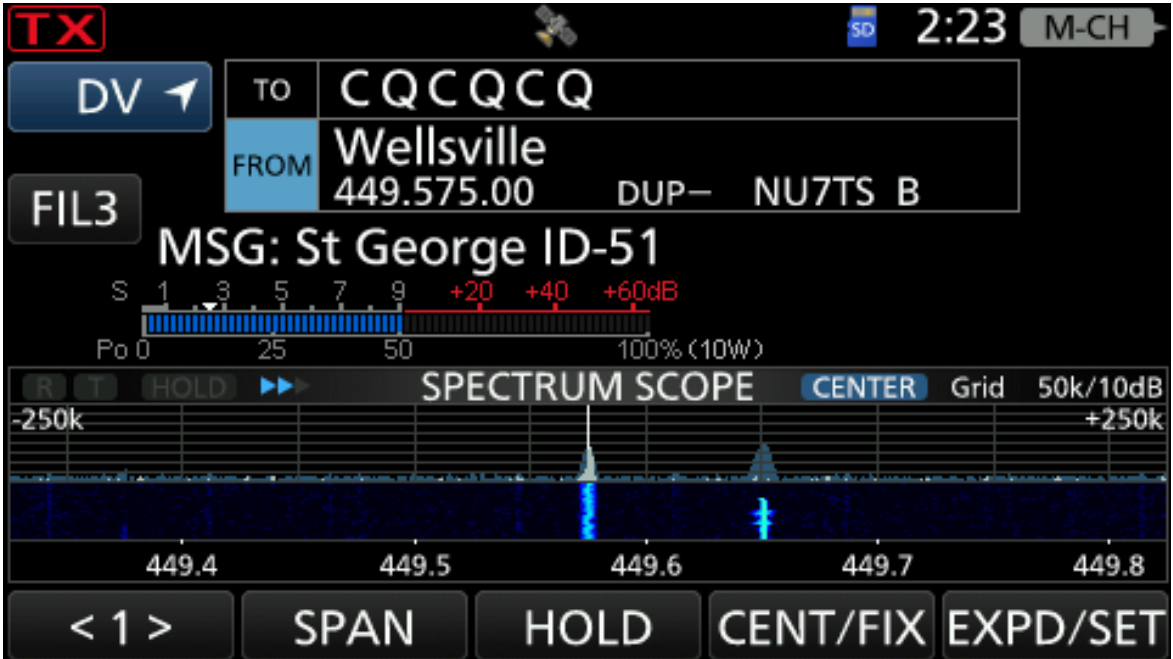
If your audio "clips" because of excess audio drive level, it will create harmonics and cause digital modes to fail.

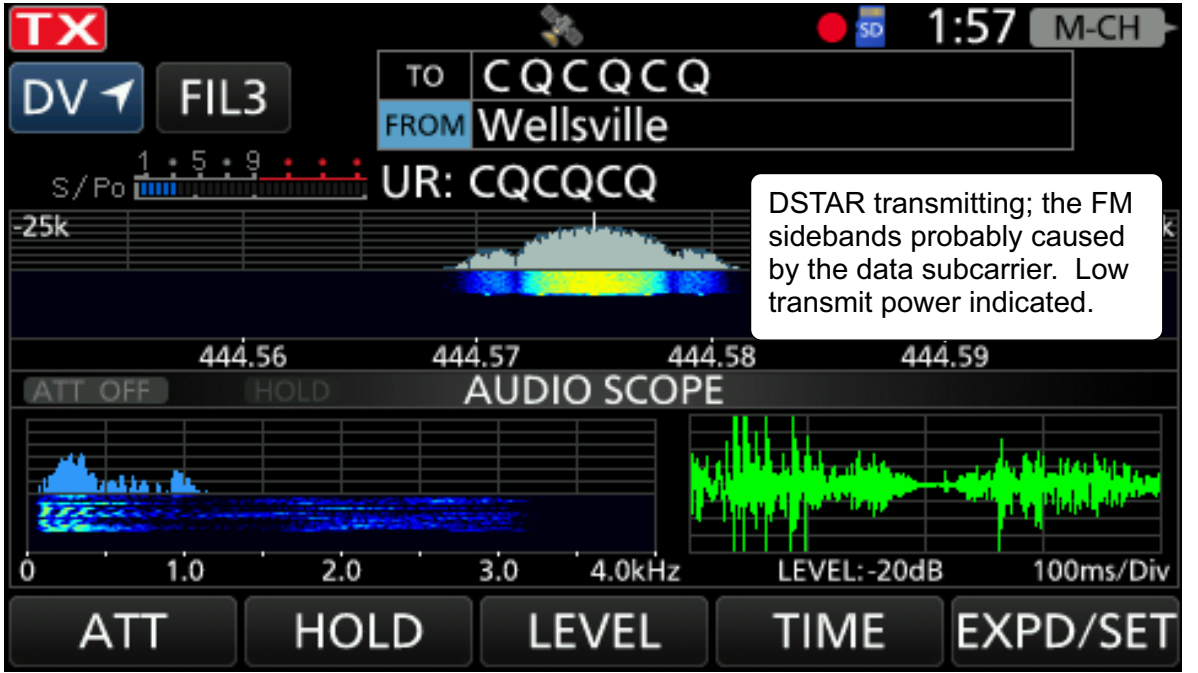
FM: Using another radio, listen to your own signal and increase audio drive until it is not louder but also starts to distort, then back off about 20 percent.

SSB: Increase audio drive until the ALC starts to activate and leave it there.

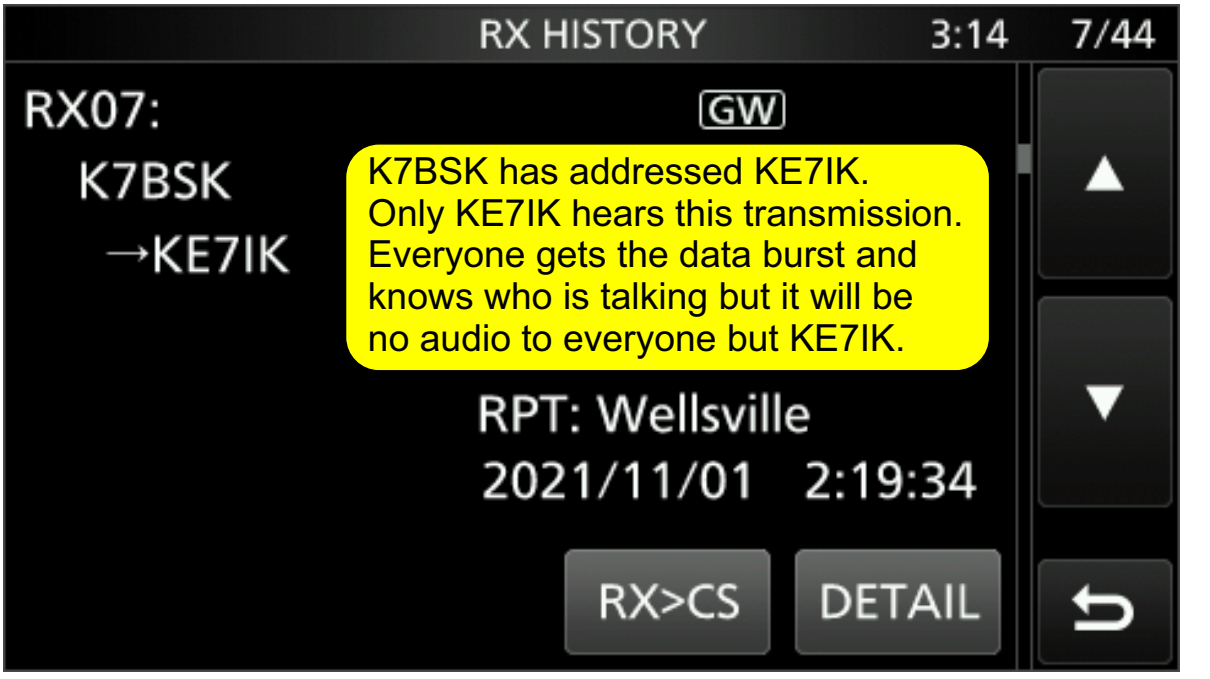
A good discussion on audio drive levels:
https://www.febo.com/packet/layer-one/transmit.html

# IC-705 Screenshots

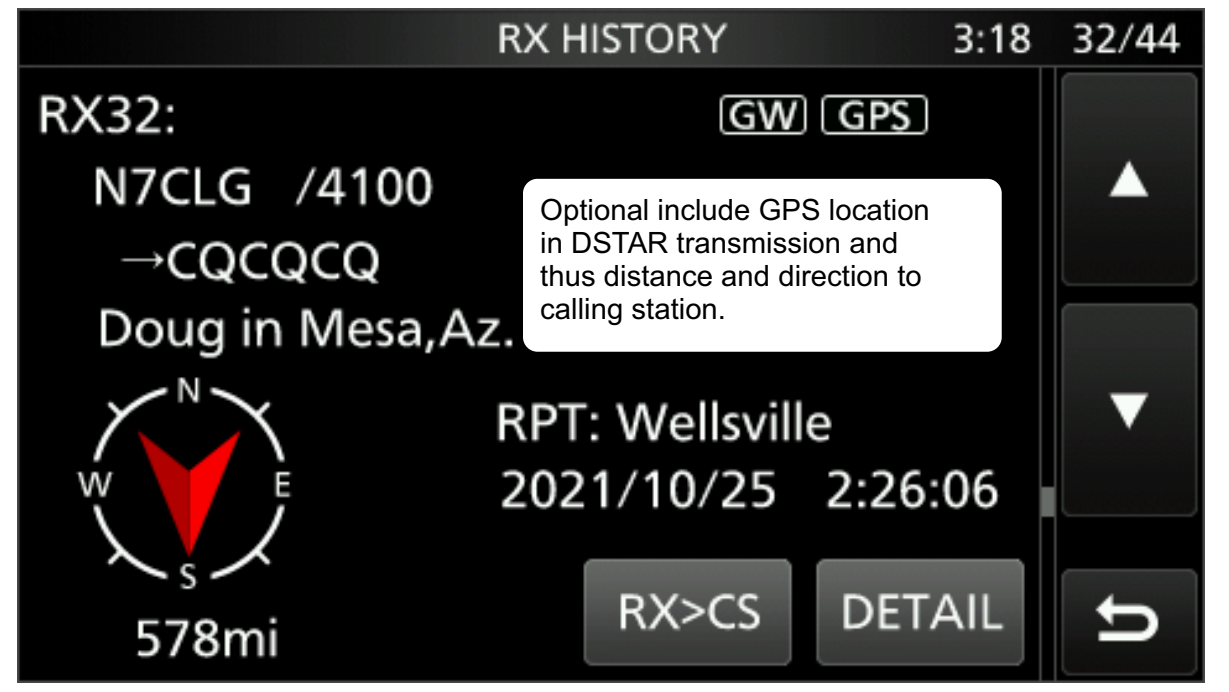

TX
SD
2:23
M-CH
DV
TO
CQCQCQ
FROM
Wellsville
449.575.00
DUP–
NU7TS B
FIL3
MSG: St George ID-51
S 1 3 5 7 9 +20 +40 +60dB
Po 0 25 50 100% (10W)
R T HOLD
SPECTRUM SCOPE
CENTER
Grid
50k/10dB
-250k
+250k
449.4
449.5
449.6
449.7
449.8
< 1 >
SPAN
HOLD
CENT/FIX
EXPD/SET

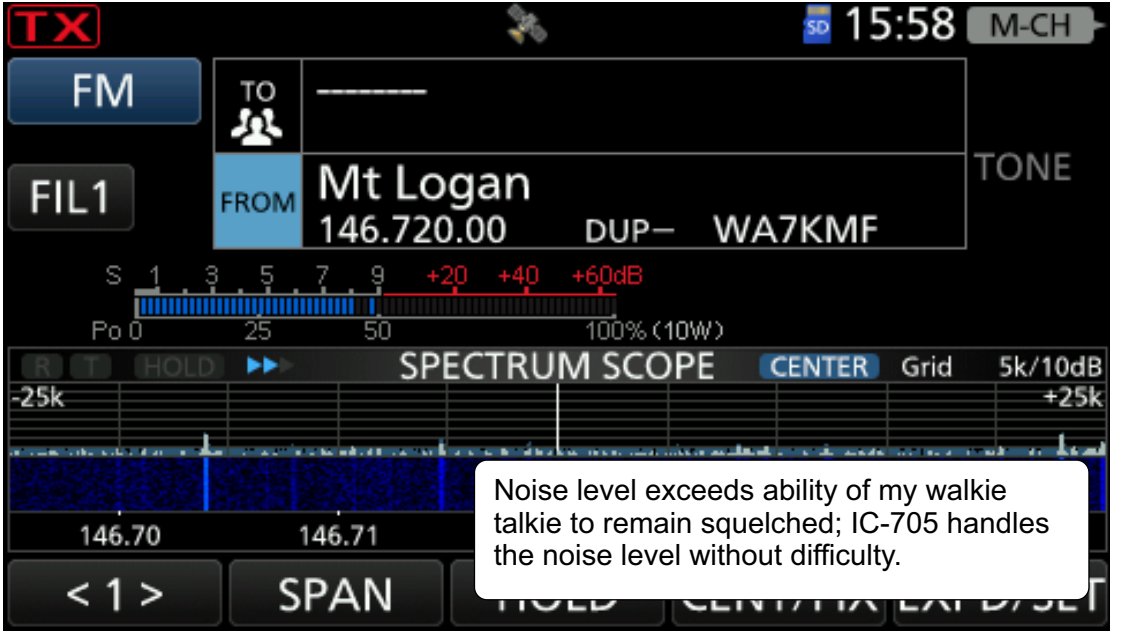


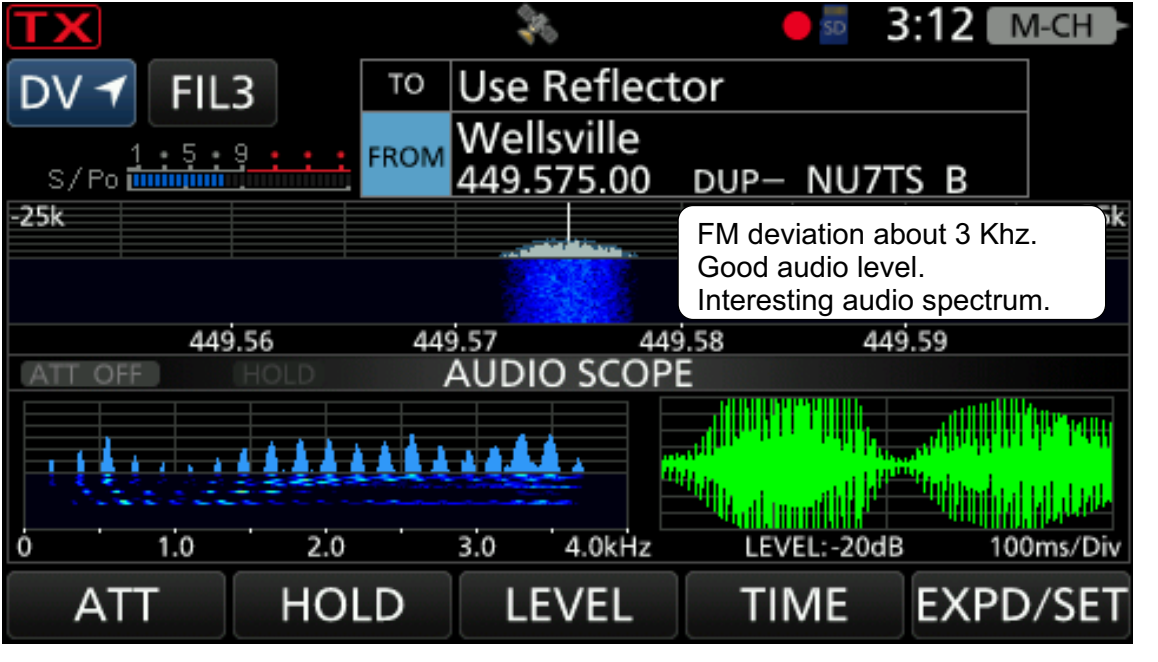

DSTAR transmitting; the FM sidebands probably caused by the data subcarrier. Low transmit power indicated.

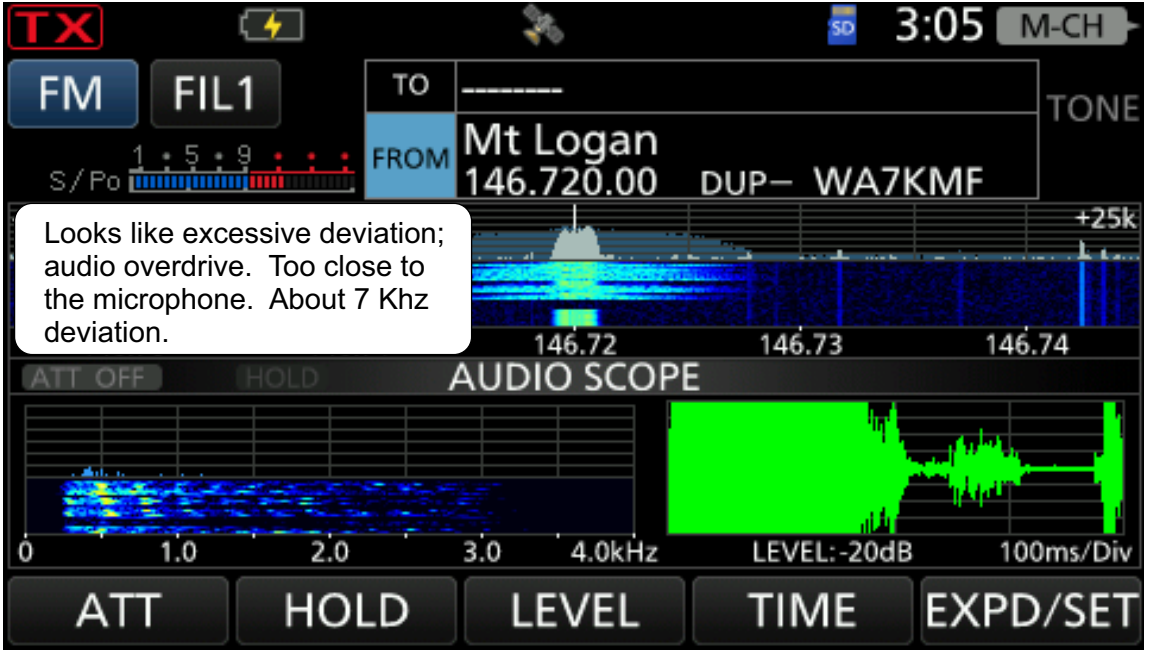

RX HISTORY
3:14
7/44
RX07:
GW
K7BSK
→KE7IK
K7BSK has addressed KE7IK.
Only KE7IK hears this transmission.
Everyone gets the data burst and
knows who is talking but it will be
no audio to everyone but KE7IK.
RPT: Wellsville
2021/11/01 2:19:34
RX>CS
DETAIL


RX HISTORY
3:17
18/44
RX18:
GW
GPS
W7ROI /705
→CQCQCQ
Tim-West Jordan UT
W7ROI has addressed to CQ so everyone can hear it.
N
W
E
S
RPT: Wellsville
2021/11/01 2:07:42
79.3mi
RX>CS
DETAIL


RX HISTORY
3:18
32/44
RX32:
GW
GPS
N7CLG /4100
→CQCQCQ
Doug in Mesa,Az.
Optional include GPS location in DSTAR transmission and thus distance and direction to calling station.
N
W
E
S
RPT: Wellsville
2021/10/25 2:26:06
578mi
RX>CS
DETAIL


TX
15:58
M-CH
FM
TO
FIL1
FROM
Mt Logan
146.720.00
DUP–
WA7KMF
TONE
S 1 3 5 7 9 +20 +40 +60dB
Po 0 25 50 100% (10W)
R T HOLD
SPECTRUM SCOPE
CENTER
Grid
5k/10dB
-25k
+25k
146.70
146.71
Noise level exceeds ability of my walkie talkie to remain squelched; IC-705 handles the noise level without difficulty.
< 1 >
SPAN


TX
3:12
M-CH
DV
FIL3
TO
Use Reflector
FROM
Wellsville
449.575.00
DUP– NU7TS B
S/Po
1 • 5 • 9
-25k
FM deviation about 3 Khz.
Good audio level.
Interesting audio spectrum.
449.56
449.57
449.58
449.59
ATT OFF
HOLD
AUDIO SCOPE
0
1.0
2.0
3.0
4.0kHz
LEVEL:-20dB
100ms/Div
ATT
HOLD
LEVEL
TIME
EXPD/SET


TX
3:05
M-CH
FM
FIL1
TO
FROM
Mt Logan
146.720.00
DUP– WA7KMF
TONE
S/Po
1 5 9
Looks like excessive deviation; audio overdrive. Too close to the microphone. About 7 Khz deviation.
+25k
146.72
146.73
146.74
ATT OFF
HOLD
AUDIO SCOPE
0
1.0
2.0
3.0
4.0kHz
LEVEL:-20dB
100ms/Div
ATT
HOLD
LEVEL
TIME
EXPD/SET