Encoding Test for various APRS implementations:

Comparison of readability between systems on a Kenwood D710GA

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Version 0.3, Dec. 20, 2021

Executive Summary:

During the testing of a variety of two-way radios, including the Kenwood D72A, Kenwood D710A and several Dire Wolf based Terminal Node Controller (TNC) deployments using a group of non-TNC transceivers all at 1200 baud, it was shown that:

- The Kenwood D710 can decode D72A/D710A packet signals down to nearly the lowest receive level capabilities of the D710A/G (1 bar on the Kenwood S meter).
- Testing indicates that a variety of other Transceivers using the Dire Wolf software TNC and an AllStar sound card (in this case a DINAH interface) and leveraging the 6 pin mini-din interface, are also decoded successfully by the D710G at levels at or somewhat below 1 bar on the Kenwood S meter.

When combined with the decoding tests performed by John Langner WB2OSZ, this testing indicates that a software TNC approach using the Dire Wolf software, 6 pin mini-din interface and a DINAH AllStar sound card is as good or better at encoding and decoding APRS packets when compared with the Kenwood TM-D710A/TH-D72A, and such designs would be suitable for use during the Appalachian Trail Golden Packet event.

Introduction:

A variety of APRS devices are being developed to augment the traditional Kenwood TM-D710A/G radios typically used during the ATGP event. John Langner WB2OSZ has performed a series of excellent studies on decoding of APRS packets by comparison with the Kenwood D710A/G:

- https://github.com/wb2osz/direwolf/blob/master/doc/WA8LMF-TNC-Test-CD-Results.pdf
- https://github.com/wb2osz/direwolf/blob/master/doc/User-Guide.pdf
- A Better APRS Packet Demodulator, part 1, 1200 baud
- A Better APRS Packet Demodulator, part 2, 9600 baud

John's analysis shows that the Dire Wolf software TNC is able to decode packets which the D710A/G fails to decode. In short Dire Wolf decoding capability is typically as good as or, more correctly, better than the packet decoding capability of the D710.

This leaves open the question of whether the Dire Wolf software TNC approach can encode packets to the same quality as packets encoded by the D710. The information and testing details in this report compare the encoding capabilities of the Kenwood D72A, Kenwood D710A, and several different transceivers using an AllStar sound interface (based on the DINAH product) and the Dire Wolf software TNC.

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Test objective/procedure:

The objective is to ensure that Dire Wolf software TNC implementations using an AllStar sound interface can encode APRS packets with as good quality as the Kenwood D710A. The reference system for decoding the packets in this test is a Kenwood D710GA. The methodology is to compare the lowest signal level at which the D710GA can decode packets encoding by a variety of systems. Any system encoding packets which can be read at the same signal level as those encoded with the test D710A will be considered to encode packets of equal to or better quality than a Kenwood D710A.

To perform these measurements, we must control:

- Near field effects: we need to ensure that signals are received only through the antenna
- The strength of the signal entering the transceiver: we need to be able to reduce the signal until the D710G no longer decodes the packets in the received signal.

There are perhaps three options to provide these controls:

- One can perform the test in a single location using faraday cages to eliminate the near field effects and attenuators to adjust the signal strength.
- One can use multiple locations at varying distance from the test station and move from location to location to control the signal strength.

or one can, as was done in these tests, pursue a hybrid:

- Choose a remote location to eliminate the near field effects, and partially attenuate signal and provide additional attenuation using a step attenuator, in this case an MFJ-762 step attenuator.
    - https://mfjenterprises.com/products/mfj-762
    - Tested to be approximately linear at 145 MHz through about 30 dB. At higher attenuation, bleed through reduces attenuation by perhaps 10 dB at full scale.

Specific test procedure:

- Kenwood TM-D710GA at AB1PH home QTH used as reference test system.
- Lightly used local digital frequency of 145.070 MHz was used for test.
- Location of rigs was Adam's farm, about 2.9 miles from the home QTH on a path with no topographic obstructions.

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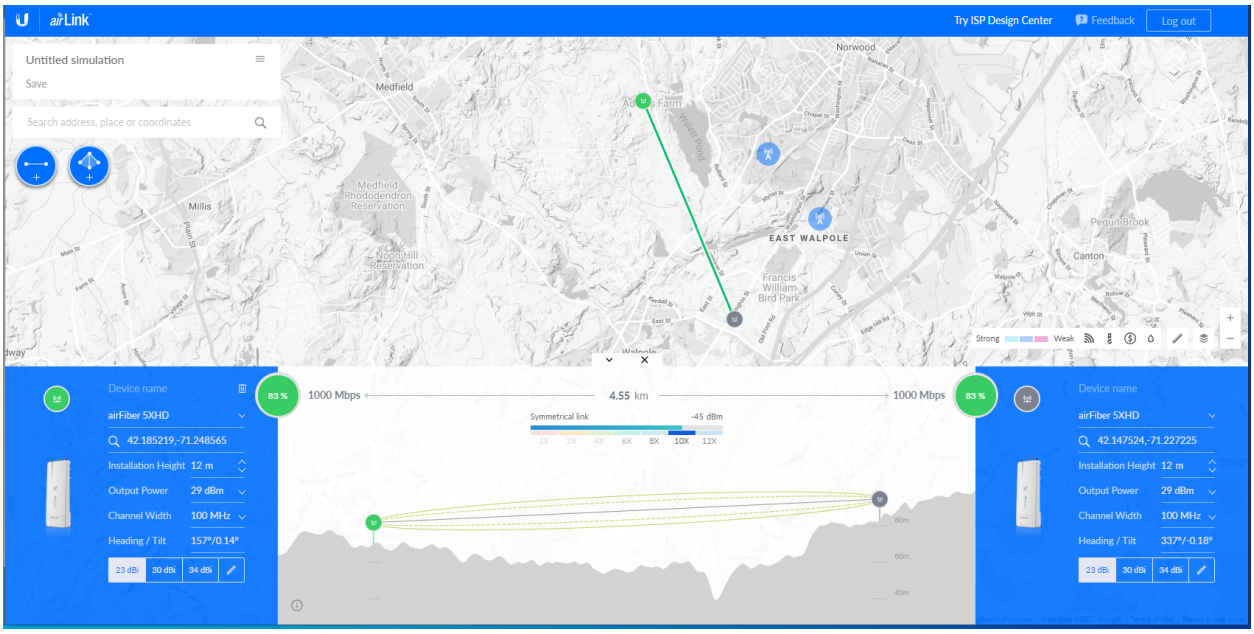

Fig. 1: link analysis of test path

A list of rigs tested is given below:

Transceiver	TNC	Notes
Kenwood TH-D72A	Internal TNC	
Kenwood TM-D710A	Internal TNC	
Yeasu FT817ND	Dire Wolf/DINAH TNC	ATGP Mark 2 appliance
Kenwood TM-V71A	Dire Wolf/DINAH TNC	ATGP Mark 2 appliance
ICOM IC-208	Dire Wolf/DINAH TNC	ATGP Mark 2 appliance
Alinco D135T MKiii	Dire Wolf/DINAH TNC	ATGP Mark 2 appliance

Table 1: list of rigs tested

The ATGP Mark 2 appliance is described at:

- https://github.com/APRSFoundation/aprsappliance/config/allstar-based-build/appalachian-trail-golden-packet-aprs-appliance-20211014-v.2.pdf

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The ATGP Mark2 Appliance consists of:

- PI Zero 2W (for this system).
- MakerSpot 4-Port Stackable USB Hub HAT for Raspberry Pi Zero V1.3 (with Camera Connector) and Pi Zero W /2W (with Bluetooth & WiFi)
    - https://www.amazon.com/gp/product/B01IT1TLFQ/
- USB WIFI FOB for second WIFI connection.
- USB Puck – GPS.
- Standard DINAH version of the AllStar interface.
    - https://hamprojects.info/dinah/
- Configuration specific case.

Running:

- Raspian Buster (still debugging an issue with gpsd and BullsEye).
    - https://drive.google.com/file/d/12wrsro36rXmHPEV3nN5AIed0L-8qv3so/view?usp=sharing
- Dire Wolf 1.7 (dev).

This device is connected to all the non-D710/D72 rigs using the 6-pin mini-din interface or, for the Alinco Dr-135T, the comparable DB-9 interface.

The rigs were run at about 5 watts nominal output to a mag-mount 5/8 vertical antenna with an SWR of about 1.02:1.

The test process was:

- The D710GA at the home QTH was placed in packet12 mode with its output connected through AGWPE to the AGWmon packet monitoring software.
- Rigs at Adam's Farm were brought on line.
- The D710-/D72 were placed in packet12 mode with their ports connected to a laptop running Winlink Express.
- Systems using the ATGP APRS appliance Mark 2 were connected to Dire Wolf from the laptop running Winlink Express using TCP/IP KISS over port 8001.
- 5 connection attempts (the default number from Winlink Express) were sent at each level of attenuation.
- The number of bars on the Kenwood D710GA were recorded.
- The AGWMon screen was reviewed to confirm packet decode (or decode failure).
- Attenuation was increased (attenuations documented in appendix - raw results) until D710GA no longer decoded packets.

Note that as designed, this is a test of 1200 baud performance.

Comments on Kenwood S-meter:

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The Kenwood S meter is not calibrated among units, so the results of testing must be considered comparative. A nominal listing of S meter behavior was received as part of a request in a mailing list request. It is provided below, but it has not been validated.

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Email from J. D. Barron jeter.d.barron@gmail.com via group.io to main, Nov. 18, 2021, 2:01 PM:

"1 bar means a weaker signal and all bars means a lot of signals.
I don't think that the correlation to a relative S meter reading is particularly meaningful, especially as it makes little difference if the signal is strong enough for full quieting.
Full Scale 144 MHZ –96dBm (3.54µV)
Full Scale 440 MHZ –96dBm (3.54µV)
Min Scale 144 MHZ –118dBm (0.28µV)
Min Scale 440 MHZ –118dBm (0.28µV)
Other bands may vary
As far as S meters and calibration I never thought much about it myself."

The Kenwood TM-710GA is rated on receive at:

Sensitivity (VHF/UHF)	Less than -16dBµ (0.16µv)

- https://www.kenwood.com/usa/com/amateur/tm-d710ga/spec.html

so minimum scale on the S meter is above the minimum sensitivity of the receiver, and signals below this presumably can still be detected (confirmed by our tests).

Sound levels in the Raspian Buster image for the ATGP APRS appliance:

During early discussions regarding the development of the ATGP appliance, concern was expressed that we would need to adjust sound levels for each radio, and this would be an excessive training load on the community. The 6-pin mini-din connector was adopted among other reasons because, in principle, it standardizes the sound levels. For the default Raspian image supporting the appliance:

- https://drive.google.com/file/d/12wrsro36rXmHPEV3nN5AIed0L-8qv3so/view?usp=sharing

standard sound levels have been established as shown in the below figures from the alsamixer -c 1 command.

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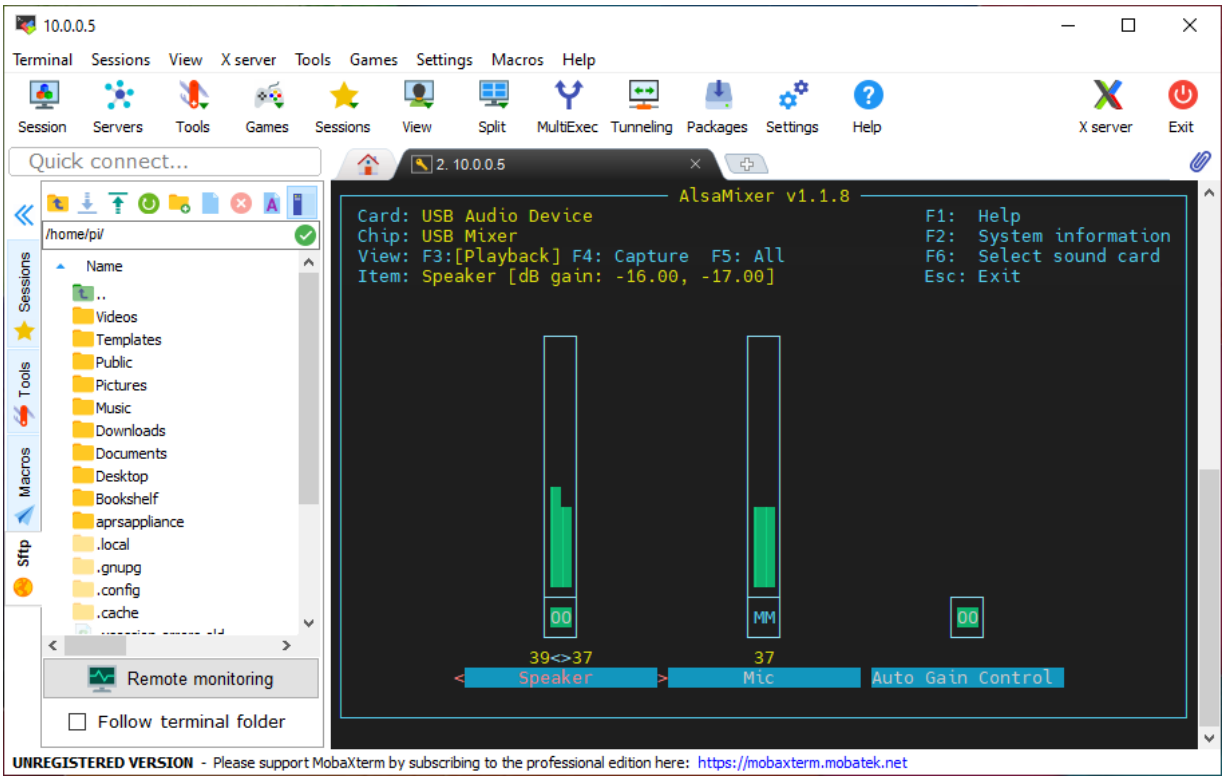

Figure 2: alsamixer -c 1 command output Playback/microphone

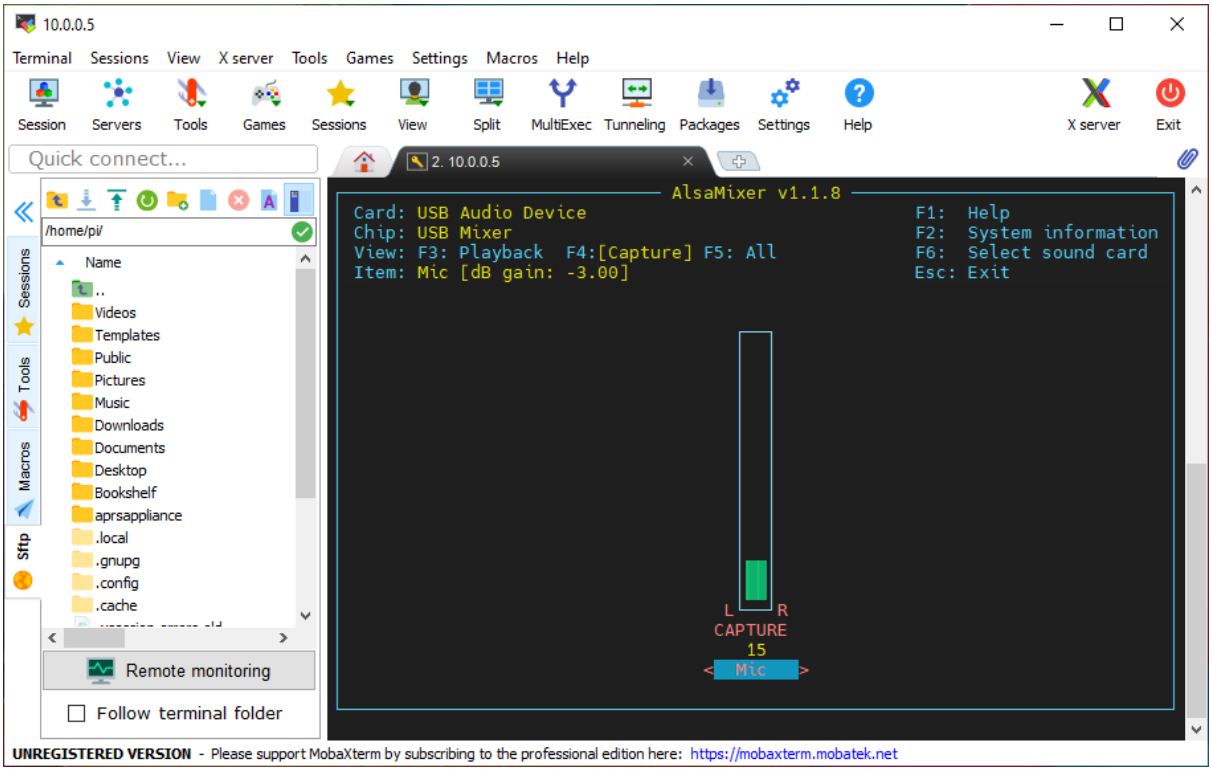

Figure 3: alsamixer -c 1 command: capture levels

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Based on our testing, the speaker level controls the audio supplied to the transmitter and has been set to 39<>37. The received signal is controlled by the capture level and has been set at 15.

These levels were used without change for testing of all rigs. This appears to confirm the hypothesis that using the 6-pin mini-din interface allows us to use standard levels for 1200 baud; it is anticipated users will not be changing sound setting in the standard image for 1200 baud when connected through the 6-pin mini-din interface.

Levels, in particular transmit levels, will need to be different for 9600 baud.

Results/Conclusions:

The results from the test are shown below:

Transceiver	Minimum bars for decoding	Notes
Kenwood TH-D72A	1 bar	
Kenwood TM-710A	1 bar	
Yeasu FT817ND	1 bar solid	3 out of 5 requests decoded < 1bar
Kenwood TM-V71A	Busy < 1 bar	
ICIM IC-208	Busy < 1 bar	
Alinco DR-135T MKiii	1 bar solid	4 out of 5 requests decoded < 1 bar

Table 2: Results of Test

Based on these results, the testing suggest that all systems using ATGP APRS Mark 2 appliance were as good as or possibly better than the Kenwood TM-D710A or Kenwood TH-D72A in the quality of transmitted packet. Based on this testing we would expect that an ATGP site using an ATGP APRS Mark2 appliance connected to a transceiver using a 6-pin mini-din, with the standard alsmamixer settings would perform on transmit as well as or better than a Kenwood TM-D710A.

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Appendix – Raw Data:

RX Attenuation	RX Signal (bars on D710GA)	Decode	Notes
0 dB	6 bars	Y	
10 dB	3 bars	Y	
13 dB	2 bars	Y	
16 dB	1 bar	Y	
20 dB	1 bar	Y	
23 dB	Busy, no bars	N	

Table 3: Kenwood TH-D72A performance

RX Attenuation	RX Signal (bars on D710GA)	Decode	Notes
0 dB	6 bars	Y	
10 dB	3 bars	Y	
13 dB	3 bars	Y	
16 dB	1 bar	Y	
20 dB	1 bar	Y	
23 dB	Busy, no bars	N	

Table 4: Kenwood TM-D710A performance

RX Attenuation	RX Signal (bars on D710GA)	Decode	Notes
0 dB	5 bars	Y	
10 dB	1 bar	Y	
13 dB	1 bar	Y	
16 dB	Busy, no bars	3 out of 5 decoded	
20 dB	Busy, no bars	N	
23 dB	Busy, no bars	N	

Table 5: Yaesu FT-817ND performance

RX Attenuation	RX Signal (bars on D710GA)	Decode	Notes
0 dB	6 bars	Y	
10 dB	4 bars	Y	
13 dB	3 bars	Y	
16 dB	2 bar	Y	
20 dB	1 bar	Y	
23 dB	Busy, no bars	Y	
24 dB	Busy, no bars	N	
25 dB	Busy, no bars	N	

Table 6: Kenwood TM-V71A

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Appendix – Raw Data:

RX Attenuation	RX Signal (bars on D710GA)	Decode	Notes
0 dB	6-7 bars	Y	
10 dB	3-4 bars	Y	
13 dB	2-3 bars	Y	
16 dB	1-2 bar	Y	
20 dB	1 bar	Y	
23 dB	Busy, no bars	Y	
24 dB	Busy, no bars	Y	
25 dB	Busy, no bars	Y	
26 dB	Busy, no bars	3 out of 5 decoded	
27 dB	Busy, no bars	N	

Table 7: ICOM IC-208

RX Attenuation	RX Signal (bars on D710GA)	Decode	Notes
0 dB	6 bars	Y	
10 dB	2-3 bars	Y	
13 dB	2 bars	Y	
16 dB	1 bar	Y	
20 dB	Busy, no bars	4/5 first run;5/5 second run	
23 dB	Busy, no bars	N	

Table 8: Alinco DR-135T MKiii performance