# FreeDV+ Performance vs. Ionospheric Propagation

Simulations using PathSim by AE4JY

by Rick Peterson, WA6NUT

May 2019

# **Table of Contents**

1.	Introduction	3	
2.	Test Setup	3	
3.	Test Results	4	
4.	Conclusions	5	
5.	More Screenshots	5	
6.	References	6	
Appendix 1: Screenshots 1-49			
Appendix 2: Screenshots 5-1514			

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# 1. INTRODUCTION

FreeDV plus Video is a new amateur radio soundcard mode combining digital voice (FreeDV) and video (ZL2AFP's FFT-TV) on HF. The performance of FreeDV with propagation (using PathSim) has been documented by Tony Bombardiere, K2MO, in one of his excellent videos (see "FreeDV HF Path Tests" – his videos are posted to his "Sandydiesel" channel on YouTube).

The author (WA6NUT), seeing Tony's work, felt that a modest PathSim study should be made for FreeDV plus Video. Users of FreeDV plus Video know that this mode requires careful frequency tuning for the received video signal -- this might indicate particular sensitivity to Doppler frequency spread effects as the HF signal propagates.

# 2. TEST SETUP

The test setup is shown in Figure 1 (p. 8). Three laptop PC's were used. The first laptop generated the composite digital voice (FreeDV) and video (FFT-TV) signal, applying this signal to the PathSim input at the second laptop. The video consisted of the Microsoft test video WNDSURF1.AVI played in a continuous loop. After processing by PathSim (simulating the effects of the selected standard propagation), the PathSim output signal was applied to the third laptop. This laptop used the FreeDV and FFT-TV receiving software to provide voice and video display. One of the video

subcarriers is highlighted in yellow on the bottom WinWarbler waterfall. The frequency of the highlighted subcarrier is displayed on the WinWarbler AFC readout (about 2.100 kHz). The FreeDV SNR reading on each screenshot provides an indication of received voice quality. Screenshots were taken of the laptop screen for each standard PathSim propagation mode selected (shown in Appendix 1 and 2, pp. 9 and 14).

# 3. TEST RESULTS

The objective of this study was to determine the sensitivity of FreeDV plus Video to differential time delay and Doppler frequency spread. The four standard propagation modes in Appendix 1 were selected for this study. Screenshots 1 and 4 (see Appendix 1, p. 9) have low values of time delay and Doppler spread, so one would expect only minor effects to be noticed in the received FreeDV and FFT-TV video. Examination of Screenshot 1 (p. 10) and Screenshot 4 (p. 13) verifies this. However, the anomalies in Screenshot 4 show that the higher Doppler spread value (= 1.5 Hz) may exceed the maximum value for acceptable video. Screenshot 1 (FreeDV plus Video) can be compared with K2MO's video "Test #1", 1400 mode (FreeDV only, no video).

Screenshot 2 has a low time delay value and a high Doppler spread value, so one would expect poor performance if FreeDV plus Video is sensitive to Doppler spread. Examination of Screenshot 2 (p. 11) shows the video image obscured by noise, and that the Doppler spread value (= 10 Hz) far exceeds the value for acceptable video. Screenshot 2 (FreeDV plus Video) can be compared with K2MO's video "Test #2", 1400 mode (FreeDV only, no video).

Screenshot 3 has a high time delay value and a low Doppler spread value, so one would expect poor performance if FreeDV plus Video is sensitive to time delay. Examination of Screenshot 3 (p. 12) shows only minor artifacts in the received video image, and that FreeDV plus Video is not particularly sensitive to differential time delay.

Comparison of Screenshots 1, 3 and 4 shows that the video component handles Doppler spread up to 1 Hz with acceptable image quality. Screenshot 3 (FreeDV plus Video) can be compared with K2MO's video "Test #4", 1400 mode (FreeDV only, no video).

# 4. CONCLUSIONS

FreeDV plus Video shows sensitivity to Doppler frequency spread, with the ability to tolerate Doppler frequency spread up to about 1 Hz (only five of the PathSim simulations have Doppler frequency spread values exceeding 1 Hz). The mode shows good tolerance to differential time delay values up to (and perhaps beyond) 7 mS (none of the PathSim simulations have time delay values exceeding 7 mS).

High-latitude (over-the-pole) paths are especially difficult for the video component of FreeDV plus Video, making contacts between the central U.S. and Europe almost impossible.

It may be helpful to remember that the FFT-TV image is a sideways waterfall, with frequency along the vertical axis and time along the horizontal axis. Brightness and color are affected by frequency modulation (or phase change) in the received subcarriers. A new "waterfall" (image) is generated every second. This may explain some of the unusual propagation-caused artifacts in some of the received images (the High Latitude Quiet screenshot, for example). It may be possible to show correspondence between propagationcaused features in the FreeDV waterfall and artifacts in the received video image.

# 5. MORE SCREENSHOTS

Screenshots were taken for almost all the remaining PathSim standard propagation simulations. See Appendix 2, p. 14.

6. **REFERENCES** 

PathSim by Moe Wheatley, AE4JY

https://www.moetronix.com/ae4jy/pathsim.htm

Use of High Frequency Ionospheric Channel Simulators (CCIR 520-2)

http://www.itu.int/dms\_pubrec/itu-r/rec/f/R-REC-F.520-2-199203-W!!PDF-E.pdf

Testing of HF Modems with Bandwidths of Up to About 12 kHz Using Ionospheric Channel Simulators (ITU-R F.1487)

http://www.itu.int/dms\_pubrec/itu-r/rec/f/R-REC-F.1487-0-200005-I!!PDF-E.pdf

Jacobs, G., Cohen, T., Rose, R., "The New Shortwave Propagation Handbook", CQ Communications, 1995, Section 7.12, pp. 7-25 to 7-26

Blaunstein, N. and Plohotniuc, E., "Ionospheric and Applied Aspects of Radio Communication and Radar", CRC Press, 2008, pp. 136-138

http://www.books.google.com/books?isbn=1420055178

K2MO's FreeDV video, "FreeDV HF Path Tests"

https://www.qsl.net/wa6nut/FreeDV HF Path Tests - K2MO.mp4

FreeDV website

https://freedv.org

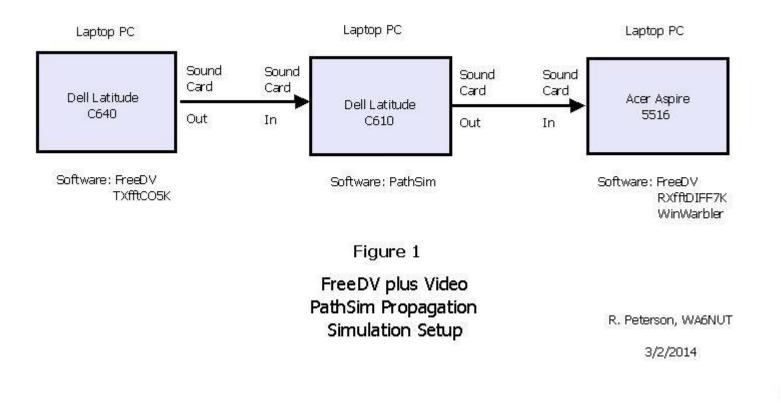
FreeDV plus Video website

https://www.qsl.net/wa6nut/FreeDVplusVideo

Microsoft VFW Test Video, WNDSURF1.AVI (part of AVISAMPLE.EXE)

http://cd.textfiles.com/10000soundssongs/AVI/

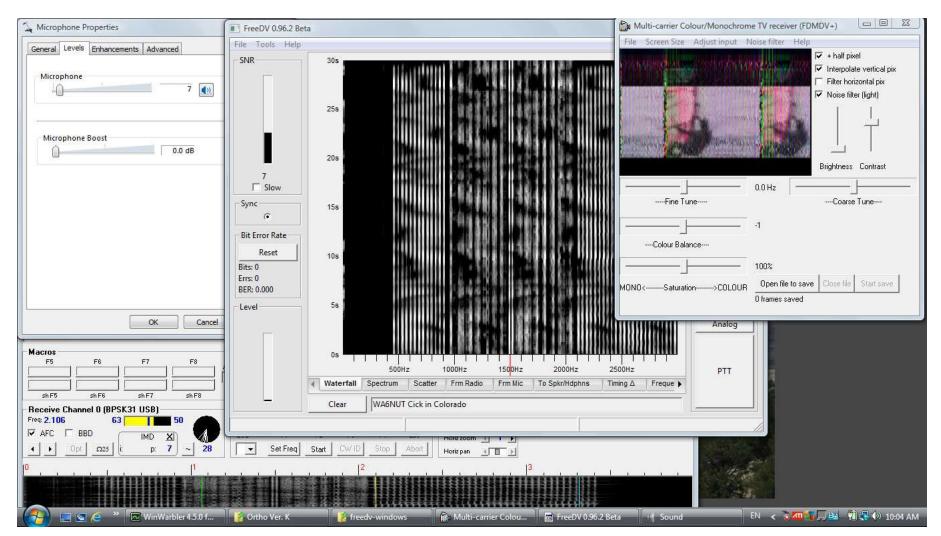
LAST REVISED: This document last revised 3/6/14. Format changes 5/4/19



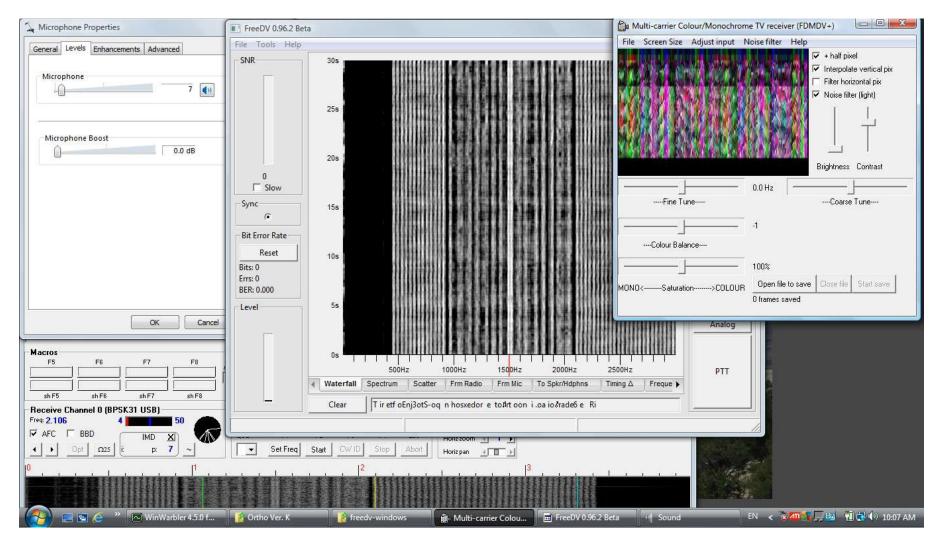
# **Receiver Screenshots with PathSim Standard Simulations**

# Appendix 1

Screenshot	Page	Simulation	Diff. Time Delay (mS)	2 Sigma Doppler Spread (Hz)
1	10	CCIR 520-2 Poor	2.0	1.0
		K2MO FreeDV video Test #1		
2	11	High Latitude Moderate	3	10
		K2MO FreeDV video Test #2		
3	12	Mid Latitude Disturbed NVIS	7	1
		K2MO FreeDV video Test #4		
4	13	Low Latitude Moderate	2	1.5



Screenshot 1: CCIR 520-2 Poor

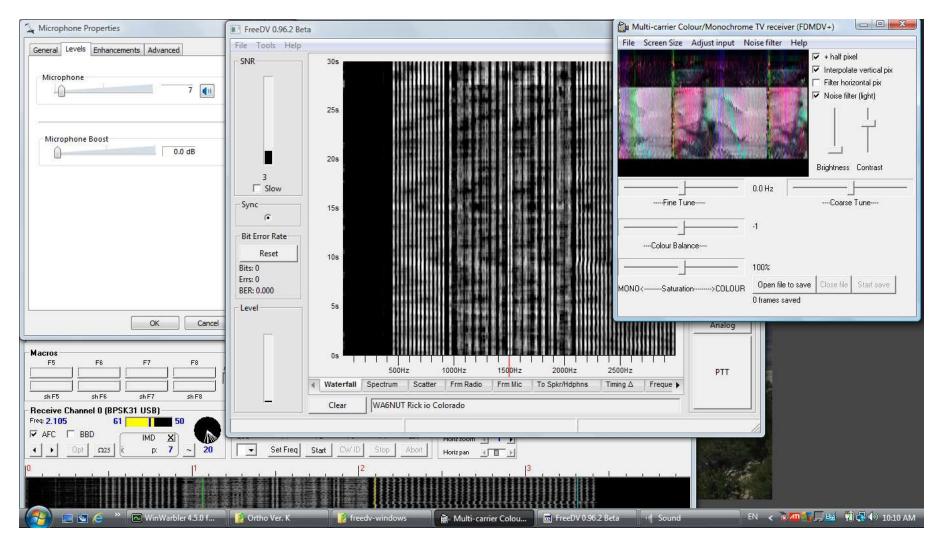


Screenshot 2: High Latitude Moderate

#### Multi-carrier Colour/Monochrome TV receiver (FDMDV+) A Microphone Properties FreeDV 0.96.2 Beta File Screen Size Adjust input Noise filter Help File Tools Help General Levels Enhancements Advanced + half pixel SNR 30s ✓ Interpolate vertical pix Microphone Filter horizontal pix 7 -0 ✓ Noise filter (light) 25s Microphone Boost Û-0.0 dB 20s Brightness Contrast 6 ☐ Slow 0.0 Hz ----Fine Tune------Coarse Tune----Sync 15s 6 -1 Bit Error Rate ----Colour Balance--Reset 10s 100% Bits: 0 Errs: 0 Open file to save Close file Start save >COLOUR MONO<---BER: 0.000 --Saturation O frames saved 5s Level OK Cancel Analog Macros 0s F5 F6 F8 500Hz 1000Hz 1500Hz 2000Hz 2500Hz PTT Waterfall Spectrum Scatter Frm Radio Frm Mic To Spkr/Hdphns Timing $\Delta$ Freque ) sh F5 sh F6 shF7 sh F8 Clear WeNUTo Receive Channel 0 (BPSK31 USB) Freq: 2.105 27 50 AFC BBD IMD X . . . Set Freq 4 Ω25 p: 7 • Start Horiz pan 📄 EN < 🕉 🏧 🐴 💭 👪 📲 📢 🖓 10:15 AM N (2 WinWarbler 4.5.0 f... Multi-carrier Colou 👼 FreeDV 0.96.2 Beta Ortho Ver. K freedy-windows

# **FreeDV+ Ionospheric Propagation**

Screenshot 3: Mid Latitude Disturbed



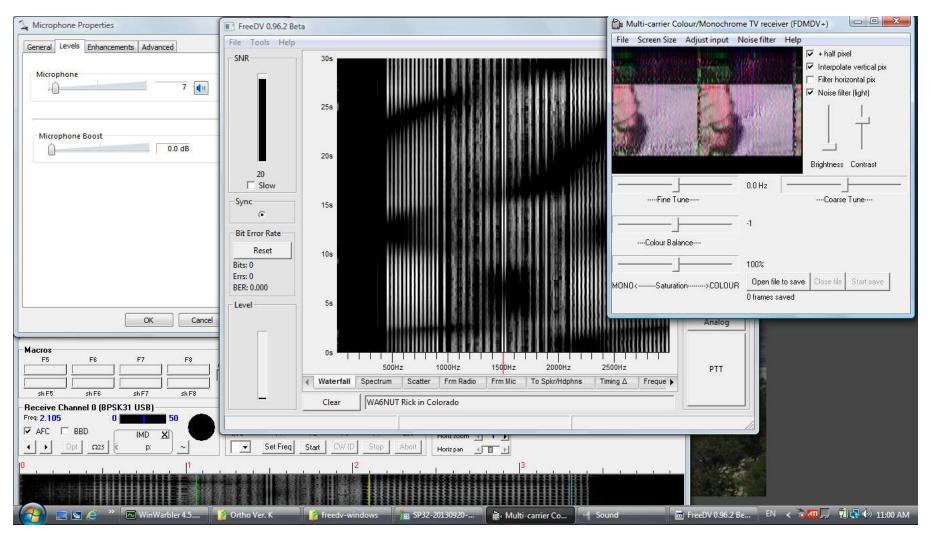
Screenshot 4: Low Latitude Moderate

# **Receiver Screenshots with PathSim Standard Simulations**

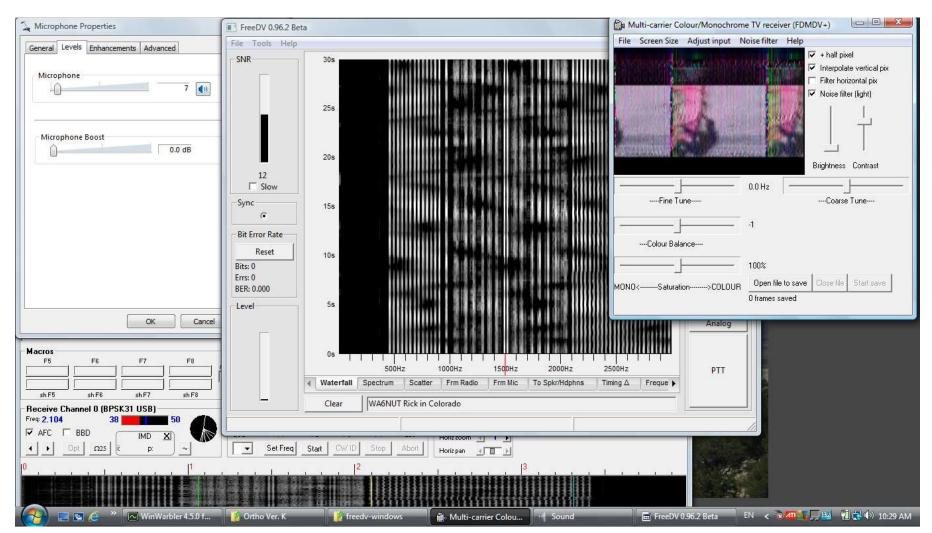
# Appendix 2

Screenshot	Page	Simulation	Diff. Time Delay (mS)	2 Sigma Doppler Spread (Hz)
5	16	CCIR 520-2 Good	0.5	0.1
6	17	CCIR 520-2 Moderate	1.0	0.5
		CCIR 520-2 Poor (see Appendix 1)		
7	18	Doppler Fading		
8	19	Flutter Fading	0.5	10.0
9	20	High Latitude Disturbed	7	30
		High Latitude Moderate (see Appendix 1)		
10	21	High Latitude Quiet	1	0.5
11	22	Low Latitude Disturbed	6	10
		Low Latitude Moderate (see Appendix 1)		
12	23	Low Latitude Quiet	0.5	0.5

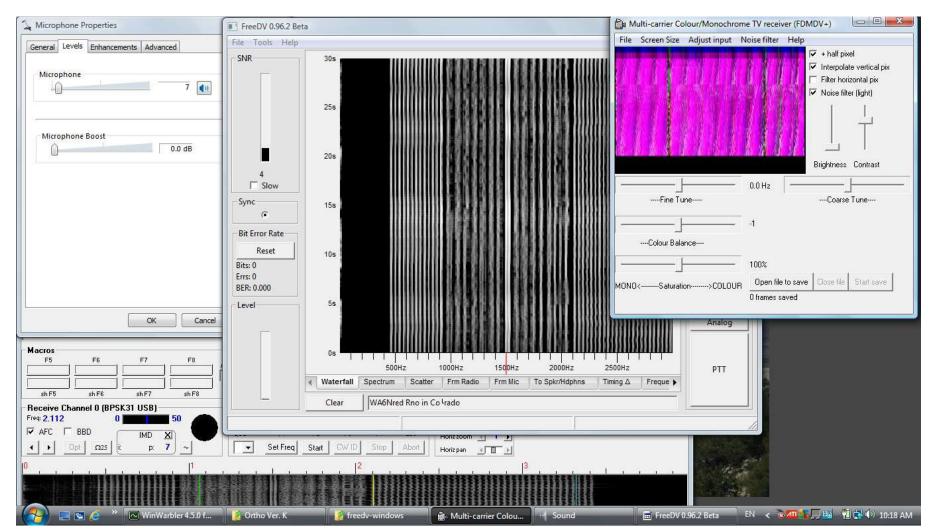
Screenshot	Page	Simulation	Diff. Time Delay (mS)	2 Sigma Doppler Spread (Hz)
13	24	Mid Latitude Disturbed	2	1
		Mid Latitude Disturbed NVIS (see Appendix 1)		
14	25	Mid Latitude Moderate	1	0.5
15	26	Mid Latitude Quiet	0.5	0.1



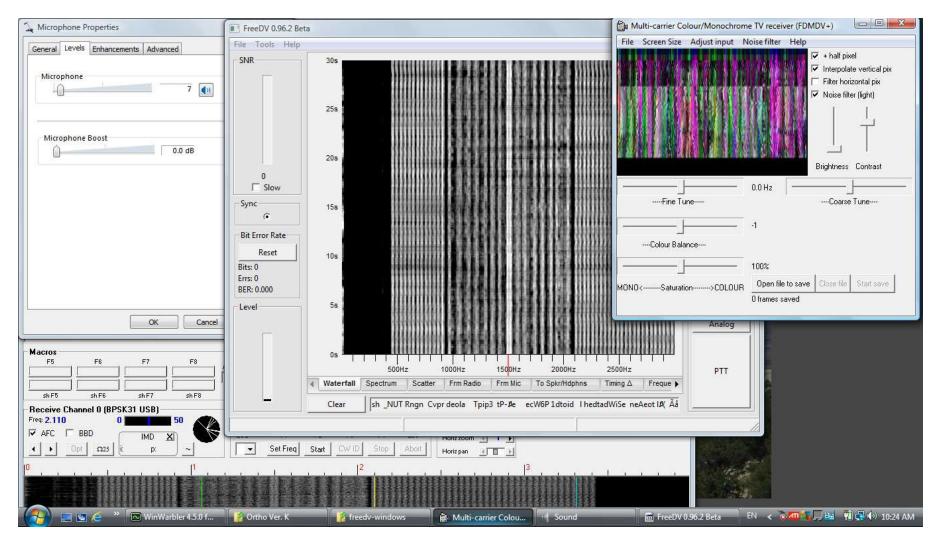
Screenshot 5: CCIR 520-2 Good



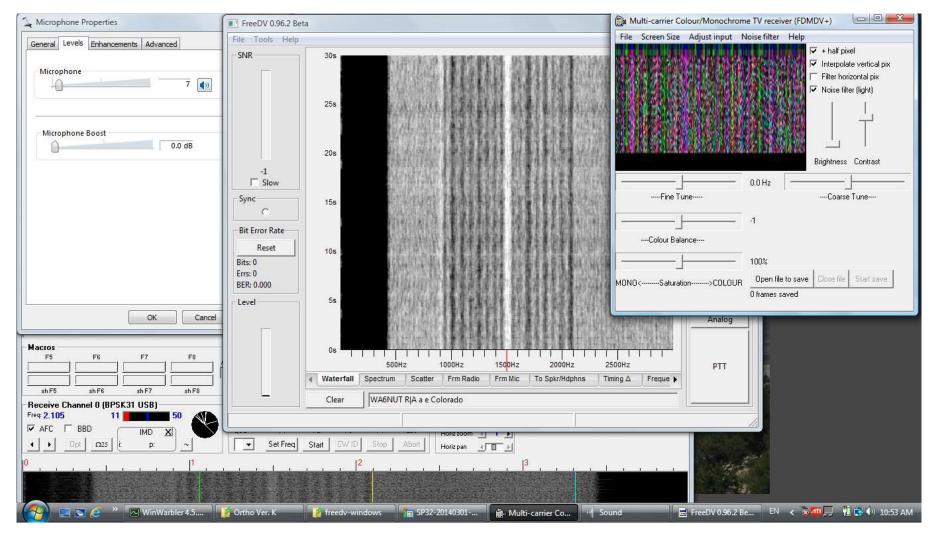
Screenshot 6: CCIR 520-2 Moderate



**Screenshot 7: Doppler Fading** 



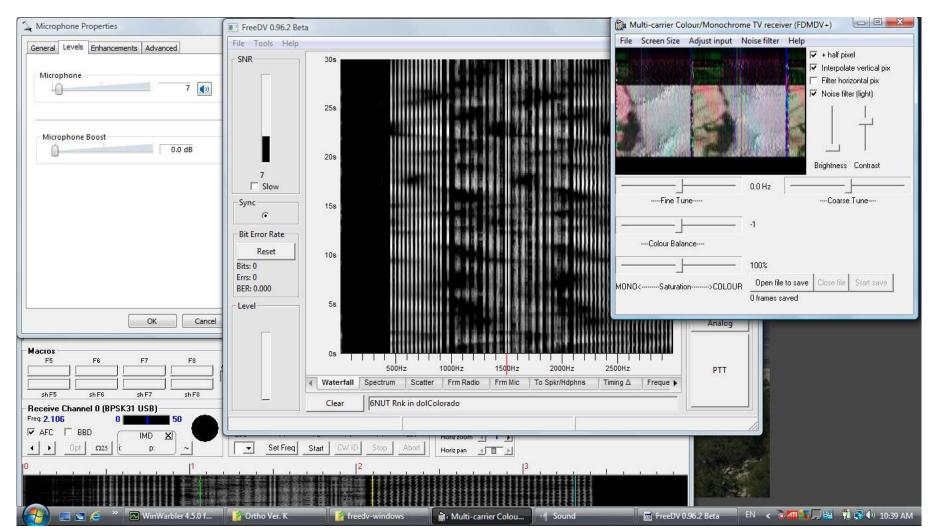
**Screenshot 8: Flutter Fading** 



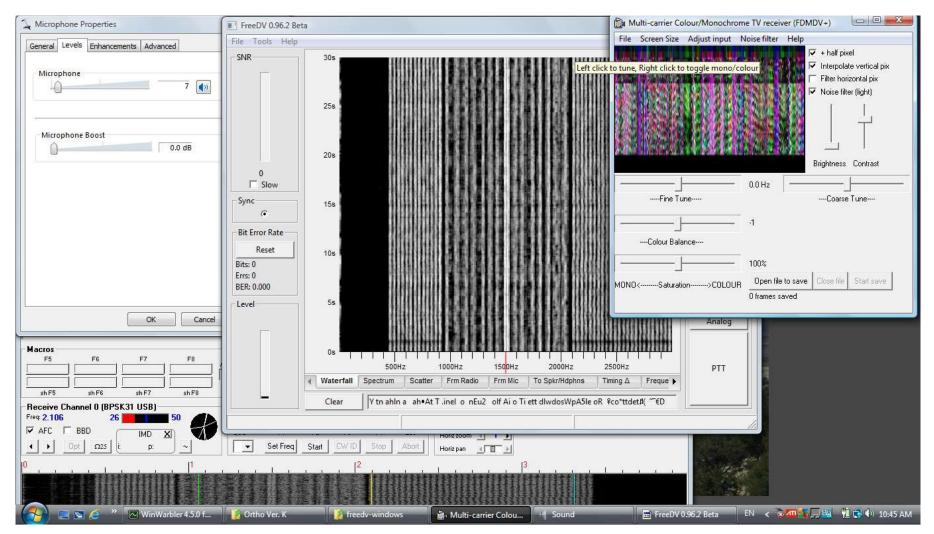
**Screenshot 9: High Latitude Disturbed** 

# May 2019 Rick Peterson, WA6NUT

Page 20



Screenshot 10: High Latitude Quiet

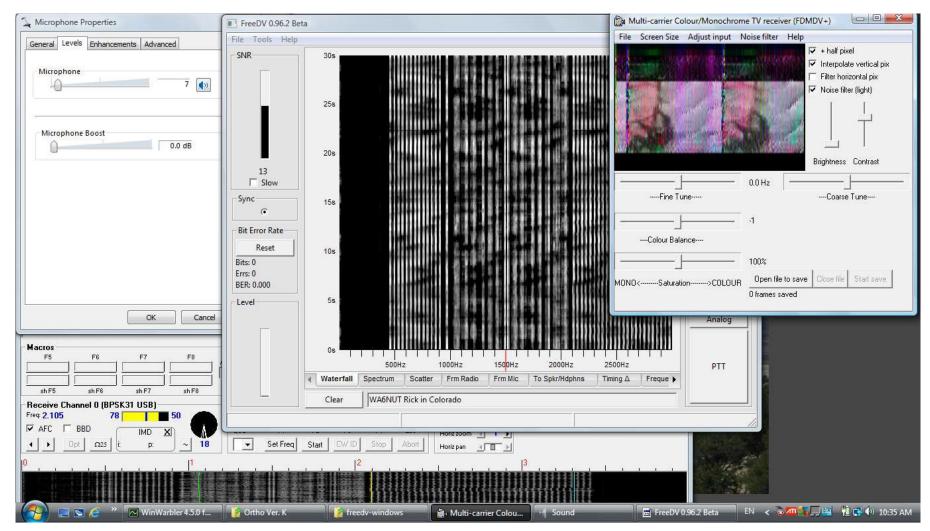


Screenshot 11: Low Latitude Disturbed

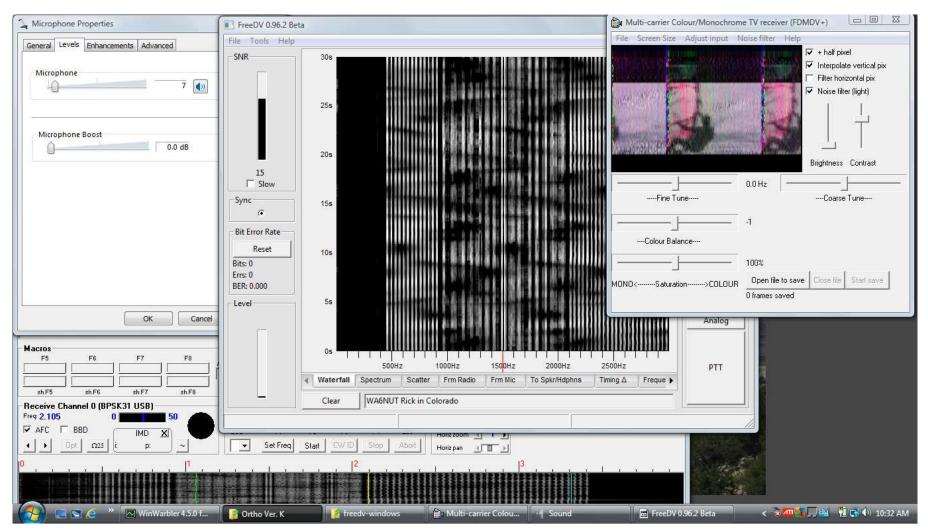
#### Multi-carrier Colour/Monochrome TV receiver (FDMDV+) Microphone Properties FreeDV 0.96.2 Beta File Screen Size Adjust input Noise filter Help File Tools Help General Levels Enhancements Advanced ✓ + half pixel SNR 30s Interpolate vertical pix Microphone Filter horizontal pix 7 -0-✓ Noise filter (light) 25s Microphone Boost 0.0 dB 0 20s Brightness Contrast ☐ Slow 0.0 Hz ----Fine Tune-------Coarse Tune----Sync 15s G. -1 Bit Error Rate ----Colour Balance-Reset 10s Bits: 0 100% Errs: 0 Open file to save Start save MONO<-----Saturation-->COLOUR BER: 0.000 0 frames saved 5s Level OK Cancel Macros 0s IIIIIIIIIIIIIIIIIIIIIII 500Hz 1000Hz 15<mark>0</mark>0Hz 2000Hz 2500Hz F7 F5 F6 F8 PTT Scatter Frm Radio Waterfall Spectrum Frm Mic To Spkr/Hdphns Timing ∆ 4 Freque ) sh F5 sh F6 shF7 sh F8 WA6NUT Rick in Colorado Clear Receive Channel 0 (BPSK31 USB) Freq: 2.106 61 AFC T BBD IMD Q25 26 • Set Freq Start 4 Opt D) Stop . Horiz pan 🔄 🚺 🕨 EN < 😿 🛄 💭 🐐 📢 10:48 AM WinWarbler 4.5.0 for... Ortho Ver. K freedv-windows Multi-carrier Colour... FreeDV 0.96.2 Beta Sound

# **FreeDV+ Ionospheric Propagation**

Screenshot 12: Low Latitude Quiet



Screenshot 13: Mid Latitude Disturbed



Screenshot 14: Mid Latitude Moderate

#### \_\_\_\_\_X\_\_ Multi-carrier Colour/Monochrome TV receiver (FDMDV+) Microphone Properties FreeDV 0.96.2 Beta File Screen Size Adjust input Noise filter Help File Tools Help General Levels Enhancements Advanced ✓ + half pixel SNR 30s ✓ Interpolate vertical pix Microphone Filter horizontal pix 7 📢 Noise filter (light) 25s Microphone Boost 0.0 dB 0-20s Brightness Contrast 15 ☐ Slow 0.0 Hz -----Fine Tune---------Coarse Tune----Sync 15s G. -1 Bit Error Rate ----Colour Balance---Reset 10s 100% Bits: 0 Errs: 0 Open file to save ->COLOUR MONO<--------Saturation--BER: 0.000 0 frames saved 5s Level OK Cancel Analog Macros 0s F5 F6 F7 F8 500Hz 1000Hz 1500Hz 2000Hz 2500Hz PTT Scatter Frm Radio Timing ∆ 4 Waterfall Spectrum Frm Mic To Spkr/Hdphns Freque sh F5 sh F6 shF7 shF8 Clear WA6NUT Rick in Colorado Receive Channel 0 (BPSK31 USB) Freq: 2.105 72 1 AFC T BBD IMD X Set Freq 4 Opt 025 p: 22 • Start Horiz pan 🔣 🔲 🕑 🔄 FreeDV 0.96.2 Be... EN < 🕉 📶 💭 👘 📢 10:57 AM 📅 5P32-20130920-... 🙀 Multi-carrier Co... 🐼 WinWarbler 4.5.... 🥻 Ortho Ver. K freedy-windows + Sound

# **FreeDV+ Ionospheric Propagation**

Screenshot 15: Mid Latitude Quiet