

# **FreeDV plus Video: How We Got Here**

**by Rick Peterson, WA6NUT  
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## How We Got Here

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## How We Got Here

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#### **Introduction**

FreeDV plus Video (FreeDV+) is a multimedia HF mode combining narrow band TV (NBTv) and digital voice (FreeDV). This article chronicles the development of this mode, including many truly serendipitous moments.

There is a user group for FreeDV+,<sup>1</sup> and the Messages pages on the group's site serve as a running history for FreeDV+. The author has included message numbers and dates (within brackets [ ]) referencing corresponding posts on the group's Messages pages.

#### **Beginning with NBTv**

It all began around 2004 when the author, then living in California, discovered the NBTv software created by Dr. Con Wassilieff, ZL2AFP.<sup>2</sup> With the first ZL2AFP software I tried, I transmitted monochrome video at a frame rate of 1.9 F/S to another operator across town, Ken, W6OYT. The video was generated in a manner similar to analog SSTV. I was intrigued by the idea of TV, even at a low frame rate, being transmitted on HF.

Then Con developed a new version of NBTv, called "FFT-TV," employing multiple subcarriers. With this software Lou, ACØX, and I exchanged monochrome video between Colorado and Minnesota, on 20 meters (in 2005). And I had only an indoor dipole here in Colorado!

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Con's next development was another multi-carrier mode, but with full color. Frame rate was 0.9 F/S, with 36-line resolution. It employed 49 subcarriers, 13 for chrominance and 36 for luminance. The separation between subcarriers was about 43 Hz, each luminance subcarrier carrying information for its corresponding image line using frequency modulation (so this mode is actually an analog mode – not digital). Con's “FFT-TV,” now known as “OFDM NBTv,” is the basis of today's “FreeDV plus Video” (FreeDV+).

I enjoyed experimenting with this new software, sending it from one PC to another. But, at some point, I realized that something was lacking with NBTv. Ham radio is all about communication, usually by voice. But think how voice communication could be enhanced if the voice signal was accompanied by video. With combined voice and video, a ham could be seen, as well as heard, over HF!

### **SSB plus Video (A Hardware Solution)**

Being an analog circuit design engineer by occupation, my first attempt at simultaneous voice and video was to shift the baseband FFT-TV subcarriers up in frequency, and to restrict the baseband voice signal to 0 - 1 kHz, separating the FFT-TV and voice signals with analog filters (I later found that a commercial product, the Adonis Electronics ST-12 “Voice Mixer,”<sup>3</sup> used a similar technique to combine voice and analog SSTV). This scheme would require modifying the FFT-TV software, and Con, ZL2AFP, kindly gave me permission to do so. He provided the source code for FFT-TV, written in PowerBasic, a compiled Basic well-suited for real-time signal processing applications. I designed the analog filters and printed circuit boards for the hardware. The scheme, called “SSB plus Video,” produced satisfactory video, but the voice signal, lacking high frequencies, had a muffled sound and was definitely not of communication quality. The

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scheme also required building specialized hardware [#2 (9/13/10) - #13 (3/26/11)]

### **FDMDV plus Video (A Software Solution)**

At that time, FDMDV, developed by Cesco Lanza, HB9TLK, was the popular digital voice mode. It, like FFT-TV, was a multi-carrier mode. What if the FDMDV signal could be sandwiched between the FFT-TV chrominance and luminance subcarriers? So I again modified Con's software, this time making a space for the FDMDV subcarriers just above the 13 chrominance subcarriers and just below the 36 luminance subcarriers. This scheme, called "FDMDV plus Video," had the advantage of requiring no specialized hardware, just an extra sound card (a \$5 device using a USB port). And now the voice quality was clear, and the video quality was also good. All testing was done PC-to-PC. [#14 (7/6/11) - #22 (7/31/12)]

But FDMDV required the use of a proprietary CODEC, and FDMDV fell into disuse when the developer of the CODEC software threatened legal action. At this point, Dr. David Rowe, VK5DGR, introduced CODEC2 and FreeDV<sup>4</sup> came into being. Now amateurs had an open-source, narrow-bandwidth digital voice mode suited for HF operation. [#23 (12/9/12)]

### **FreeDV plus Video**

It was easy to convert the ZL2AFP software from "FDMDV plus Video" to "FreeDV plus Video." The first implementation used the FreeDV "1400" mode. The "1400" mode used 75 Hz subcarrier spacing.

At this point I started transmitting from a transmitter to a receiver, transmitting into a dummy load, instead of the PC-to-PC testing done

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previously. Several problems were immediately obvious:

- 1 The first was that the hues in the received video were extremely sensitive to the receiver tuning. Tuning to within  $\pm 1$  Hz was required for good color quality. This would require transceivers with DDS tuning, with 1 Hz resolution. Since transceivers are rarely accurate to 1 Hz (unless GPS-locked), some means would be required to expedite tuning the received video to correct for frequency errors in the transmitting and receiving transceivers. Fortunately, in my previous experiments with color FFT-TV, I had found that *WinWarbler* (a PSK31 application)<sup>5</sup> employed an AFC feature with a frequency readout useful for tuning the received video. *WinWarbler* would also be useful with FreeDV+.

A similar technique is used by some amateurs for accurately measuring frequency for the ARRL Frequency Measuring Test (FMT) held each Spring.<sup>6</sup> The FMT measurements use *Spectrum Lab* software to measure the absolute frequency of an RF carrier; *WinWarbler* software is used for tuning the received FreeDV+ video by allowing the operator to compensate for the relative frequency offset between the transmitting and receiving transceivers.

- 2 There was interaction between the video and digital voice signals. The video was noisy, and the FreeDV SNR was degraded. About this time I discovered that FreeDV+ was actually using a technique known as Frequency Division Multiple Access, or FDMA. This technique is used in communication satellites to combine diverse signals, combining FM broadcast, TV broadcast, and other signals as downlinks to ground stations.<sup>7</sup> And, just as I had observed, FDMA produces

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interaction between these diverse signals. This interaction produces IM (intermodulation) products and IMD (intermodulation distortion).

### Dealing with IMD

The first step in reducing IM products was to change the NBTv subcarrier spacing to 37.5 Hz, a submultiple of the 75 Hz spacing of the FreeDV (“1400” mode) subcarriers. Some improvement of the IMD problem was observed, but noise in the received image and degraded FreeDV SNR were still present (and, without a spectrum analyzer, I was unaware that my FreeDV+ signal had unacceptable splatter on adjacent frequencies). [#19 (1/15/12)]

The second step in reducing IM products was to configure the software so that the levels of the video subcarriers could be adjusted with respect to the FreeDV subcarrier levels (the video subcarrier levels should be adjusted to be about the same as the FreeDV levels). [#33 (11/13/14)]

The third step in reducing IM products was also borrowed from communication satellite technology. Communication satellites use a technique called adaptive predistortion (APD) to reduce IMD. APD is a scheme that linearizes the TWT (or solid-state) amplifiers used for the downlink. At that time (and even now), only Apache Labs products offered APD (called “PureSignal”). I purchased their low-end SDR transceiver (the ANAN-10E),<sup>8</sup> and configured it, along with my Ameritron AL-811 amplifier, for PureSignal. With the ANAN-10E's spectrum display of my transmitted signal, I was able to see the splatter on adjacent frequencies, the result of IMD. But, when I turned the PureSignal feature ON, I saw all that splatter magically disappear! Finally, I had a signal I could actually put on the air! No longer was I

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restricted to a signal I could only transmit into a dummy load!<sup>9</sup>  
[#36 (2/23/16)]

## Where We Are Now

FreeDV+ continues to evolve. Recent developments include:

- 1 Using a batch file to open the FreeDV+ apps, by simply clicking on a desktop icon.<sup>10</sup> [#45 (2/6/19)]
- 2 Combining the second soundcard and radio-to-PC interface in a single unit (a modified MFJ-1204).<sup>11</sup> [#49 (6/26/19) - #51 (7/18/19)]

And we're still waiting for other manufacturers to adopt adaptive predistortion in their HF transceivers. Both Flex Radio (6000-series) and Elecraft (K4) have provisions in their hardware for APD, but haven't completed development of the FPGA's and software required for APD.

Be assured that the FreeDV+ story hasn't ended. There's more to come. Stay tuned!

## References

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