

See the full User Manual at:

https://github.com/drowe67/freedv-gui/blob/master/USER_MANUAL.md

FREEDV USER MANUAL APPENDIX v1.0

Reference - FreeDV v1.4 devel

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OPERATIONAL NOTES – BASED ON DAILY USE BY UK NETS

Which Mode to Use?

FreeDV includes a number of selectable modes which can be used for experimentation. These modes represent the development history of FreeDV.

For HF, use 700D by default, as it has the greatest sensitivity due to error protection, and uses the least bandwidth.

On a receiver with DSP filters (or a WebSDR), you can reduce the 700D receive bandwidth to a little more than the transmitted signal bandwidth, say 1.2KHz, centred on the FreeDV signal. This stops the receiver AGC responding to out of band signals.

If you experience audio drop outs with 700D, check that the squelch is turned off, as there is a 700D squelch bug that affects low SNR signals. There are also other causes of 700D audio drop out that can be resolved by selecting 700C or 1600 – See the last section.

2020 mode provides a wider audio bandwidth, but requires a PC with an Intel I3, I5, I7 or I9 series processor or equivalent e.g. from AMD.

800XA is intended for VHF/UHF use. 800XA, as it's FSK, can be used with class C PA's.

Receive Diversity

Considerable operational benefit has been achieved by using a WebSDR for diversity reception. This usually requires a second PC. The connection between the WebSDR and FreeDV can be made with a Virtual Cable. (e.g. <https://www.vb-audio.com/Cable/index.htm>) for Windows. This method has been found to work well with Fixed and Cellular internet connections, provided jitter rates on these connections is low. It is also useful to have a list of suitable WebSDR's in the Browsers favourites list, as the best diversity source can vary with propagation throughout the day. Listening to yourself coming back via a WebSDR is also a useful way to check your FreeDV setup and propagation conditions.

The Virtual Cable is just driver software. The 'cable input' can be selected via the Windows control panel speaker symbol. The 'cable output' can be selected via the FreeDV Tools/Audio config menu. Transmit tab options can be set to 'none'. It's advisable to check this menu is what you expect every time you activate FreeDV, before clicking START, as other applications, connecting and disconnecting USB devices, and Windows updates can change these settings. These changes can also change previous audio drive levels from the PC.

For Mac Users:

Download Soundflower from <https://github.com/mattgalls/Soundflower> Once installed, to receive from a WebSDR use System Preferences-Sound to set the output from the Web Browser to Soundflower 64ch; then set the FreeDV Tools/Audio Config Menu 'From Radio to Computer' to 'Soundflower (64ch)' and 'From Computer to Speaker' to 'Built-in OutputSoundflower (2ch)'. Transmit tab options can be set to 'none'.

For Ubuntu Users:

Nothing needs to be downloaded. At a shell prompt, issue the command:

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$ sudo modprobe snd-aloop
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You will then be asked for the root password. On the Ubuntu sound menu, select 'Analogue Output – Built-in Audio'. On the FreeDV Tools/Audio Config Menu you will see many options. The following selection was made when a USB sound card and a USB headset were connected to the computer. On 'From Radio to Computer' select: Loopback: PCM (hw:1,1)(4). On 'From Computer To Speaker/Headphones' select: HDA Intel PCH: ALC221 Analog (hw:0,0)(0). You may have to experiment with the selectable options on your computer.

PTT

While FreeDV has its own on screen PTT button. A simple alternative solution is to use Full Duplex from the Options/Half Duplex menu (you need to deselect the default Half Duplex). The only PTT line then required is the normal transceiver PTT. Don't use the PTT switch on the transceivers microphone, as this microphone will pick up other background shack noises, and these will get mixed into the digital FreeDV audio.

Headsets

To date, it seems that all USB headset types work equally well with FreeDV. Typical prices range from \$15 to \$25 in major PC stores. You may find that it's more convenient to select

the PC's Speakers on Tools/Audio Config for audio output, rather than using the headset ear pieces. (See comments in the section below re headphones).

FreeDV Audio Equaliser

With earlier versions of FreeDV, a lot of experimentation was conducted using the tools/filter menu. It was thought that microphone pre-emphasis was beneficial with some voices, but there was no consistent opinion about this. FreeDV v1.4 devel has an auto equaliser which is 'on' by default for 700C and 700D. Since this feature was introduced, for most voices, there has been little benefit in using the microphone in equaliser.

Received FreeDV audio quality can be influenced by the type of speakers or headphones used. The mechanical pressure on the ears from some headsets can make a significant difference to audio quality. If there is concern about received audio quality, it is useful to try a different set of headphones or speakers, even if a music CD sounds OK on these devices. Supermarkets sell USB powered speakers for around \$7. Alternatively, attempts can be made to equalise headphones or speakers using the FreeDV speaker out equaliser.

Microphone Levels and ALC

This comment is relevant to transceivers with ALC:

When setting FreeDV up for transmit: Set the microphone level initially to zero, and then progressively increase the microphone level, watching the FreeDV RF output increase in response on the transceiver power meter or an SWR Bridge. At some point, as the microphone level is increased, the RF output will stop increasing. At this point, the ALC is sensing the peaks in the FreeDV waveform, and is preventing the audio drive level increase further. Reduce the microphone gain very slightly from this point to ensure linear operation. If you get this wrong, and provide excessive audio input, the ALC will probably resolve the problem for you.

Expected FreeDV FWD indications on an SWR Bridge

These comments are relevant to simple (cheap) SWR bridges that use a transmission line type sensor, and typically have a level set control knob:

Check your antenna VSWR with an AM carrier without modulation. A 100W SSB transceiver may produce 20 to 25W of AM carrier.

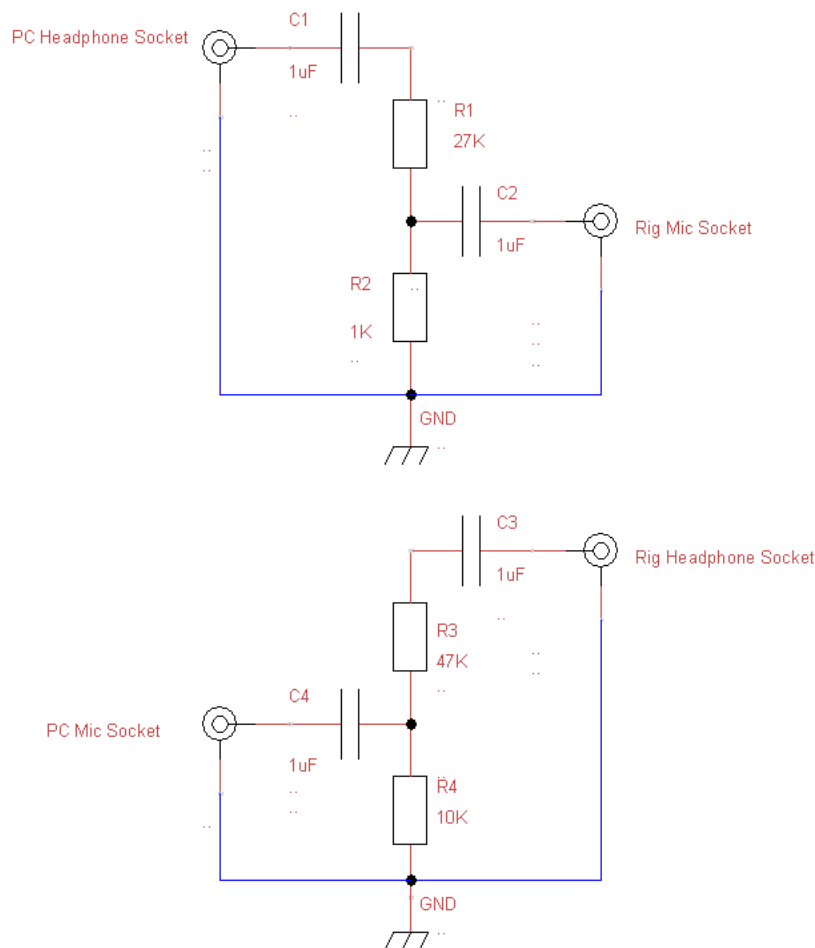
Assuming the antenna VSWR is reasonable, and the AM carrier SWR meter FWD indication is at Full Scale Deflection (the SET position), a switch to FreeDV LSB or USB, without adjusting the sensitivity knob, will indicate something in the region of 33% of Full Scale Deflection. This is because the SWR bridge responds differently to a signal with rapidly varying amplitude components like FreeDV. Depending on the time constants in the SWR bridge detector circuit, you may notice the SWR bridge needle apparently 'vibrating' slightly in response to the rapid amplitude changes in the FreeDV signal.

The RMS RF output power (dummy load heating effect) from a 100W PEP SSB transceiver producing FreeDV is likely to be in the region of 15 to 20W.

Note: The 33% of SWR bridge full scale deflection is not a system setup requirement. It is however what the user is likely to observe.

Connecting older Transceivers to a PC

Many new transceivers interface with a PC via a USB connection. Older transceivers can be connected to a PC via the transceiver's 'microphone' or 'aux audio in', and 'audio out', 'headphone', or 'speaker' connectors. On the PC, connections are made through the PC's 'microphone in' and 'headphone out' jacks. Obtaining the correct audio levels requires potential dividers using fixed or variable resistors, and some capacitors to guarantee DC isolation between the PC and transceiver. Example potential dividers for a 1995 ICOM transceiver are as follows:



PC headphone jack centre to Rig Mic jack centre, 27K. Rig Mic jack centre to ground 1K.

Rig headphone jack centre to PC Mic jack centre 47K. PC Mic jack centre to ground 10K.

Precautionary 1uF (non electrolytic) DC isolating capacitors are used on the jack inputs and outputs of the potential dividers.

RF decoupling capacitors across the Rig Mic input, and ferrite beads, may be advantageous in some circumstances. The use of screened audio cable is recommended. To avoid damaging the PC's internal sound card, a second USB sound card can be obtained for less than \$7 from major PC stores.

When adjusting the Rig microphone input attenuator values, it is advisable to keep the audio level into the Rig high, and then attenuate this by setting the Rig microphone gain to a low value, say 20-30%. This will minimise any RF pick up problems. Keep in mind that the PC also has audio level/volume controls that will impact Rig audio drive levels.

FANS and RF

The FreeDV Codec does not like background fan noise in the shack, e.g. from a linear. This results in the received signal sounding like it includes distorted fan noise.

A very similar noise is produced if RF is getting into the microphone lead, or sensitive parts of a PC. The noise can be seen on the FreeDV 'frm mic' tab on transmit. This generally does not happen with coax fed balanced antennas, but may be noticed with high impedance antenna feeds which use an ATU in the shack. The usual Amateur Radio practices of ferrite beads, decoupling capacitors, and sensible grounding, will usually resolve these problems if they occur.

Common Problems – Finger Trouble!

Check the FreeDV Tools/Audio Config menu every time you activate FreeDV, before clicking the START button. This confirms the settings are what you expect. Other applications, connecting and disconnecting USB devices, and Windows updates can change these settings. They can also change previous audio drive levels from the PC.

It's not uncommon to select Analog on FreeDV to listen to the channel to check for QRM, and then go onto transmit, expecting to radiate FreeDV. You then wonder why no steady FreeDV power is showing on the SWR Bridge/Power Meter!

A FreeDV signal looks the same on a waterfall display if it is being transmitted as USB or LSB. LSB FreeDV transmissions cannot be decoded if the transceiver is tuned in with USB selected and vice versa.

Net Discipline

FreeDV is like FM in that the strongest signal always wins due to capture effect. Consequently, poor net discipline can easily result in doubling. To avoid possible chaos with a large net, it is important that the station currently transmitting clearly hands transmission to the following station on the net. A net controller, who everyone can hear, can be beneficial. Quick unexpected 'break in' should be avoided. Leave breaks for new stations to call in frequently.

Suggestions

After completing a FreeDV QSO, disconnect FreeDV, switch back to SSB, and continue the conversation. You will be surprised how bad SSB sounds, particularly if signals are below S9+! This comparison is most impressive if there is a lot of lightning static around.

Doppler, Delay Spread, and Audio Drop Outs for those who are interested

The following description attempts to describe a complex subject in simple terms:

The Ionosphere consists of ionised 'clouds' in different layers. The clouds are moving, and their layers may not be moving in the same direction, or at the same speed. This movement causes a Doppler shift on HF signals. The Doppler shift is not much, just a few Hz, but this can have an effect on FreeDV. On HF, signals are normally received by more than one path. Amateurs refer to this as multipath. Each path may have a different Doppler shift. These phenomena result in the terms 'Doppler Spread' and 'Delay Spread', which are used to describe the operating limits of digital radio modems.

FreeDV 700D is a narrow band signal. This is achieved by having many low data rate QPSK carriers very close together. When Doppler is present, it can cause the 700D carriers to overlap resulting in poor FreeDV SNR, even if the signal is strong. Problems may also occur if the Delay Spread is beyond the modem's limits. This causes transmitted symbols (bits) to overlap in time.

The Doppler can experience 'gust' type events, where it suddenly increases for around 1 second. This can result in occasional brief audio drop outs on 700D, when it's specification is temporarily exceeded. This does not always occur, and is less likely during the summer months. The Doppler is usually worst an hour before sunset and an hour after sunrise (approximately), particularly during the winter. It also has a latitude dependency, getting worse with increasing latitude. At UK latitudes, the Doppler may cause a 1 second audio drop out once every 5 to 60 seconds. FreeDV 700C and 1600 modes are less vulnerable to these effects, as they have a wider bandwidth. If audio drop out is a problem, a switch of the net to 700C or 1600 may resolve it, increasing the receiver bandwidth if required.

Doppler and delay spread are path dependent, and unique to every transmitter receiver pair. Consequently, not all members of a net may experience the same effects at the same time. Receive diversity, using a remote WebSDR, can therefore significantly reduce the effect of any drop outs.

Doppler and delay spread cause the patterns on the waterfall display. Sometimes these patterns are like a steady 'Barber Pole', which makes it easy to calculate the Doppler and Delay Spread from the waterfall axes. The increased 'gust' Doppler, which causes the audio drop outs, cannot be seen on the waterfall, as it's beyond the waterfall resolution limits.

2020 mode, which provides wider audio bandwidth, has similar Doppler limitations to 700D, but also requires an SNR above 12dB to give good performance.

You may experience Doppler drop out problems with 700D, 700C, or 1600, at VHF/UHF, on an SSB transceiver, if you use these modes mobile, or if the signal is affected by local trees being blown around by the wind (which produce Doppler), or on long Tropo paths.

Operational use of FreeDV by the amateur community has helped the understanding of Doppler and delay spread effects, and aids future modem development efforts. One restriction we have to work with is that the majority of amateur transceivers contain filters with phase characteristics designed for analogue modes, which are not ideal for optimal digital modes requiring bandwidths beyond a few hundred Hz. This constrains some solutions to Doppler gusts. Cell phones, digital TV etc., and some commercial HF transceivers, contain filters specifically designed for digital modes.

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Thanks to Steve, M0MOI, for the Macintosh Virtual Cable text.