

Elad FDM-Duo Internal Soundcard Audio Levels and using the IQ Mode

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The FDM-Duo has internal software that appears as a USB Soundcard, allowing input and output of audio from a PC. The soundcard is shown in the list of Audio Devices as *FDM-Duo Line* where it appears as a standard 16-bit audio device that behaves like any other standalone USB audio soundcard that has no software volume or level control associated with it other than anything Windows Mixer may offer.

On receive the level out of the Duo's soundcard can be adjusted via menu item 6, 'AUX VOL' which also affects the level coming out of the analogue audio port, the 3.5mm jack on the front panel.

On transmit, however, there are two very different ways of using this soundcard. The normal way, used for most datamode software, is the default. There is no level adjustment option in the menu settings, so a bit of investigation was needed to see what input level was needed for maximum RF output using SSB. But 'input' or 'drive level' in this context needs to be explained first.

The Meaning of Drive Level

A 16 bit soundcard on receive delivers its digitised data as a signed number ranging from -32768 for the maximum negative excursion of the input voltage to the A/D up to +32767 for the maximum positive value. Any attempt to increase the input voltage results in clipping at these values. The same applies on transmit, where a stream of values ranging from -32768 to +32767 generate the maximum output from the D/A converter driving the transmitter. These are the maximum values possible in a signed 16 bit integer so it is impossible to drive any harder. (The Duo does not have an actual D/A converter on transmit as everything is done digitally, but we don't need to know this and it makes no real difference to the functionality).

Within this document I will refer to the Tx drive as a value of ± 32767 for maximum, and for reduced drive (lower transmitted power) values like ± 10000 or ± 400 . The \pm can be omitted in general usage and just refer to drive levels of 32767, 10000, 400 etc. These are the peak, or the maximum and minimum values of the digitised waveform. Often drive will be referred to by a [negative] value in dB. A drive with a peak of 3277, for example, would be at 20dB below maximum. (The digital values are equivalent to voltage, so the 20.LOG form is used for dB). Users of GNU Radio and other DSP writers invariably normalise everything to ± 1 peak to peak. So in those terms, +1.00 is equivalent to +32767 and -1.00 to -32768, and in general terms a drive level of 1.00 is peak-peak maximum. -20dB is 0.10 and -3dB is 0.707

Normal Soundcard Usage

In this mode of operation, the digital input waveform is lowpass filtered to approximately 2800Hz before conversion to RF. This is comparable in operation to a normal SSB transmitter driven, for example, from the audio output from a PC. Testing of the digital drive level was performed in two ways to ensure the numbers needed were known precisely. Initially, several .WAV files were prepared off-line, using custom software to write a 1kHz sinewave at various amplitudes such as 32767 peak-peak (0dB amplitude) 16383 (-6dB) etc. The Duo was set to 5MHz and the 0dBm output connected to a scope to observe the generated output level. Replaying these audio files using a simple PLAYWAV routine, where the 16 bit values in the .WAV file go unmodified to the soundcard, initially revealed that maximum RF output was obtained with an input that had to be backed-off somewhat, to around -7.7dB (13500 or 0.41).

The soundcard drive was then replaced with that from the *TCUBE* software Audio Tone Generator package [1] That allows the level to be continuously adjusted. Checks revealed that when set to 0dB *TCUBE* did correctly deliver a maximum peak of 32767, and that the dB level control gave the expected reduction in values. It was then observed that RF output level behaved erratically as the drive was rapidly varied within the range 0dB

down to -7dB; it 'bounced around' somewhat. What was happening is that a (software) Automatic Level Control ALC has been implemented in the drive chain in an attempt to make it less sensitive to typical usage. Other users had reported some uncertainty when using the 'Pwr' control within the WSJT-X and other datamode packages. Those appears to work perfectly with maximum drive. ALC action explains this uncertainty. It appears to have a time-constant of a few hundreds of milliseconds - hence the bouncing observed on the output level as drive was varied over -7 to 0dB, so responds to the PEP of most typical modulations, keeping within the linear range at all times. Below -7dB, output falls progressively with no more ALC action.

The LSB/USB control behaves as expected, giving an RF output below or above the dial setting equal to the tone frequency. If a stereo digitised waveform is delivered to this audio interface operated in normal mode, only signals appearing on the LEFT channel are used. Anything on the RIGHT channel is ignored.

IQ Mode of Operation

There is another way of using the internal soundcard that provides greater flexibility for generating arbitrary drive waveforms than a system emulating an SSB transmitter can offer. That is to use it as a stereo device with a dual I/Q or quadrature data stream. Using it in this way the incoming digital audio is filtered to a wider bandwidth, 4kHz. Since it is now a quadrature stream, positive and negative frequencies are permitted (the relative phase of the I and Q signals) so that 4kHz filtering actually allows for a 8kHz RF bandwidth, from 4kHz below the dial frequency to 4kHz above.



IQ Mode is set using a CAT command sent to the FDM-Duo immediately BEFORE going into Tx by asserting the RTS line on the virtual COM port. The command required is "IQ1;" (the semi-colon is the terminator). A software timeout, or watchdog, of 30 seconds is applied to this IQ1; setting. When IQ Mode is activated 'IQ' appears in the display, shown by the green arrow in the picture.

If no further commands are sent on the CAT interface, transmission stops after this interval, even if the RTS line remains active, and the radio drops back into Rx with IQ mode now

disabled. The Tx timeout is reset if RTS Tx control is dropped, but then the IQ Mode has been cancelled, so if RTS is then asserted with no further CAT control, normal Tx audio mode is now in use, (equivalent to the CAT command "IQ0;"). Even in Receive, if IQ mode is set the timeout acts to cancel it after the 30 seconds. To maintain IQ mode during long transmission periods, the "IQ1;" command has to be sent at regular intervals where it resets the software watchdog each time. The command has to be sent, initially before each period of transmission, and then repeatedly for any Tx periods greater than 30s.

IQ Mode Levels

The TCUBE software can generate a quadrature signal, although the 'polarity' or relative phase of the quadrature relationship cannot be flipped. Thus only one direction of frequency conversion could be observed. Driving with an audio tone of 2000Hz and the FDM-Duo dial set to 5.1MHz resulted in RF output at 5098kHz so the fixed I/Q phase relationship is here corresponding to a negative frequency. The USB/LSB

setting has no effect on the direction of conversion in IQ Mode, and in fact the Mode select button has no action at all when in IQ mode.

No ALC action is implemented when in IQ mode and full RF output is seen at 32767 / 0dB drive, with signal reducing progressively from 0dB when testing using the *TCUBE* software. Custom stereo .WAV files were generated with quadrature 1kHz tones in each channel, using opposite polarities of phase shift in each file. With the dial set to 5.1MHz, one replayed file resulted in output at 5101kHz, the other at 5099kHz, confirming full negative frequency operation.

References

I2PHD's *TCUBE* Audio Generator with IQ outputs. <https://www.i2phd.org/tcube/tcube.html>

