Tuboid DirectX Plug-in Beta 1 User Manual
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1 Installation of Tuboid Plug-in

The readme.txt file in the beta version zip file "tuboidBeta1.zip" has a full explanation of how to install the Tuboid DirectX plugin into the Windows environment. You have to copy two DLLs from the zip file into a directory on your computer, and then run a specific command within a command line window, to register DLLs, making it available to applications as a DirectX audio filter plug-in.

2 Functionality of Tuboid Plug-in

The Tuboid plug-in is a DirectX audio filter plug-in, which is a software implementation of an Over-Threshold Power Function (OTPF) feedback distortion synthesizer. "Nonlinear distortion synthesizer using over-threshold power-function feedback" is the title of US Patent 4,710,727 (December 1, 1987, Inventor Thomas E. Rutt, now abandoned), available at http://www.coastin.com/USPatent-4710727.pdf .

OTPF feedback closely emulates the soft limiting input/output response characteristics of Vacuum tube triode grid limit distortion, as described in: "Vacuum Tube Triode Nonlinearity as Part of The Electric Guitar Sound", T. E. Rutt, Presented at the 76th Convention of Audio Engineering Society 0ctober 8-11, 1984, New York (Preprint 2141 F-5), available at http://www.coastin.com/AESPaper.pdf . A summary of the findings of that paper are included as an appendix to this user guide.

The name "Tuboid" connotes an intelligent device which emulates the distortion characteristics of a vacuum tube.

Figure 1 is a conceptual diagram of an OTPF feedback Distortion Synthesizer.

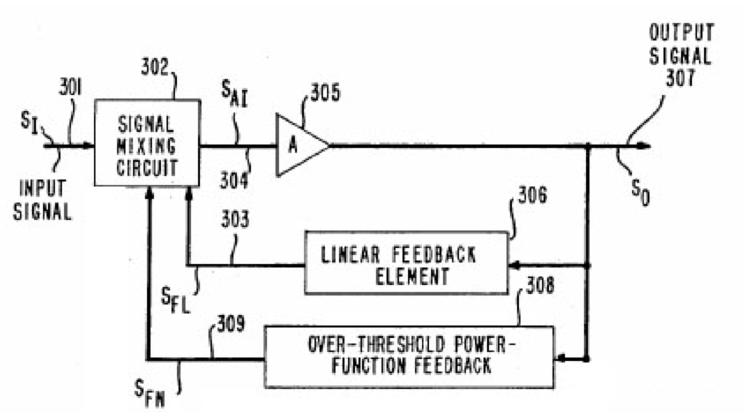

Figure 1 – Over-Threshold Power Function Feedback Distortion Synthesizer

Si = So / Gain + Sfn

Sfn = Ktp * (So – Stp) ** b , for So greater than or equal to Stp

Sfn = 0, for So less than Stp and greater than Stn

Sfn = – Ktn * |(So – Stp)| ** b , for So less than or equal to Stn

Assuming the open-loop gain of amplifier A (305) is large, the linear gain of the synthesizer is determined by the transfer characteristic of the linear feedback element (306). When the output signal, So, becomes greater than a positive threshold value, Stp, or less than a negative threshold value, -Stn, OTPF feedback (from 308) is applied to the signal mixing circuit (302).

Anti-causal analysis simplifies the understanding the operation of an OTPF feedback distortion synthesizer. Figure 2 shows a graph of the input signal level, Sin, which would be required to cause the production of a given output signal level, Sout, with linear region gain of 5, and a cubic power function.

For the region above the positive threshold, Stp = .5, the effect of cubic power function feedback is shown for four different feedback gain constants: Ktp = 0 , .5 * KtpOpt. ; KtpOpt, and 2 * KtpOpt. For the region below the negative threshold, Stn = -.7, the effect of cubic power function feedback is shown for four different feedback gain constants: Ktn = 0 , .5 * KtnOpt, KtnOpt, and 2 * KtnOpt .

The optimum values for feedback gain, KtpOpt and KtnOpt are defined as the specific values which result in the maximum allowable peak input signal level being equal to the maximum allowable peak output signal level, for the positive an negative portions of the output signal, respectively. An important feature of an OTPF feedback distortion synthesizer that it always behaves as an instantaneous soft limter, and never results in clipping of the output signal peak levels (even at maximum allowable peak input signal levels), if the non-linear gain constants not set to be less than these optimum values.

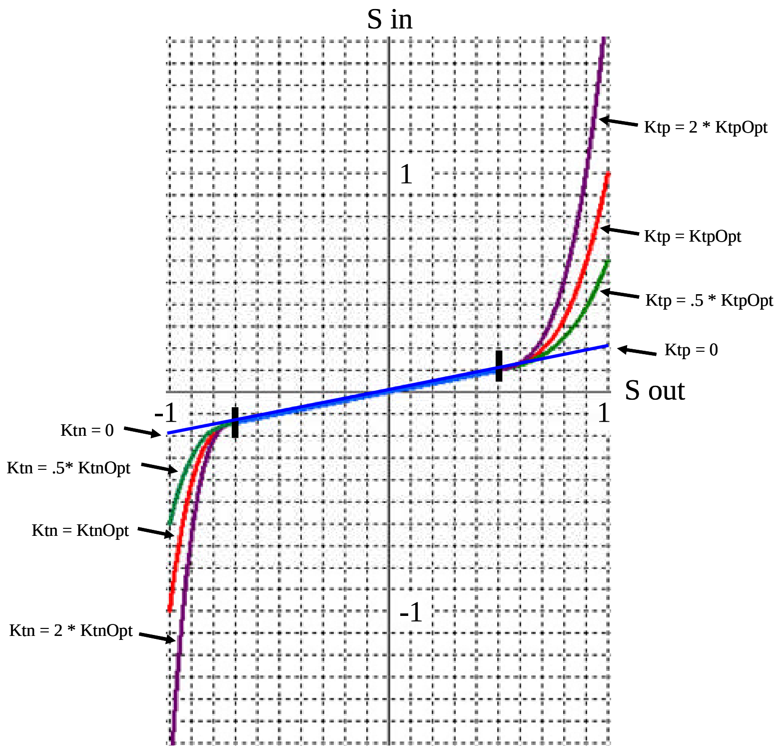

Figure 2 – Anti-causal Graph of OTPF Feedback - Gain= 5, Stp = .5, Stn = -.7, b = 3

The Tuboid DirectX plug-in controls are shown in the top portion of Figure 3. They are:

- the linear gain (labeled “Gain”) of the synthesizer
- the threshold level for the positive output signal (labeled “Threshold Pos”),
- the threshold level for the negative output signal (labeled “Threshold Neg”),
- the multiplier to apply to the optimal non-linear gain constant for the positive side of the output signal (labeled “Squash Pos”, values >= unity), and,
- the multiplier to apply to the optimal non-linear gain constant for the negative side of the output signal (labeled “Squash Neg”, values >= unity).
- the non-linear transfer characteristic is shown as a graph (instantaneous output signal level on vertical axis, versus instantaneous input signal level on horizontal axis).

3 Example Screen Clips using Tuboid Plug-in

Figures 3 and 4 are screen clips showing the results of applying two different setting of the Tuboid plug-in to a full scale 100 Hz triangle wave. The plug-in was run as a DirectX plug-in, within Adobe Audition 1.5.

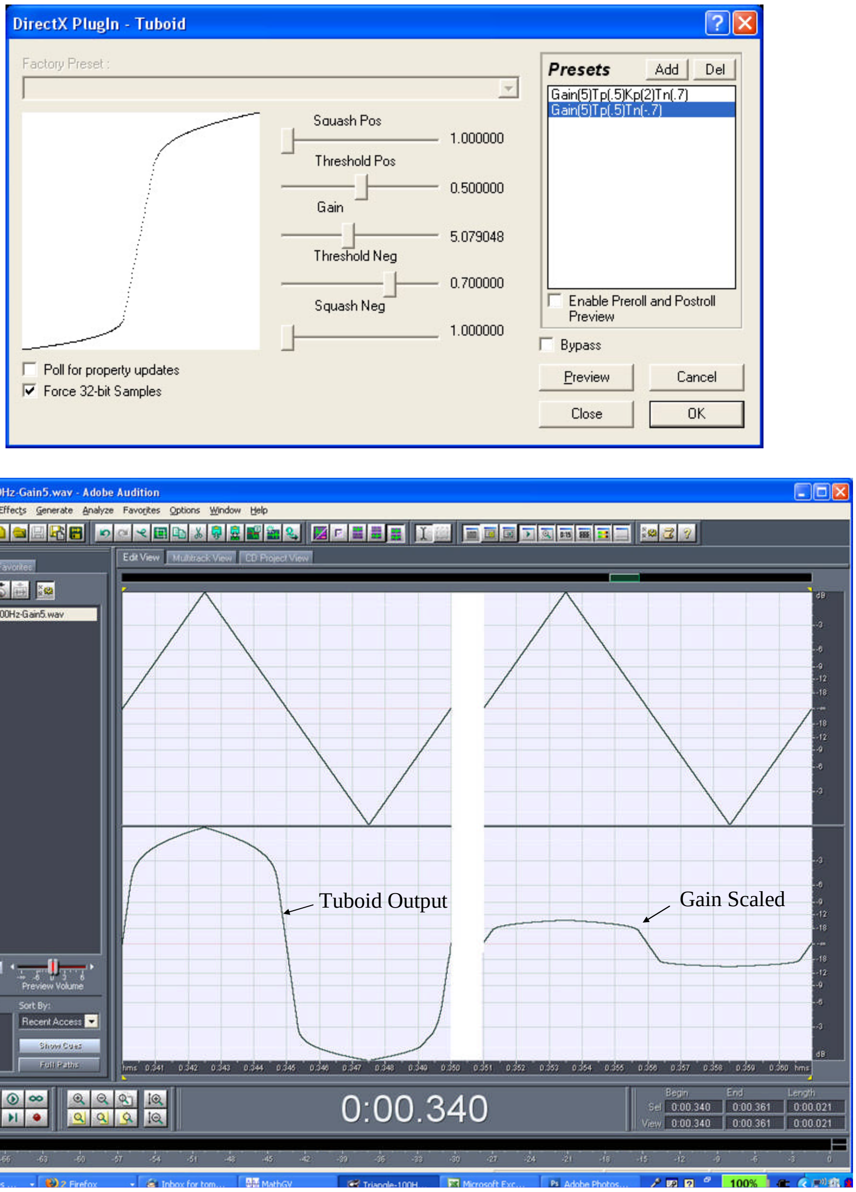

Figure 3 – Adobe Audition Screen Clips – Tuboid Plug-in settings and Full Scale Triangle Wave Response: Gain = 5, Tpos = .5, TNeg = .7

Figure 3 shows an example of the Tuboid plug-in, set to operate as shown in Figure 2, using the optimal values KtpOpt and KtnOpt (i.e, unity Squash values). The upper waveform is the 100 Hz input triangle wave. The lower left waveform is the output of applyng the Tuboid plug-in as an effect. The lower right waveform is Tuboid plug-in output, scaled down to the relative level of the input (i.e., the output signal level divided by the linear gain), demonstrating its soft limiting of the input signal.

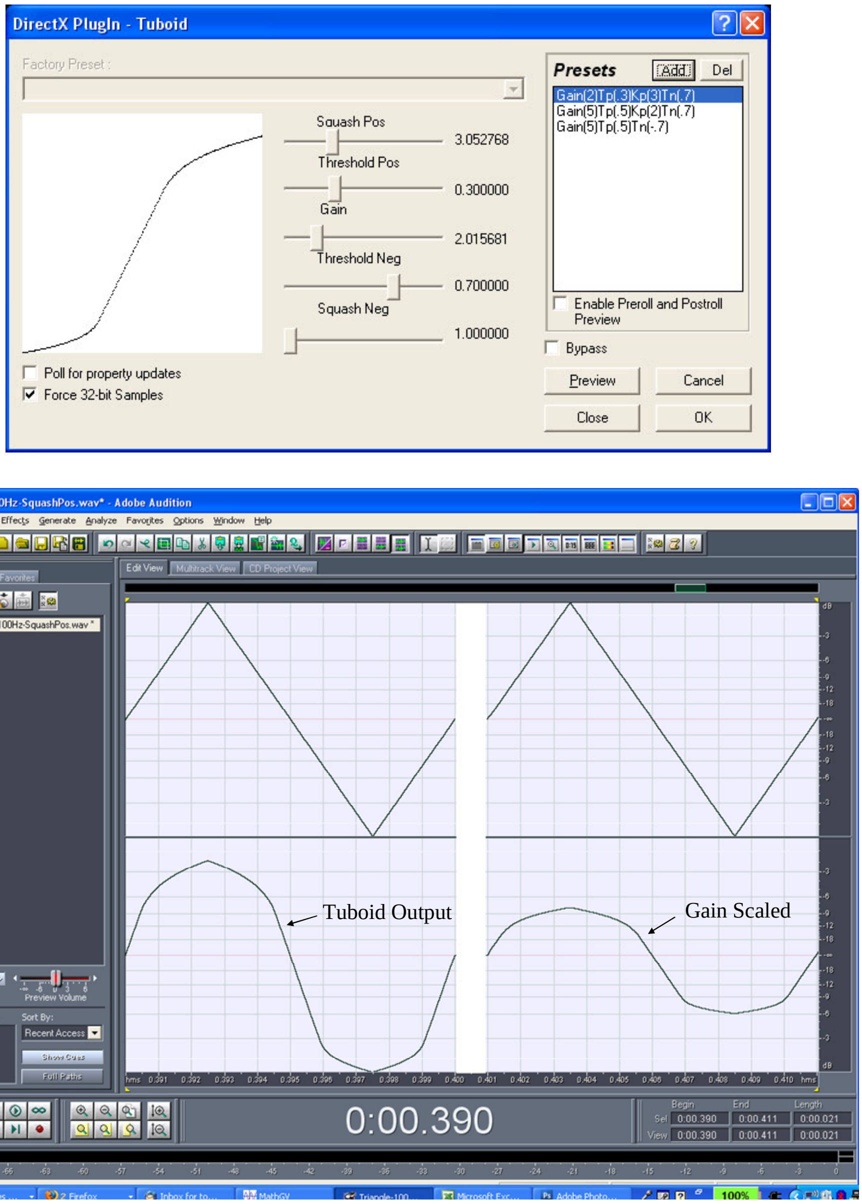

Figure 4 – Adobe Audition Screen Clip – Tuboid Plug-in settings and
Full Scale Triangle Wave Response: Gain = 2, Tpos = .3, TNeg = .7, SquashPos = 3.

Figure 4 shows a the results of a different setting of the Tuboid plug-in, with Gain =2, and a positive Squash value of 3. Note that, because the linear gain is smaller than that in Figure 3, the resulting instantaneous distortion of the output signal is less.

Appendix A – AES Paper on Grid Limit Distortion

Figures A-1 thru A-4 are reproduced from the paper: “Vacuum Tube Triode Nonlinearity as Part of The Electric Guitar Sound”, T. E. Rutt, Presented at the 76th Convention of Audio Engineering Society 0ctober 8-11, 1984, New York (Preprint 2141 F-5), available at http://www.coastin.com/AESPaper.pdf .

These figures provide a summary of the findings of that paper.

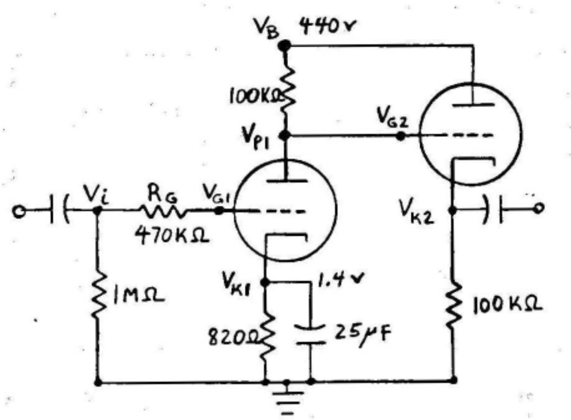

Figure A-1 - Class A triode stage with DC coupled cathode follower stage.

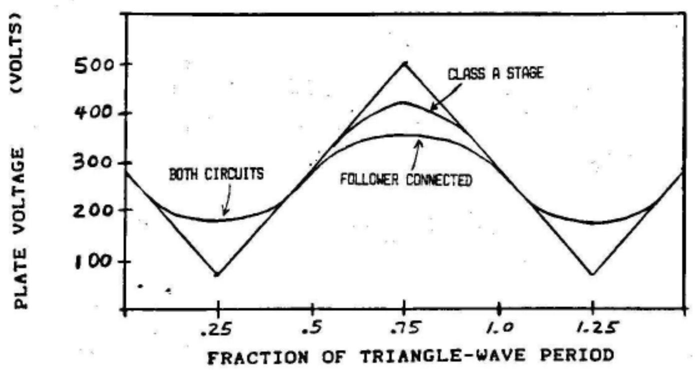

Figure A-2: Triangle-wave response, with modereate overload. Plate voltage of class A triode (see Figure A-1), is shown along with scaled and shifted input triangle wave. In first half cycle, the first stage grid current feedback distortion is evident. In second half cycle the plate voltage Vpl with follower connected is decreased relative to the class A plate saturation curve (with the follower stage not connected), due to grid current flow into cathode follower).

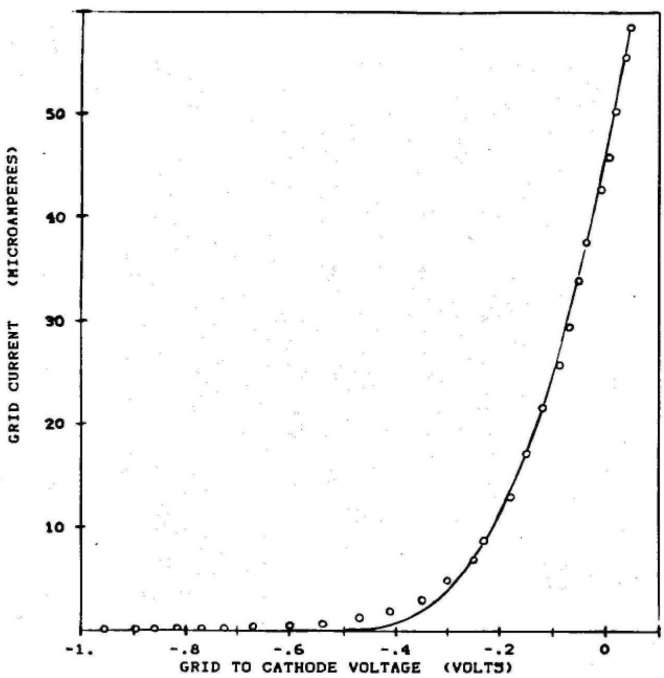

Figure A-3 - Grid current vs. grid to cathode voltage, 12AX7 triode. Circles indicate measured points, curve shows fitted equation. Ig = 3.le-4 * (Vgk + .53)**3 amperes.

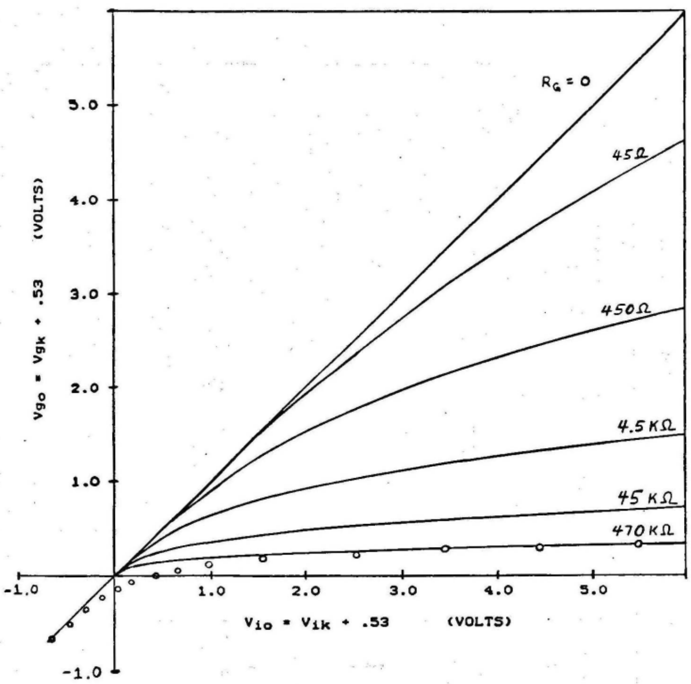

Figure A-4 – Grid Current Feedback: Vio = Vgo + a * Rg*(Vgo)**(3) , a = 3.le-4 amperes