ChowTape User Manual

ChowTape is an analog tape machine physical model, originally based on the Sony TC-260. The current version can be used to emulate a wide variety of reel-to-reel tape machines, using physics-based emulation algorithms[1]. The plugin is currently available for Windows, Linux, Mac, and iOS in the following formats: VST/VST3, AU, LV2, AAX, AUv3, and Standalone.

Installation

To install ChowTape for desktop, download the plugin installer from the ChowDSP website. If you would like to try the latest changes (unstable), you can download the latest Nightly build. It is also possible to compile the plugin from the source code. ChowTape for iOS can be downloaded from the App Store.

Figure 1: *A Sony TC 260 reel-to-reel tape machine*

[1]The plugin is based off a 2019 DAFx paper "Real-time Physical Modelling for Analog Tape Machines".

Figure 2: *ChowTape User Interface*

Controls

ChowTape contains a wide range of controls allowing the user to design the the physical characteristics of the tape machine and magnetic tape being emulated. Several of the controls even allow the user to achieve more "extreme" results than would be possible with a physical tape machine.

Main Controls

Input Gain controls the gain level going into the rest of the plugin. Note that abnormally large levels can cause the plugin to become unstable, so it is recommended that sound levels are at or below unity gain going into the plugin, and any extra gain should come from the input gain control.

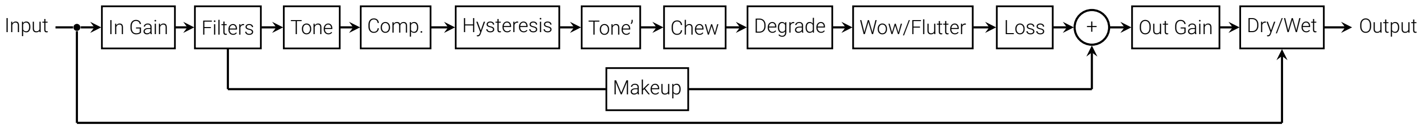

Figure 3: *Signal flow for the ChowTape plugin. Note that the Tone block contains a set of pre-emphasis filters, while the Tone' block contains the corresponding post-emphasis filters.*

Dry/Wet allows the user to choose how much of the signal they want to the plugin's processing to affect.

Output Gain controls the level coming out of the plugin.

Stereo - Mid/Side: When using ChowTape in "Stereo" mode, the plugin will process the input signal as a left/right pair. In "Mid/Side" mode, the plugin will encode the input signal as a mid/side pair, process the mid/side signal, and then decode the signal back to a left/right stereo pair at the output.

Oversampling controls the amount of oversampling being done internally within the plugin. More oversampling will result in a higher quality sound with fewer aliasing artifacts and better noise characteristics, but will also use more CPU. It is recommended to use as much oversampling as your CPU will allow.

Mix Group: When using ChowTape on multiple channels in a mix, you can synchronize parameters between plugin instances belonging to the same mix group. Essentially, all the plugin instances in the same mix group will share the same parameters.

Figure 4: *Input filter controls*

Input Filter Controls

The ChowTape input filters apply a low-cut and high-cut filter to the input signal before it is passed on to the rest of the plugin. The **Low Cut** and **High Cut** knobs control the cutoff frequencies of the two filters. The **Makeup** control allows the signal cut out by the input filters to be added back to the output of the plugin. This can be useful for allowing sub-bass frequencies to pass through the plugin unaffected.

Figure 5: *Tape hysteresis controls*

Hysteresis Controls

The hysteresis processing is the most important section of the plugin. Hysteresis is a complex nonlinear phenomenon that describes many natural processes in physics, biology, economics, and more. In particular, magnetic hysteresis describes the process by which tape becomes magnetised when subjected to a strong magnetic field. ChowTape emulates magnetic hysteresis, using the Jiles-Atherton[2] model of magnetic hysteresis. Magnetic hysteresis is largely responsible for the "warm" sound often associated with analog tape distortion.

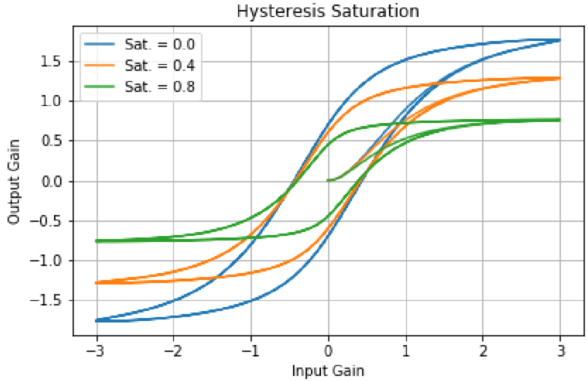

Figure 6: *Hysteresis curves with varying saturation*

Drive controls the level of amplification done by the hysteresis process. This differs from the input gain in that it affects the nonlinear characteristic of the hysteresis process.

Saturation controls the level at which the hysteresis function saturates. Higher values correspond to a lower saturation point, resulting in a more distorted sound.

Bias controls the amount of bias used by the tape recorder. Tape bias is the addition of an inaudible high-frequency signal to the audio signal[3]. At lower bias levels, the hysteresis curve becomes "wider", thus creating the "deadzone" effect often associated with underbiased tape.

[2] Jiles, D.C.; Atherton, D.L. (1984) "Theory of ferromagnetic hysteresis" *Journal of Applied Physics*.

[3] More information on tape biasing

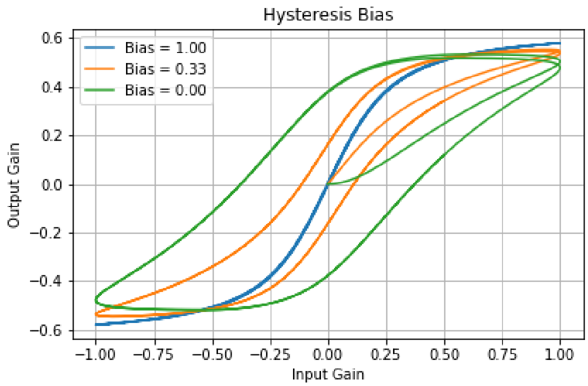

Figure 7: *Hysteresis curves with varying bias*

Hysteresis Mode selects the equation solver used to solve the Jiles-Atherton equation in real time. ChowTape currently supports the following hysteresis modes:

- 2nd-order Runge Kutta (RK2)
- 4th-order Runge Kutta (RK4)
- 4-iteration Newton Raphson (NR4)
- 8-iteration Newton Raphson (NR8)
- State Transition Network[4] (STN)
- Version 1.0 processing (V1)

The Runge-Kutta solvers are computationally cheaper, but somewhat less accurate than the Newton-Raphson solvers. Similarly, the higher-order solvers will be more accurate, but will also consume more compute resources. The State Transition Network is designed to be a computationally cheaper approximation of the NR8 solver; although it distorts more harshly at extreme settings. The V1 mode reverts to a different parameterization of the hysteresis equation that was used in earlier versions of the plugin. It is recommended to use higher-order solvers for mix busses and key tracks in a mix, while using lower-order solvers for less important tracks.

[4]Parker, J.D. et. al. (2019) "Modelling of Nonlinear State-Space Systems using a Deep Neural Network" *Proc. 22nd Int. Conference on Digital Audio Effects*.

Figure 8: *Tape compression controls*

Compression Controls

The compression section applies a characteristic compression curve to the signal, which can be useful for reducing the dynamic range of the signal before going into the hysteresis processing.

Amount controls the level at which the compression curve starts to take effect. At 0 dB, the compression has no effect on the signal. At 9 dB, any signal above -9 dB will start to be compressed.

The **Attack** parameter controls how quickly the compression will start to take effect once the signal enters the range where it is being compressed.

Similarly, the **Release** parameter controls how quickly the compression backs off once the signal is no longer in the compression region.

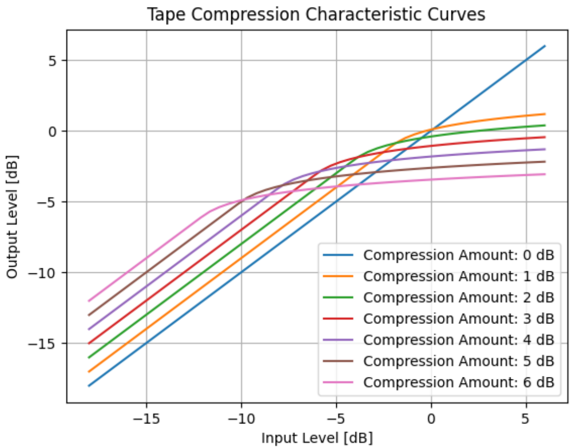

Figure 9: *Tape compression characteristic curves*

Tone Controls

The tone section applies a set of pre-/post-emphasis filters to the signal before and after the hysteresis processing is applied. The filters work similar to RIAA filters, in that the pre- and post-filters have exact opposite frequency responses.

The **Bass** and **Treble** knobs control the frequency response of the pre-emphasis filter, and the post-emphasis filter will automatically adjust. The **Frequency** knob controls the transition frequency between the bass and treble sections of the filter.

Figure 10: *Loss filter controls*

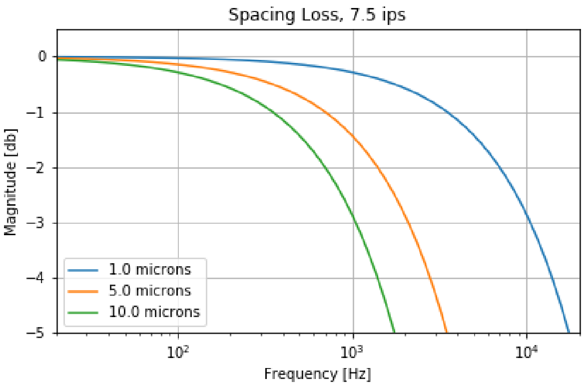

Figure 11: *Spacing loss at 7.5 ips*

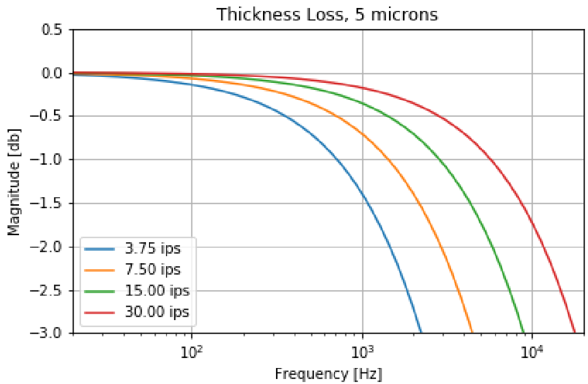

Figure 12: *Thickness loss for 5 micron tape*

Playhead Controls

Physical tape machines also have a frequency response that is affected by the amount of space between the playhead and the tape, the width of the playhead gap, and the thickness of tape used. The frequency responses of each of these "loss effects" is also dependent on the tape speed.

Spacing controls the amount of space between the playhead and the tape, measured in centimeters.

Thickness controls the thickness of the tape, measured in centimeters.

Gap controls the width of the playhead gap, measured in millimeters.

Azimuth controls the playhead alignment angle[5]. A misalignment between the playhead and the tape causes a corresponding time misalignment between the two stereo tracks on the tape, resulting in a stereo "widening" effect.

Speed controls the tape speed as it effects the above loss effects, measured in inches per second (ips). While this control is continuous, the parameter can be quantized to the standard speeds for reel-to-reel tape machines: 3.75, 7.5, 15, and 30 ips.

[5] More information on playhead azimuth.

Tape Degradation Controls

The degradatation parameters control a simulation of old tape that has been used over and over, and has started to degrade. **Depth** controls the intensity of the wear on the tape. Enable the **0.1x** option to make this control more subtle.

Amount controls the amount of wear, typically corresponding to the age of the tape.

Variance adds a time-varying randomness to the degradatation.

Envelope applies an amplitude envelope to the tape noise.

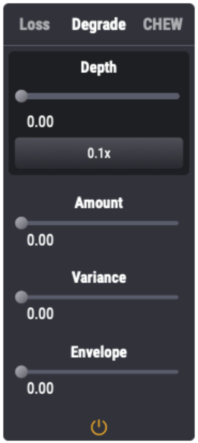

Figure 13: *Degradation controls.*

Chew Controls

The chew parameters simulate tape that has been chewed up by a broken tape machine. **Depth** controls how deep the tape is chewed, **Frequency** controls how much space there is between bits of tape that have been chewed up, and **Variance** determines how much randomness there is in determining the amount of space between chewed up sections.

Wow and Flutter Controls

Tape machines also exhibit timing irregularities, often due to small imperfections in the mechanics of the machine causing the tape to subtly speed up and slow down while being played back. The flutter characteristic in this plugin was captured from an original Sony TC-260 tape machine.

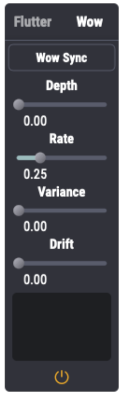

Figure 14: *Wow controls.*

Depth controls the depth of the flutter and **Rate** controls the rate of flutter, with higher values causing the flutter to occur faster. Note that the flutter rate can be synchronized to the tape speed, or to the tempo of the song.

"**Wow**" is similar to flutter but on a much longer time scale, and contains similar controls, as well as **Variance** and **Drift** which control the random irregularities that cause the wow characteristic.

Presets

Presets provide a quick way to achieve a specific sound with the plugin. ChowTape comes with a set of built-in factory presets. To contribute your presets to be added to the factory presets list for future releases, see the Presets GitHub issue.

User Presets

To save the current plugin state as a user preset, open the presets menu, and select "Save". The first time a preset is saved, you will be asked to choose a preset folder. All future presets will be saved to this folder, and when the plugin opens, it will search this folder, as well as any subfolders, to load new user presets. Presets located in subfolders will be placed in their own groups in the preset menu.

Open Source

ChowTape is open-source software that is free (as in "free beer"), and free (as in "free speech"), under the General Public License. As a research project, the goal of developing this plugin is to help advance the body of knowledge of real-time audio signal processing. Therefore, keeping any part of this project behind a paywall, or licensing this software under a proprietary license would be antithetical to that goal. As an open-source project, ChowTape is open to outside contributors. For more information, see our Contributing page.

Feedback

If you notice any bugs, or have any questions, feel free to email me directly, or create an issue ticket on GitHub. GitHub issues are preferred, since they are publicly visible.

Acknowledgements

Thanks to Yann from SINK Music for helping to create this user manual, as well as all the users of ChowTape who have made efforts to help improve the plugin.

Enjoy!

Jatin Chowdhury

https://github.com/jatinchowdhury18/AnalogTapeModel