TIATracker v1.0

Manual

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1 Introduction

TIATracker is a new music routine for the Atari VCS and a tracker/sequencer application for the PC for composing music that can then be played by the music routine on the VCS for inclusion in games and demos.

This manual targets both musicians and coders. For the impatient, section 2 “Quickstart“ provides a very brief introduction to get you started. Section 3 “VCS Audio“ explains the basic concepts and limitations of audio on the VCS from a user’s point of view. Skip this if you know the VCS already. Section 4 “For the Musician“ explains the concepts behind TIATracker and how to compose music with it, and 5 “For the Coder“ provides information and instructions to the coder how to integrate TIATracker music into their projects.

Several features and optimizations that are already planned have not yet made it into the current version. Contact me for requests, comments and bug reports at andre.wichmann@gmx.de and watch https://bitbucket.org/kylearan/tiatracker/ for new versions. Until then, have fun dealing with the limits of VCS music!

2 Quickstart

To quickly start composing music with TIATracker without reading the whole manual, follow these basic steps:

1. Adapt the keyboard shortcuts in the file "**keymap.cfg**" to your keyboard layout.
2. In the Options tab, select a preset **pitch guide** or create a new one if you roughly know which notes you will mainly want to use in your song.
3. Create or import instruments for your song in the "Instruments" and "Percussion" tabs. TIATracker supports two types of instruments:
   - **Melodic instruments** have a base waveform and an ADSR envelope for setting the volume and change the frequency at which a note gets played. Depending on the waveform, different notes are available (displayed on the piano keyboard at the bottom of the window). The duration of a note will be defined in the patterns of your song.
   - **Percussion instruments** can set a different waveform, frequency and volume value each frame. The duration of a percussion sound is determined by the number of frames, as each frame gets played exactly once. The pitch of a percussion instrument is defined by its frequency values and cannot be changed in the song.

   In both instrument editor tabs, right-click in the envelope area to insert or delete frames. In the percussion editor, right-click in the waveforms area to select and set a specific waveform, left-click to set the last selected waveform, or use the mouse wheel to scroll through all available waveforms. Press a key on the piano keyboard to hear the instrument.
4. The main track editor tab combines a **pattern editor** and **sequencer**. Right-click either in the column with the pattern names or in the timeline (on the right side) to get a pattern context menu. Use it to create, add, delete and move patterns, set the start pattern or edit goto commands. Right-click in a row of a pattern to get a channel and row/note context menu. Use it to insert or delete a row and to edit notes/commands in the row.

   A row can contain a percussion sound, a melodic instrument note, a **hold** command ("|") which continues to play the last note, a **pause**/rest command ("-") which sends a melodic instrument into release and then ends the note, or a **slide** command ("SL n") which changes the frequency of the currently played melodic instrument note. A pause or slide command is only valid while a melodic instrument note is playing.
5. The **Info** tab displays a detailed breakdown how many resources the song will use when played on the VCS. Use the "**export**" menu item to generate .asm files to include in your source code.

3 VCS Audio

The Atari VCS has 2 audio channels. For each channel there are three parameters that can be set to produce sound:

- **Waveform** (“Distortion”). There are 11 different waveforms: Silence, white noise, and 9 others. Two of them have the same timbre, but different frequency ranges (see below).
- **Frequency**. There are only 32 frequencies that each waveform can be played at. These frequencies unfortunately do not match traditional notes. Instead, many notes are missing completely, and most of the notes that are available are off-tune to varying degrees. Even worse, the frequency ranges differ across waveforms. Notes that are available for some waveforms are missing for others. Frequencies will differ slightly depending on whether the VCS is a PAL or NTSC machine.
- **Volume**. There are 16 different volume levels available.

The VCS has no filters, in-built ADSR envelopes are other features; only the three parameters above define the sound output for each channel.

For technical details and a list of all waveforms and frequencies see Eckhard Stolberg’s “Atari 2600 VCS Sound Frequency and Waveform Guide“ at http://home.arcor.de/estolberg/texts/freqform.txt. To hear all available waveforms and frequencies, have a look at the melodic or percussion instrument tabs in TIATracker.

4 For the Musician

TIATracker, the tracker/sequencer application, can be used to compose and hear VCS music on the PC. It uses the sound emulation routines from the VCS emulator Stella, which are good but not perfect, and when a song is finished, you can export it to source code for inclusion into a game or a demo. Some of the general concepts are very similar to concepts from tracker/sequencer software for other platforms, but some of them are very specific to the VCS.

The file “keymap.cfg” which is in the same folder as the TIATracker program itself contains all keyboard shortcut definitions. You will want to adapt this to your local keyboard layout and personal habits.

4.1 General Concepts

Song anatomy

A song in TIATracker is defined by two ***sequences*** of patterns, one sequence per channel. A ***pattern*** is a list of rows, each containing a note, a pause or a command, that will be played sequentially and that can be of variable length. Each sequence can play the same pattern multiple times, and playback of both channels is independent from each other, i.e. a pattern playing on one channel does not need to have the same length as the pattern playing at the same time on the other channel.

The player routine updates once per TV ***frame***, i.e. 50 times per second on PAL systems and 60 times per second for NTSC. A ***speed*** value defines how may frames a note is played before the next row in the pattern is consulted for what to play next. For example, a speed of five means that every five frames a new note gets played, which means 10 notes per second will be played on a PAL system (or 12 notes on an NTSC system). Even and odd rows can have different speed values so that every second note can last shorter or longer than the others, potentially giving the music a "funky" style.

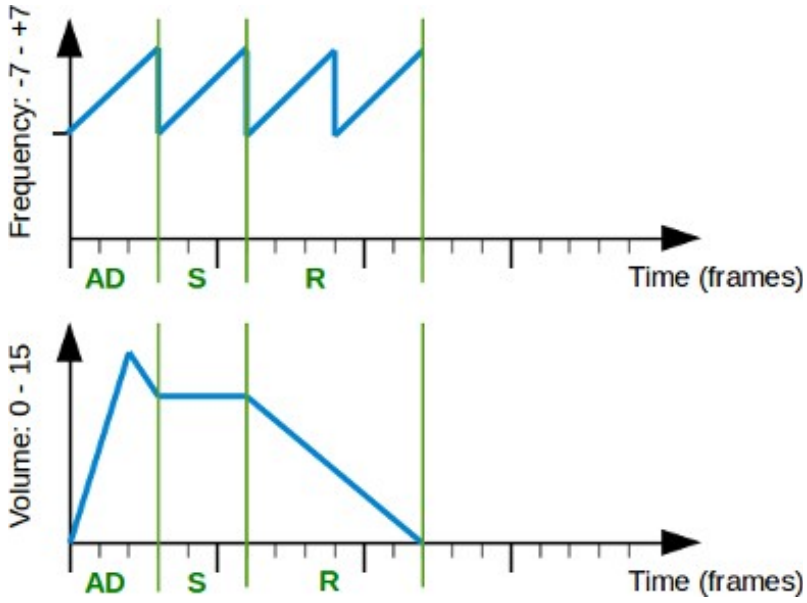
Instruments

There are two fundamentally different types of instruments in TIATracker: Percussion and melodic instruments. Both types get updated by the player every frame.

Percussion instruments can set a new value for waveform, frequency and volume each frame. When a percussion is encountered in a pattern, each frame of the respective percussion instrument gets played exactly once, unless a new note in the pattern interrupts it and cuts it off. A percussion instrument cannot be played at a different pitch, since each frame exactly defines which frequency to use.

Melodic instruments have a base waveform value that stays the same for all its frames, but they can be played at different frequencies as defined in the patterns to form melodies. To modulate each note, a melodic instrument can set a different volume value each frame and modify the note frequency by a value between -7 and +7 for arpeggio or tremolo effects.

A melodic instrument's lifetime is divided into three phases: Attack/Decay, Sustain, and Release. Together they define frequency and volume ***ADSR envelopes*** for this instrument, as depicted in the following graphics (the small ticks mark frames, the larger ticks the song speed, in this case 5).



The ADSR envelope models the fact that notes can be played with different durations. When a note starts, all frames of the Attack/Decay phase are played. Afterwards, the Sustain phase frames are

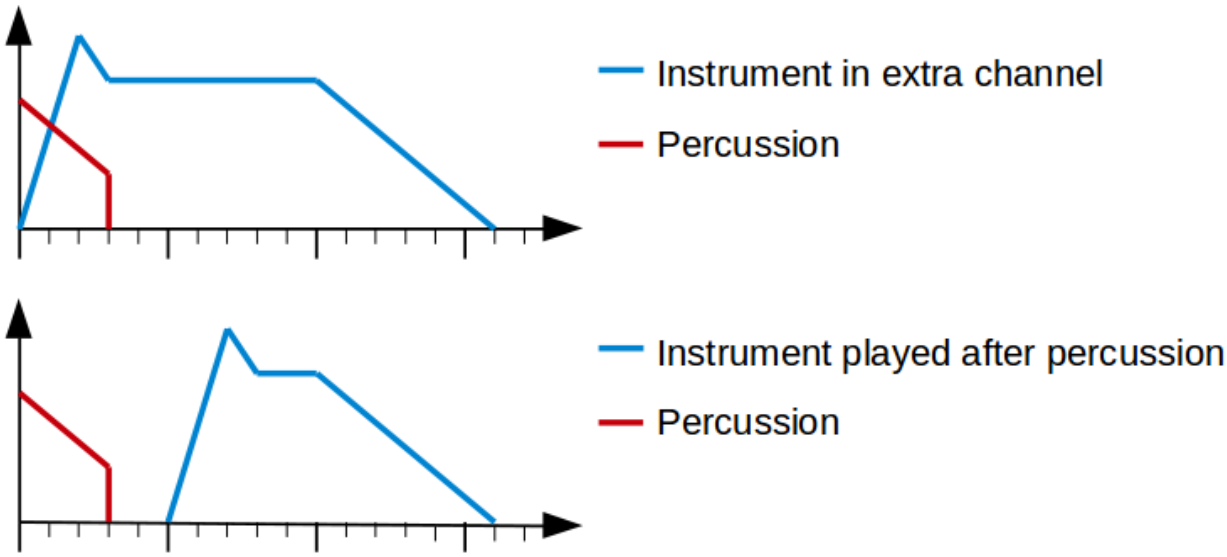
played in a loop. When a pause note is encountered in the pattern, the Release phase frames are played once and the note ends. If a new note is encountered in the pattern instead of a pause, the new note simply cuts off the current instrument without sending it into the Release phase.

Since melodic instruments can be used to play different notes, they have a base waveform that cannot be changed each frame. This is because available frequencies vary across different waveforms, and thus playing a specific note for one waveform makes no sense for another waveform, where the frequency for that note might not be available. For the same reason, percussion instruments cannot be played at different frequencies, as they might set different waveforms each frame.

Frequency values range between 0 and 31, and the frequency value can modulate the currently played frequency by +/- 7.. Note that the this might cause an underflow or overflow for some notes. In that case, the values simply wrap from low to high frequencies or vice versa, which might or might not be intended by the musician.

Overlay Percussion

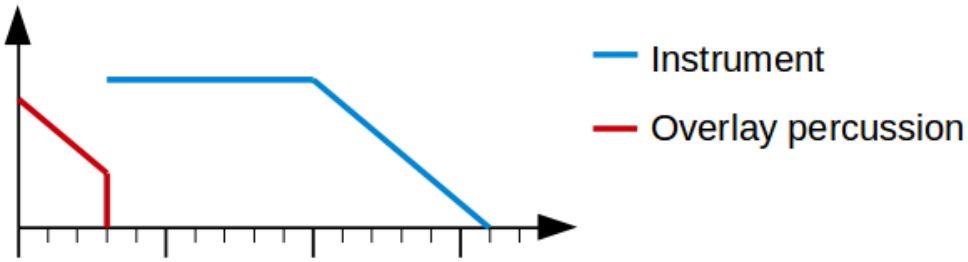
In normal music, you typcially have percussion instruments and melodic instruments playing at the same time, for example by arranging them in different channels. With only two channels, this is more difficult to do on the VCS, and the composer will have to play percussion and melodic instruments in the same channel in quick succession to create the audio illusion that they are played simultaneously. This is depicted in the following graphics.



The top picture shows the ideal situation, where the melodic and percussion instruments are played simultaneously in different channels. The bottom picture shows what happens if the composer plays them one after the other in the same channel. In this example with a song speed of 5, you have a gap of two ticks after the percussion has finished before the next note is played.

TIATracker has the option to mark a percussion instrument as an ***overlay*** instrument. When an overlay percussion instrument has finished playing, the next note will be fetched out of order regardless of tempo. If it is a note for a melodic instrument, it will be played immediately, skipping

its Attack/Decay phase and starting it in the Sustain phase right away. This is depicted in the following graphics.



Since percussion instruments are often louder, this can help to create the illusion that both instruments have been played at the same time but the percussion instrument has drowned out the first couple of frames from the melodic instrument.

4.2 Creating Instruments

TIATracker supports up to 7 melodic and up to 15 percussion instruments.

Melodic Instruments

In the melodic instruments editor tab, use the drop-down list in the top left corner to name your melodic instrument and to switch between the available instruments. The ***import*** and ***export*** buttons save and load individual instruments independent from the song, and ***delete*** clears the envelope and name of the currently selected instrument.

You can select the base waveform with the drop-down list in the lower right. Apart from the physically available waveforms, there's also a special convenience waveform called ***Pure Combined***. This combines the two so-called "pure" waveforms (Pure Low and Pure High), which have the same timbre but different note ranges, into one "virtual" waveform with 64 instead of 32 frequencies. This allows the musician to compose a melody without having to switch between the two real "pure" waveforms depending on which note is needed. When the song gets exported and played on the VCS, TIATracker will automatically generate two different instruments (which share the same envelope) using the two "pure" waveforms and assigns the notes in the song accordingly. For this reason, the Pure Combined waveform counts as two instruments.

The ADSR envelope can be defined using the ***envelope length***, ***sustain start*** and ***release start*** controls. Note that a melodic instrument does not need to have an attack/decay phase, but the sustain and release phases both need to contain at least one frame. In the middle of the window, the volume and frequency envelopes are graphically displayed with the sustain phase highlighted in the background. Left-click in a frame to set a new value, and right-click for a context menu to insert and delete individual frames.

The ***peak volume*** control shows the highest volume value of the whole envelope. Use it to shift all volumes up and down, to make the instrument louder or quieter as a whole.

Finally, click and hold on a key on the piano keyboard to hear how the melodic instrument sounds.

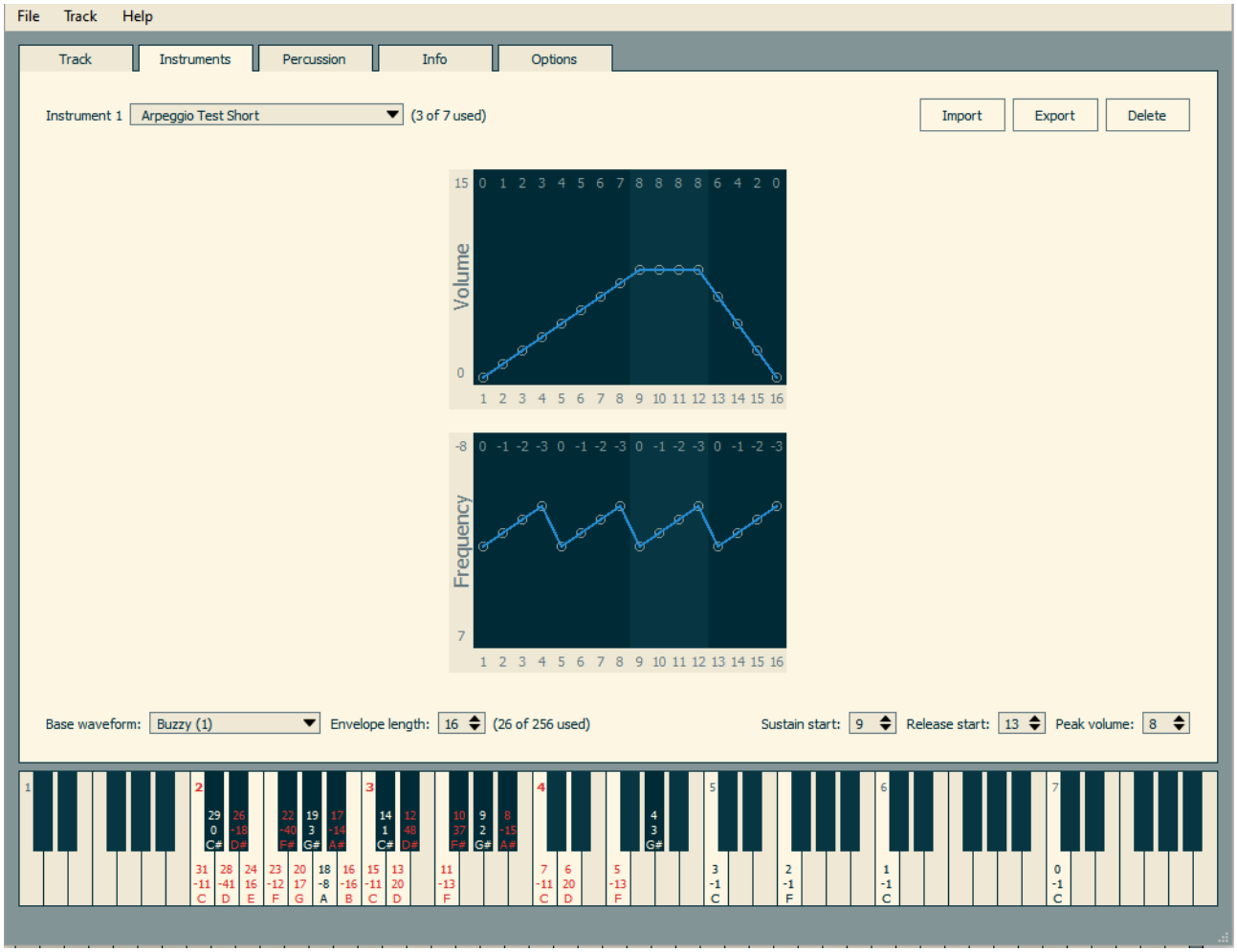


Illustration 1: The melodic instrument editor tab

The Piano Keyboard

The piano keyboard at the bottom of the window displays which notes are available for the selected waveform, and how off-key they sound. Each available note has its frequency value listed as well as the percentage how far it deviates from the “real” frequency of the note. If this percentage is greater than a threshold value (which can be adjusted in the Options tab), the note is displayed in red.

The exact details which notes are available for each waveform and how much out of tune they are depends on the currently selected pitch guide (see XXX). Note that this is only a visual aid for the musician. The song itself stores raw frequency values instead of notes, so selecting a different pitch guide will only change the *labels* on the piano keyboard and the rows in the track, not how the song sounds.

Apart from clicking with the mouse, you can also use keyboard shortcuts to access three consecutive octaves on the piano keyboard. Small numbers printed in red on the top of each C note key denote which three octaves can currently be accessed via keyboard shortcuts, and you can shift these three octaves also via a set of keyboard shortcuts.

Percussion Instruments

The percussion instruments editor tab is very similar to that for melodic instruments. In addition to setting the values for volume and frequency, you can also set the waveform individually per frame. Right-click in the waveform area to select and set the waveform for a frame. A left click sets it to the last selected waveform, so you can use it to quickly set several frames to a specific waveform. In addition, you can use the mouse wheel to cycle through all available waveforms.

Since percussion instruments cannot be played at different pitch, the piano keyboard does not display any pitch guide. Use any key to on the piano keyboard to hear how the currently selected percussion instrument sounds.

4.3 Composing Music

The user interface in the “Track” tab is used to compose a song and mainly consists of three areas, from left to right: The instrument selector, the pattern editor, and the timeline. Above those are the player and some option controls.

4.3.1 Instrument selector

Use the ***instrument selector*** to select the melodic or percussion instrument you want to use for editing. Depending on the selected instrument, the piano keyboard will show which notes are available based on the waveform of the melodic instrument and the pitch guide selected in the options tab. In case of percussion instruments, no pitch guide is shown and any key can be used to enter the percussion instrument into a pattern.

4.3.2 Timeline

The ***timeline*** on the right side of the window summarizes the pattern sequences for both channels, with alternating colors signifying when a new pattern starts. Hover the mouse over a pattern to see its name in a tooltip, and left-click on a pattern to jump to that position in the pattern editor. A right-click opens a pattern context menu which can also be accessed by right-clicking in the pattern area of the pattern editor, as described in the next section.

The blue line marks the current position of the editor cursor. The orange line shows the current position of the song player.

4.3.3 Pattern Editor

The ***pattern editor*** area in the center of the “Track” tab combines an way for entering notes into patterns and a sequencer for arranging the patterns into a song. For each channel, the patterns are displayed in the order they should be played. The rows of each pattern are displayed in the inner columns, and the outer columns contain the pattern names and potential goto commands. In the center between the channels are timestamps for the current position. Use the mouse wheel or the corresponding keyboard shortcuts to move the editing cursor (the highlighted row in the middle). A right-click in the area with the pattern names opens a pattern-specific context menu where you can

modify the pattern sequence. A right-click on a specific row opens a context menu for modifying rows.

Editing a pattern

A row in a pattern can either be a percussion instrument, a note for a melodic instrument, a “hold” command, a “pause” command, or a “slide” command. Use the instrument selector to change the currently active instrument.

- To enter a note for a ***melodic instrument***, you can use the piano keyboard on the bottom of the screen. Which notes are available for a given melodic instrument depends on the selected pitch guide (see section XXX). Alternatively, three octaves are mapped to keyboard shortcuts (see section 6.1.3). The currently selected octaves are displayed in red on the piano keyboard, and they can be changed using keyboard shortcuts as well. If you select a melodic instrument in the selector, the octaves automatically get set so that the lowest note of the instrument is in the lowest octave accessible via keyboard.

  If you want to enter a note with a specific frequency value not available on the piano keyboard, use the “Change frequency...” item in the context menu.

- To enter a ***percussion instrument***, simply press any key on the piano keyboard or use any corresponding keyboard shortcut.

- A “***Hold***” command is shown as a “|” symbol in the pattern and can be entered with the corresponding keyboard shortcut. When playing the song, it means that the currently played note should continue playing. In case of a percussion instrument, this means that it simply continues to play frame after frame and that it falls silent afterwards. In case of a melodic instrument, it means that the sustain phase is looped as long as more “Hold” commands are encountered.

- A “***Pause***” command is shown as a “=” symbol in the pattern and can be entered with the corresponding keyboard shortcut. When a melodic instrument is currently played, it will cause it to play its release phase and fall silent afterwards.

  It is not valid to place a “Pause” after a percussion instrument or a “Hold” command. This will throw an error when the player routine of the tracker arrives at that row, and will cause undefined behavior in the VCS player routine. (This is due to size optimizations of the VCS player routine.)

- A “***Slide***” command is only valid when a melodic instrument is currently playing, and modifies the frequency of the currently played note by a value between -7 and +7. Use the “Set to slide...” item in the context menu to enter this command.

  It is not valid to place a “Slide” after a percussion instrument or a “Hold” command. This will throw an error when the player routine arrives at that row, and will cause undefined behavior in the VCS player routine.

You can also insert or delete rows in a pattern by using the context menu or the corresponding keyboard shortcuts. Note that editing a row in a pattern means that all occurrences of that pattern in the sequences will be modified.

As a pure visual aid, the pattern editor highlights every n-th row of a pattern so that something like regular measures can be visualized, helping the musician to recognize where for example a beat starts. The "***Rows per beat***" control specifies the distance between two highlighted rows.

Sequencing

The pattern context menu, accessible via right-click either in the area with the pattern names or in the timelime, is used to create, delete, rename and order patterns in a channel sequence as well as set start patterns and goto commands. For each channel there is one pattern marked as the ***start pattern***, which is where replay begins. From there, it will play patterns in the order as they are displayed in the sequence and the timeline. A ***goto*** command at the end of a pattern forces the player to jump to the specified pattern. That way, loops can be created.

The same pattern can be played several times during a sequence. The "***insert pattern***" menu item lets you either insert an existing pattern, or create and insert a new, empty pattern. If you ***create*** a ***new*** pattern, a dialog appears where you can specify the name and the length of the new pattern. The "***Align***" button automatically sets the length to a value so that the end of the new pattern aligns itself with the end of the pattern played at the same time in the other channel. This makes it easier to keep patterns in both channels in sync.

You can also ***duplicate*** a pattern. This creates a copy of the current pattern which you can then edit without changing any occurrences of the original pattern in the sequences.

"***Remove pattern***" only removes the current instance of a pattern from the sequence; the pattern itself can still be used elsewhere. If you remove the last instance of a pattern, TIATracker will ask if it should delete the pattern definition itself as well, in which case you will no longer be able to insert it again into the song. Note that when you later export your song to assembly language, unused patterns will not get exported and will not use any resources, so you don't need to delete unused patterns if you think you might need that pattern later.

4.3.4 Song Player

even/odd tempo

Play/stop; errors

Follow

Loop Pattern

Mute channel

4.4 Info and Options Tabs

Pitch Guide

5 For the Coder

Export data vs. complete. Worst case measure

which to include where

resource consumption: see info tab

page boundary pitfalls

6 Appendix

6.1.1 Licences and Third-party Code

The tracker application is published under GPLv2 and can be found at https://bitbucket.org/kylearan/tiatracker. It uses SDL2 (https://www.libsdl.org) and Qt5 (http://www.qt.io). It also uses the TIA sound emulation from the Stella emulator (http://stella.sourceforge.net).

The player routine for the VCS is published under the Apache license v2 (http://www.apache.org/licenses/LICENSE-2.0).

6.1.2 Acknowledgements

Thanks to Nikola “juice” Fox for feedback and advice on TIATracker and how trackers work in general.

Also big thanks to Thomas Jentzsch for spending a lot of time with a very early alpha version of TIATracker and coming back with good questions and suggestions.

Sagamusix was kind enough to answer my newbie questions about tracker keyboard shortcuts and German vs. international musical scales.

6.1.3 Keyboard Shortcuts

The file “keymap.cfg” in the TIATracker folder contains the definitions for all keyboard shortcuts. In its default configuration, it’s configured for a German keyboard layout and loosely follows some conventions from OpenMPT.