



OPEN SOURCE HARDWARE



Technical Details

RETROCADE SYNTH



Overview

The RetroCade synth puts classic audio chips in the hands of musicians and hackers.


There are several Open Source VHDL recreations of classic audio chips available on the Internet. The RetroCade project connects these hardware definitions to the ZPUino Soft Processor which allows everything to be controlled by an Arduino style sketch.



The heart of the project is the ZPUino soft processor which is a 32 bit soft processor running at 100Mhz. It uses a modified version of the Arduino IDE which allows everything to be controlled by a sketch. By connecting the classic audio chips to the ZPUino's Wishbone bus we are creating a System on a Chip solution for generating audio!



Features

- Hardware
 - Xilinx FPGA
 - 2 – ¼" Stereo Audio Jacks
 - MIDI – In, Out, Through
 - uSD Card
 - MicroJoystick – 4 directions, Select
 - 2x16 LCD Display
 - 16 Analog inputs for sliders and knobs
 - 16 Digital inputs for switches and peripherals
 - Synth
 - Commodore 64 SID
 - Atari STYM2149
 - Amiga MOD Files
 - Dashboard (Optional)
 - VSTi plugin or standalone executable
 - Control all features in real time
 - Full source code for easy customization
 - Made with SynthMaker
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FPGA Technology

What is an FPGA?

Why use an FPGA?

Microcontroller vs. FPGA?

Open Source Papilio FPGA



What is an FPGA?

- FPGA's (Field Programmable Gate Array) are like the rewritable CD's of electronics.
- You use a bit file to burn a hardware design onto an FPGA.
- When you burn a hardware design to an FPGA it BECOMES that hardware.
- Hardware designs can be anything you can dream up, in this case it is a ZPUino processor with Open Source recreations of classic audio chips connected.
- You can easily burn other hardware designs to the FPGA. After loading the RetroCade bit file you can play PacMan by loading a bit file that turns the Papilio FPGA into a PacMan Motherboard!

Why use an FPGA?

- The FPGA allows us to do things that would not be possible otherwise!
- We can connect multiple audio chips at the same time.
- We can connect as many instances of an audio chip as can fit in the FPGA. (I.E. a 12 voice SID chip!)
- We can make a library of hardware based digital effects and connect them to the outputs of the audio chips.
- The audio chips are connected inside the FPGA so no messy wiring is needed.
- The final solution is a very fast **HARDWARE** solution, not software emulation.

Microcontroller vs. FPGA?

- The Arduino is an example of a Microcontroller and the Papilio is an example of an FPGA.
- The Arduino uses a sketch to tell it what to DO.
- The Papilio uses a bit file to tell it what to BE.
- For the RetroCade, we load a bit file that tells it to BE an Arduino compatible system with audio chips attached.
- Once we tell it to BE an Arduino compatible piece of hardware we then load the RetroCade sketch to tell it what to DO.
- Sketches are loaded with a modified version of the Arduino IDE!

ZPUino System on Chip

What is ZPUino?

What's in the RetroCade bit file.

ZPUino System on Chip Solution

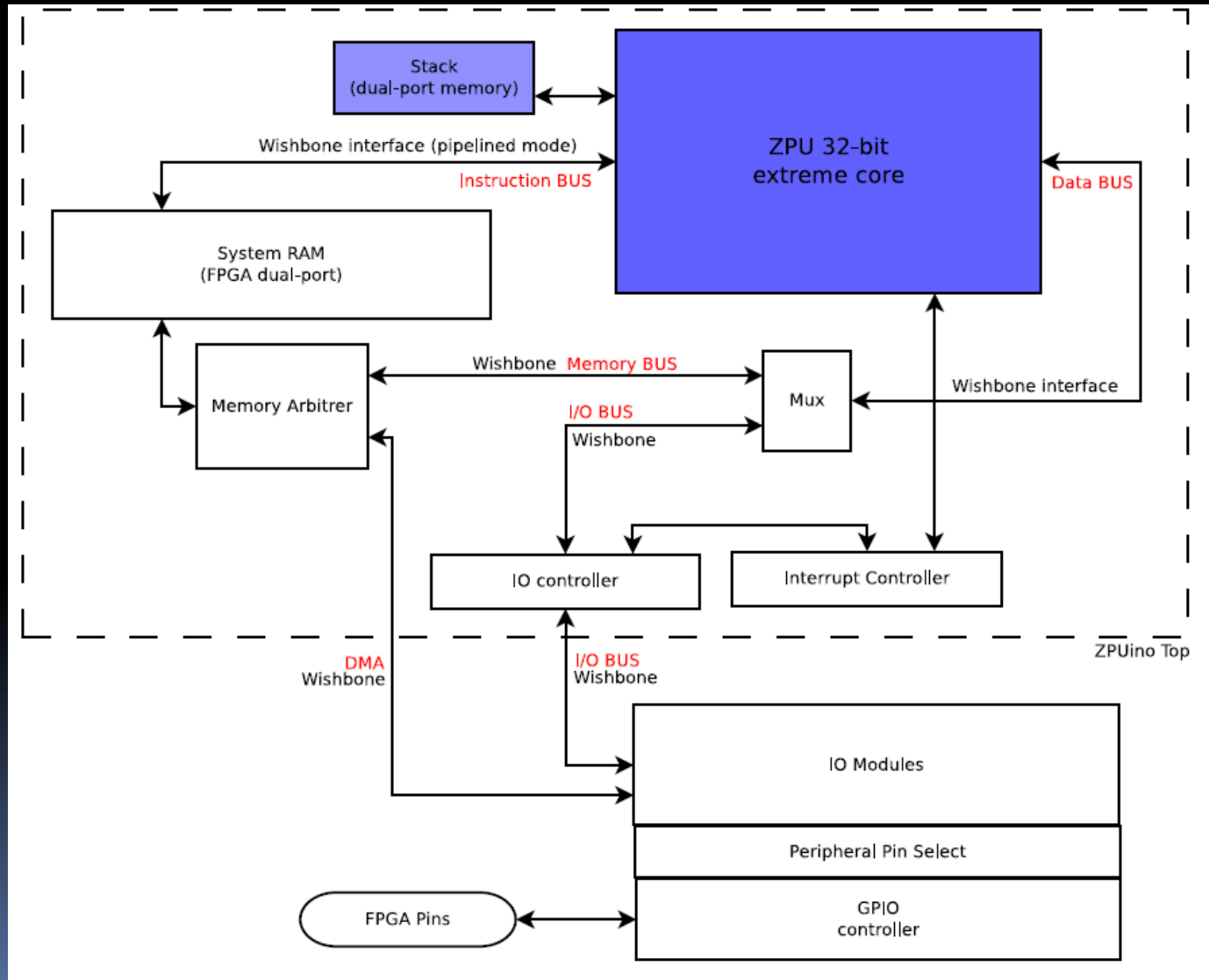


ZPUino³²

What is ZPUino?

- ZPUino is the heart of the RetroCade Synth project.
- 32 bit soft processor running at 96Mhz.
- Uses a modified version of the Arduino IDE to load sketches.
- Wishbone bus for connecting peripherals such as our audio chips.
- Actively maintained and developed by Alvaro Lopes.
- To learn more visit: <http://www.alvie.com/zpuino>

ZPUino Block Diagram



What's in the RetroCade bit file.

RetroCade Bit File

Soft Processor



Wishbone Bus

Peripherals

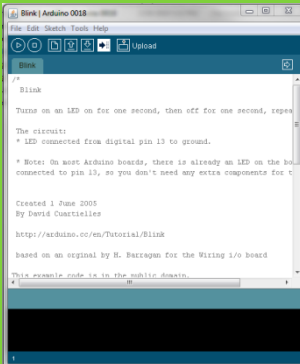
Atari ST - YM2149



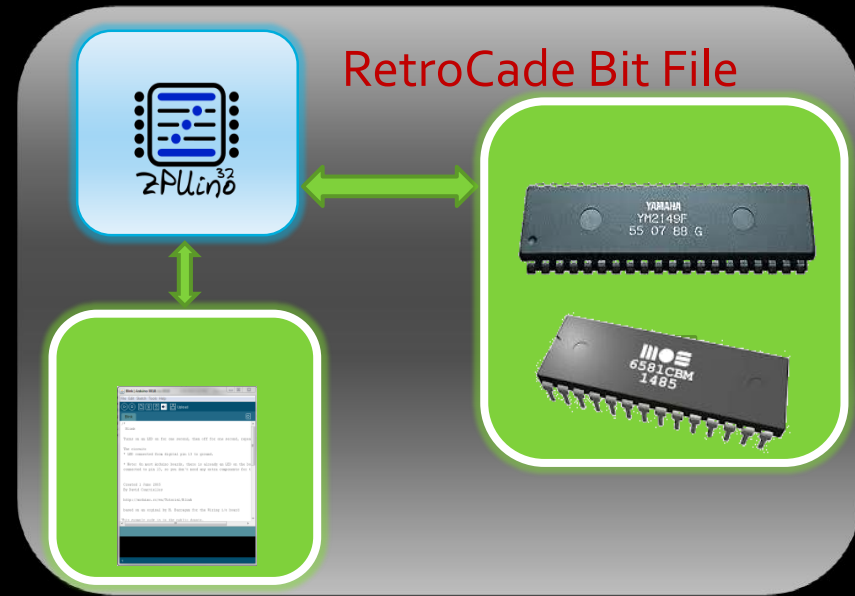
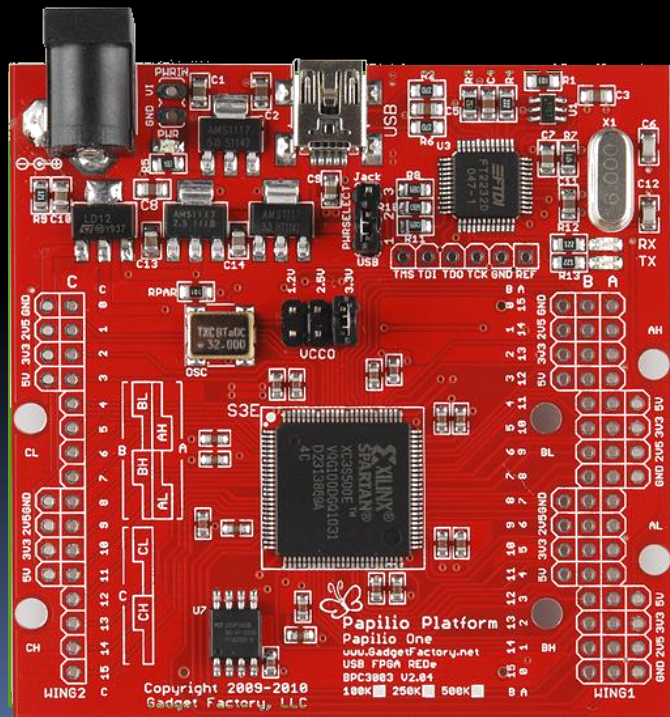
Commodore - SID



System RAM
RetroCade Code




ZPUino System on Chip Solution





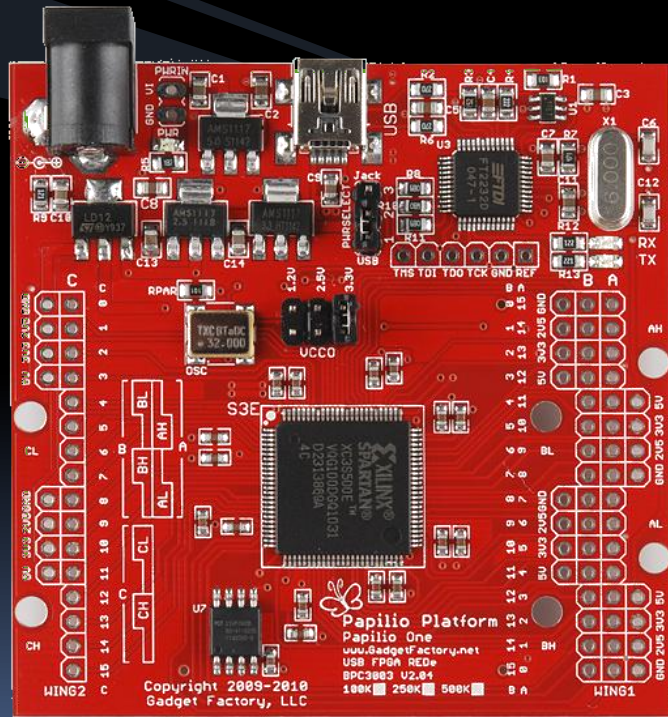
Audio Chips

- The audio chips are Open Source VHDL implementations that recreate the SID and YM2149 inside the FPGA.
 - It is not software, the VHDL files tell the FPGA how to connect transistors inside the FPGA to make real hardware.
 - The VHDL files are created by talented VHDL developers by studying datasheets, observing the original chips, and even from interviews with the original designers.
 - VHDL Developers like MikeJ@FPGAArcade.com and Jan Derogee decided to release their work as Open Source, which allowed us to connect them to the ZPUino and make the RetroCade Synth.
 - There are many more VHDL definitions for other classic audio chips, like the NES and Atari 2600, that can be implemented.
 - The designs are not perfect, but they are VERY good. Since they are Open Source we will be able to fix any bugs.
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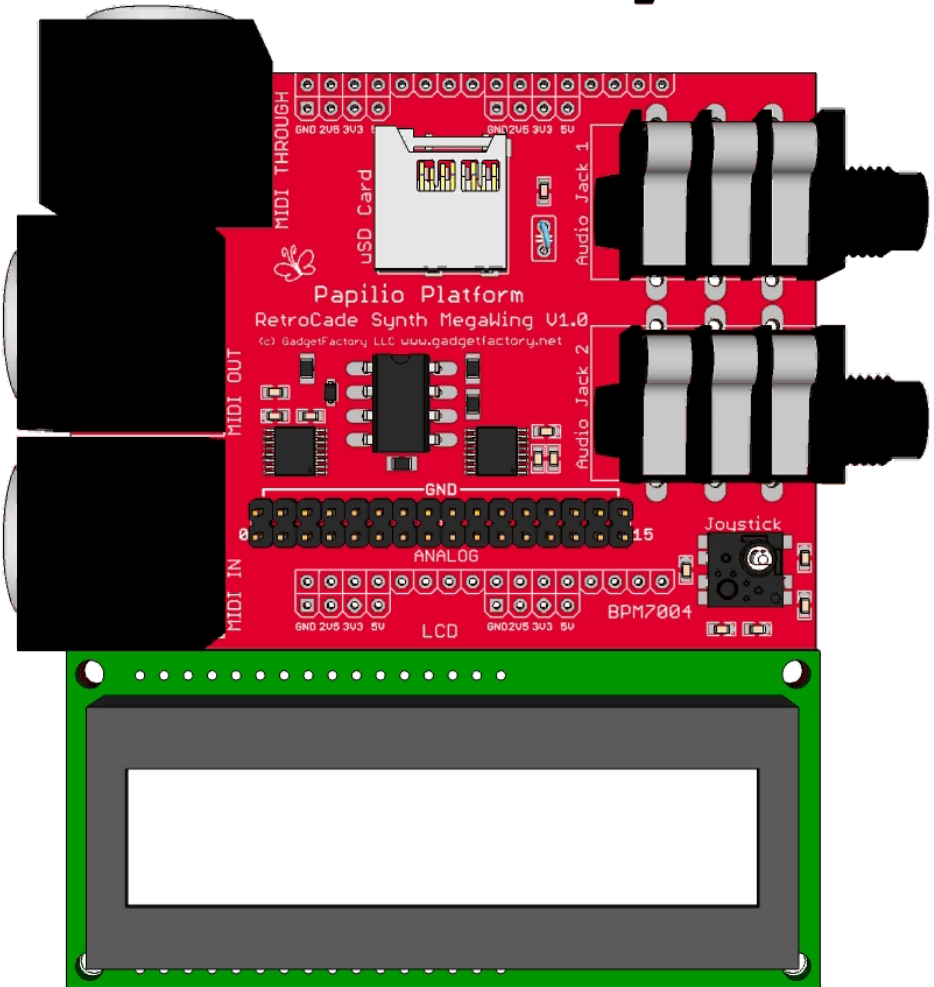
Hardware

Papilio FPGA

RetroCade MegaWing

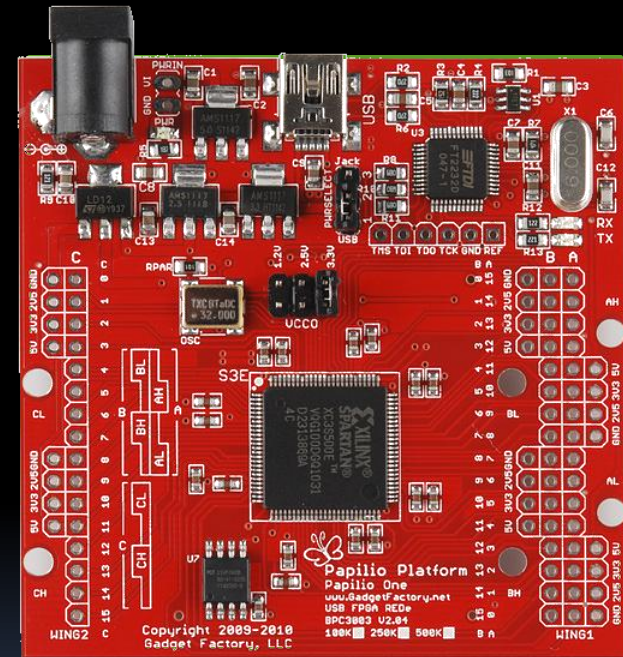


RetroCade Synth



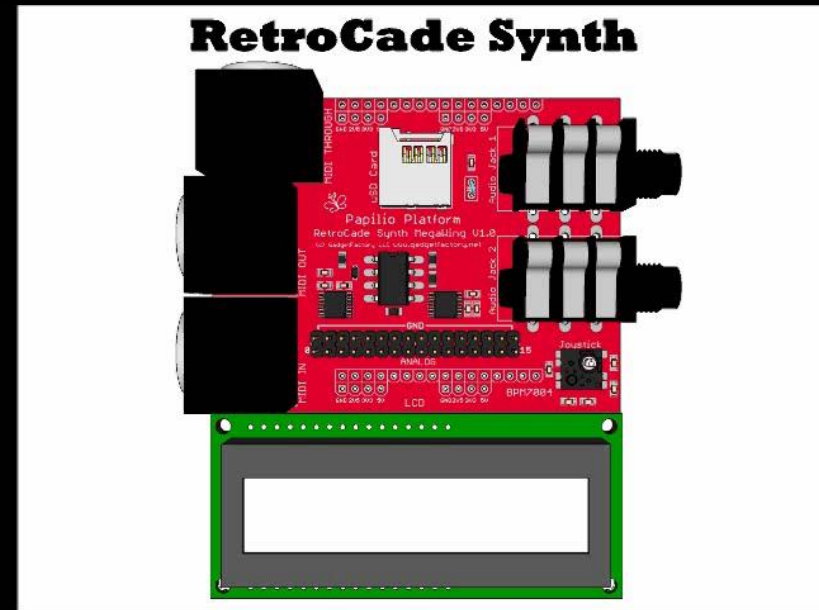
Open Source Papilio FPGA

- The RetroCade Synth is built on the Open Source Papilio FPGA boards.
- Everything needed to load bit files over USB is integrated into the board.
- Papilio MegaWings are like Arduino Shields. Connect the RetroCade MegaWing, load the RetroCade bit file and you have the RetroCade Synth.
- Swap out the RetroCade MegaWing for the Arcade MegaWing, load the PacMan bit file and you have the PacMan Motherboard! Completely new hardware with minimal fuss.



RetroCade Megawing

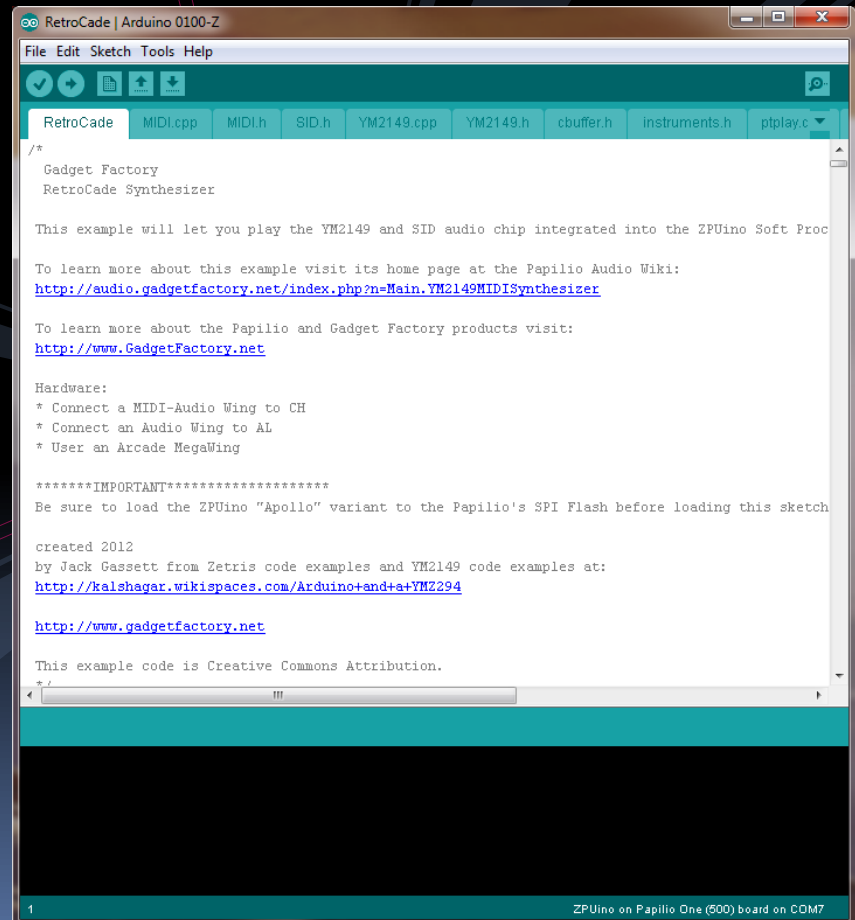
- Snaps onto Papilio FPGA
- 2 – 1/4" Stereo Audio Jacks with 18 bit Delta Sigma DAC
- MIDI – In, Out, Through
- uSD Card for MOD, MIDI, ym, sid, and config files
- MicroJoystick – 4 directions, Select
- 2x16 LCD Display
- 16 Analog inputs for sliders and knobs
- 16 Digital inputs for switches and peripherals



ZPUino Sketch

The Sketch defines the RetroCade's firmware and handles all MIDI functionality and implements support for all file formats.

- MIDI Functionality
- Modify Control Change #'s
- Manage Amiga MOD Files
- Manage Ym Files
- Set default states
- Pitch Bend



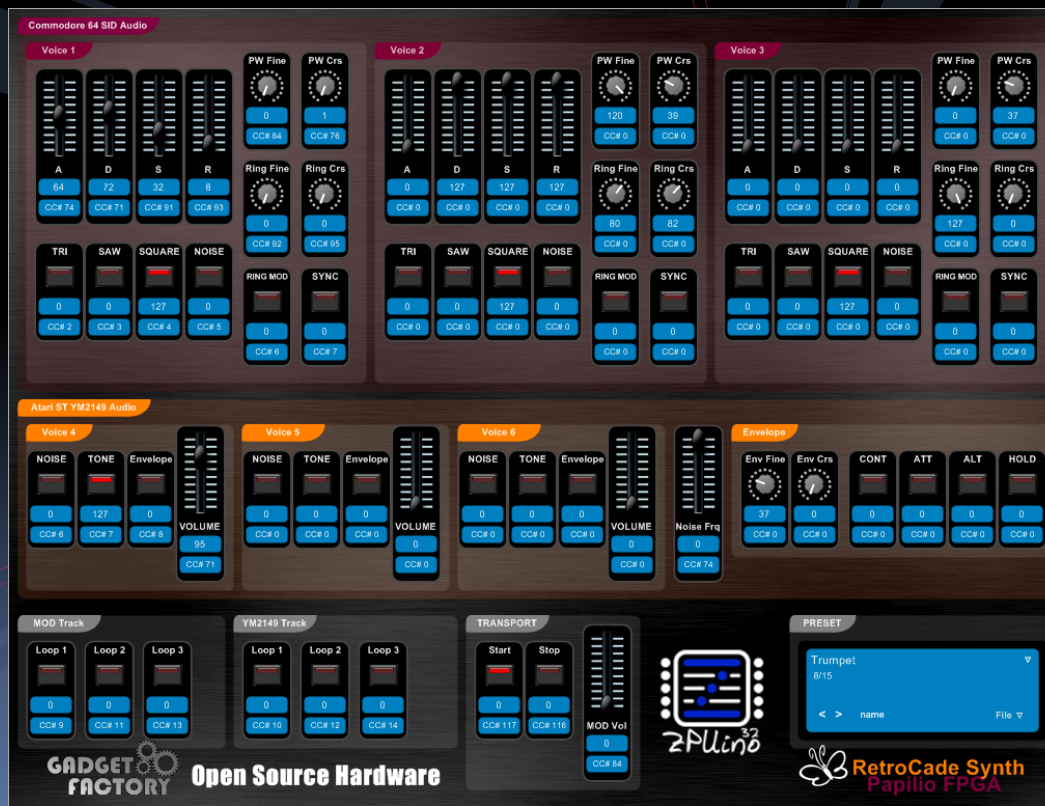
The screenshot shows the Arduino IDE interface with the RetroCade sketch loaded. The window title is "RetroCade | Arduino 0100-Z". The menu bar includes "File", "Edit", "Sketch", "Tools", and "Help". The toolbar contains icons for opening, saving, and running. The file explorer shows the sketch files: "RetroCade", "MIDI.cpp", "MIDI.h", "SID.h", "YM2149.cpp", "YM2149.h", "cbuffer.h", "instruments.h", and "ptplay.c". The main text area contains the following code:

```
/*  
  Gadget Factory  
  RetroCade Synthesizer  
  
  This example will let you play the YM2149 and SID audio chip integrated into the ZPUino Soft Proc  
  
  To learn more about this example visit its home page at the Papilio Audio Wiki:  
  http://audio.gadgetfactory.net/index.php?n=Main.YM2149MIDISynthesizer  
  
  To learn more about the Papilio and Gadget Factory products visit:  
  http://www.GadgetFactory.net  
  
  Hardware:  
  * Connect a MIDI-Audio Wing to CH  
  * Connect an Audio Wing to AL  
  * User an Arcade MegaWing  
  
  *****IMPORTANT*****  
  Be sure to load the ZPUino "Apollo" variant to the Papilio's SPI Flash before loading this sketch  
  
  created 2012  
  by Jack Gassett from Zetris code examples and YM2149 code examples at:  
  http://kalshegar.wikispaces.com/Arduino+and+a+YM2294  
  
  http://www.gadgetfactory.net  
  
  This example code is Creative Commons Attribution.  
*/
```

The status bar at the bottom indicates "ZPUino on Papilio One (500) board on COM7".

Control Dashboard

- The Control Dashboard is made with SynthMaker in order to make it as easy as possible for anyone to make changes to the interface.
- The Control Dashboard can be used as a VSTi Plugin, a Standalone Executable, or in SynthMaker.
- The Dashboard is provided as an intuitive way to control the RetroCade Synth but is not required. All RetroCade functions can be controlled from a MIDI controller.



Supported Files

The RetroCade Synth can loop files as backing tracks.

The following is supported from SPI Flash now:

- Amiga MOD files – Can be created with OpenMPT, Renoise, or any MOD tracker.
- YM files – Can be created with Arkos Tracker or any YM tracker.

The following will be supported:

- MIDI files from a SD card or SPI Flash.
- SID files from SD card or SPI Flash.