Build Your Own Portable Gaming System

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If you have not already done so:

Download the pre-requisites instructions and complete all downloads and installations

http://prereqs.codemash.org/

Download at least one Doom1 WAD to your laptop
https://www.wad-archive.com/wad/Doom-Shareware-v1.9

Slide deck download (PDF):
https://github.com/DigiTorus86/Teensy-R4ge-Pro/tree/master/documents

Session Objectives

Load and run different emulators and games on the hardware.

Learn how to use the Teensy Audio Library and hardware peripherals in custom games and other programs.

Troubleshoot and resolve any lingering hardware issues.

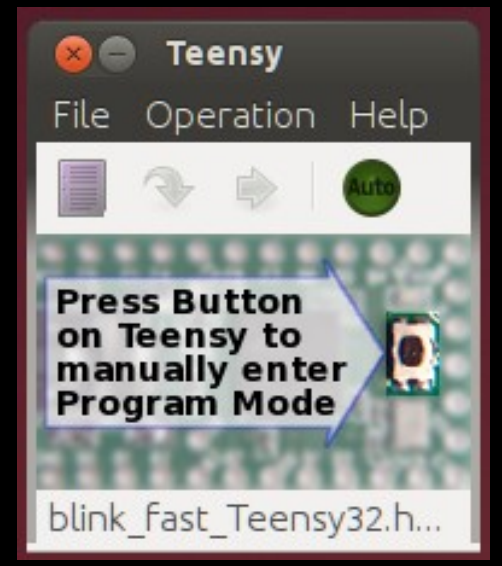
Pre-Requisites

- Working Teensy R4ge Pro with 8MB PSRAM installed
- VS Code with Platformio and Teensy platform
- Arduino IDE with Teensyduino
- Micro SD card formatted for FAT32
- Clone of https://github.com/Jean-MarcHarvengt/MCUME/
- Clone of https://github.com/DigiTorus86/Teensy-R4ge-Pro/

IDE Setup and Verification

Are you ready?

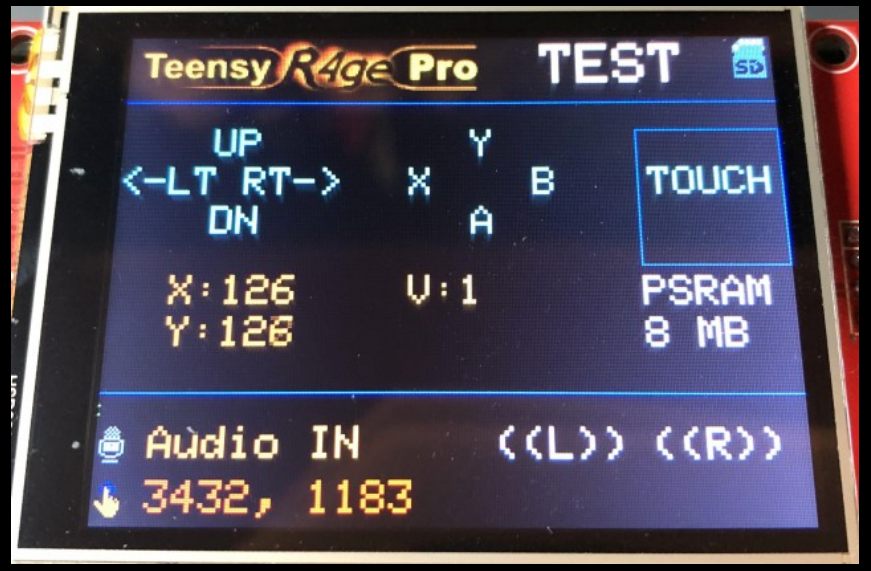
Arduino IDE



1. Ensure Teensy is connected to your laptop via USB
2. Launch the Arduino IDE
3. Open the teensy-r4ge-pro-test sketch
4. Under Tools → Board, select “Teensy4.1”
5. CPU Speed: “600 MHZ”
6. Select the Port that the Teensy is on (this will vary by system and OS)
7. Programmer: “AVR ISP” or “AVR ISP mkII”
8. Go to Sketch → Upload (or click the right arrow button)
9. Should compile and the Teensyduino app should launch

Verification

- Ensure that all peripherals are still working as expected. Use the instructions in the header comments if needed.
- Change line 155 to some other (family-friendly) short word.
- Re-upload and verify that the title text changed accordingly.
- The test app is a good resource for simple example code to use the hardware and peripherals.



Doom

What to do when all hell breaks loose

A Brief History

- Originally released in December 1993
- Source code released in 1997
- Many sequels and spin-offs

Prepare the SD Card

1. Create a local folder named “MCUME-SD”
2. Extract the sd.zip file from the MCUME repo to it.
3. Copy the DOOM1.WAD file to the data folder.
4. Copy the contents of MCUME-SD to the micro SD card root.
   (The data folder should be at the SD root.)
5. Insert the SD card into the Teensy.

Source and Settings

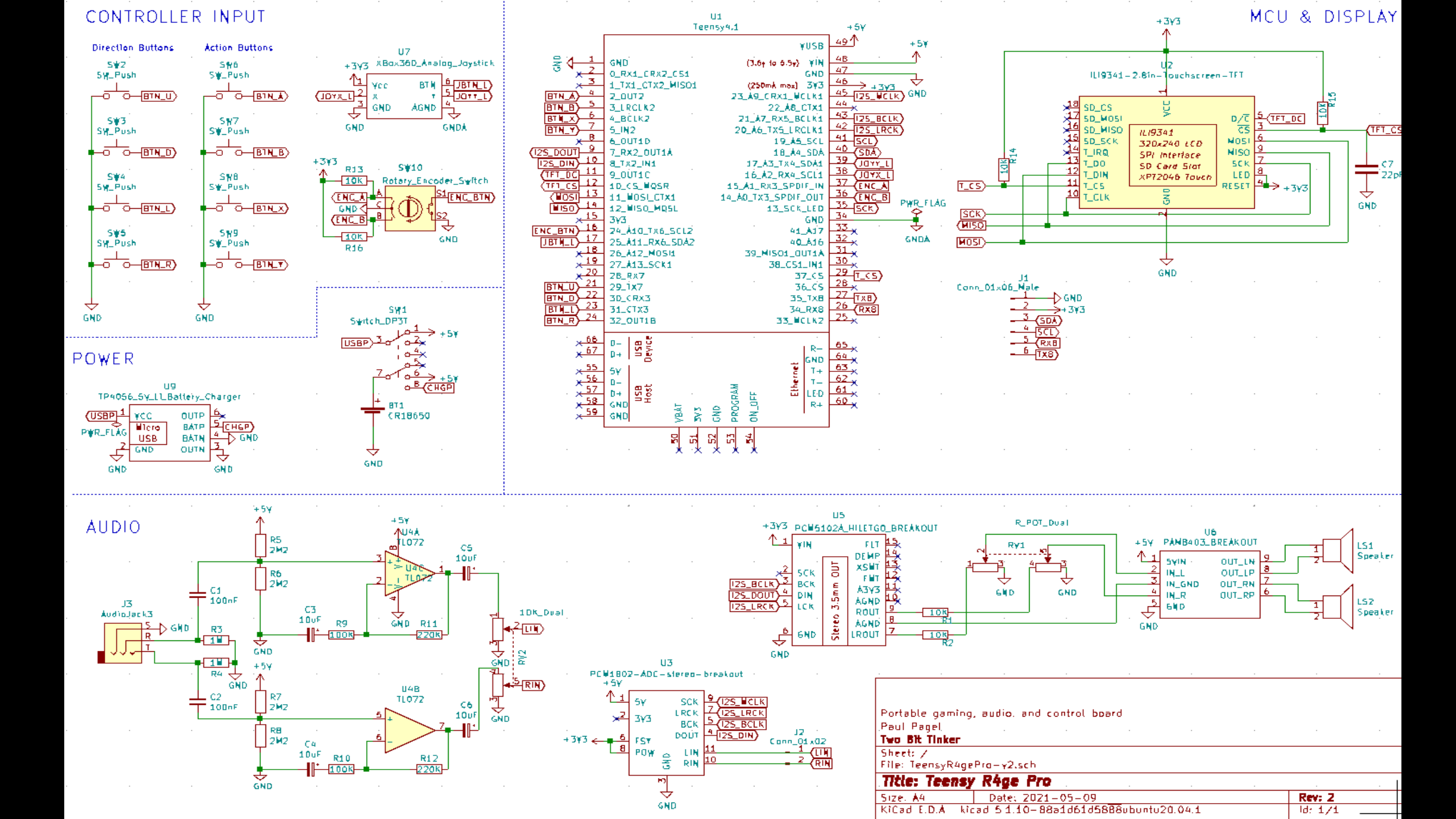
1. In the ArduinoIDE, open the Teensy-R4ge-Pro/MCUME/teensydoom/ folder.
2. Under Tools → Optimize, select “Faster”
3. Upload the sketch to the Teensy.

Doom Modifications — iopins.h

```
#define TFT_CS          10
#define TFT_RST         255

#define PIN_JOY2_A1X    16
#define PIN_JOY2_A2Y    17
#define PIN_JOY2_BTN    25
#define PIN_KEY_USER1   2 // BTN A
#define PIN_KEY_USER2   3 // BTA B
#define PIN_KEY_USER3   4 // BTN X
#define PIN_KEY_USER4   5 // BTN Y
```

```
// Second joystick
#define PIN_JOY1_BTN     24  // Encoder button
#define PIN_JOY1_1       29  // UP
#define PIN_JOY1_2       30  // DOWN
#define PIN_JOY1_3       32  // RIGHT
#define PIN_JOY1_4       31  // LEFT
```


CONTROLLER INPUT
Direction Buttons
Action Buttons
SW2 SW_Push BTN_U
SW3 SW_Push BTN_D
SW4 SW_Push BTN_L
SW5 SW_Push BTN_R
SW6 SW_Push BTN_A
SW7 SW_Push BTN_B
SW8 SW_Push BTN_X
SW9 SW_Push BTN_Y
GND
U7 XBox360_Analog_Joystick
+3V3
JOYX_L
JOYY_L
JBTN_L
GNDA
R13 10K
SW10 Rotary_Encoder_Switch
ENC_A
ENC_B
ENC_BTN
R16 10K
SW1 Switch_DP3T
USBP
CHGP
+5V
BT1 CR18650
POWER
U9 TP4056_5V_LiBattery_Charger
PWR_FLAG
U1 Teensy4.1
+5V
GND
BTN_A
BTN_B
BTN_X
BTN_Y
I2S_DOUT
I2S_DIN
TFT_DC
TFT_CS
MOSI
MISO
ENC_BTN
JBTN_L
BTN_U
BTN_D
BTN_L
BTN_R
USB Device
USB Host
Ethernet
VBAT
3V3
PROGRAM
ON_OFF
PWR_FLAG
MCU & DISPLAY
U2 ILI9341-2.8in-Touchscreen-TFT
ILI9341 320x240 LCD SPI Interface SD Card Slot XPT2046 Touch
SD_CS
SD_MOSI
SD_MISO
SD_SCK
T_IRQ
T_DO
T_DIN
T_CS
T_CLK
D/C
CS
MOSI
MISO
SCK
LED
RESET
R14 10K
R15 10K
C7 22pF
J1 Conn_01x06_Male
SDA
SCL
RX8
TX8
AUDIO
U4A TL072
U4B TL072
C1 100nF
C2 100nF
C3 10uF
C4 10uF
C5 10uF
C6 10uF
R5 2M2
R6 2M2
R7 2M2
R8 2M2
R9 100K
R10 100K
R11 220K
R12 220K
R3 1M
R4 1M
J3 AudioJack3
10K_Dual
RV2
LIN
RIN
U5 PCM5102A_HILETGO_BREAKOUT
Stereo 3.5mm OUT
R_POT_Dual
RV1
R1 10K
R2 10K
U6 PAM8403_BREAKOUT
LS1 Speaker
LS2 Speaker
U3 PCM1802-ADC-stereo-breakout
J2 Conn_01x02
Portable gaming, audio, and control board
Paul Pagel
Two Bit Tinker
Sheet: /
File: TeensyR4gePro-v2.sch
Title: Teensy R4ge Pro
Size: A4
Date: 2021-05-09
Rev: 2
KiCad E.D.A. kicad 5.1.10-88a1d61d58~88ubuntu20.04.1
Id: 1/1

Doom Modifications - platform

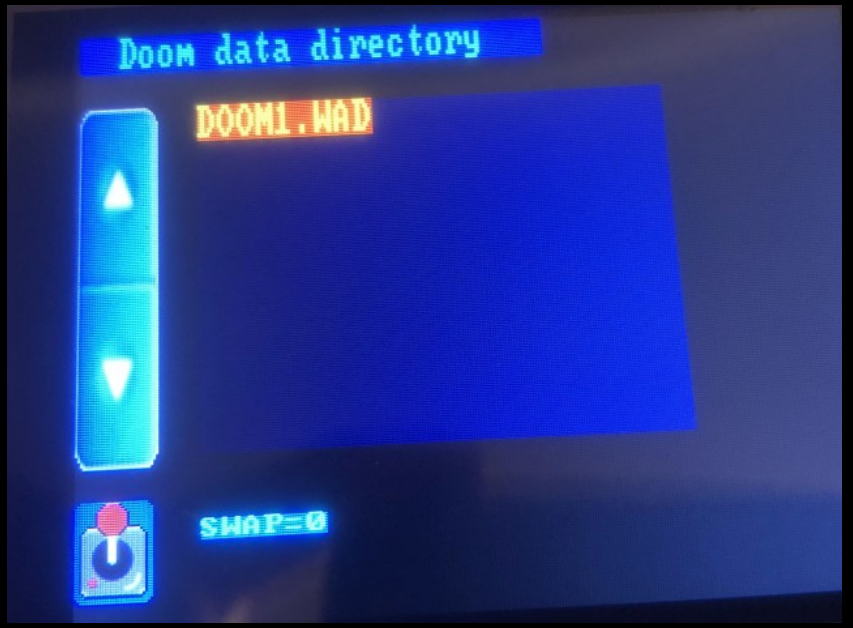
platform_config.h changes:

```
#define INVX        1
#define INVY        1
#define ILI9341     1
```

Running the Emulator

- Use the Up/Down buttons or joystick to change selection.
- Press rotary encoder button to select file.
- Press Y button to reset emulator.

If screen is blank, re-insert SD card and reboot hardware.



Playing Doom™

- Change menu selection: Up/Down buttons or joystick
- Select menu, get item: A button
- Fire: Rotary encoder button
- Door/switch: B button
- Show Map: X button

Unfortunately, no sound available.

Other Emulators

Running old systems on new hardware

General Instructions

- Obtain emulator game files.
- Copy game files to corresponding emulator folder on SD card.
- Copy the iopins.h and platform_config.h files from the Digitorus86/Teensy-R4ge-Pro/MCUME folder to the MCUME/MCUME_teensy41/ folder.
- Load the emulator into ArduinoIDE.
- Select the appropriate Tools->Optimize setting.
- Upload to the Teensy.

Castaway — Atari ST

1. Save .st game files to “st” folder on SD card.
2. Copy the iopins.h and platform_config.h files from the Teensy-R4ge-Pro/MCUME/teensycastaway41/ to the MCUME/MCUME_teensy41/teensycastaway41/ folder.
3. Load into ArduinoIDE and select “Smallest Code” option.

Castaway — Verified Games

- 1943 (with sound)
- 23 Games
  - Battlezone
  - Joust
- Arkanoid
- Caves of Rigel
- Crossbow
- Defender of the Crown
- Dragon Spirit
- Flying Shark
- Fusion
- Ivanhoe
- Karate King
- Slightly Magic
- Super Sprint
- Twin World

Ultimate Amiga Emulator

1. Save .ADF or .HDF files to “amiga” folder on SD card.
2. Copy the iopins.h and platform_config.h files from the Teensy-R4ge-Pro/MCUME/teensyuae41/ to the MCUME/MCUME_teensy41/teensyuae41/ folder.
3. Load into ArduinoIDE and select “Smallest Code” option.

Nofrendo — NES

1. Save files to “nes” folder on SD card.
2. Copy the iopins.h and platform_config.h files from the Teensy-R4ge-Pro/MCUME/teensynofrendo/ to the MCUME/MCUME_teensy/teensynofrendo/ folder.
3. Load into ArduinoIDE and select “Faster” option.

Nofrendo — Verified Games

- Super Mario Brothers
- Tetris
- Donkey Kong
- Donkey Kong Jr.
- Elevator Action
- Galaga
- Faxanadu
- Ms. Pac Man
- Q*Bert
- Xevious

USB Keyboard

Teensy can act as a USB host for peripherals, such as a keyboard. Some games (especially for computer emulators) will require a keyboard.

To use:

- Attach host cable to Teensy with black wire to left, red to right.
- Attach USB device to host cable.

UAE — Verified Games

- Battle Squadron
- Elite
- SturmTruppen
- Turrican
- Turrican 3

Custom Sketches

Creative DIY Hackery

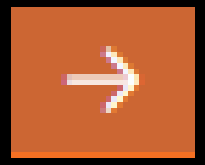
VS Code + PlatformIO

If you plan to do any custom development, VS Code + PlatformIO is **STRONGLY** recommended!

- Modern IDE
- Much better developer experience
- Excellent industry support

VS Code + PlatformIO

1. Launch VS Code.
2. File → Open folder:
   Teensy-R4ge-Pro/PlatformIO/teensy-r4ge-pro-test
3. Make sure the Teensy is connected to your laptop.
4. Click the upload button in the
   bottom toolbar.

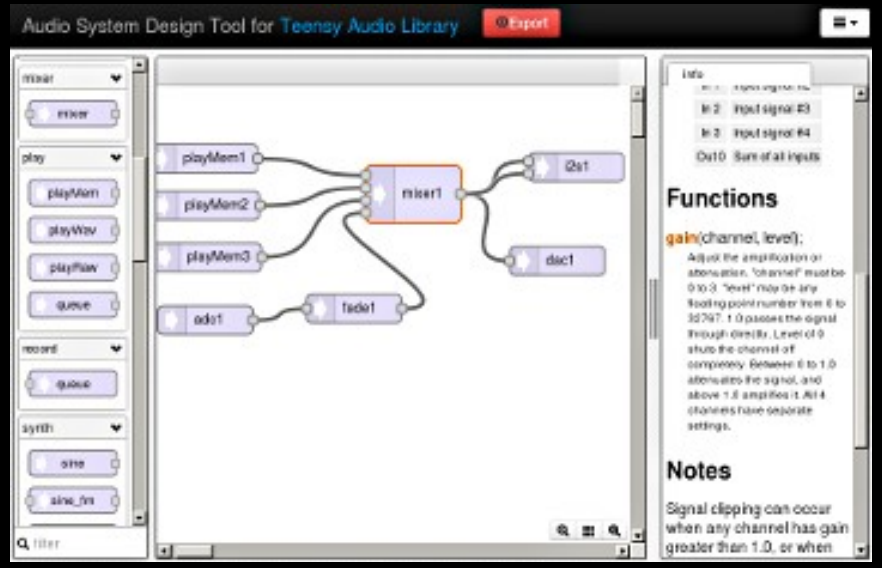


Teensy Audio

Teensy 4.1 is capable of sophisticated, high-quality audio generation, capture, and processing.

Online Audio Design GUI
https://www.pjrc.com/teensy/gui/

Imports and exports C code



Teensy Audio Network

Basic Structure:

Source(s) → Effects/Filters/Mixers → Output

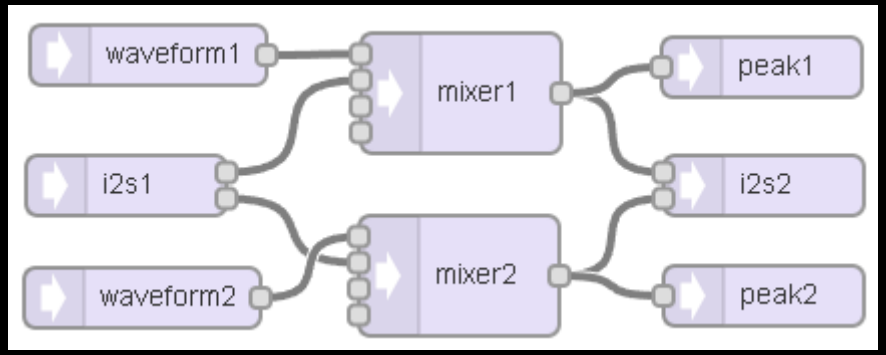
Synthesizers
WAV files → Low Pass → I2S DAC (Inter IC Sound)
I2S ADC

Chorus/Reverb
Channel Mix

Teensy Audio - Import

1) Launch Teensy Audio GUI in browser:
   https://www.pjrc.com/teensy/gui/?info=AudioMixer4
2) Copy the code between the //GUItool comments in test sketch
3) Click IMPORT on the Audio GUI and paste into the textbox

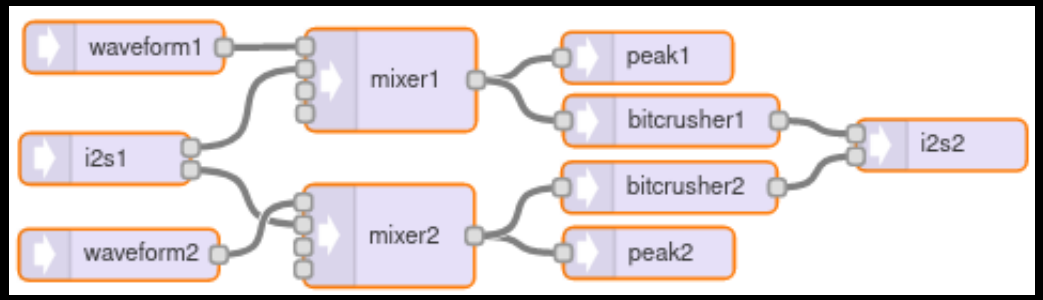
Sources



Output

Teensy Audio - Export

1) Modify the signal chain as shown:
2) Export to clipboard and paste back into sketch.



3) Add the following at line 185 in the sketch:

```
bitcrusher1.bits(4);
bitcrusher2.bits(8);
```

4) Upload the sketch and hear the difference by pressing the left and right buttons.
5) Experiment with other bit values and/or filters.

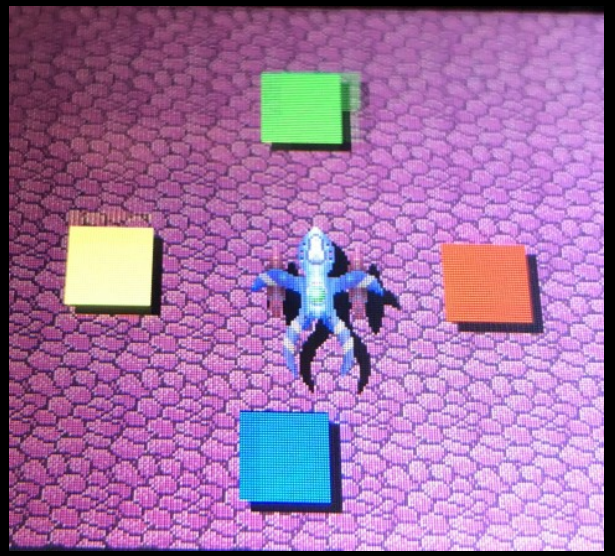
```
// GUItool: begin automatically generated code
AudioInputI2S            i2s1;           //xy=668.75,348
AudioSynthWaveform       waveform2;      //xy=676.75,404
AudioSynthWaveform       waveform1;      //xy=679.75,283
AudioMixer4              mixer2;         //xy=834.75,393
AudioMixer4              mixer1;         //xy=835.75,302
AudioAnalyzePeak         peak1;          //xy=985.75,289
AudioAnalyzePeak         peak2;          //xy=986.75,403
AudioEffectBitcrusher    bitcrusher2;    //xy=998.75,364.75
AudioEffectBitcrusher    bitcrusher1;    //xy=999.75,325.75
AudioOutputI2S           i2s2;           //xy=1157.75,340
AudioConnection          patchCord1(i2s1, 0, mixer1, 1);
AudioConnection          patchCord2(i2s1, 1, mixer2, 1);
AudioConnection          patchCord3(waveform2, 0, mixer2, 0);
AudioConnection          patchCord4(waveform1, 0, mixer1, 0);
AudioConnection          patchCord5(mixer2, peak2);
AudioConnection          patchCord6(mixer2, bitcrusher2);
AudioConnection          patchCord7(mixer1, peak1);
AudioConnection          patchCord8(mixer1, bitcrusher1);
AudioConnection          patchCord9(bitcrusher2, 0, i2s2, 1);
AudioConnection          patchCord10(bitcrusher1, 0, i2s2, 0);
```

Teensy Graphics

- Use the Teensy-specific (xxx_t3) graphic libraries for most applications.
- Use the direct memory access (DMA) libraries for situations where fastest performance is required. https://github.com/KurtE/ILI9341_t3n
- Graphics performance limited by speed of SPI bus between Teensy and the display.

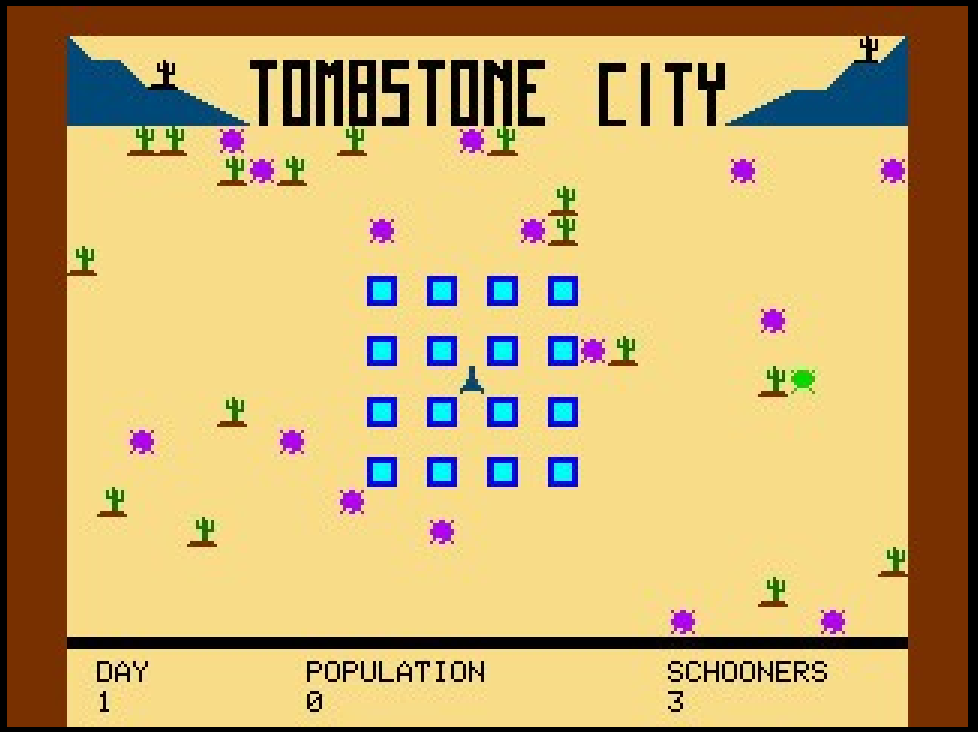
Teensy Graphics — Demo

- Load the sketch: Teensy-R4ge-Pro/PlatformIO/teensy-r4ge-pro-shooter-demo
- Demonstrates full screen scrolling, transparent drawing, and simple rotational movement.



Tombstone City

- Teensy-R4ge-Pro/PlatformIO/teensy-r4ge-tombstone
- An emulation of the classic TI-99/4A game by John Plaster for Texas Instruments
- Tile-based graphics



Gravitack

- Teensy-R4ge-Pro/PlatformIO/teensy-r4ge-gravitack
- Vector-based homage to the arcade console game

External Hardware

Creative DIY Hackery

Ideas and Next Steps

Where do you go from here?

Topics

- Sensors and other peripherals
- Common Protocols (I2C, SPI, UART, CAN bus)
- Motor and servo control
- SD Cards
- DMA
- VGA Output
- Making your own PCBs
- Surface mount soldering

Project-Driven Discovery

Find something you want to do (real-world application)

…something that excites you

…something that you can accomplish in less than 1 month

…and figure out how to do it!

CodeMash Contest

Categories

- Audio Alchemy
- Maker Magic
- Technical Wizardry

Bring submissions to the Maker Space before noon on Friday for consideration. CodeMash staff will take a short video, along with your name and email. Must be present Friday afternoon to win.

Questions?

Resources

- Adafruit GFX Library
  https://learn.adafruit.com/adafruit-gfx-graphics-library/overview
- PJRC Forum
  https://forum.pjrc.com/
- Amp Hour Podcast / EEV Blog

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