SON 2026-2027 lecture 1

3TC Audio Project @ INSA Lyon

Tanguy Risset & Romain Michon

https://inria-emeraude.github.io/son/

SON Introduction

- **Course website**: https://inria-emeraude.github.io/son/
- **Course github**: https://github.com/inria-emeraude/son
- **Teensy Audio Library**: https://www.pjrc.com/teensy/td_libs_Audio.html
- **Teachers**: Tanguy Risset (INSA TC), Alexandre Bento (INSA IF), Clemens Wegener (Inria), Benjamin Quiédeville (Inria/GRAME) and Romain Michon (U. Saint-Etienne, creator of the SON course)
- **3 weeks**
  - ~20h as course (with your laptop)
  - ~40h as project in binome
  - 1 day of demos at the end of the course

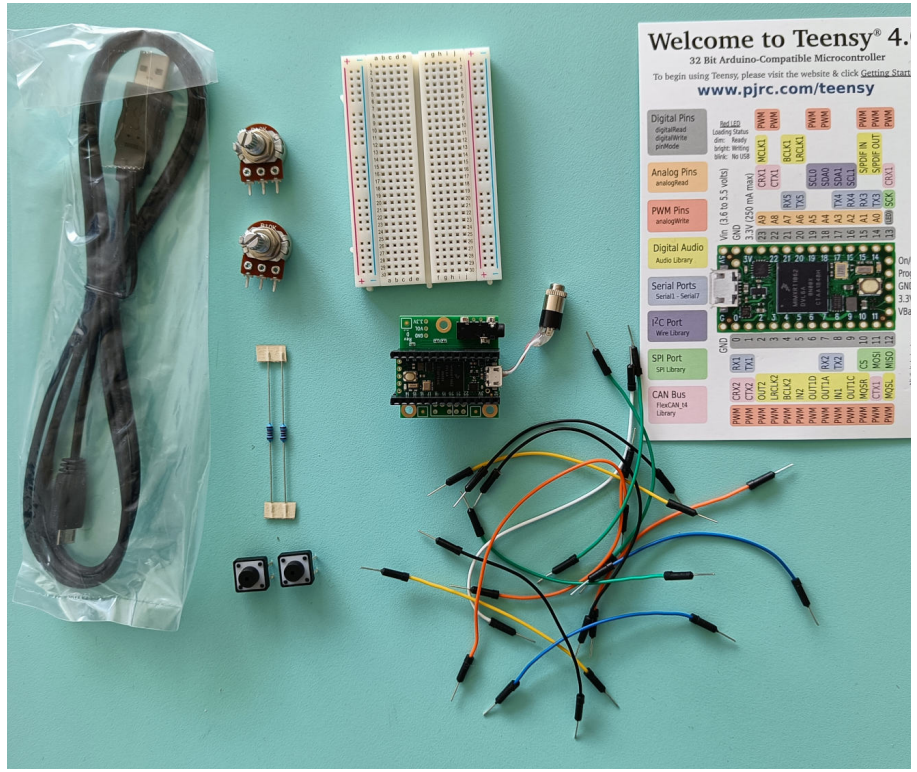
The SON kit

SON kit:

- A teensy with its audio shield, the USB cable and the welcome notice
- 2 potentiometers, 2 buttons, 2 resistors
- A Breadboard and jumper cables

Be gentle with the kit

Don't forget to give it back at the end of the project



Course schedule (1)

Part 1: Lectures (Amphi Chappe)

- **Lecture 1:** **Course Introduction and Programming Environment Setup** -- *02/02/2027 14h00-16h00*
- **Lecture 2:** **Audio Signal Processing Fundamentals** -- *03/02/2027 :08h00-10h00*
- **Lecture 3:** **Digital Audio Systems Architectures and Audio Callback** -- *03/02/2027 10h00-12h00*
- **Lecture 4:** **Hardware Control and Audio Codec Configuration** -- *04/02/2027 08h00-10h00*
- **Lecture 5:** **Audio Processing Basics I** -- *04/02/2027 10h00-12h00*
- **Lecture 6:** **Audio Processing Basics II** -- *05/02/2027 08h00-10h00*
- **Lab** -- *05/02/2027 10h00-12h00*
- **Lecture 7:** **Introduction to Faust** -- *08/02/2027 08h00-10h00*
- **Lecture 8:** **Faust on the Teensy and Advanced Control** -- *08/02/2027 14h00-16h00*
- **Project Validation Session** -- *08/02/2027 16h00-18h00*

Course schedule (2)

Part 2: project 9x4h Slots (Salle TD/TP/anywhere)

- **Independent work on Projects** -- *09/02/2027 - 19/02/2027*

Milestones sessions:

- **mid-term milestone**: 5mn presentation for each project (TP4, 12/02/2027 14h)

Project presentation sessions (Friday 19/02/2027 all day):

- **Demos in Chappe Hall**: 15mn presentation for each project

Course Overview

- SON is the only project *with all students*
- SON activates the following skills:
  - programming (C/C++)
  - signal processing
  - embedded systems
  - hardware/software interface
  - immagination
  - autonomy
  - intensive project
- SON is intensive during 17 days

How is course evaluated

- The evaluation is based 100% on the project quality
  - Final demos with other TC teachers
  - A video demo is required (1:30 approx), should be fun
- A github site is a plus
- A poster is required which on your project
  - it is evaluated in the ASDS course (in parallel of SON)

What is a good project?

- The form of the project is quite free, it can be
  - hardware oriented (controler with 3D pinting stuff, electronics etc)
  - software oriented (various interface on host)
  - audio oriented (in C++ or Faust)
  - sound synthesis or audio effect
  - any original idea
- We require that:
  - There is some signal processing
  - The signal processing should be executed on the teensy

How are evaluated projects?

- Evaluation takes into account
  - overall quality
  - robustness/stability
  - novelty/originality
  - demo
  - Human/machine interface

what about AI

- Students are welcome to use help from any places:
  - existing code/libraries on the web
  - IA helpers
  - Human friends, etc...
- The rules are:
  - You should understand your code and be able to explain it
  - Be honest with yourself and with others

Choosing binomes

Binomes rules:

- each binome is composed ot 2 people
- of the same 3TC group (Semester 2)

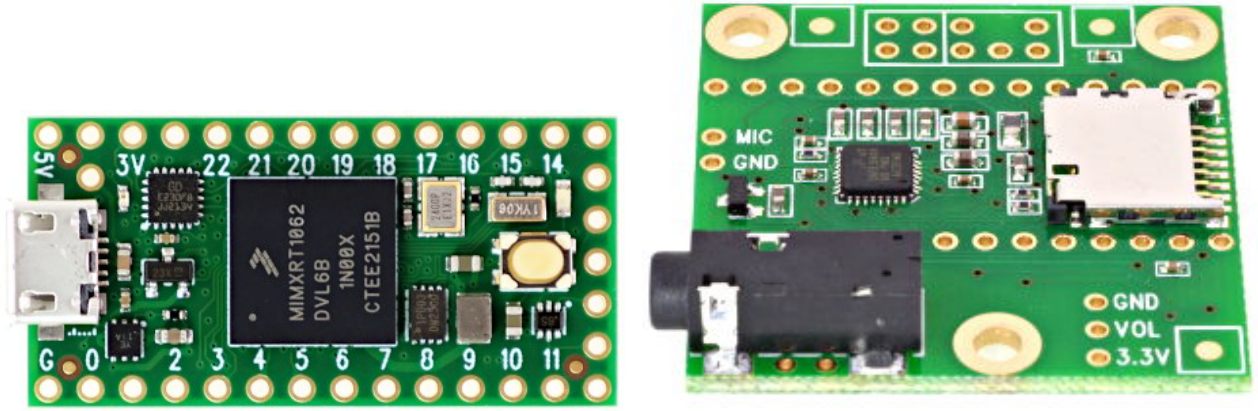
procedure (now):

- Once the binome is constituted, queue on the side of the Amphi
- Indicate your names to the first teacher (and get a *binome number*, remember it)
- Get a son-kit for your binome

Pause: Binome Selection

Course 1 part 2: the teensy

The Teensy 4.0 and Audio Shield

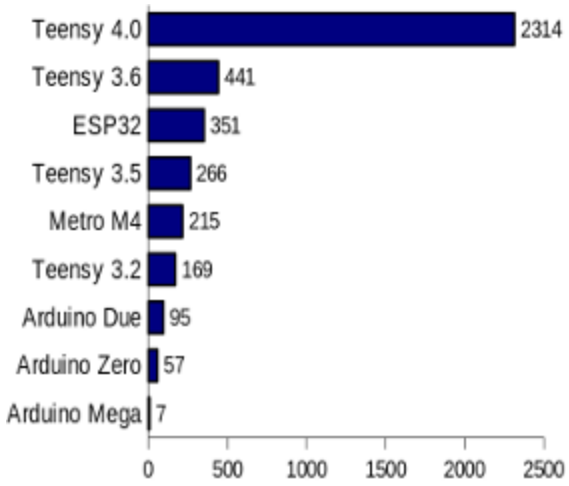


The Teensy 4.0 (left) and the associated audio adapter board (right)

- The Teensy 4.0 is a microcontroller-based development board developed by PJRC. : https://www.pjrc.com.

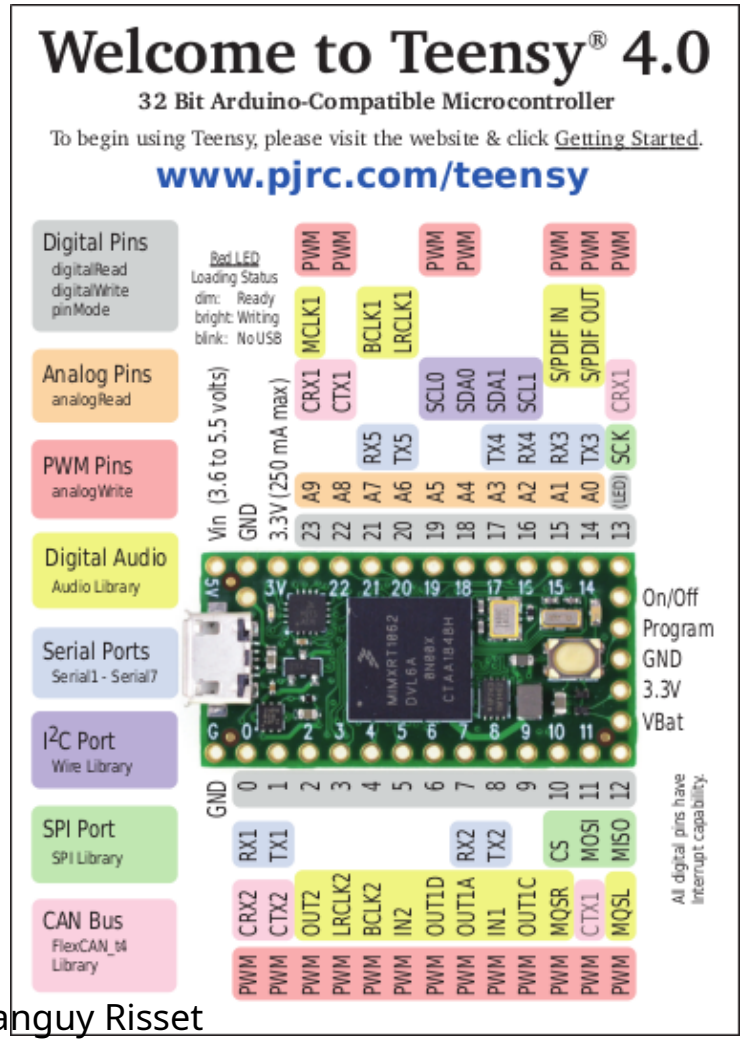
Cortex-M7 ARM processor

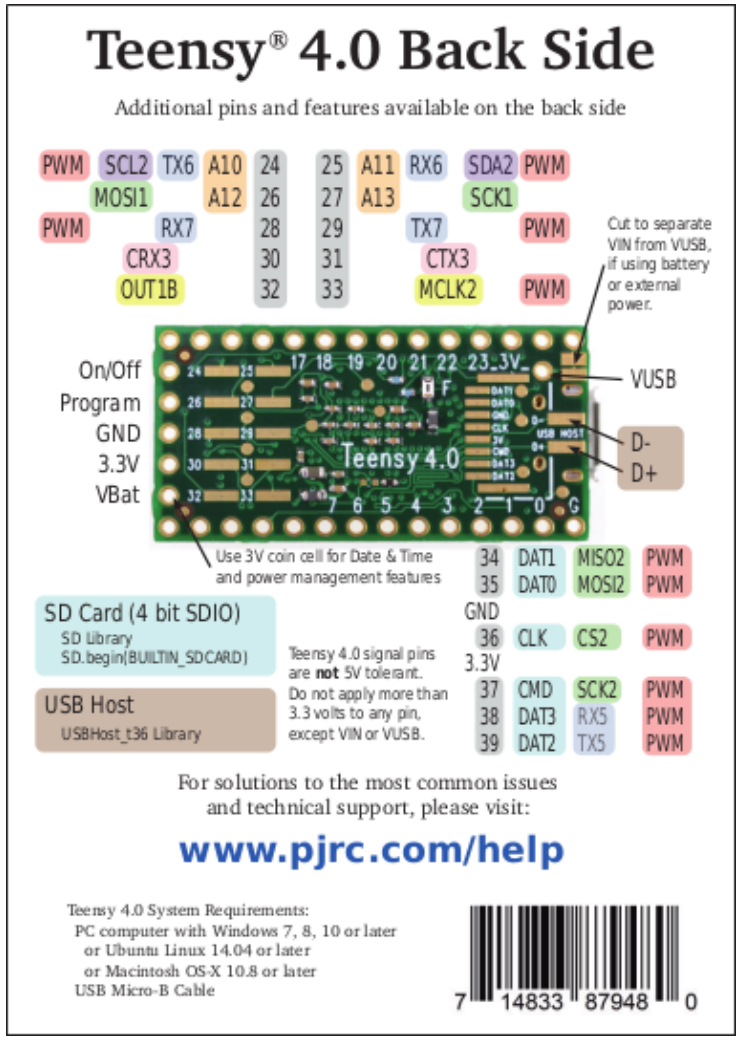
- Powerful ARM Cortex-M7 processor (i.MX RT1062: 600 MHz with a Floating Point Unit - FPU)
- DSP extension (ISA ARMv7E-M: SIMD instr., MAC instr., Saturation, etc.)
- Use efficiently in the Teensy Audio library



Teensy performance from Core Benchmarks

The pinout reference card





Pins of the Teensy

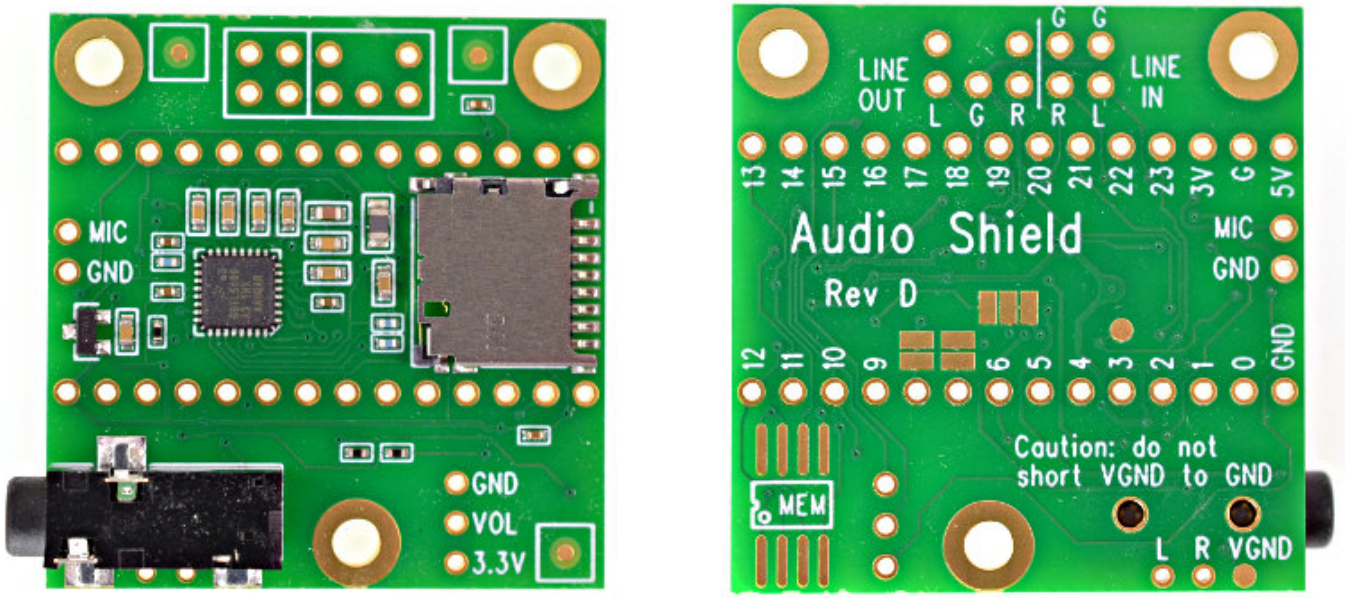
- **The pins are not 5V tolerant. Do not drive any digital pin higher than 3.3V.**
- 40 pins (24 easily accessible), used as GPIO (General Purpose Input/Output) or for integrated serial protocols (UART, I2C, SPI etc.)
- Pins have several names: Pin 19 is also A5 (Analog input) is also SCL0 (I2C clock) is also PWM (analog output)
- Pins with orange 'A*' names can be used for analog or digital input/output (e.g. potentiometer)
- Other pins are used for digital input/output only
- PJRC function are: `analogRead`, `analogWrite`, `digitalRead`, `digitalWrite`

Pins of the Teensy

- Some of the pins are used to communicate with the audio adator
- Some (other) pins will be used to interface hardware (buttons, potentiometers, etc)
- The USB connector between the Teensy and the host computer is used to:
  - Power the teensy by host
  - program the teensy with arduino on host (JTAG protocol)
  - Serial (or UART, i.e. ascii characters) communication between host and teensy
  - Other control protocols (MIDI, OSC, etc.
  - stream audio (i.e. use teensy as an audio card)

The Audio Adapter Board

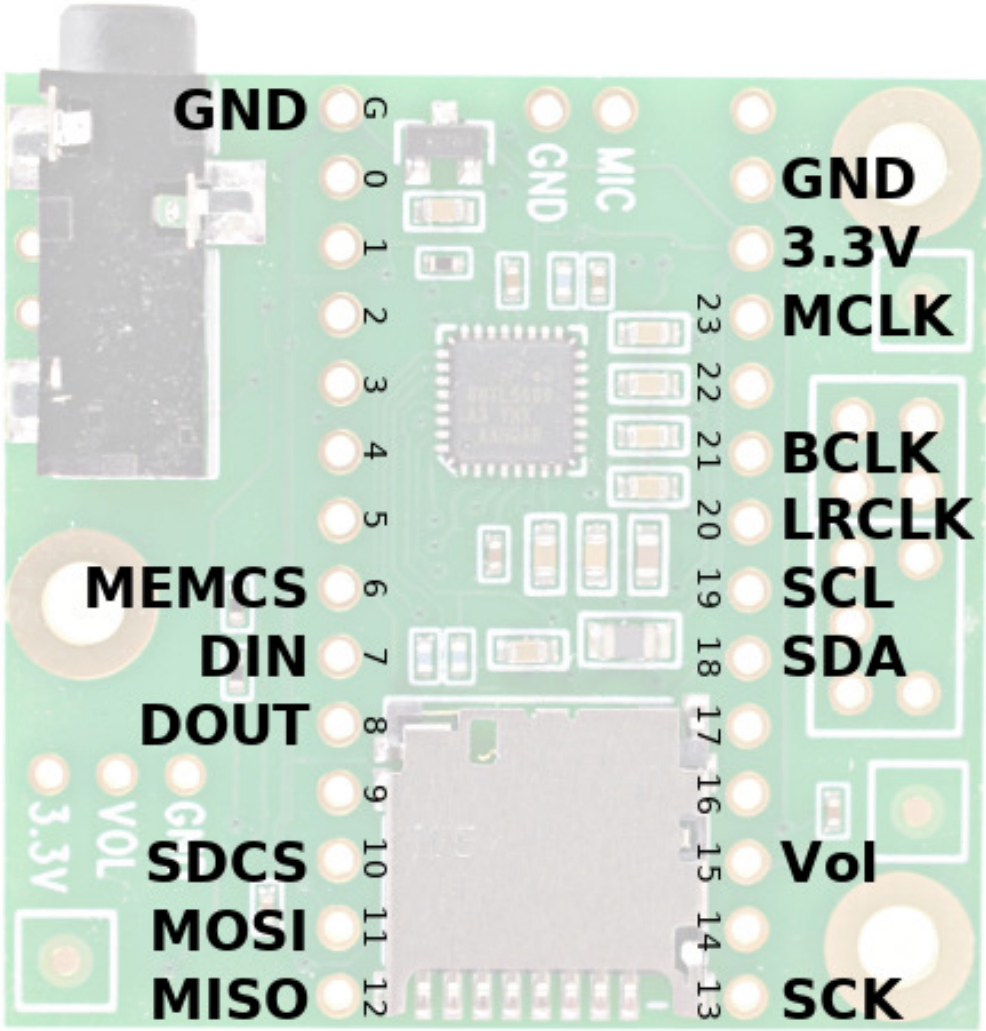
The audio adaptor board provided by PJRC that integrates a **low power stereo audio codec** (NXP Semiconductors SGTL5000 codec) and a **SD card reader**.



The Teensy audio adaptor (rev. D)

Audio Adaptor pins

- The PJRC audio shield page indicates pins used by the codec and the SD card.
- I2S (or I^2S: Inter-IC Sound, a declination of I2C) is used to transfer samples bit by bit between the teensy and the audio codec in both direction (i.e., from and to the teensy)
- The pins 6-8, 10-13, 15, 18-21 and 23 **cannot be used in your design**



The Teensy Development Framework: `teensyduino`

- The Arduino IDE software with the Teensyduino add-on is is used in SON: https://www.pjrc.com/teensy/td_download.html
- Should work on MAC OS, Windows and Linux
- The installation procedure can be found on the PJRC website (note that it slightly varies between platforms): https://www.pjrc.com/teensy/td_download.html

End of Lecture 1