
DIGITAL MUSIC WORKSHOP / 05 / DIGITAL AUDIO ON MCU

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- small computation
- platforms + setups

SMALL COMPUTATION

- Why make musik on a *Microcontroller Unit* (MCU)?
- if you don t feel it, don t do it. it s a lot of (extra) work. (e.g Automatique Orchestra)
- programming audio on mcu has 2 main areas:
 - DSP
 - communication

DSP

- from numbers to voltage and vice versa
- *integer/fixed-point* versus *floating point*
- no floating-point units (FPU) not *floating point* @note(only modern MCU have them)

COMMUNICATION

- e.g MIDI via Serial or USB
- MIDI controller or receiver

----- PLATFORMS + SETUPS -----

from *bare-metal* to *low-level* hardware. a series of typical platforms + setups:

- MCU + direct output
- MCU + resistor ladder
- MCU + external Digital-Analog Converter (DAC)
- MCU + internal DAC + Analog-Digital Converter (ADC)
- MCU + external DAC + ADC with *Inter-IC Sound* (I2S)
- MCU + external Audio Codec (CODEC)

----- MCU + DIRECT OUTPUT -----

- Pulse-width modulation (PWM) + Low-pass filter (LPF)
- e.g. Arduino Uno (Pin 3 with analogWrite())
- usually setup needs an additional amplifier (e.g. Operational Amplifier (OpAmp) LM386)

----- MCU + RESISTOR LADDER -----

- Resistor ladder a series of resistors
- uses a lot of pins, but little overhead
- usually setup needs an additional amplifier

----- MCU + EXTERNAL DIGITAL-ANALOG CONVERTER (DAC) -----

- dedicated Integrated Circuit (IC) with simple or no protocol
- smaller MCUs are sometimes challenged by audio rate
- e.g. `Arduino Uno` + `MCP4912` (SPI, 12BIT, mono)
- usually setup needs an additional amplifier

----- MCU + INTERNAL DAC + ANALOG-DIGITAL CONVERTER (ADC) -----

- internal DAC e.g. Teensy 3.2 (Pin A14 with `analogWrite()`)
- internal ADC e.g. Teensy 3.2 (Pin A10 with `analogRead()`)
- usually setup needs an additional amplifier

----- MCU + EXTERNAL DAC + ADC WITH *INTER-IC SOUND* (I2S) -----

- I2S interface standard for digital audio devices
- @note(not to be confused with *I2C*)
- only available on *modern* MCUs (e.g Teensy 3+, ESP32)
- usually has built-in amplifier for headphones or line-out and sometimes has built-in amplifier for microphone + line-in

----- MCU + EXTERNAL AUDIO CODEC (CODEC) -----

- CODEC external component (or IC), combination of ADC + DAC
- usually has built-in amplifier for headphones or line-out and sometimes has built-in amplifier for microphone + line-in
- e.g. Teensy 3.2 + Audio Adaptor Board + Audio Library
- e.g. DAISY SEED
- e.g. @TBR e.g. Klangstrom (STM32 + WM8731)