Democracy DEV Board Specification

Summary

1. GENERAL FEATURES

Democracy DEV is a powerful audio processing card for musical instruments - more specifically for the guitar. Raspberry Pi 3 processor board is directly plugged on the Democracy DEV and gives a high computational power in a Linux - based environment. A Cirrus Logic audio codec - also plugged on the Democracy DEV board - completes this system. FPGA on Democracy DEV board adds an alternate possibility to process digital audio with extremely low latency.

For audio processing, the Democracy DEV board includes several analog audio inputs and outputs. For control purpose, the Democracy DEV board includes in/out Midi sockets, footswitches and a universal control pedal interface.

Thanks to the numerous features of Democracy DEV board, several applications are targeted:

Control pedal processor

Many effects pedals or synthesizers have an input for a control pedal. The Democracy DEV board is able to emulate a control pedal and then modify the effects or synthesis in function of the audio content. For example, the amount or the range of an effect could be automatically related to the guitar note pitch. In addition, a control pedal can be connected to the Democracy DEV board for adding a human control to the automatic one provided by Democracy DEV board processing.

Synthesizer

Democracy DEV board runs a BENTI physical model guitar synthesizer. Alternatively, Fluidsynth, a real-time software (open-source) synthesizer based on the SoundFont 2 specifications, runs on Democracy DEV board, giving access to libraries of thousands musical instrument sounds (guitar or other).

Pure data

“Pure Data is an open source visual programming language. Pd enables musicians, visual artists, performers, researchers, and developers to create software graphically, without writing lines of code ...”. Users have first to create or modify Pure Data patches on laptops or tablets, then load and run them in Democracy DEV board.

2. ARCHITECTURE

The Democracy DEV board is connected to the Raspberry Pi through a 40-pin connector. Democracy DEV board peripherals are connected to the Raspberry mainly by UART, I2C or SPI serial links, with the addition of a few GPIOs.

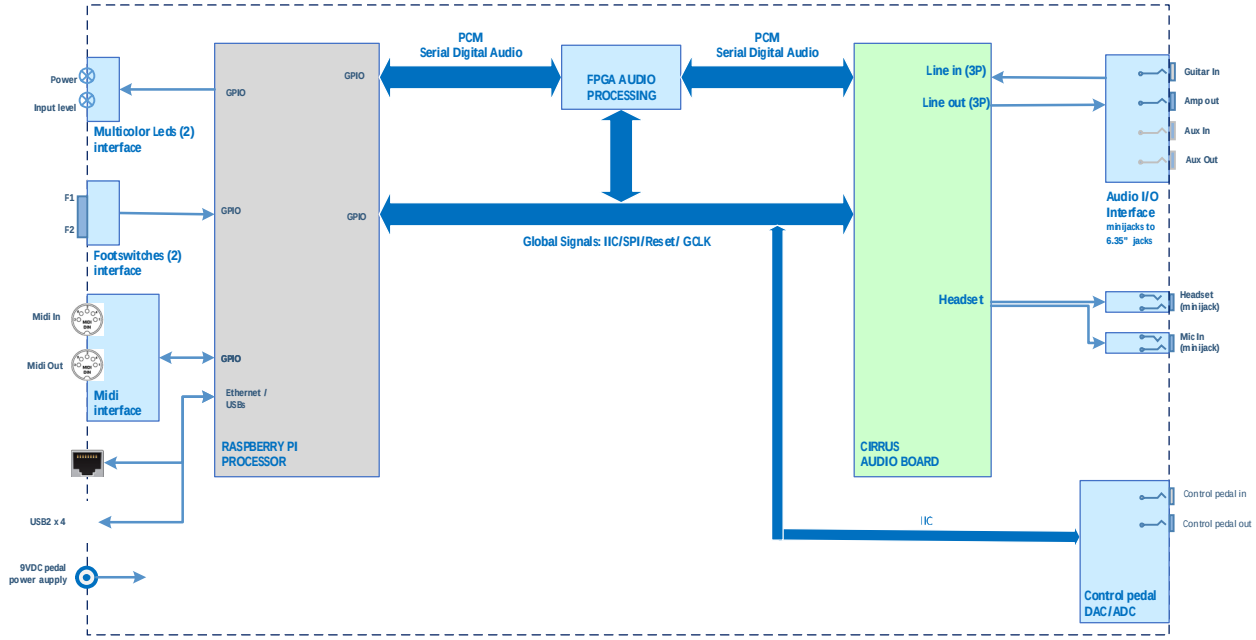

Figure 1: Block diagram of Democracy DEV board

2.1 Hardware

2.1.1 Audio I/Os

- Four 6.35 mm mono jack sockets
  - 1) High Z guitar input with selectable audio bypass
    - Input impedance: ~250 kΩ
    - Full scale input level: 1 Vrms
    - Analog PGA: 0 – 31 dB
    - Digital volume: -64 – +31.5 dB
    - THD: 0.035 %
  - 2) Aux line input
    - Input impedance: 47 KΩ
    - Full scale input level: 1 Vrms
    - Analog PGA: 0 – 31 dB
    - Digital volume: -64 – +31.5 dB
    - THD: 0.035 %
  - 3) Amp output
    4) Aux line output

        - Output impedance: 16 Ω
        - Full scale output level: 1 Vrms
        - Digital volume: -64 – +31.5 dB
        - THD: 0.005%

- Two 3.5 mm stereo jack socket
    - Headphone output
        - Output impedance: 0.2 Ω
        - Full scale output level: 1 Vrms
        - Digital volume: -64 – +31.5 dB
        - THD: 0.0035 %
    - Microphone input
        - Input bias resistor: 2.2 kΩ
        - Microphone bias level: 2.8 V
        - Full scale input level: 63 mVrms
        - Analog PGA: 0 – 31 dB
        - Digital volume: -64 – +31.5 dB
        - THD: 0.01 %
        -

2.1.2 Control I/os

- Two 6.35 mm stereo jack sockets
    - 2x dual foot switch pedal inputs
- Two 6.35 mm stereo jack sockets
    - Universal control pedal input (passive 10k, passive 50k, active 5V)
    - Universal control pedal output (passive 10k, passive 50k, active 5V)
- Two 5-pin DIN sockets
    - Midi input
    - Midi output

2.1.3 Computer I/Os and signaling

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- Computer connections
    - Ethernet 10/100
    - 4x USB USB2.0
- Two RBG LEDs (32’768 colors)
    - Input level peak-meter (green-orange-red)
    - Processor activity / error signaling

2.1.4 I/Os localization

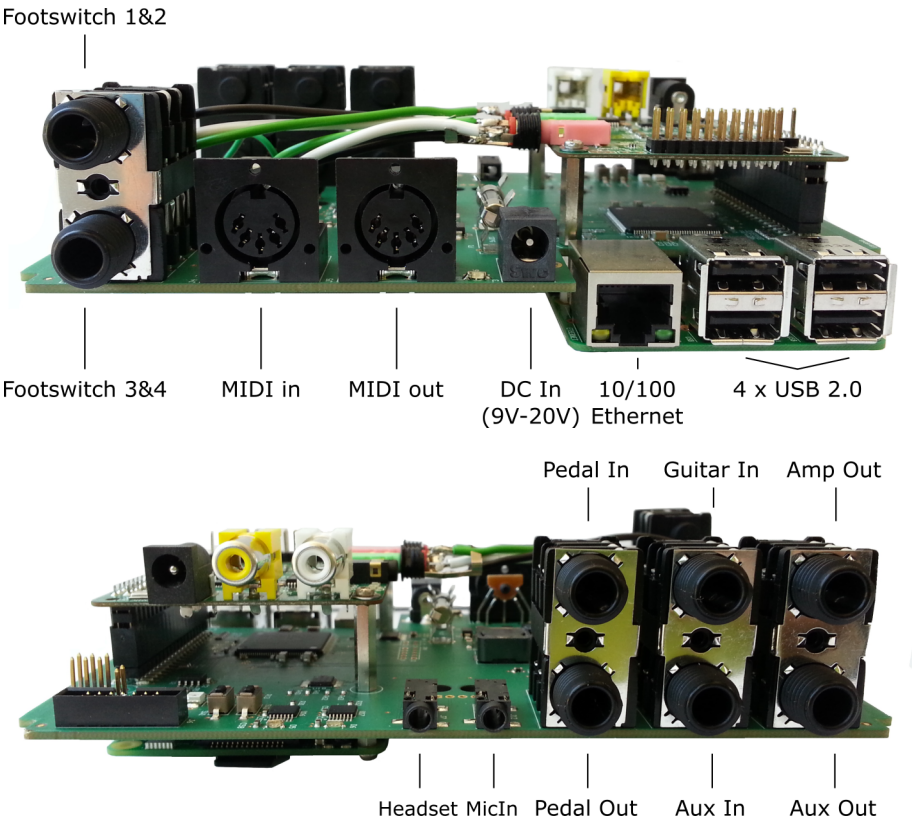

Figure 2: Connectors

2.1.5 Audio processing

- Raspberry Pi 3 Model B
  - 1.2GHz Broadcom BCM2837 64-bit (Quad-core Cortex-A53)
  - 32kB L1 cache, 512kB L2 cache
  - 1GB LPDDR2 RAM
  - Integrated radio (BCM43438)
    - 802.11n WiFi
    - Bluetooth Smart 4.1

- Cirrus Logic Audio board
  - Based on Cirrus Logic WM5102 audio codec
  - HD audio (24 bits at 192 kHz)

- Xilinx Spartan 6 SLX9 FPGA
  - Speed grade -2
  - Maximum 375 MHz global clock
  - 9152 logic cells
  - 16 DSP slices
  - Low latency audio processing

- Fully programmable control pedal processing
  - Support and emulate virtually any type of control pedal (passive and active)
  - 12–bit ADC
  - 10K/50K 8-bit digital potentiometers

2.1.6 Power supply

- 9VDC power supply (external AC/DC adapter)
  - 9V to 20V
  - Idle with WiFi: ~0.25 mA @ 9V
  - Negative tip (positive sleeve) barrel power jack 
  - 2.1 mm inner diameter, 5.5 mm outer diameter

2.1.7 Mechanical

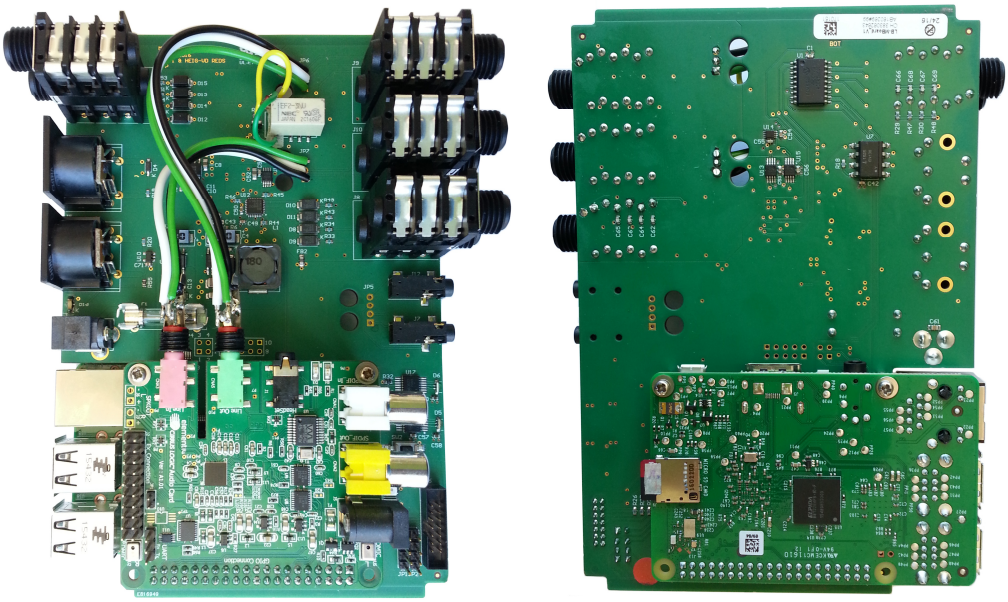

Figure 3: Top and bottom views

- Dimensions (fully assembled, without enclosure)
  - Length: 160 mm
  - Width: 124 mm
  - Height: 47 mm

2.2 Software

2.2.1 Linux BSP

- Linux Raspberry kernel 4.4.8
  - With patches for Cirrus Audio
  - and Democracy DEV board
- Root filesystem based on Raspbian-Jessie 2016-05-10

2.2.2 User programs

- Example programs and scripts to access low-level hardware

    - Audio mixer control
    - Control pedal configuration
    - RGB LEDs control
    - Footswitch input
    - Audio bypass selection
- Guitar Input level monitoring - LED peak-meter
- Pitch extraction
    - Monophonic
    - Polyphonic
- Guitar synthesizer (physical model)
- Fluisynth (SoundFont synthesizer)
- Pure Data

3. SPECIFIC FUNCTIONS

3.1 Switchable Audio Bypass

The Democracy DEV board has a switchable audio bypass between Guitar In and Amp Out. Guitar In goes directly to Amp Out when the Democracy DEV board is not powered or when the audio bypass is enabled (default). The audio does not even reach the Democracy DEV board's logic in this state. The audio bypass can be disabled by the Raspberry Pi 3. In this case, Guitar In is routed to Line In and Line Out is routed to Amp Out.

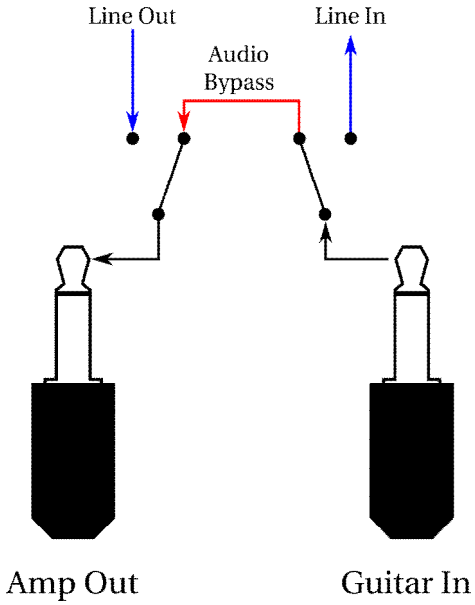

Figure 4: Audio bypass principle

Aux In and Aux Out are not affected by the audio bypass.

3.2 Programmable control pedal

The Democracy DEV board features a universal programmable control pedal. It is used to interface with almost any control pedal on the market. Both Pedal In and Pedal Out support a wide variety of modes.

3.2.1 Supported modes

Here is an overview of the supported modes.

- **Passive TRS** (**Tip** expression): The control is done using a variable resistor that can be measured between tip and sleeve, while the full resistor can be measured between ring and sleeve.
- **Passive TRS** (**Ring** expression): The control is done using a variable resistor that can be measured between ring and sleeve, while the full resistor can be measured between tip and sleeve.
- **Passive TS**: The control is done using a variable resistor that can be measured between tip and sleeve, while the full resistor in not available.
- **Active**: The control is done using a variable voltage between tip and sleeve. The voltage swings between 0 and 5V.

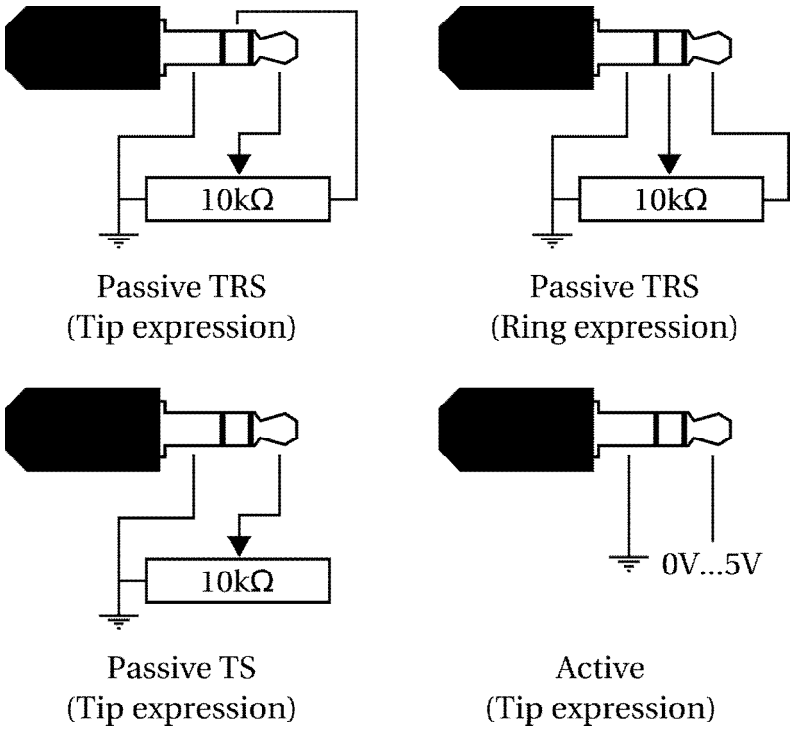

Figure 5: The four modes of the programmable control pedal

3.2.2 Pedal input

The control pedal input is achieved by a reconfigurable crossbar (the pedal engine) that possibly converts the input impedance into a voltage. It is connected to a 10-bit Analog Digital Converter (ADC) before sending the values to the Raspberry Pi 3, as shown in Figure 6.

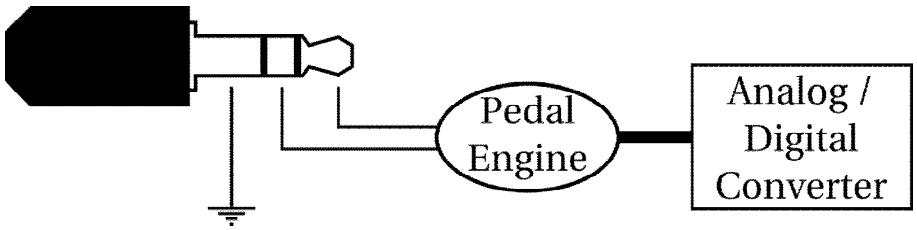

Figure 6: Control pedal input

The pedal input can support any nominal resistor, other than just 10kΩ or 50kΩ.
The ADC is fully integrated inside Linux Industrial I/O (IIO) subsystem. It can be easily read out as a result.

3.2.3 Pedal output

The control pedal output is achieved by two 8-bit digital potentiometers (10kΩ and 50kΩ) connected to the reconfigurable crossbar, as shown in Figure 7.

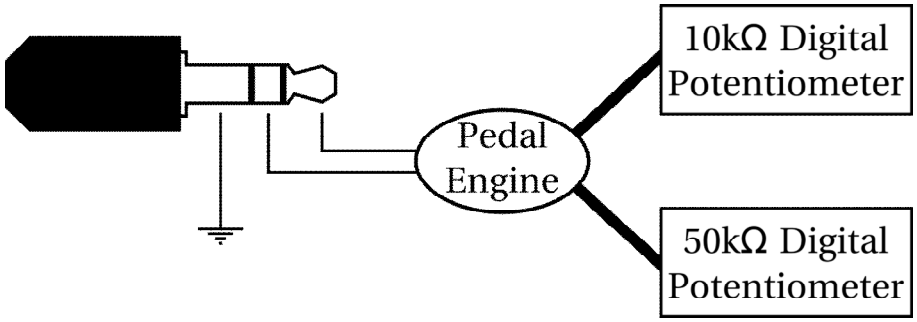

Figure 7: Control pedal output

Both potentiometers are connected to the Raspberry Pi 3. They are fully integrated inside Linux Industrial I/O (IIO) subsystem. They can be easily controlled as a result.

3.3 Footswitches

The Democracy DEV board has two stereo footswitches inputs. Each stereo jack can thus have up to two switches, as illustrated in Figure 8. When the first switch is closed, it connects the tip to ground (sleeve). Conversely, when the second switch is closed, it connects the ring to ground. These events are detected by the Democracy DEV board and an action can take place as a reaction.

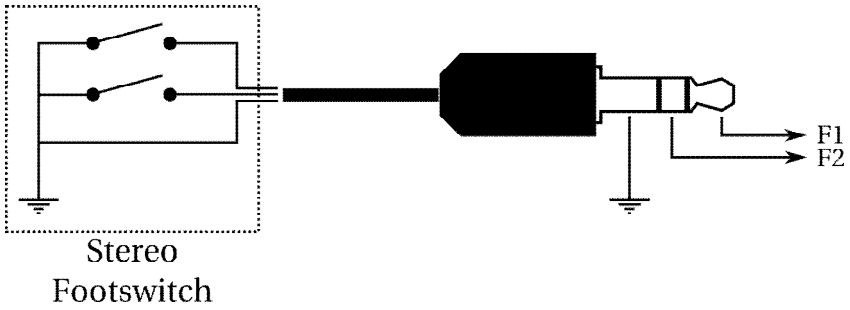

Figure 8: Stereo footswitch principle

The footswitch interface is of course also compatible with any mono footswitch.

3.4 LEDs

The Democracy DEV board has two bright RGB LEDs. They are connected to the Raspberry Pi 3. As a result they are versatile and can visually indicate the current status. The color can be controlled by setting the current inside each individual R/G/B LED. This is achieved using an RGB LED driver with an internal current source and independent PWM controls for each channel.

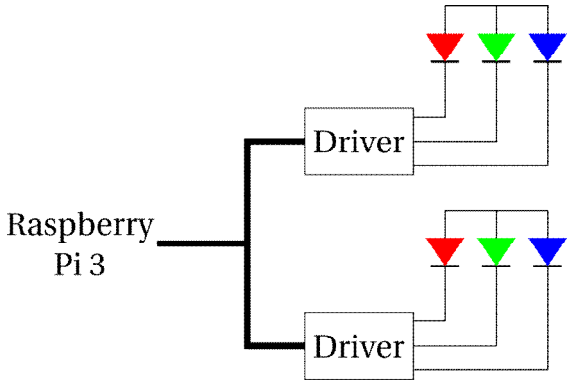

Figure 9: Two RGB LEDs

3.4.1 Power LED

The power LED is used to indicate the status of the Raspberry Pi. Here are the current states:

- Off: CPU is off
- Green, blinking: CPU is up and running

3.4.2 Peak-meter LED

The peak-meter LED is used as a Digital Peak Programme Meter (PPM) to indicate the input level on Guitar In. The dynamic is set according to IEC 60268-18, thus the integration time is 5 ms and the return time is 1.7 s.

Indicated levels are as follow:

- Green: over – 40 dBFS and below -12 dBFS
- Orange: between -12 dBFS and -6 dBFS
- Red: over -6 dBFS