ABcolor

Audio Bass development board REV5

Features

- Audio Bass Color Effect
- Digitally tunable analog filter 80 Hz - 250Hz
- Digitally tunable analog gain 2x - 100x
- Power supply from **6.5V** to **18V**; max. 2A
- **User interface:** OLED 1,3", Encoder, 3x Capacitive Touch Button, Haptic Feedback
- **Input:** Audio signal from 3,5mm Jack, BNC or internal microphone
- LED's included: 20x Digital LED, 10x Analog LED, LED strip light, 1x Test LED
- **Programming:** SPI - IDC connector, UART - IDC connector, USB-C
- **3D printed parts**

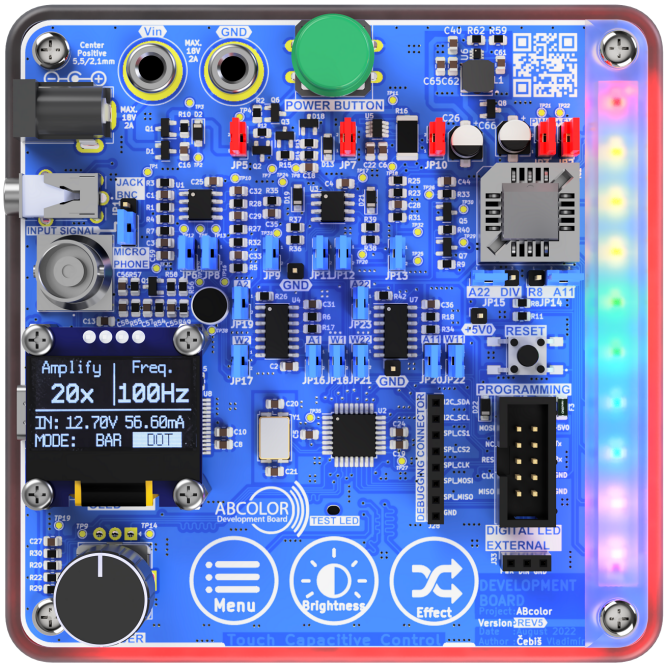

Figure 1: The ABcolor dev. board REV5

Applications

- HW/SW educational purpose
- Hardware simulation - SPICE simulator
- Hardware measuring - Osciloscope/DMM
- Software integration - Arduino IDE, Microchip Studio
- HW/SW debugging - Logic analyzer

General Description

The **ABcolor** is a development board designated for **educational purposes** based on the ATmega328p microcontroller. The external or internal analog signal is processed and visually interpreted by 3 types of LEDs in the bass frequency range. The entire solution contains jumpers, test points and debugging connectors for easy measurement, verification and testing of functionality.

The analog part of ABcolor can be simulated and verified by hardware measurement. Digitally tuneable gain and filter cut off frequency are set up by digital SPI potentiometers. For debugging I^2C and SPI bus it is possible to use debugging connector on the board. Individual analog or digital parts can be disconnected using jumpers.

Programming connector contains combination of ISP and UART interface. It is possible to upload the program via USB-C after burning the bootloader. More detailed information about programming is described in subsubsection 2.3.2.

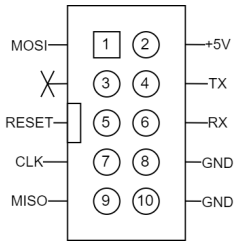

Figure 2: Programming connector - ISP/UART

Contents

1 Overview

This chapter contains a general description of the entire ABcolor and serves as an introduction and a basic idea of its use. This chapter provides answers to:

- **How is it composed?** In subsection 1.1 is a description of the individual construction parts.
- **What makes it light up?** In subsection 1.2 describes the light sources used and their location.
- **What can I use for connection?** In subsection 1.3 describes all used connectors.
- **How can I control it?** In subsection 1.4 describes user interface.

Detailed description of individual parts, functions with the block diagram is given in the next section 2.

Figure 3: ABcolor development board REV5

1.1 Construction - 3D print

FDM, the most popular 3D printing technology, was used as the simplest solution for the construction part of ABcolor. Maximum required dimensions for the printing area do not exceed 110 x 110 mm. Difusers are printed from transparent filament because they are used as a light guide. Figure 4 describes the decomposed construction of the ABcolor.

- **Difuser 1:** is located on the top side of the PCB. Designed as light guide for analog LED only.
- **Difuser 2:** is located on the bottom side of the PCB. Designed as light guide for digital LED and LED strip light which are placed on the bottom side of the PCB.
- **Difuser 3:** is located on the bottom side of the Body. Designed as light guide for residual light.
- **Body:** main part of the construction connects all transparent parts.

More detailed information about the location and parameters of the LEDs used in the ABcolor is given in the subsection 1.2.

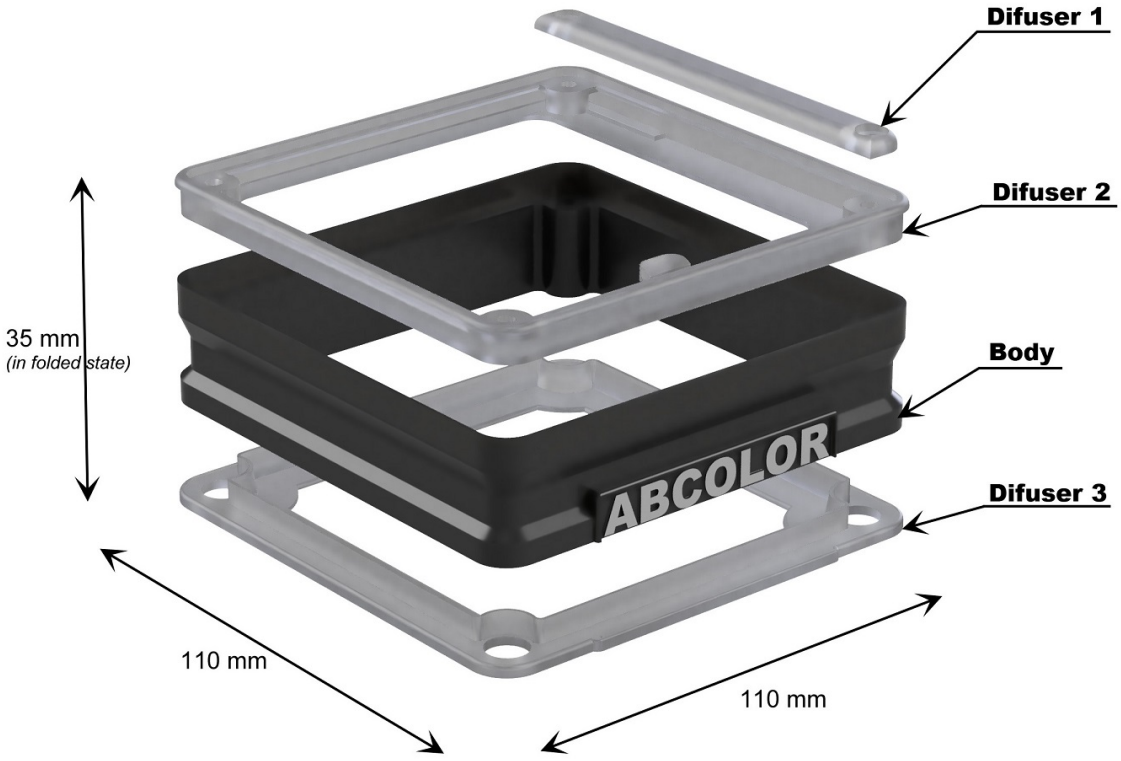

Figure 4: 3D printed parts : Model documentation

1.2 LED lights

In the ABcolor dev.board has been used 3 types of LED's which are controlled by microcontroller or analog voltage level driver. The location of used LED's is shown in colour on the Figure 5 and detailed cross-section of the model with description is on Figure 7.

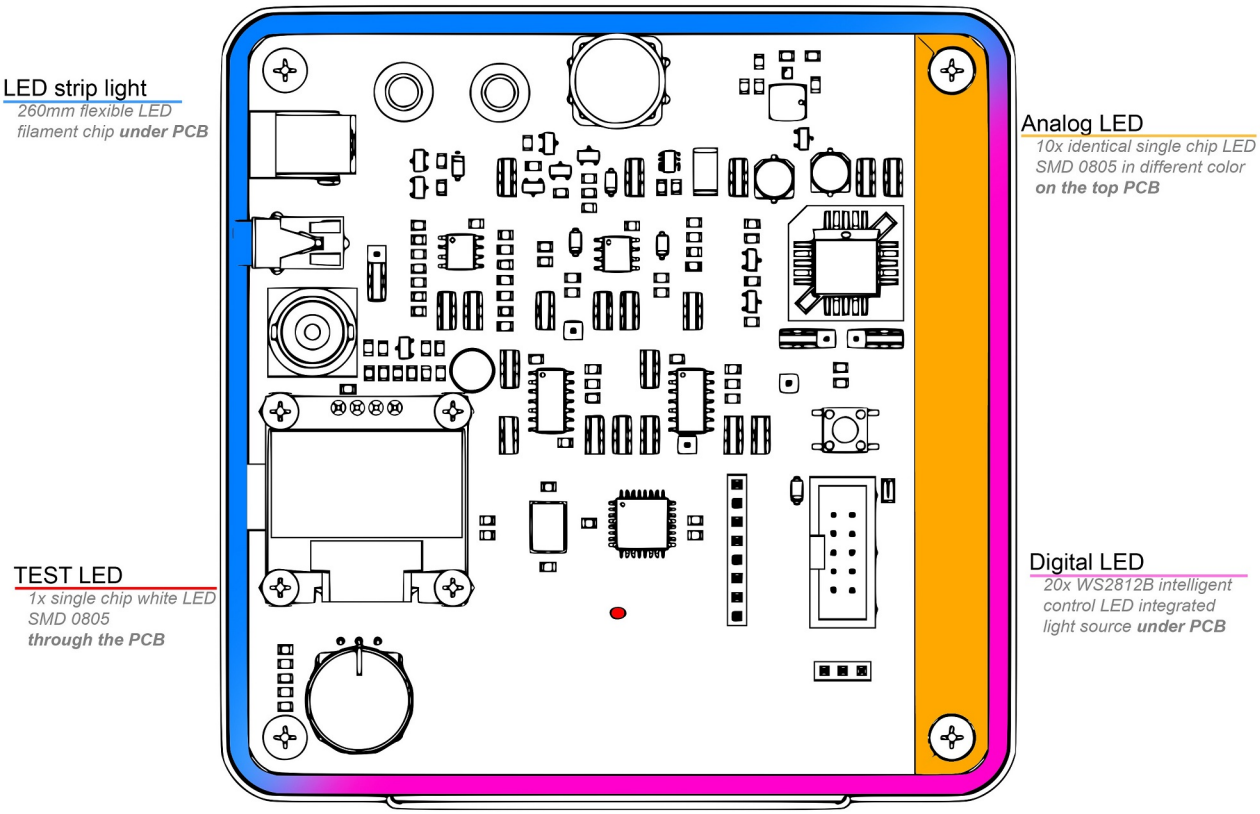

Figure 5: Connectors overview

- **LED strip light: (marked in blue)** is controlled by microcontroller with possibility of PWM regulation. Powered from +5V_Power line. This **flexible LED filament chip** comes with a diameter of 2mm and a length of 260mm. The filament is flexible and can be bent and folded at will. With a 3V power supply and max. 80mA, it emits light 360 degrees.
- **Digital LED: (marked in pink)** is controlled by microcontroller and powered from +5V_Power line. **WS2812B** is a intelligent control LED light source that the control circuit and RGB chip are integrated in a package of 5050 components. It internal include intelligent digital port data latch and signal reshaping amplification drive circuit. Also include a precision internal oscillator and a 12V voltage programmable constant current control part, effectively ensuring the pixel point light color height consistent. Max. current 60mA per chip (3x20mA per color channel).
- **Analog LED: (marked in orange)** is controlled by **LM3914 Dot/Bar Display Driver** and powered from +5V line. Single chip in standard 0805 package in different color with most similar parameters as possible. Parameters taken into account are luminous intensity, viewing angle and continuous forward current $\approx$ 20mA.
- **TEST LED: (marked in red)** is controlled direct from GPIO of microcontroller.

The following cross-section on Figure 7 shows the LED's placement and mechanical design of the 3D printed parts. The cross-section is made from the front side from which the inscription ABCOLOR in white can be seen. Figure 6.

Figure 6: Front side with ABCOLOR inscription in white

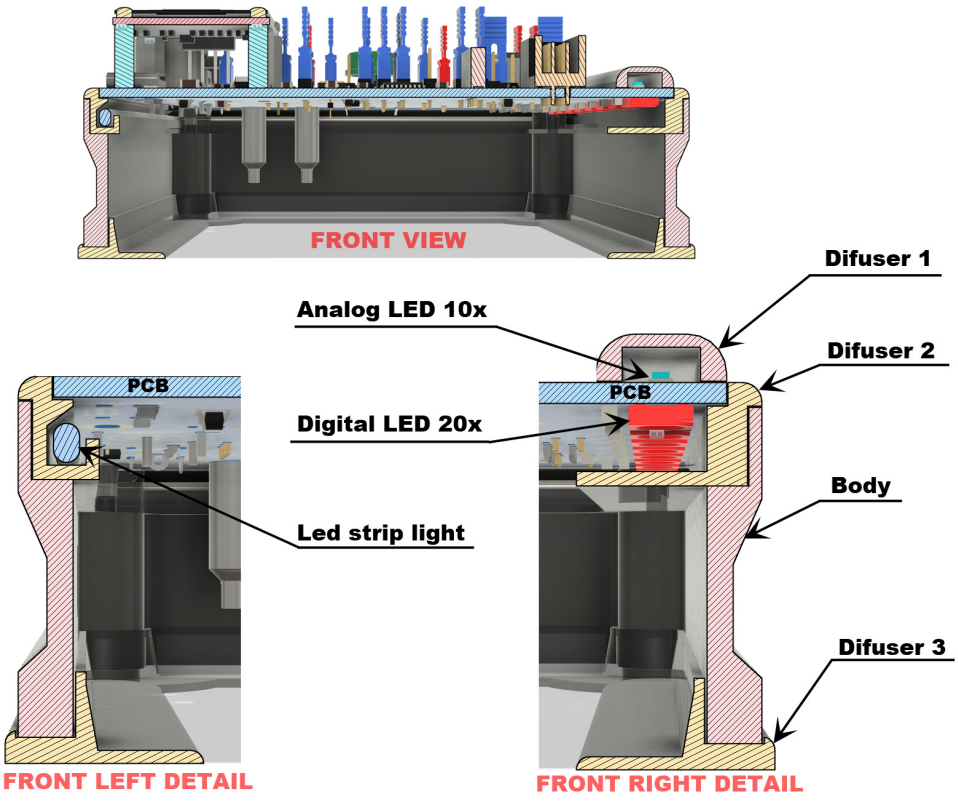

Figure 7: Cross-section : detailed description

1.3 Connectors

Multiple connectors types are used in the ABcolor for ease of use. The following Figure 8 shows all the connectors marked in color.

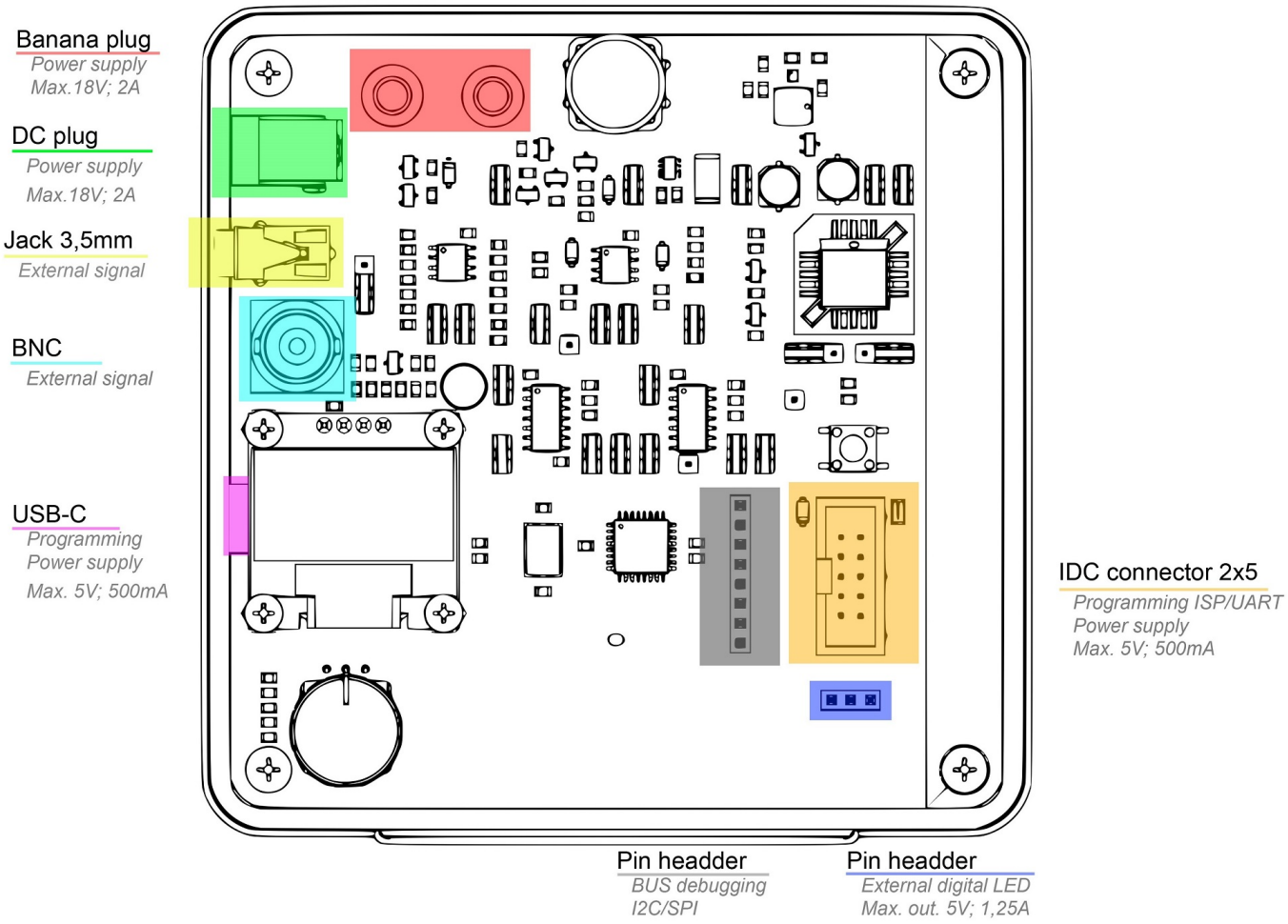

Figure 8: Connectors overview

- For main power supply can be used two types of connectors:
  - **Banana plug** ⌀ 4mm (marked in red)
  - **DC plug** 5,5x2,1mm (marked in green) with positive center
- For external analog input signal can be used two types of connectors:
  - **Jack 3,5mm** (marked in yellow)
  - **BNC** (marked in light blue)
- For power supply and programming can be used two types of connectors:
  - **USB-C** (marked in pink)
  - **IDC connector** (marked in orange) Pinout in Figure 2.
- **Pin header for external digital LED** (marked in blue).
- **Pin header for BUS debugging** (marked in grey)

1.4 User interface

For basic setup and operation, the ABcolor includes OLED display, rotary encoder, touch buttons and mechanical buttons. Figure 9 shows the exact position.

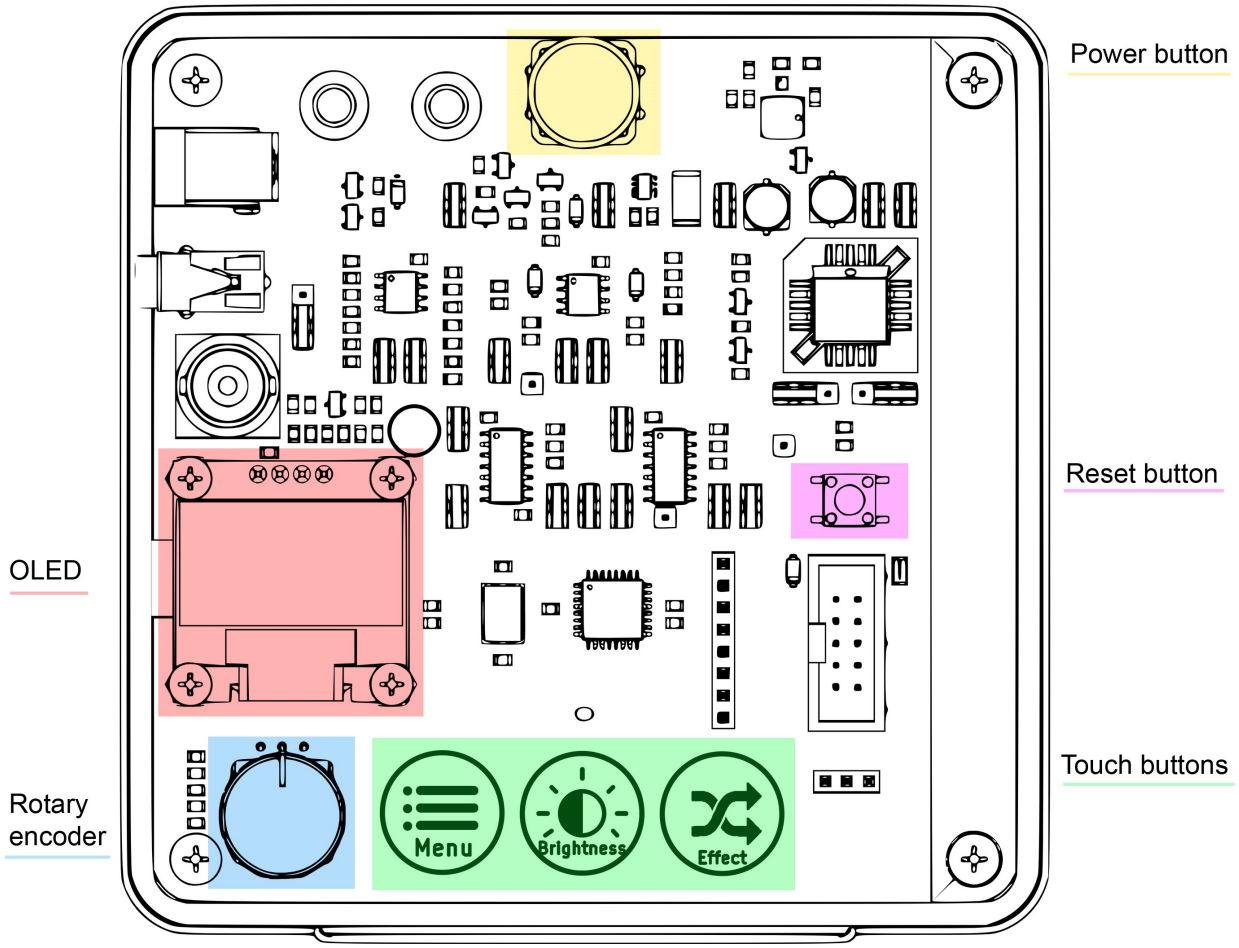

Figure 9: User interface

- **OLED** (marked in red): display with white characters and compact size. Main chip SSD1306, diagonal 0.96", resolution 128x64 pixels, power consumption 80 mW; I^2C communication interface.
- **Rotary Encoder** (marked in blue): incremental encoder with button. 20 pulses/360°. 5VDC; 5mA.
- **Power button** (marked in yellow) : switches the ABcolor ON and OFF if it is powered from the main power supply only. Designed for minimum leakage current.
- **Reset button** (marked in pink) : grounds the reset pin of the MCU.
- **Touch button** (marked in green) : contains three capacity areas on the PCB. The **CAP1203** sensor controller is used for sensing of interaction. Main features of CAP1203: Programmable sensitivity, automatic recalibration, calibrates for parasitic capacitance, individual thresholds for each button, I^2C communication interface.
- **Haptic feedback** : DC vibration motor is located under the PCB and it is PWM regulated by MCU.

2 Detailed Description

The ABcolor is separated to the three parts: Power supply, Analog and Digital part. Detailed decription is shown in block diagram Figure 10.

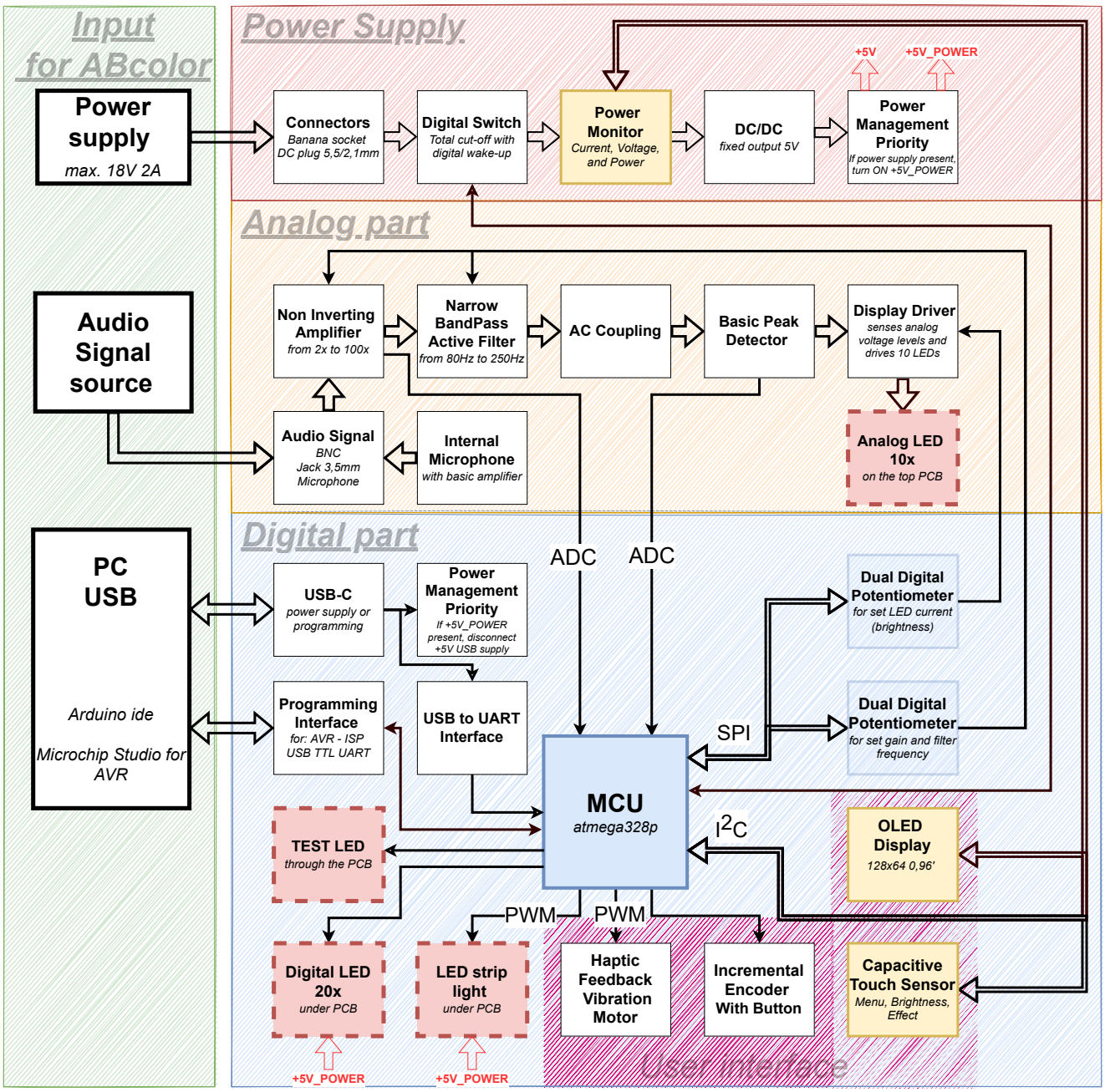

Figure 10: Block diagram

2.1 Power supply part

Contains banana socket and DC plug for connect of **main power supply**. Low leakage digital switch (Power button) is used for turning ON and OFF. For monitoring of power consumption there is used sense resistor 100mΩ with **INA219** power monitor. In the ABcolor there are two power lines +5V and +5V_POWER. Buck converter supplies both of this lines in power part. If the main power source is not used, +5V supply line from USB-C or programming connector can be used for minimum limited functionality. Basic power management priority ensures correct choice of active power lines.

2.2 Analog part

The user must select the source of the signals. Signal source can be external (BNC/jack 3,5mm) or internal (microphone). Analog part is created by **LM2904** Low-power dual operational amplifier. Analog signal processing includes a non-inverting amplifier, narrow bandpass active filter, full wave rectifier and basic peak detector. Whole analog part can be simulated with LTspice and compared with real measured data. For example the graph in the Figure 11 shows a comparison of the measured values with the simulated values of the whole analog part with set up cut off frequency 80Hz. Gain and filter cut off frequency are digitally tuneable by digital SPI potentiometers controlled by MCU via SPI bus.

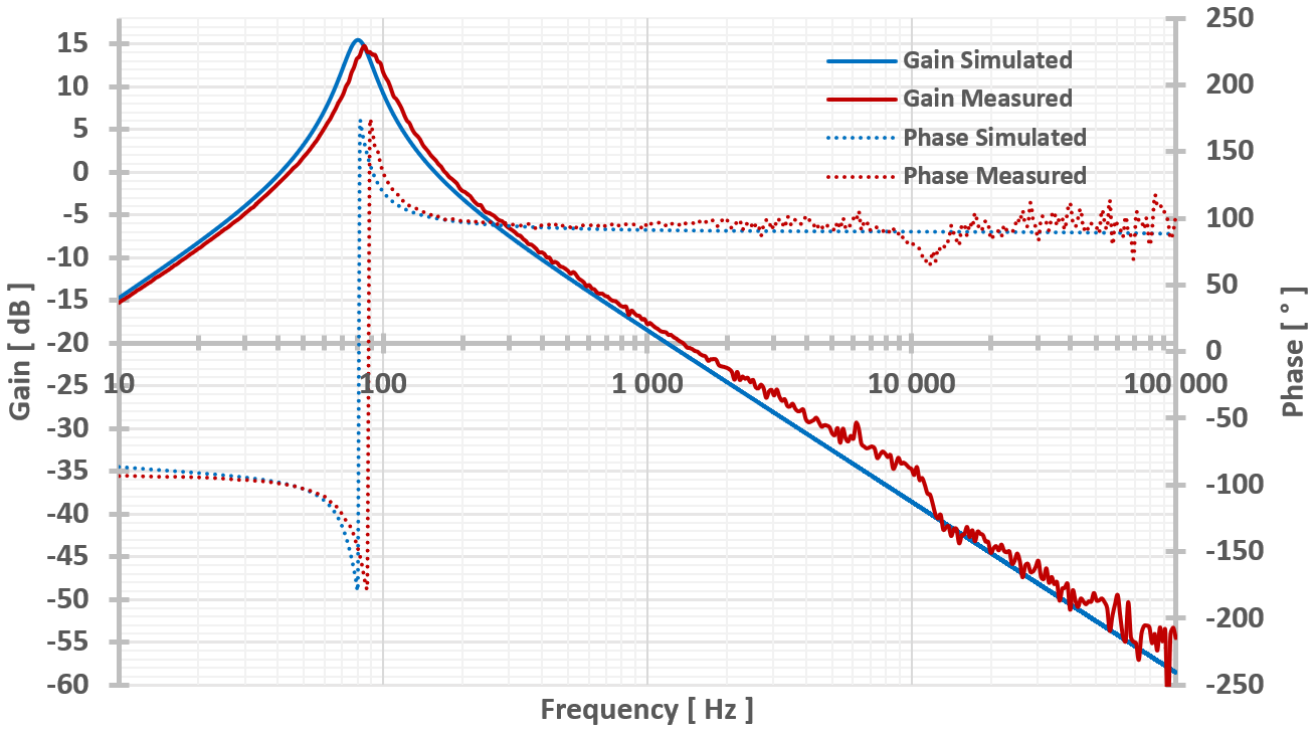

Figure 11: Signal processing comparison simulation and measurement

The analog part contains **LM3914** Dot/Bar Display Driver which is a monolithic integrated circuit that senses analog voltage levels and drives analog 10 LED's. LED current and internal voltage reference can be tuned with digital potentiometers or can be set using voltage divider which is included in ABcolor.

2.3 Digital part

The digital part is based on the ATmega328p microcontroler, which is used in arduino platform. The ATmega328p is supported with a full suite of program and system development tools which includes: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators, and evaluation kits.

Digital part includes user interface, connectivity for programming, LED's and digitally adjustable potentiometers. Block diagram is shown on the Figure 10.

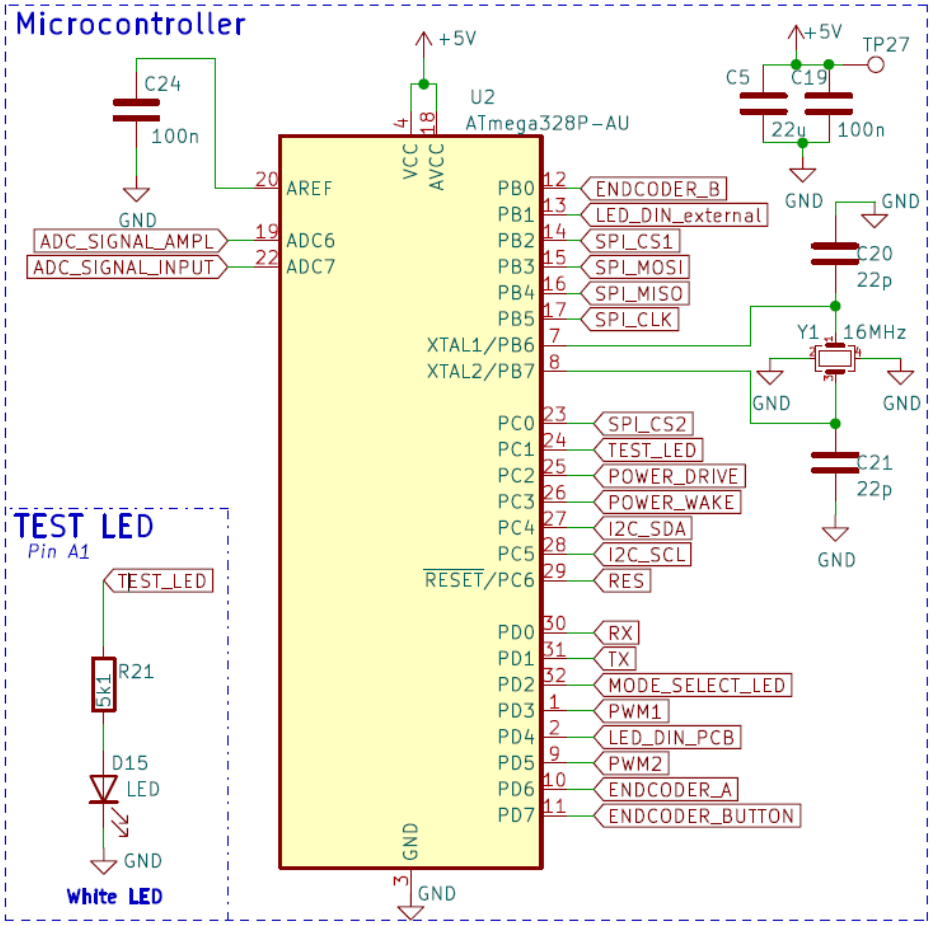

Figure 12: ABcolor - MCU port planning

2.3.1 Software

Basic program for the ABcolor includes menu system and basic user settings. On the Figure 14 is shown preview and control method. The control interface is shown on the Figure 9.

2.3.2 Programming

The ABcolor can be programmed using the USBASP programmer, TTL UART programmer, via USB-C or some other programmer, which using signals contains in the ABcolor programming connector. Figure 2. A simplified and illustrative programming method is shown in Figure 13.

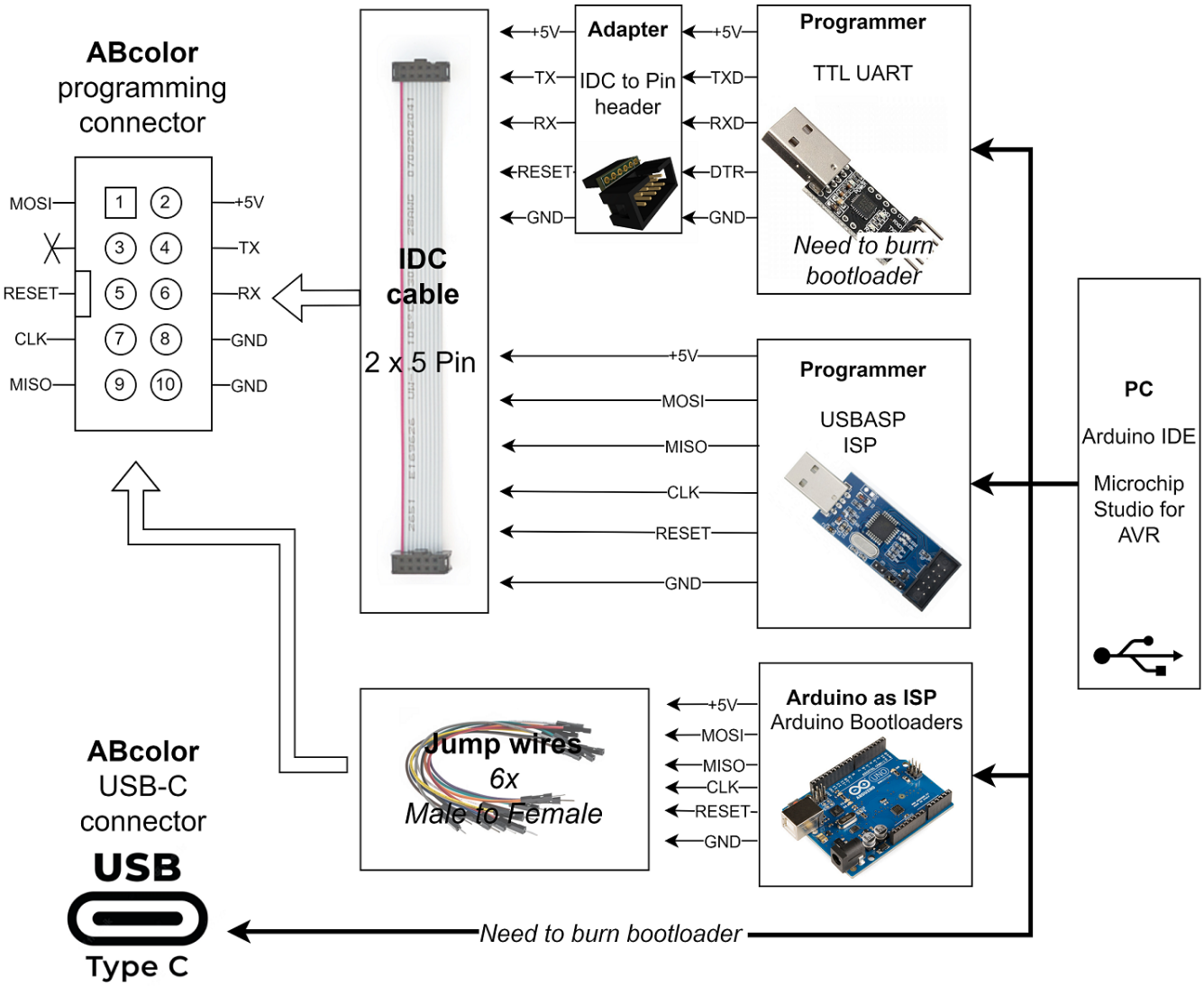

Figure 13: Example of programming

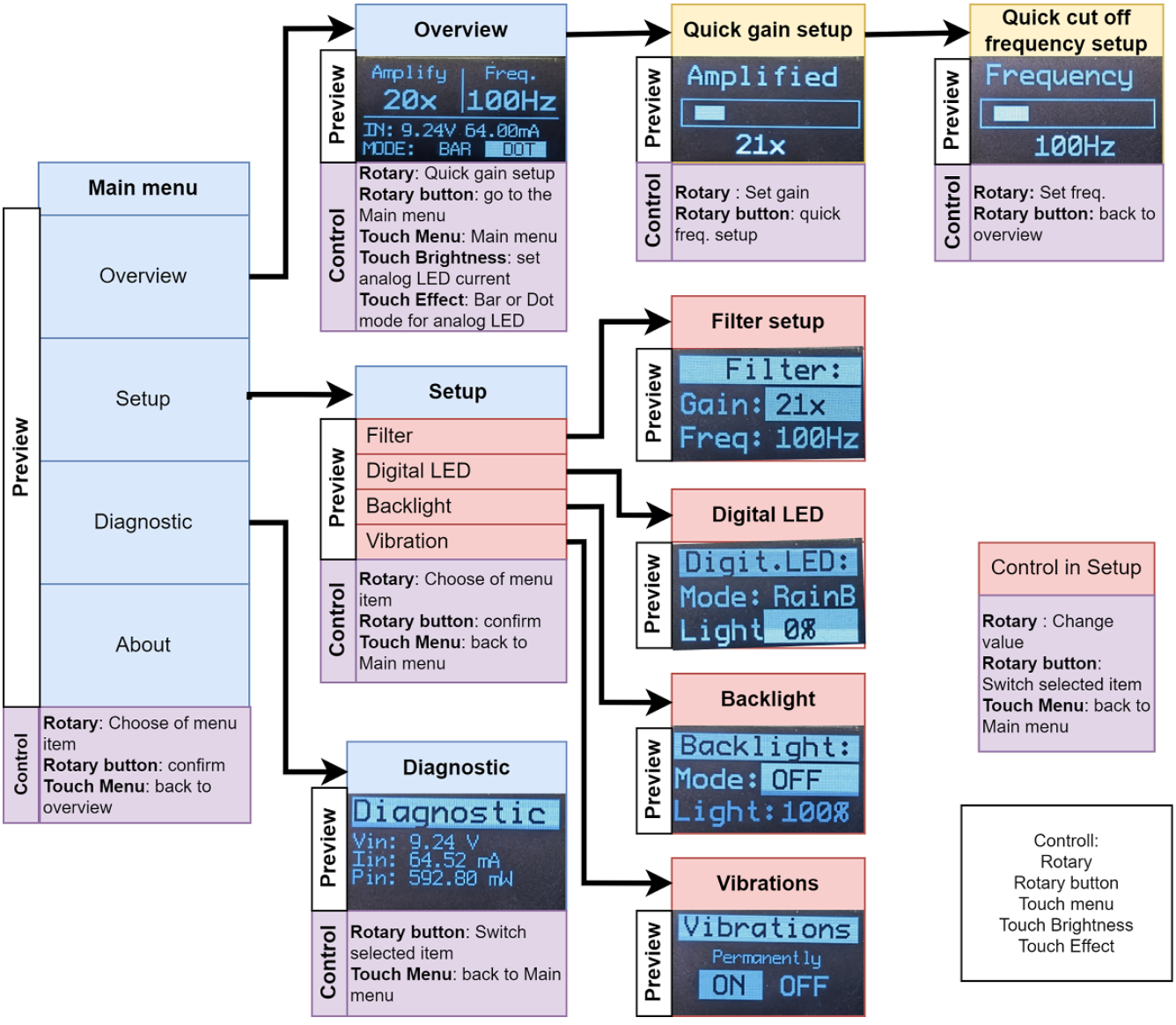

Figure 14: Preview of basic program

3 Electrical Specifications

All specifications are in $+25°C$.

Table 1: ABcolor Data Sheet Specifications

Parameter	**Symbol**	**Min.**	**Typ.**	**Max.**	**Unit**	**Block**
Input supply voltage	V_M	6.5	12.0	18.0	V	Main power supply
Current consumption	I_M	20	120	2000	mA	
Leakage current in OFF state	IL_M	-	52	-	µA	
Input voltage	V_U	-	5	-	V	USB power supply
Current consumption	I_U	-	100	500	mA	
Input voltage	V_P	-	5	-	V	Programming power supply
Current consumption	I_P	-	100	500	mA	
Input signal voltage	V_I	0.1	-	1.2	V	Input analog signal
Input signal frequency range	F_I	20	-	20 000	Hz	
Digitally tunable voltage gain	G_I	6	-	40	dB	
Bandwidth of the analog filter	B_I	-	4	-	-	
Analog LED's	LED_A	5	10	20	mA	LED's consumption per single chip
Digital LED's	LED_D	-	20	60	mA	
LED strip light	LED_S	-	-	80	mA	