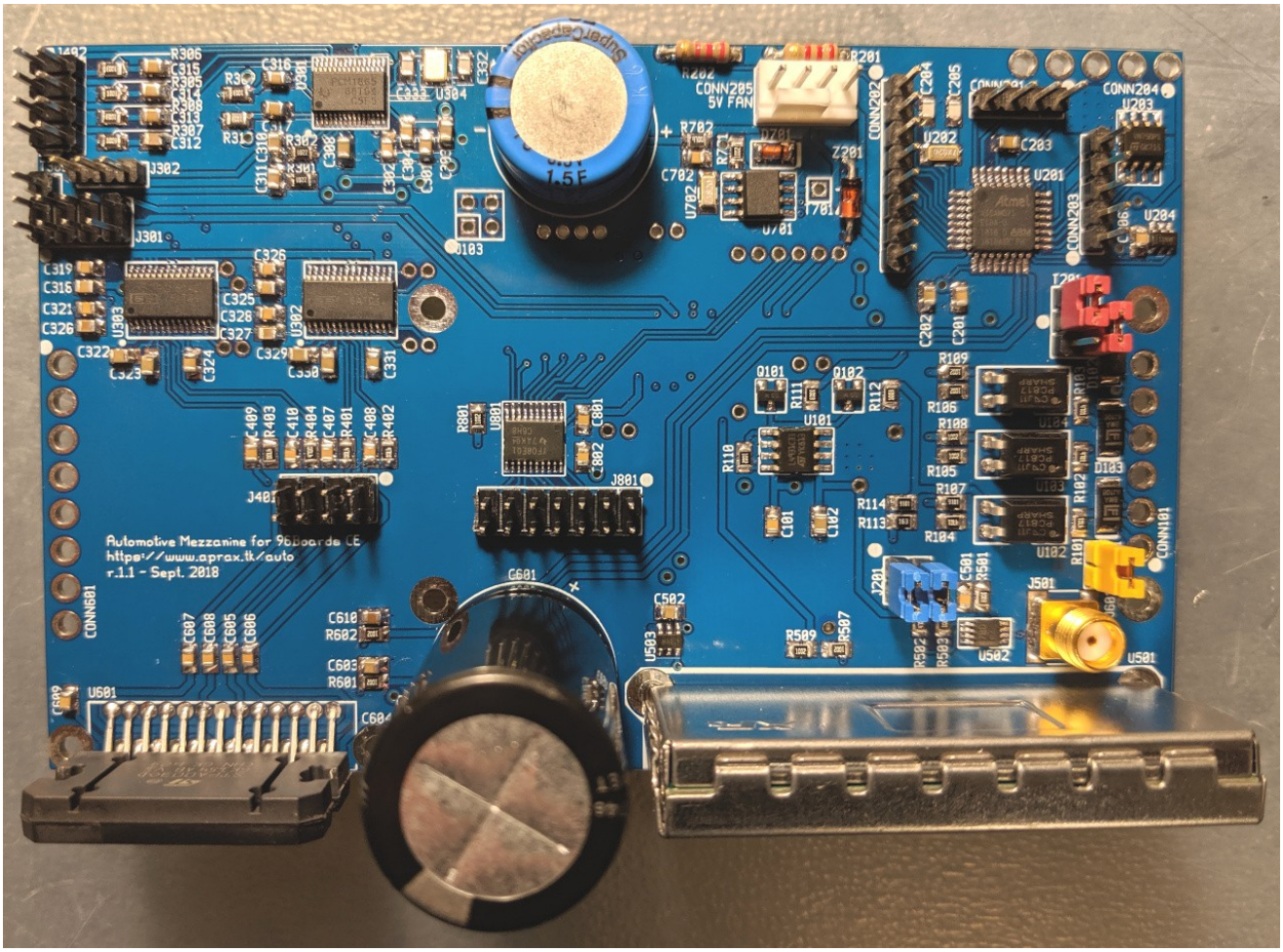
Automotive Mezzanine – User's guide.

The Automotive Mezzanine for 96boards Consumer Edition single board computers is designed to be universally compatible with all boards conforming to the 96boards CE specifications.

Nevertheless, issues with compatibility are not impossible, and the suitability of a specific SBC may depend on the features that it implements.

For example;
- The Dragonboard 410C does not implement a digital audio input on its low speed header, making it impossible to receive audio from the microphone or other audio inputs.
- The Rock960 does not implement a digital audio signal between the SoC and the bluetooth module, which would make it an enormous task to implement audio for a phone call in Android, which does not implement HFP over HCI.



** This board has been tested with Dragonboard 820C (recommended), Hikey960, and Dragonboard 410C (with the above noted feature compromise).

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Basic Connections

The user must supply and attach, by soldering, a basic automotive pigtail adapter that is compatible with their vehicle's wiring harness.

<u>CONN101: Power and input status signals.</u>
CONN101-1: Battery
CONN101-2: Ignition/Accessory
CONN101-3: Signal 1
CONN101-4: Signal 2
CONN101-5: Ground
CONN101-6: Ground

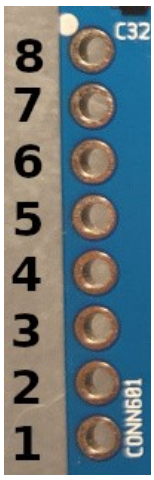
Note that it is not necessary to attach both ground pins. Additional ground connections are provided for convenience.

If desired, signal 1 and 2 can be used to input additional status signals, such as for lighting or reverse.

<u>CONN204: Steering wheel and power output.</u>
CONN204-1: 5V output (switched by microcontroller) – 2A max.
CONN204-2: 14V output (switched by microcontroller) – 6A max, internally regulated.
CONN204-3: Steer-2
CONN204-4: Steer-1
CONN204-5: Ground

The supported steering wheel interface is the variable resistance to ground type, in which each button on the steering wheel will connect to ground through a distinct resistance. Together with the R20x resistor pulling the line up to 3.3v, each button will yield a different voltage in the range of 0-3.3v. The microcontroller is programmed to recognize the distinct voltages and issue USB-HCI commands to the SBC based on the button states.

*** If there is any question as to the nature of the steering wheel interface on the vehicle, it is important to measure the voltage on the steering wheel interface to make certain that the vehicle is not supplying a voltage to them. Supplying any voltage in excess of 3.3v may cause damage to the microcontroller.

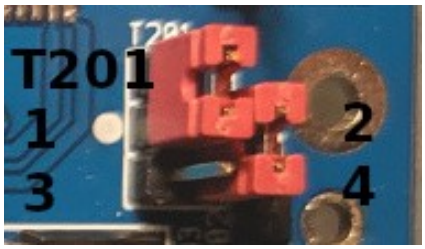


<u>CONN601: Speakers</u>
CONN601-1: Right-Front (-)
CONN601-2: Right-Front (+)
CONN601-3: Left-Front (-)
CONN601-4: Left-Front (+)
CONN601-5: Right-Rear (+)
CONN601-6: Right-Rear (-)
CONN601-7: Left-Rear (+)
CONN601-8: Left-Rear (-)

Power configuration

Input power configuration is controlled by the 4 pin header marked J101 with the single pin T201.

J101-1: SBC DCIN
J101-2: SBC DCIN
J101-3: Battery
J101-4: Ignition/Accessory



T201 is connected to the output of the same switch as CONN204-2.

Power modes

Powered-by-SBC: It is possible to power this board using the DC power jack on the SBC, however in order for it to work in this mode, it remains necessary to supply power to the Ignition/Accessory signal. Place a jumper between J101-1 and J101-3, and further make a connection between CONN101-1 and CONN101-2.

*** WARNING: When powered via SBC, power MUST NOT BE SUPPLIED TO THE AMPLIFIER! Remove the jumper from J601.

Low power instant wake: For when the SBC is able to achieve Deep Sleep with a very low power consumption. This will allow the board to awaken when the Ignition/Accessory signal is applied, and sleep when it is removed. Place a jumper across J101-1 and J101-3. Note: neither Dragonboard 820C, nor Hikey960 are currently able to achieve this low power state.

MCU-controlled: (Pictured above) Primarily for when you are unable to achieve Deep Sleep with low power consumption with the SBC. Place a jumper across T201 and J101-1, and across J101-2 and J101-4. In this mode, power is supplied along 2 paths;
a) Ignition/Accessory --> DCIN,
b) Battery --> Switch U203 --> DCIN.

In this mode, power sequencing works as follows;
1) When the ignition switch is turned on, power is supplied to the SBC via path (a), which powers on the microcontroller.
2) The microcontroller switches on U203, activating path (b).
3) If the Ignition/Accessory line is switched off momentarily (such as during engine start), power continues to be delivered by path (b), allowing the SBC to continue booting.
4) When the vehicle is shut off, power continues to be supplied by path (b).
5) When conditions are met (i.e. completed a countdown), the microcontroller deactivates U203, and power is no longer supplied.

Ignition/Accessory only: When placing a jumper across J101-2 and J101-4 *only*, the board may be powered exclusively by the Ignition/Accessory line. The battery line in this mode will be supplied exclusively to the amplifier and Switch U203. *This mode is not recommended*, since power will be lost during engine start, requiring the boot sequence to restart.

Microcontroller

The microcontroller on this board is the Microchip Atmel SAMD21E18A-A. Communication with the SBC is by the USB line available on the 96boards High Speed connector. The USB signal flows through J201.

If external access to the USB signal is required, remove both jumpers from J201, and make connections as follows;
J201-1: USB D-
J201-2: USB D+
Note that it will further be necessary to attach a common ground, which is available at several places on the board, including CONN201-2 near to the microcontroller. When external connection is no longer required, replace the jumpers between J201-1 and J201-3, and J201-2 and J201-4.

The microcontroller is responsible for the following functions;
- Steering wheel interface (PA04, PA05… PA02, PA03 on boards < r.1.4),
- Controlling power output switches U203 (PA10) and U204 (PA11),
- Controlling PWM cooling fan CONN205 PA09, with tach input on PA08,
- Controlling enable (PA15) and unmute (PA14) signals to the amplifier.
- SBC reset signal can be pulled low by PA19.

In addition, input signals Ignition/Accessory (PA23), and Signal 1 and 2 (PA27, PA28) are available to the microcontroller, though they are also available to the SBC on GPIO A, B, C.

CONN203 can be used for attaching a 3.3v i2c touchscreen or other devices.
CONN203-1: 3.3v
CONN203-2: PA16 (I2C SDA)
CONN203-3: PA17 (I2C SCL)
CONN203-4: PA18 (INT)
CONN203-5: GND

CONN202 can be used as required based on pin features, however note that some pins are shared.
CONN202-1: PA02 (shared with SWI < r.1.4)
CONN202-2: PA03 (shared with SWI < r.1.4)
CONN202-3: PA04 (shared with SWI r.1.4+)
CONN202-4: PA05 (shared with SWI r.1.4+)
CONN202-5: PA06
CONN202-6: PA07
CONN202-7: PA08 (shared with FAN)
CONN202-8: PA09 (shared with FAN)

The microcontroller can be programmed over USB when it contains a BOSSA compatible bootloader, or via the SWD interface at CONN201.

CONN201-1: Reset – there is a voltage supervisor that holds this low until power is stabilized.
CONN201-2: Ground
CONN201-3: SWCLK
CONN201-4: SWDIO
CONN201-5: PA00 (r.1.4+)
CONN201-6: PA01 (r.1.4+)

Recommended hardware for programming: Segger J-Link EDU Mini.
Recommended software for programming: OpenOCD.

The following openocd.cfg can be used to program a bootloader.bin to the microcontroller:

```
---------------------------------------------
source [find interface/jlink.cfg]
transport select swd
set CHIPNAME at91samd21e18
source [find target/at91samdXX.cfg]
init
reset
halt
at91samd bootloader 0
reset
program bootloader.bin verify reset
shutdown
```

Real-Time Clock

This board is equipped with an NXP PCF85063AT at U701. Backup power to the RTC is stored in a 1.5F supercapacitor, which charges to approximately 2.6v. The supercapacitor can maintain RTC for multiple weeks.

The RTC is connected to the SBC on I2C-1 at address 0x51

3.3v I/O

Several signals are level shifted to 3.3v and made available at J801 for convenience and debugging.

UART0, UART1, I2C-1, GPIO-J, GPIO-L.

Suggested usage:
I2C-1 + GPIO-J + GPIO-L: Capacitive touch sensor, such as Goodix GT911.
UART0: GPS
UART1: Debug console.

J801:
J801-1: Ground
J801-2: 3.3v
J801-3: I2C-1 SDA
J801-4: I2C-1 SCL
J801-5: GPIO-L
J801-6: GPIO-J
J801-7: UART1 Rx
J801-8: UART1 Tx
J801-9: UART0 RTS
J801-10: UART0 Rx
J801-11: UART0 Tx
J801-12: UART0 CTS
J801-13: Ground
J801-14: 3.3v

Sound Processing

This board is equipped with a sound processing system consisting of;
ADC: Texas Instruments PCM1865, I2C-1@4a
2xDAC: Texas Instruments PCM5142, I2C-1@4c, I2C-1@4d.

PCM1865

The PCM1865 is capable of receiving a total of 8 analog input channels, and 2 digital input channels. It can mix any combination of inputs to produce up to 4 digital output channels, which can be output on 1 or 2 digital output lines in I2S or TDM format.

The PCM1865 has a 5-wire digital audio interface, connecting to the SBC by 4-wires consisting of FS, CLK, OUT, IN. In addition, the 5th wire of the audio interface is an output connecting to the two DAC's. Typical configuration is for the output to be thought of in a "dual stereo" configuration, where each of the DAC's receive the same input, but are able to adjust their output volume independently. In TDM mode, it is also possible to deliver different signals to each DAC, such as broadcast radio to rear speakers and navigation commands to front. It should be noted, however, that since the ADC can only receive 2 digital input channels, that it is not possible to drive 4 channels from the SBC, so 2 channels would have to be from an analog source. It also must be noted that while in a mode where it is delivering 4 channels to the DACs, it is not possible to isolate the microphone to send back to the SBC, rather the output directed to the SBC could only mirror the output directed to the DACs.

The PCM1865 is able to perform as I2S Master using 12.288 MHz crystal U304. This may be useful when partial power-down is desired, such as drive-in movie theater where the SBC can be placed into deep sleep with the LCD turned off for reduced power consumption.

Analog inputs consist of;
Microphone: J302, 2.6v bias, connected to VIN1.
Broadcast radio: connected to VIN2.
AUX-1: J402, connected to VIN3.
AUX-2: J402, connected to VIN4.

J302
J302-1: Ground
J302-2: Mic-Left, VINL1
J302-3: Mic-Right, VINR1

J402
J402-1: AUX2-Left, VINL4
J402-3: AUX2-Right, VINR4
J402-5: AUX1-Left, VINL3
J402-7: AUX1-Right, VINR3
J402-2,4,6,8: Ground

PCM5142

These DACs are connected to the PCM1865 and SBC via 3-wire I2S interface consisting of;
PCM_CLK: supplied by SBC *or* PCM1865, whichever is master
PCM_FS: supplied by SBC *or* PCM1865, whichever is master
PCM1865 I2S OUT

In addition, the PCM5142's are also connected to the PCM1865 SCK, however, it is not ever actually required, since the PCM5142s are able to generate SCK from PCM_CLK using PLL. Some people believe that supplying SCK where possible will improve the sound quality, so this is made possible when the PCM1865 is operating as I2S master.

The PCM5142's have a programmable DSP. Firmware can be generated using Texas Instruments "Purepath Studio" software.

Digital audio expansion

There is a digital audio expansion/testing interface available at J301+T301
*** WARNING: These digital signals are 1.8v. Connecting to higher voltage can damage both the automotive mezzanine, as well as the SBC!
J301-1: Ground
J301-2: I2C1 SCL
J301-3: PCM_FS
J301-4: I2C1 SDA
J301-5: PCM1865 I2S OUTPUT (also connected to DAC inputs)
J301-6: 3.3v (use ONLY for powering DUAL-VOLTAGE ICs)
J301-7: PCM_CLK
J301-8: 1.8v

T301: PCM1865 SCKOUT

Line output

There is a 4-channel line level analog output header at J401.

J401-1: Right-Front
J401-3: Left-Front
J401-5: Right-Rear
J401-7: Left-Rear
J401-2,4,6,8: Ground

Amplifier

The amplifier is an STMicroelectronics STPA003.
The key features of this amplifier are;
- low voltage stability (6V)
- able to drive 2 ohm loads.

This amplifier requires a heatsink to be installed. Any piece of aluminum or copper with a fairly large surface area should be sufficient. Note that selecting a heat sink with too small of a surface area should not cause any damage, since the amplifier has thermal safeguards. If it is observed that the volume drops after a period of high intensity output, it is likely to be activating thermal safeguards, which suggests that the heatsink is insufficient.

The amplifier has two notches which should be used to secure it to the heatsink. In addition, there are two holes through the PCB on either side of the amplifier that can be used for mounting a heatsink. These are not necessary if the board is mounted in an enclosure with an integrated heatsink, however, they are necessary if the heatsink is not mechanically mounted to the same base upon which the board is mounted – the amplifier legs are not sufficient to support the heatsink.

The amplifier enable and unmute signals are driven by the microcontroller as previously described.

The amplifier can be deactivated mechanically, by removing the jumper J601. If an external amplifier is used instead of this amplifier, it is recommended to remove the jumper from J601. If the board is being tested without a heatsink installed, the jumper must be removed from J601. If the board is being powered through the SBC, the jumper at J601 *MUST* be removed or damage is likely to the SBC.

Broadcast Radio (AM/FM)

This board is equipped with an NXP TEF6686 AM/FM Radio tuner, packaged in a shielded module. The antenna connector at J501 is an SMA-F. For wiring the automotive antenna, you should select a standard SMA-M connector.

The radio is connected to I2C-1 at address 0x64.