Peripheral Extension board for DE10-lite FPGA

By Fall 2024 Capstone group #27

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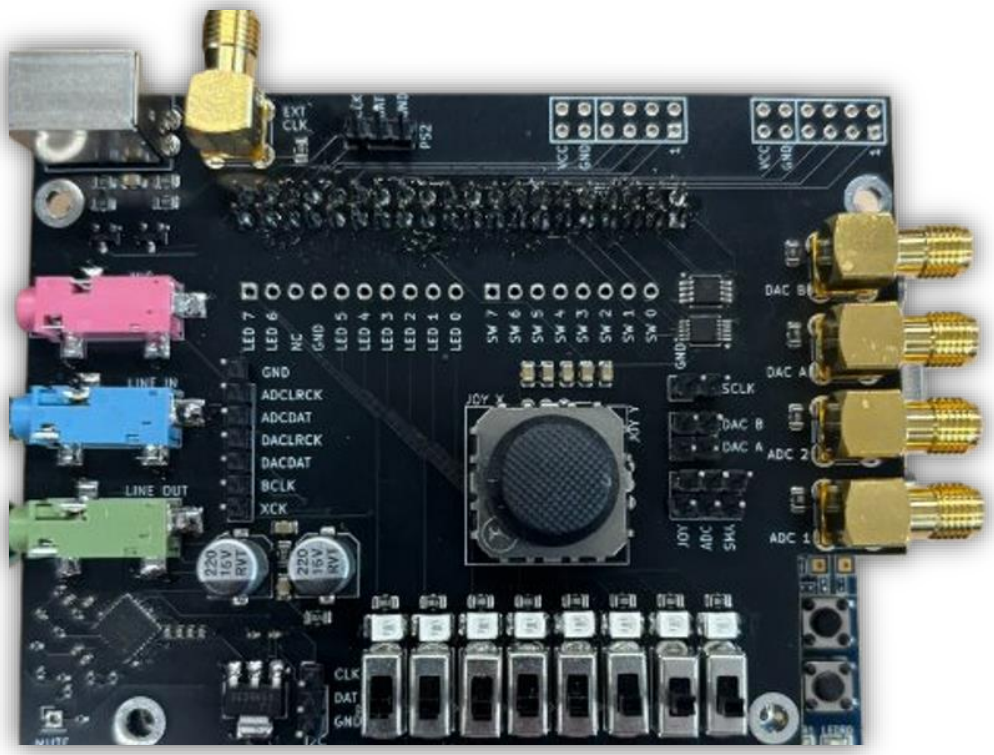
Introduction



The Peripheral Shield for the DE10-Lite board is a custom-designed hardware solution aimed at expanding the capabilities of the Altera MAX 10 FPGA development platform. Built with versatility and performance in mind, this shield brings together a suite of features that allow users to experiment with a variety of applications, ranging from analog-to-digital conversion to audio signal processing.

This shield seamlessly integrates with the DE10-Lite's 2x20 GPIO header, requiring no external power or additional cabling. The onboard peripherals include an ADC, DAC, Audio Codec with isolated power, SMA connectors, a potentiometer joystick, PMOD extensions, and more. With its modular and user-friendly design, the shield is ideal for educational labs, prototyping, and experimenting with FPGA-based solutions. This manual provides an overview of the shield's components and offers step-by-step instructions to help users make the most of this innovative platform.

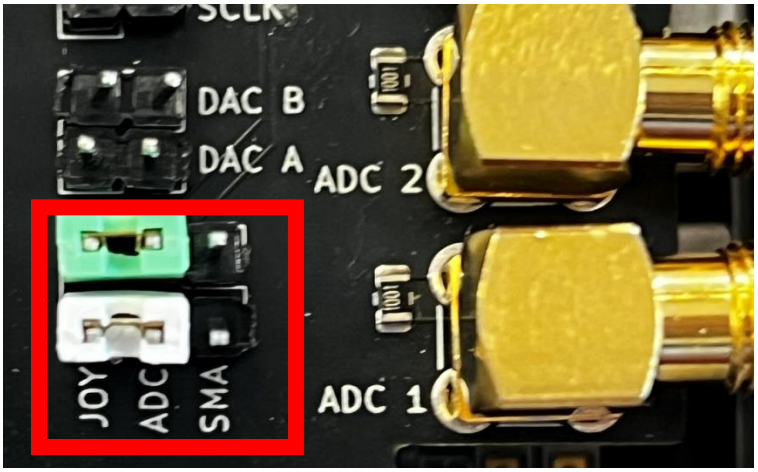
Using the components

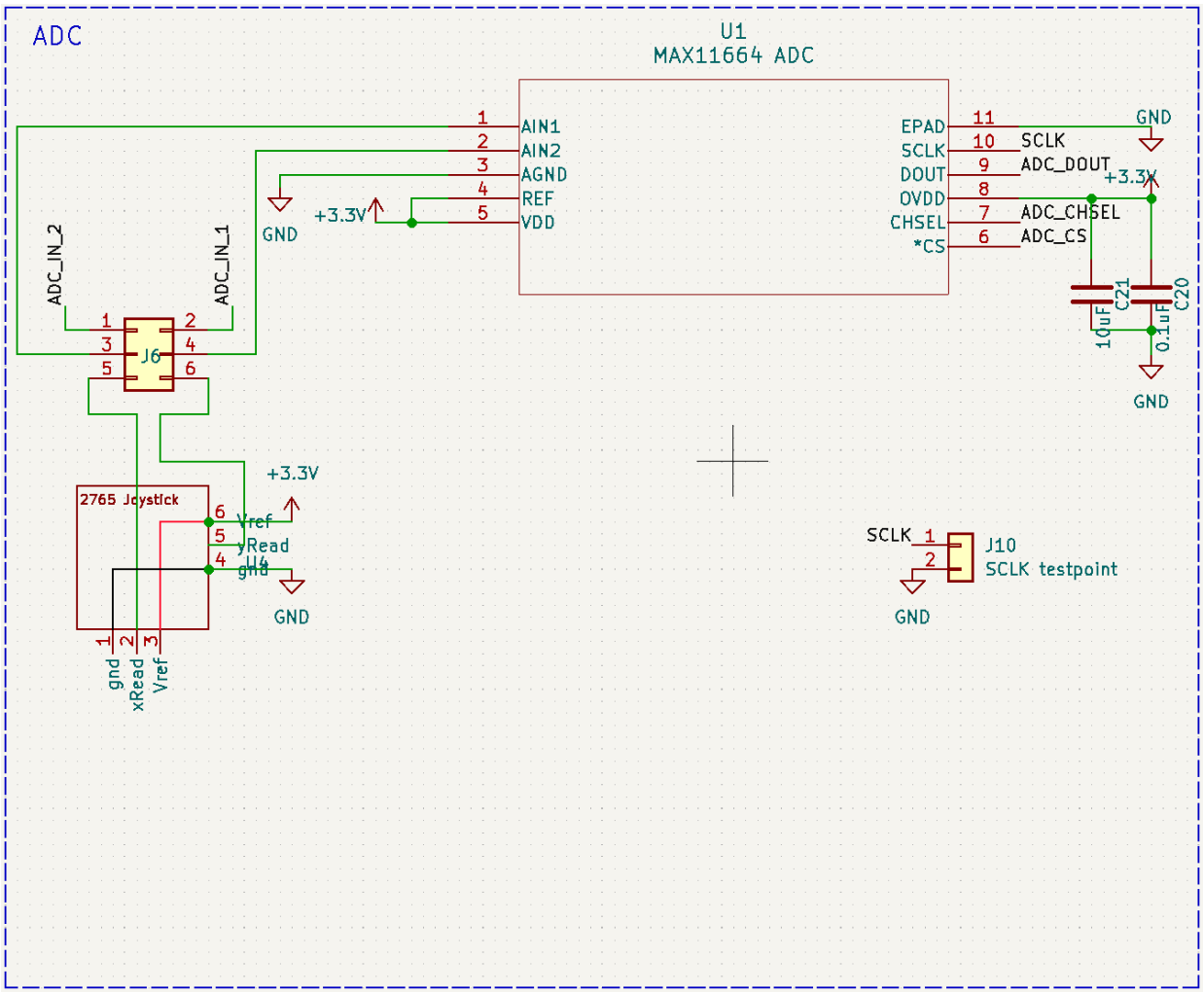
Analog-to-Digital Converter (ADC)

The MAX11664 ADC integrated into the peripheral shield provides high-resolution analog-to-digital conversion, making it ideal for applications requiring precise signal processing. With its 10-bit resolution and sampling rate of up to 500ksps, the MAX11664 ensures accurate and efficient conversion of analog signals into digital data for FPGA-based applications.

The ADC features dual single-ended analog inputs connected via SMA ports, as well as a potentiometer joystick for generating analog signals. Users can select the input source using a jumper-based configuration mechanism. The according 3x2 jumper header on the shield determines the ADC input channel and source according to the table:

Joystick input	ADC input channel 1	SMA input ADC 1
Joystick input	ADC input channel 2	SMA input ADC 2



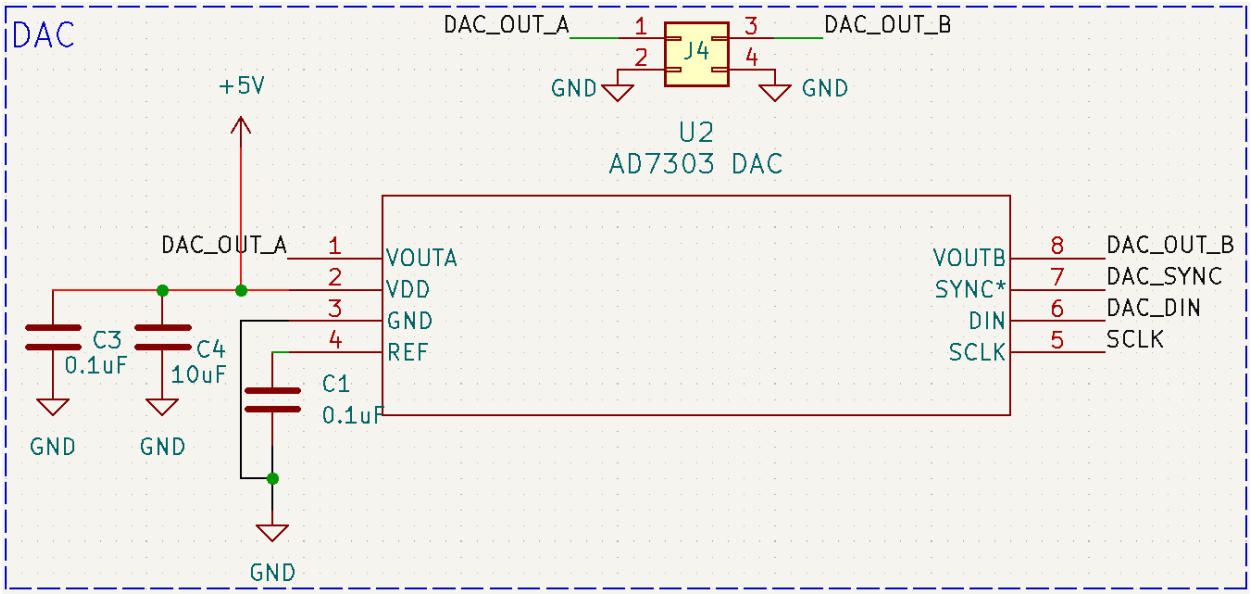


Peripheral	DE10-Lite port
SCLK	PIN_AA7
ADC_CS	PIN_AA8
ADC_CHSEL	PIN_AA9
ADC_DOUT	PIN_AB10

Digital-to-Analog Converter (DAC)

The AD7303 DAC integrated into the peripheral shield is a dual-channel, 8-bit voltage-output device designed for precise digital-to-analog conversion. With its rail-to-rail output capability and low power consumption, the AD7303 is ideal for applications requiring efficient signal generation and processing.

The DAC features two SMA connectors, each corresponding to one of its output channels. These connectors allow users to interface with external devices or measurement equipment seamlessly. The AD7303 operates from a 3.3V GPIO pin and is wired for SPI communication.



Peripheral	DE10-Lite port
SCLK	PIN_AA7
DAC_SYNC	PIN_AA5
DAC_DIN	PIN_AA6

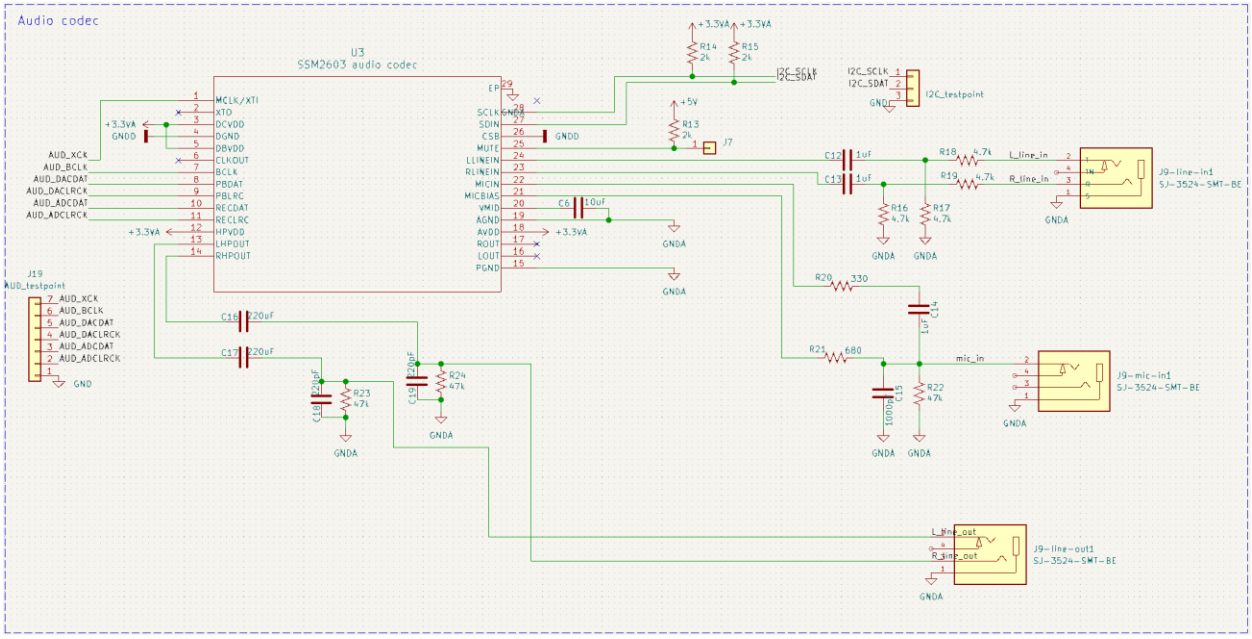
Audio Codec

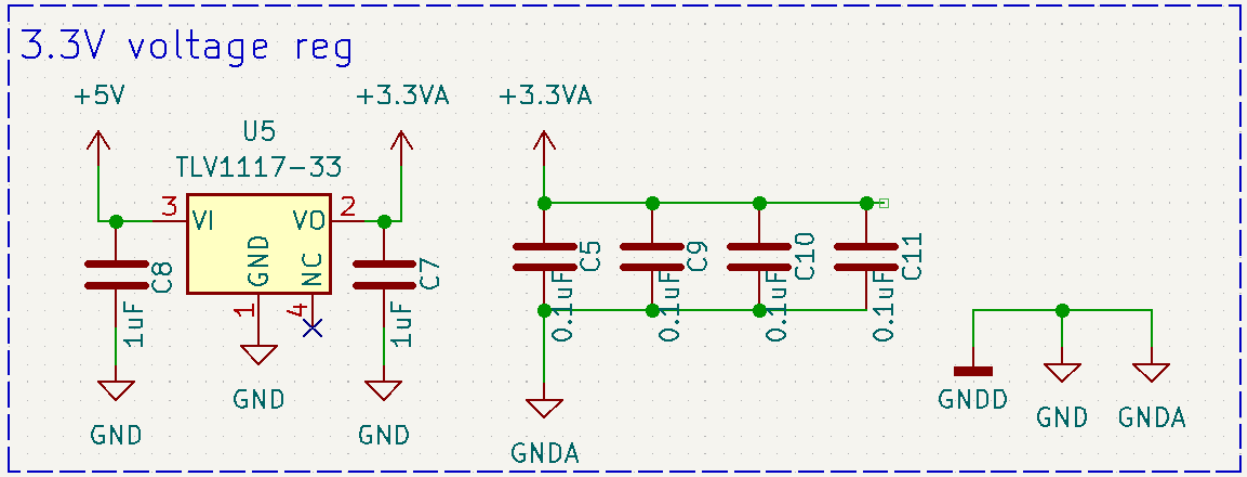
The SSM2603 audio codec integrated into the peripheral shield is a low-power stereo codec designed for applications requiring audio signal processing. The codec is equipped with three audio jack lines on the board:

- **Line In**: For external audio input.
- **Line Out**: For audio output to external devices.
- **Mic In**: For connecting a microphone.

Additionally, the codec features an exposed pin for the mute signal, allowing users to control audio output directly. Test points for all codec signals are provided next to the IC, enabling users to connect wires and observe signal behavior during operation. The codec is configured via an I2C interface, which is hard-wired on the PCB. Test points for the I2C signals are also available for monitoring communication.

To ensure optimal performance and minimize noise interference, the codec is powered through an isolated power line. The shield utilizes the 5V pin on the DE10-Lite board's GPIO header, which is converted to 3.3V using a TLV1117LV3-3 linear regulator, as recommended by the manufacturer.

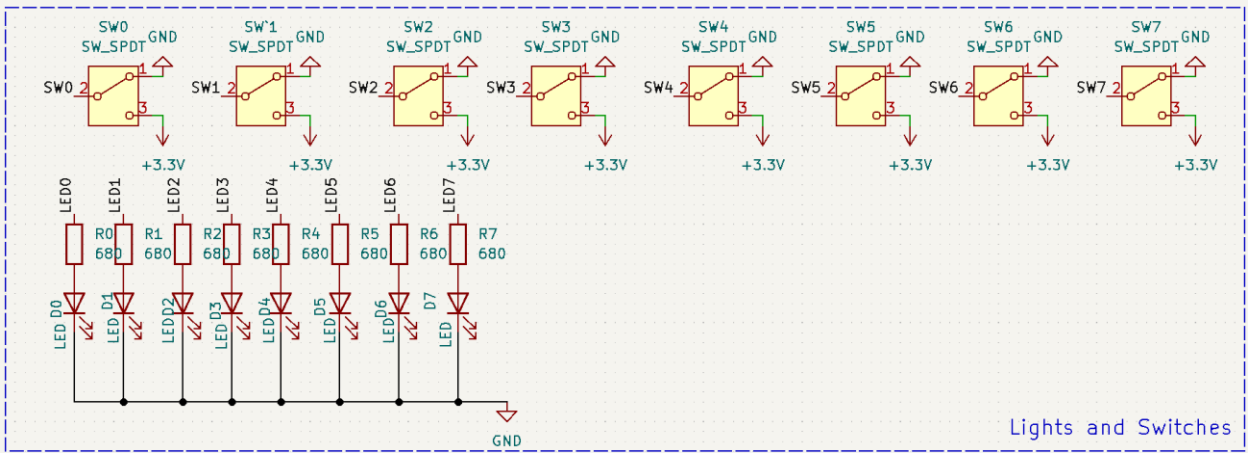




Peripheral	DE10-Lite port
I2C_SCLK	PIN_AA14
I2C_SDAT	PIN_W12
AUD_XCK	PIN_W5
AUD_BCLK	PIN_W6
AUD_DACDAT	PIN_V7
AUD_DACLRCK	PIN_V8
AUD_ADCDAT	PIN_V9
AUD_ADCLRCK	PIN_V10

LEDs and Switches

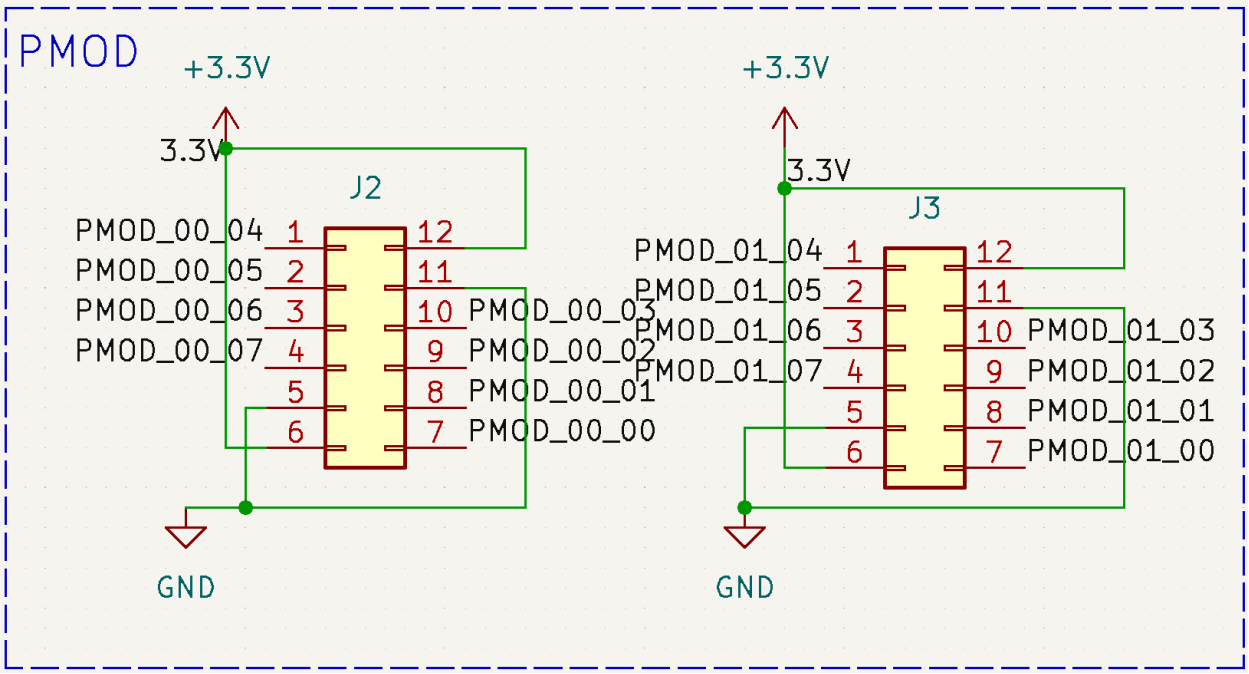
The peripheral shield is equipped with additional LEDs and toggle switches to complement the existing on-board peripherals and expand the overall input/output (I/O) capabilities of the DE10-Lite platform.



PERIPHERAL	DE10-LITE PORT
LED1	PIN_AB17
LED2	PIN_AA17
LED3	PIN_AB19
LED4	PIN_AA19
LED5	PIN_Y19
LED6	PIN_AB20
LED7	PIN_AB21
LED8	PIN_AA20
SW8	PIN_AA12
SW7	PIN_AA11
SW6	PIN_Y10
SW5	PIN_AB9
SW4	PIN_AB8
SW3	PIN_AB7
SW2	PIN_AB6
SW1	PIN_AB5

PMOD Expansion Pins

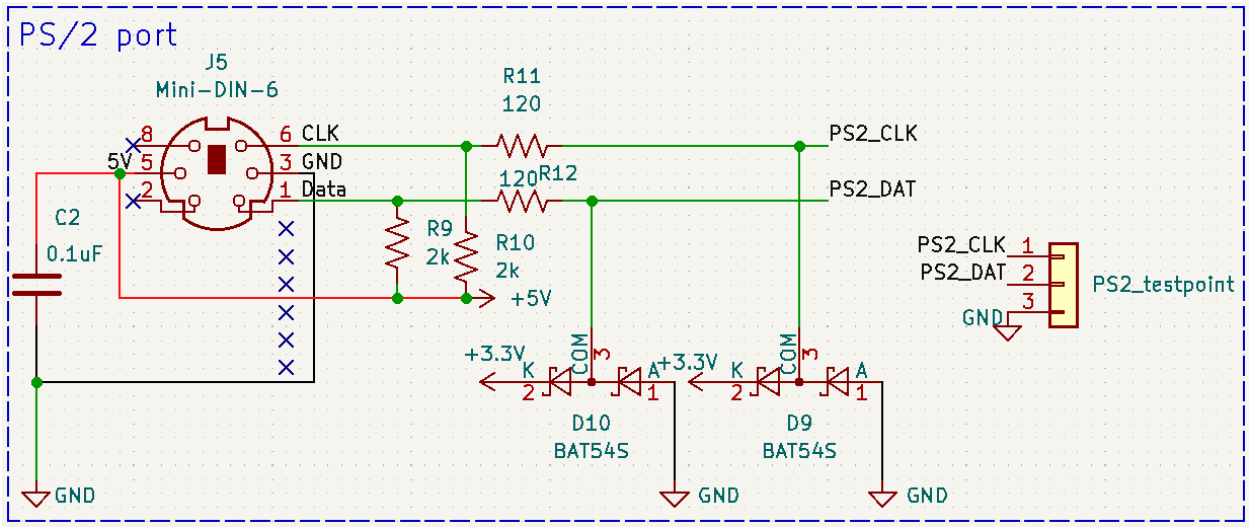
The peripheral shield includes two PMOD headers following the Agilent interface standard. These headers can be used with applicable PMOD modules to expand functionality. The PMOD pins are pass-through GPIO connections to the FPGA and can also function as general-purpose I/O.



PERIPHERAL	DE10-LITE PORT
PMOD_00_00	PIN_W11
PMOD_00_01	PIN_Y11
PMOD_00_02	PIN_AB13
PMOD_00_03	PIN_W13
PMOD_00_04	PIN_AA15
PMOD_00_05	PIN_V5
PMOD_00_06	PIN_W7
PMOD_00_07	PIN_W8
PMOD_01_00	PIN_AA2
PMOD_01_01	PIN_Y3
PMOD_01_02	PIN_Y4
PMOD_01_03	PIN_Y5
PMOD_01_04	PIN_Y6
PMOD_01_05	PIN_Y7
PMOD_01_06	PIN_Y8
PMOD_01_07	PIN_AA10

PS/2 port

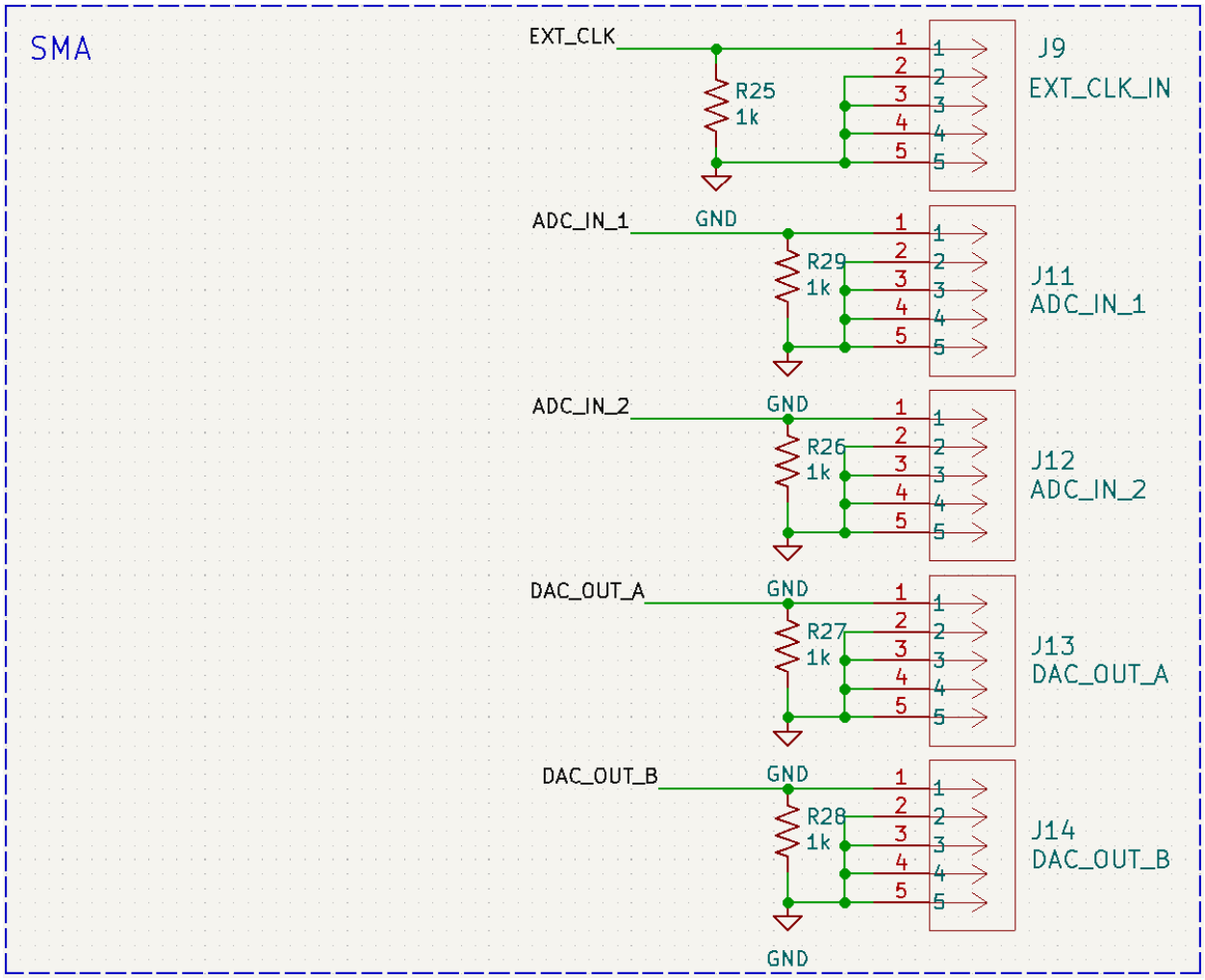
The peripheral shield includes a PS/2 port, providing support for connecting PS/2-compatible keyboards or mice directly to the FPGA. This simple serial interface allows users to receive input data from these devices during lab experiments or project development.



Peripheral	DE10-Lite port
PS2_CLK	PIN_W10
PS2_DAT	PIN_W9

SMA circuitry

The peripheral shield includes SMA connectors for input and output of analog signals in conjunction with the ADC and DAC. The board also includes an SMA connector for an external clock input.



Peripheral	DE10-Lite port
EXT_CLK	PIN_AB12

Known Issues and Recommendations

Power Supply and Current Draw

The total current draw for the DE10-Lite board and the extension shield with all peripherals active at once is estimated at 491.3 mA. This value at peak usage approaches the limit of the voltage regulator's capacity of 500mA. While it is unlikely that users will operate all peripherals simultaneously, given the shield's primary use in educational settings, users should still exercise caution when using additional expansions, like PMOD. Individual current draw values for each component are summarized below.

Peripheral	Part Number	Current Draw while Active (mA)	Number of Components	Total Current Draw (mA)	Justification
LEDs	150141AS73100	20	8	160	Datasheet
ADC	MAX11664	1.67	1	1.67	Datasheet
DAC	AD7303	2.3	1	0.75	Datasheet
Audio Codec (General)	SSM2603	19.6	1	19.6	Datasheet
Audio Codec (Headphone Amplifier)	SSM2603	62.5	1	62.5	Datasheet
Switch Pullup Resistors	N/A (10kΩ)	0.33	8	2.64	Ohm's Law
LEDs (DE-10 Lite)	Unknown (330Ω current-limiting resistors)	3.94	10	39.4	Schematic
Switch Pullup Resistors (DE-10 Lite)	N/A (120kΩ)	0.027	10	0.27	Schematic
VGA Resistor Network (DE10-Lite	N/A (Resistance varies)	22.28	1	22.28	Schematic
SDRAM (DE10-Lite)	IS42S16320D	180	1	180	Datasheet
Accelerometer (DE10-Lite)	ADXL345	0.14	1	0.14	Datasheet
FPGA (DE10-Lite)	10M50DAF484	0.60	1	0.60	Datasheet

Clock Source Configuration

During testing, it was observed that using multiple clock sources to drive peripherals resulted in unexpected behavior in the Quartus software, including irregular placement of logic gates. To mitigate this issue, users should configure the FPGA to use a single clock

source with appropriate clock dividers for different devices. This approach ensures stable and reliable operation of the shield.

Signal Observation via Test Points

The board features multiple test points for signals, including the audio codec signals, I2C and SPI interfaces pins, and intermediate signals from PS/2, DAC and ADC. Users should exercise caution when probing these test points, as improper handling could lead to short circuit, noise interference or signal distortion.

Jumper Configuration

Incorrect jumper settings for the ADC channels could result in unexpected input values. Users are encouraged to refer to the jumper configuration instructions and double-check their settings to ensure proper operation.

Recommendations for Assembly

During installation, ensure that standoffs are securely tightened to avoid mechanical instability, which could damage the board or affect signal quality.