Tech Expo, Spring 2025 – Team 27

FPGA Extension Board

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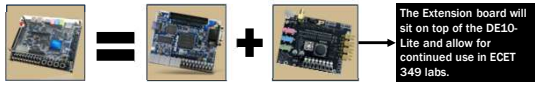
PURDUE UNIVERSITY
Polytechnic Institute

Problem Statement

The Altera DE-1 FPGA boards used in Dr. Leon-Salas' ECET 349 class are being replaced with the Altera DE10-Lite boards. This board (DE10-Lite) lacks several key peripherals for hands-on learning in Dr. Leon-Salas's labs. To address this, we designed a physical peripheral extension plug-in board as a shield to interface with the new DE10-Lite board. This solution will enable students to continue learning with the necessary peripherals while using the updated boards.

Problem Description



The Extension board will sit on top of the DE10-Lite and allow for continued use in ECET 349 labs.

- New development boards (Altera DE1-Board) for lab lack several key peripherals.
- Students can't learn the new peripherals on the DE10-Lite board hands-on.
- The current DE10-Lite does not have the same peripherals Dr. Leon-Salas would like for the lab.

Our Solution: We built an extension board that connects via the 40-pin GPIO connector on the DE1-Board with standoffs to allow for the new DE10-Lite board to have the same capabilities as the DE1-Board.

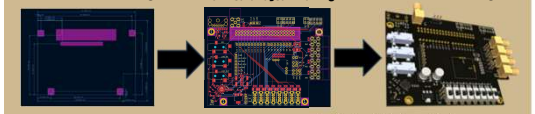
Scope of Work

- Design an extension board that can interface with the DE10-Lite development board already planned for use in other Polytech courses
- Implement all peripherals that we deem fit for use during lab
- Design software to rigorously test each peripheral for functionality and stability
- Add QR code and customized colors to board so students can scan them to access a GitHub documentation.

Design Process

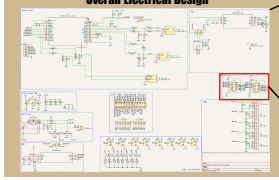
- We first tested the various options for connectivity to the extension board. Including the use of a shield and ribbon cable connection.
- We then decided on the shield design and began designing our board layout using KiCad software.

FPGA Mechanical Drawing → **FPGA Board Layout Drawing** → **3D FPGA Rendering**



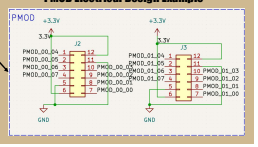
- After the CAD drawing phase, we began our electrical design. This included creating schematics for every peripheral present on our board.

Overall Electrical Design



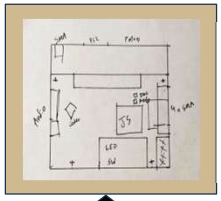
The overall electrical schematic shows all the connections present within the extension board.

PMOD Electrical Design Example



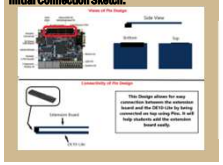
Design Evolution

1. Initial Sketch

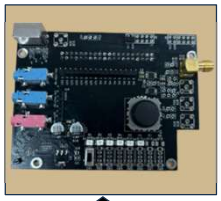


This design is the initial hand sketch of the attached shield design. We developed multiple connection options and decided on a shield design that would connect the pin connectors of the DE10-Lite to the extension board.

Initial Connection Sketch:



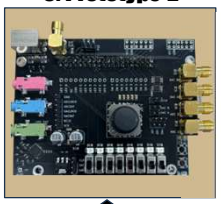
2. Prototype 1



This is the first functional prototype extension board. It includes all new peripherals and extra peripherals (joystick, audio, etc.) for students to use during lab. We noted a clearance issue with the VGA connector on the DE10-Lite. as well as some issues with peripherals' wiring.

VGA Clearance Issue:

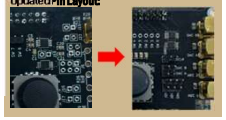
3. Prototype 2



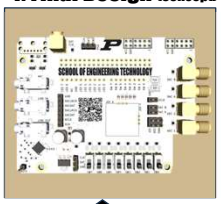
The updated Prototype includes circuitry fixes, better labeling and a more organized layout for easier use by students.

Updated Labeling:

Updated Pin Layout:



4. Final Design (Concept)



The final design features a new color board. It also includes a QR code allowing students to get information and code for the board on a GitHub Page.

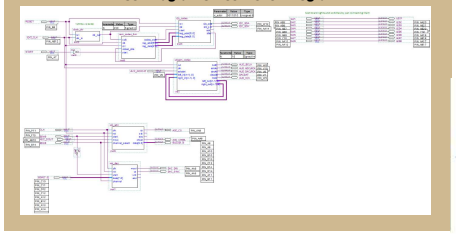
GitHub Page QR Code:

Scan Me!

Software Design

The software used for programming the target board is **Quartus Prime Lite**, which is provided free for developers by Intel corporation. The software selection is justified by support of the specific FPGA chip used on the target board, since this software can be used to program the MAX 10 FPGA device. Below is the block schematic of the testbench program that was used to test functionality of every peripheral.

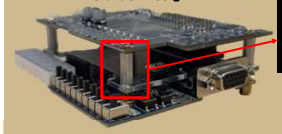
Block Diagram of Test Bench Program



Mechanical Design

The mechanical aspects of the PCB include the placement of the GPIO headers, the mounting holes, and the edge cuts. Screws are mounted through the PCB to existing standoffs on the DE10-Lite.

Standoff Design



The standoffs allow for better clearance and to ensure students can access the DE10-Lite components below the extension board.

40-Pin Header Design

We used a 40 pin extended header to connect the DE10-Lite to the extension board

Final Design

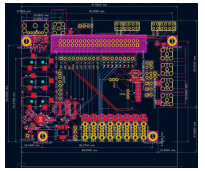
Connection Description

- PCB will mount as a shield on DE10-Lite
  - Will use existing standoffs
- Peripherals will connect through existing 2x20 and 1x18 GPIO headers on the DE10-Lite
- Critical Dimensions – Position on PCB of:
  - M3 Screw Mounting Holes
  - 2x20 Female Header
  - 1x18 Female Header

Peripheral Current Draw

Peripheral	Current Draw while Active (mA)	Number of Components	Total Current Draw (mA)
LEDs	20mA	8	160
ADC	1.67	1	1.67
DAC	0.75	1	0.75
Audio Codec (General)	35.6	1	35.6
Audio Codec (Headphone Amplified)	62.5	1	62.5
Switch Pullup Resistors	0.33	8	2.64
LEDs (DE-10 Lite)	3.94	10	39.4
Switch Pullup Resistors (DE-10 Lite)	0.027	10	0.27
VGA Resistor Network (DE10-Lite	22.28	1	22.28
SDRAM (DE10-Lite)	180	1	180
Accelerometer (DE10-Lite)	0.14	1	0.14
FPGA (DE10-Lite)	0.60	1	0.60

Final Design CAD Layout



Final Design Components

Analog/Digital		
ADC		1
DAC		2
Joystick		3
Audio		
Codec		4
Audio Jack Blue		5
Audio Jack Green		6
Audio Jack Red		7
Lights & Switches		
LED		8
SPDT Switch		9
Ports		
PS/2		10
SMA		11
Miscellaneous		
Linear Voltage Regulator		12
Adafruit Header		13
Header Screws		14

Final Design Numbered Layout

Note: The final board will be white color and have various logos as seen in (4. Final Design concept).