Revision	Date	Author	Comments
1A	2020-08-31	Tim S. timothystotts08@gmail.com	First publishable draft of the colors palette tester
2A	2020-08-31	Tim S. timothystotts08@gmail.com	Clerical corrections and additions
3A	2020-09-03	Tim S. timothystotts08@gmail.com	Clerical corrections and additions
A	2020-12-04	Tim S. timothystotts08@gmail.com	Release A of project.
1B	2020-12-04	Tim S. timothystotts08@gmail.com	Update of Vivado/SDK 2019.1 project to tool versions Vivado/Vitis 2020.2 .

https://github.com/timothystotts/fpga-colors-tester-1

Colors Palette Tester Experiment

Colors Palette Tester Experiment: Folder Structure

The colors palette tester is only implemented in Microblaze subsystem design. No straight HDL coding exists.

Project Folder	Project Description
Color-Tester-Design-AXI (Vivado 2020.2 and SDK 2020.2)	A utility designed for custom color mixing of four RGB LEDs with comparison to the same palette mix on an OLED RGB display. The design is completely in Microblaze AXI subsystem with standard Xilinx IP Integrator components, and Standalone C language program executing on the Microblaze soft processor.

In the Color-Tester-Design-AXI project, the BSP of the bootloader and the BSP of the application require that the flash family parameter be set in the xilisf configuration on the BSP configure page. The default value is 1, but must be changed to 5 as the Arty-A7-100T board has a Spansion 128Mbit serial flash for booting the FPGA.

To successfully open the project, it is necessary to add the directory arty-a7-100 from the directory board_files/ to the installation directory of Vivado 2020.2 but not to the installation directory of Vitis 2020.2. For example:

```
$ which vivado
/opt/Xilinx/Vivado/2020.2/bin/vivado
$ cd ./board_files
$ sudo cp -R ./arty-a7-100 /opt/Xilinx/Vivado/2020.2/data/boards/board_files/
# (do not copy the board_files to
# /opt/Xilinx/Vitis/2020.2/data/boards/board_files/)
```

Note that the Digilent Guide at https://reference.digilentinc.com/vivado/installing-vivado/v2019.2 indicates to install the board files by copying to the install directory of the tool, so that the board files are always found.

Colors Palette Tester Experiment: Methods of Operation

The purpose of the design is to boot a Digilent Inc. Arty-A7-100T (Artix-7) development board with PMOD KYPD and PMOD OLEDrgb peripheral boards, which are a 4 by 4 alphanumeric keypad, and a 96x64 pixel 16-bit color

OLED display panel, respectively. The PMOD KYPD connects to the FPGA with its own GPIO signals; and PMOD OLEDrgb connects to the FPGA with its own dedicated SPI bus. The PMOD KYPD connects to board PMOD port JA; a slower PMOD port. The PMOD OLEDrgb connects to board PMOD port JB; a faster PMOD port. The use of an extension cable for each makes the PMOD KYPD able to orient upright with the display, and the PMOD OLEDrgb not block other ports. See Figure 1: Arty-A7-100T Assembled with Pmod KYPD, Pmod OLEDrgb.
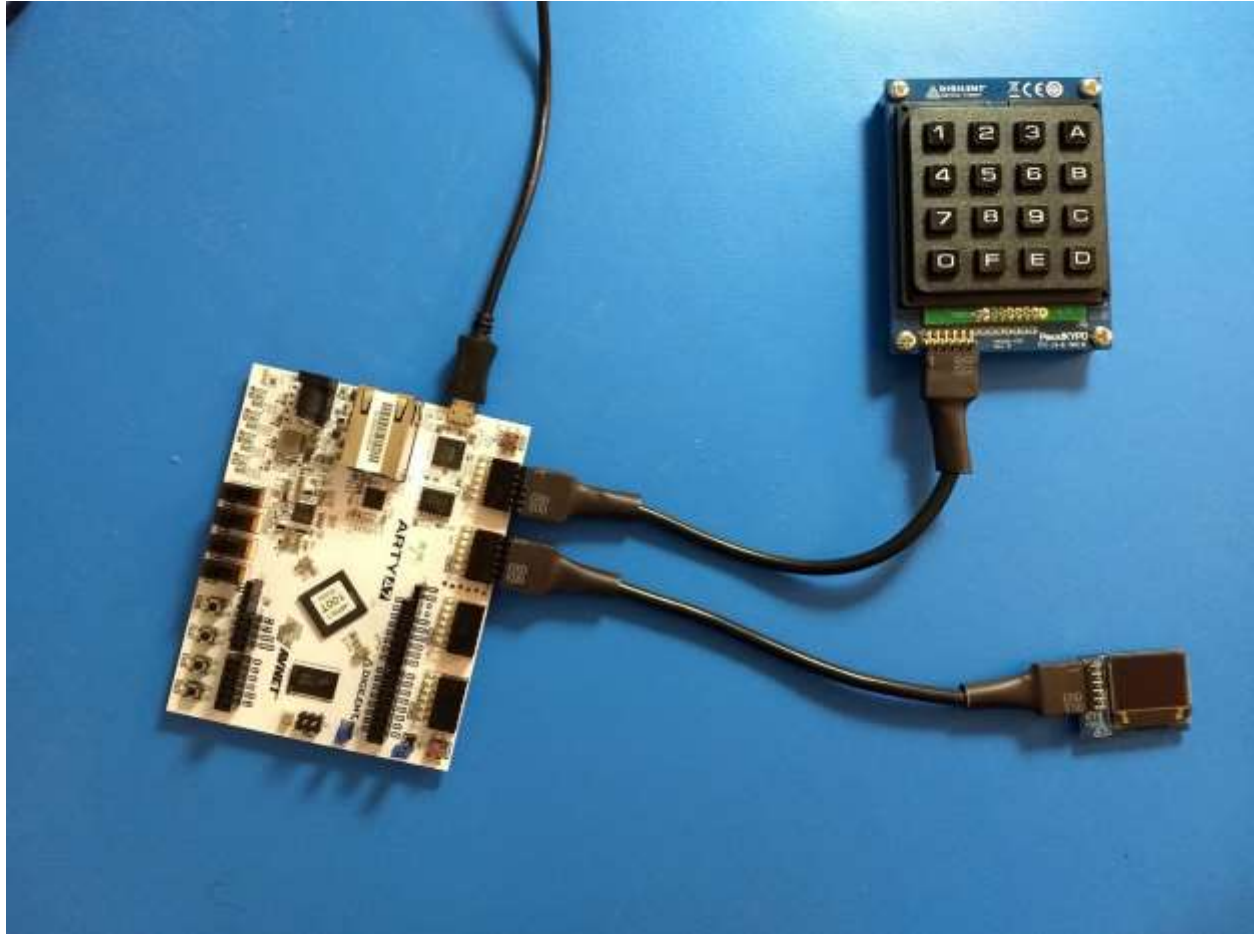

Figure 1: Arty-A7-100T Assembled with Pmod KYPD, Pmod OLEDrgb

Colors Palette Tester Experiment: Method of Operation: enter LED index and palette value on the keypad and the discrete RGB LED and display both update

Colors Palette Tester Experiment: Design Operation

With the AXI implementation, the four switches and buttons are ignored. User entry is through the Pmod KYPD keypad. To start an entry, the letter 'A' is typed, followed by a digit, '0', '1', '2', or '3'. The digit following 'A' indicates the silkscreen index of the RGB LED to update. Following this, three digits are entered with the decimal number range 000 to 255 to indicate the Red palette 8-bit value of 24-bit color. Following this, three digits are entered for the Green palette 8-bit value, and then three more digits for the Blue palette 8-bit value. After the eleventh key press, the indexed LED will display the entered color, and a corresponding line on the display will display text with foreground of the entered color.

Note that in the AXI design, drivers downloaded from Digilent Inc. for the PMOD KYPD and PMOD OLEDrgb are used in the block design with some minimal modification. The AXI implementation integrates vendor components plus adds additional C code. Note that the program is with the Standalone OS BSP, a bare-metal operating system.

Colors Palette Tester Experiment: Design Theory

Note that in the IPI-BD (called AXI) Design, drivers downloaded from Digilent Inc. for the PMOD KYPD and PMOD OLEDrgb are used in the block design with some minimal modification to target the Arty-A7-100T. Both drivers target the Arty-A7 instead of the Arty. The forked repository of "vivado-library" was also updated to properly build 16-bit RGB values for the OLED on a Microblaze processor due to a difference in endianess. The Git repository contains a submodule that pulls from a branch of the author's fork of the Digilent vivado-library repository on GitHub.

Coding style and choices of block design

Software design practices were used to author the C sources. The sources were drafted with a moderate top-level module and uses the cohesive driver modules to operate the Pmods.

Serial Flash Sector-Tester Experiment: 3rd-party references:

Digilent Inc. References

Arty – Getting Started with Microblaze Servers
https://reference.digilentinc.com/learn/programmable-logic/tutorials/arty-getting-started-with-microblaze-servers/start

How To Store Your SDK Project in SPI Flash
https://reference.digilentinc.com/learn/programmable-logic/tutorials/htsspisf/start

Vivado Board Files
https://github.com/digilent/vivado-boards

Master XDC files for all Digilent Inc. boards, including Arty-A7-100T
https://github.com/Digilent/digilent-xdc

Digilent Inc IP library for Xilinx Vivado
https://github.com/Digilent/vivado-library/

Textbook References

Use of IP Integrator to create the Microblaze AXI block diagram and synthesis:
- Tutorials followed from text to understand IPI block design,

L. H. Crockett, R. A Elliot, M. A. Enderwitz, and R. W. Stewart, *The Zynq Book: Embedded Processing with the ARM Cortex-A9 on the Xilinx Zynq-7000 All Programmable SoC*, First Edition, Strathclyde Academic Media, 2014.