Revision	Date	Author	Comments
1A	2020-09-03	Tim S. timothystotts08@gmail.com	First publishable draft of the colors palette tester

https://github.com/timothystotts/fpga-colors-tester-2

Colors Palette Tester Experiment - Zynq

Colors Palette Tester Experiment - Zynq: Folder Structure

The colors palette tester is only implemented in Zynq-7000 subsystem design. No straight HDL coding exists.

Project Folder	Project Description
Color-Tester-Design-Zynq (Vivado 2019.1 and SDK 2019.1)	A utility designed for custom color mixing of two RGB LEDs with comparison to the same palette mix on an OLED RGB display. The design is completely in Zynq-7000 AXI subsystem with standard Xilinx IP Integrator components, and Standalone C language program executing on the Zynq-7000 hard processor.

To successfully open the project, it is necessary to add the directory zybo-z7-20 from the directory board_files/ to the installation directory of Vivado 2019.1 and also to the installation directory of SDK 2019.1. For example:

```
$ which vivado
/opt/Xilinx/Vivado/2019.1/bin/vivado
$ cd ./board_files
$ sudo cp -R ./zybo-z7-20 /opt/Xilinx/Vivado/2019.1/data/boards/board_files/
$ sudo cp -R ./zybo-z7-20 /opt/Xilinx/SDK/2019.1/data/boards/board_files/
```

Note that the Digilent Guide at https://reference.digilentinc.com/vivado/installing-vivado/2018.2 indicates that an initialization script can be executed in the user's profile to set up a path to additional board files. It is the experience of this author that the TCL initialization script provides an intermittent or non-functional detection of the board files in the user's home folder. By copying to the install directory of the tool, the board files are always found. Otherwise, the following TCL command is supposed to instruct Vivado to locate the board files:

```
set_param board.repoPaths [list "<extracted path>/Vivado/board_files"]
```

Colors Palette Tester Experiment - Zynq: Methods of Operation

The purpose of the design is to boot a Digilent Inc. Zybo-Z7-20 (Zynq-7000) 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 JE; 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: Zybo-Z7-20 Assembled with Pmod KYPD, Pmod OLEDrgb.

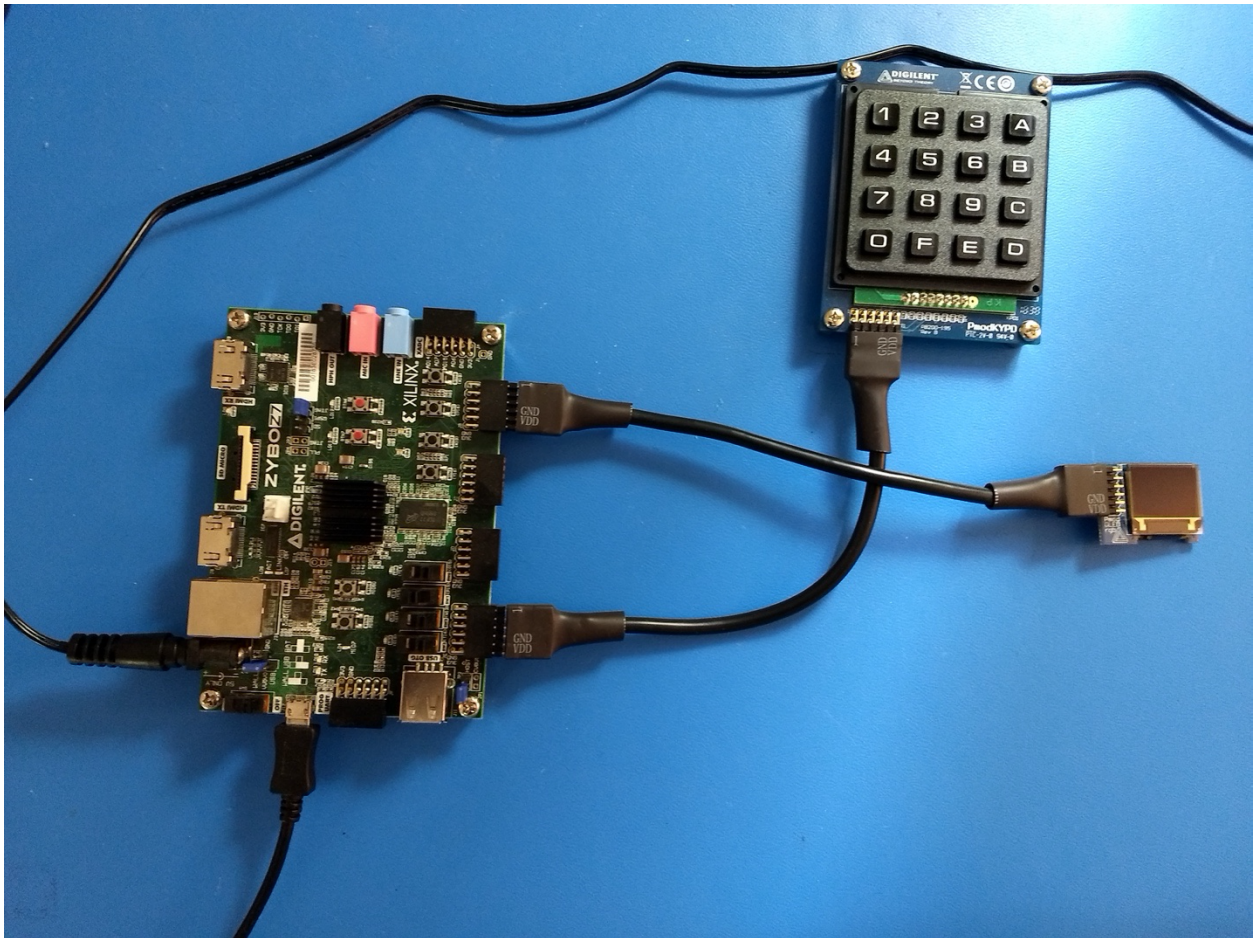

Figure 1: Zybo-Z7-20 Assembled with Pmod KYPD, Pmod OLEDrgb

Colors Palette Tester Experiment - Zynq: 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 - Zynq: Design Operation

With the Zynq 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, ‘5’, or ‘6’. 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 Zynq design, drivers downloaded from Digilent Inc. for the PMOD KYPD and PMOD OLEDrgb are used in the block design with some minimal modification. The Zynq 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 - Zynq: Design Theory

Note that in the IPI-BD (called Zynq) 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 Zybo-Z7-20. Both drivers target the Zybo-Z7-20 instead of the Arty. The forked repository of "vivado-library" was also updated to properly build 16-bit RGB values for the OLED on either a Microblaze or ARM processor, as the original code assumed a different endianness than these processors. The fpga-colors-tester-2 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

Zybo Z7 Reference Manual
https://reference.digilentinc.com/reference/programmable-logic/zybo-z7/reference-manual

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 Zybo-Z7-20
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 Zynq 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.