**Homework 6: IO, LCD Drive, and Image processing applications**

**Issued:** April 18 (Tuesday), 2023 **Due:** April 24 (Monday), 2023

**What to turn in**: **Copy the text from your MODIFIED codes and paste it into a document**. If a question asks you to plot or display something to the screen, also include the plot and screen output your code generates. Submit either a \*.doc or \*.pdf file.

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**Problem 1 (10p): LCD Drive**

Implement an LCD drive system. Please see the description in the lecture note for details.

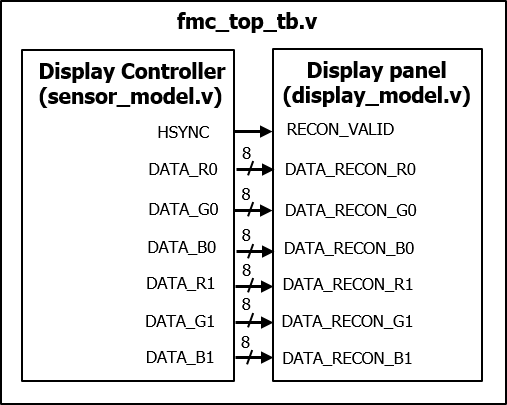
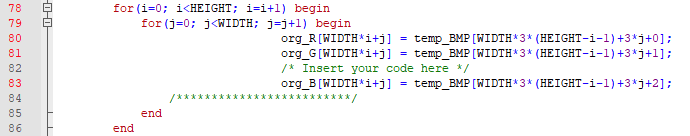


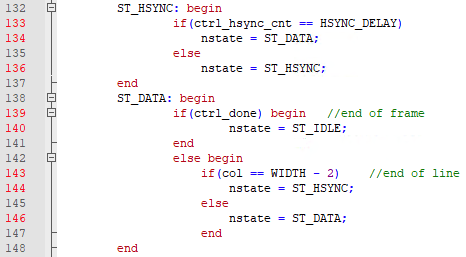
Fig. 1-1: Top test-bench module.

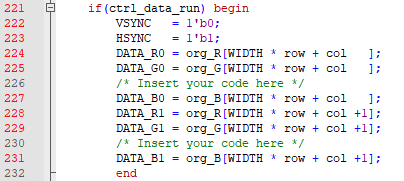
What you have to do:

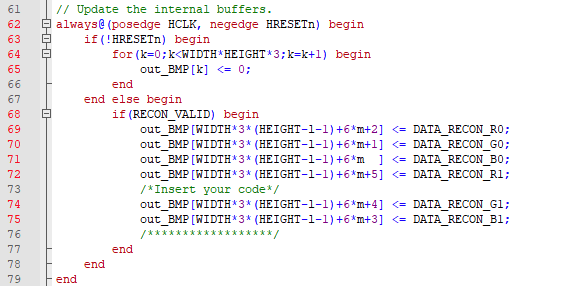
* Design an LCD drive system by completing the missing codes in the display controller (sensor\_model.v) and the display model (display\_model.v).
* Submit your RTL files.
* Capture the results, including the waveform and the output image.

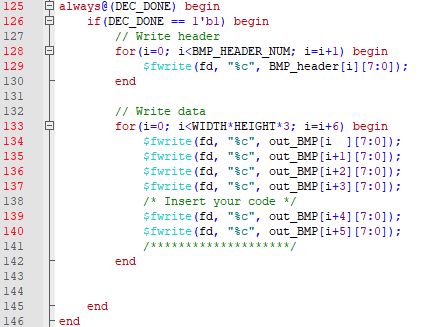
**Solution :**

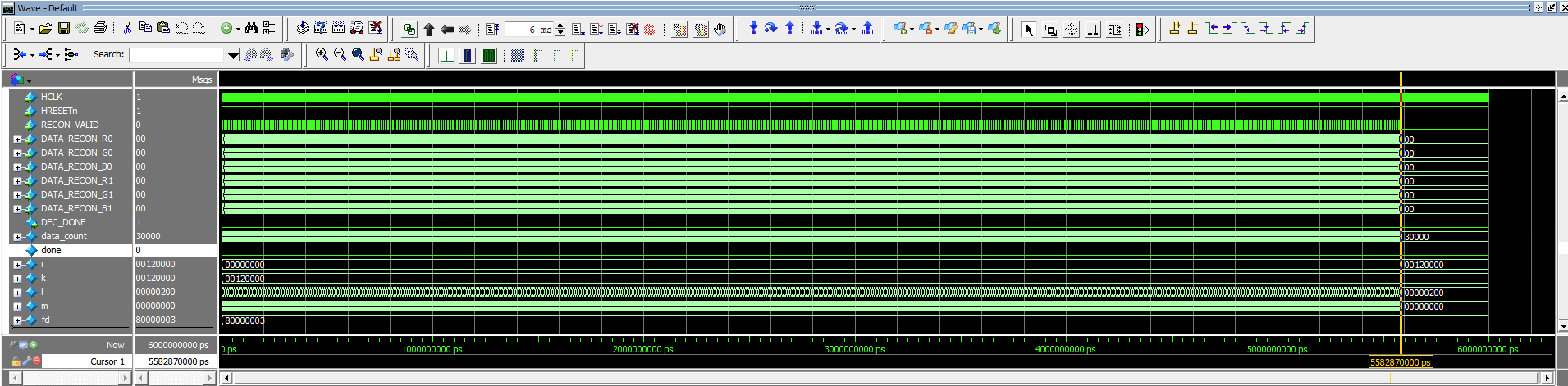
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**Problem 2 (10p): Brightness Adjustment**

Implement an LCD drive system with a brightness adjustment module. Please see the description in the lecture note for details.



Fig. 2-1: Top test-bench module.

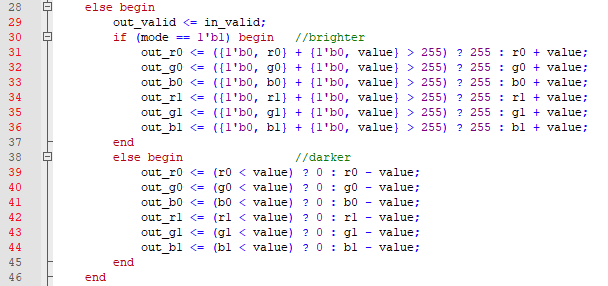
What you have to do:

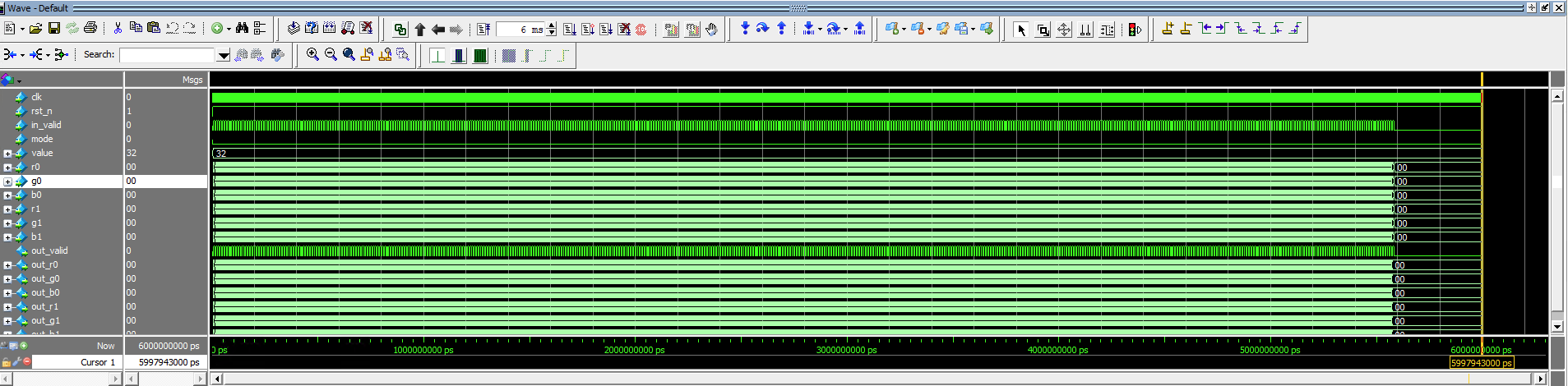
* Design an LCD drive system with a brightness adjustment module by:
  1. Reusing a sensor (sensor\_model.v) and a display (display\_model.v) in Problem 2.
  2. Completing the missing codes in brightness\_adjustment.v.
  3. Modifying the test bench to obtain images in different modes.
* Submit your RTL files.
* Capture the results, including the waveform and the output images.



Fig. 2-2: Simulation results.

**Solution :**

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**Bright 50**

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**Bright 100**

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**Dark\_50**

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**Dark 100**

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**Problem 3 (10p): Reversible color transform (RCT)**

Implement forward and inverse RCT modules and integrate them into an LCD drive system. Please see the description in the lecture note for details.

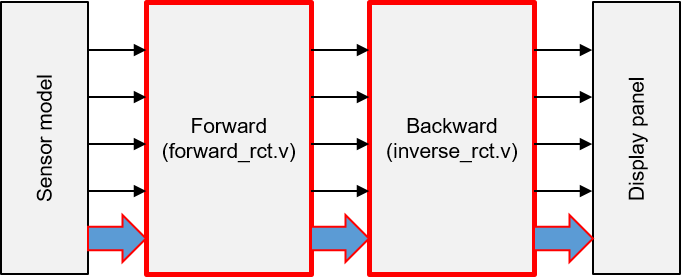
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Fig. 3-1: Simulation results.

What you have to do:

* Design an LCD drive system with RCT modules by:
  1. Reusing a sensor (sensor\_model.v) and a display (display\_model.v) in Problem 2.
  2. Completing the missing codes in forward\_rct.v and inverse\_rct.v.
* Submit your RTL files.
* Capture the results including the waveform and the output images.

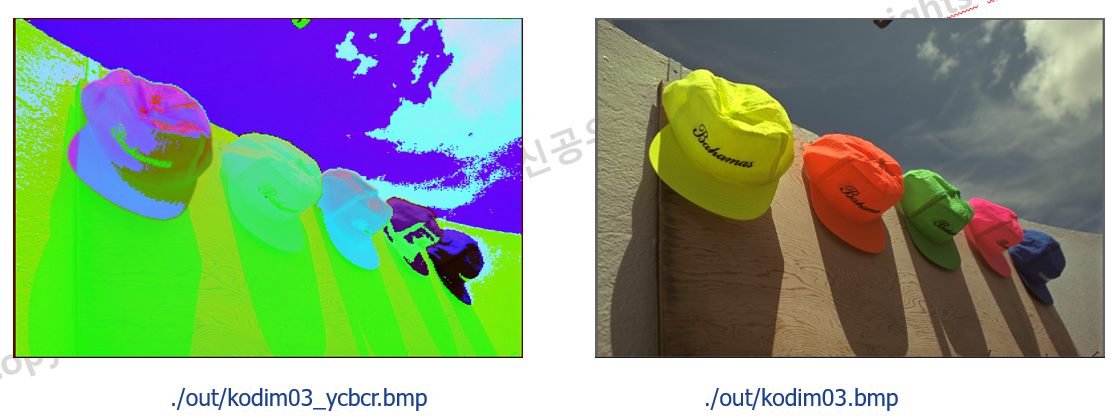
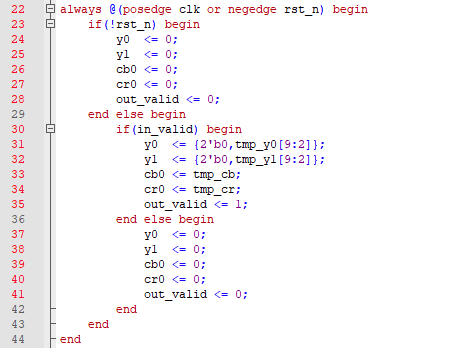
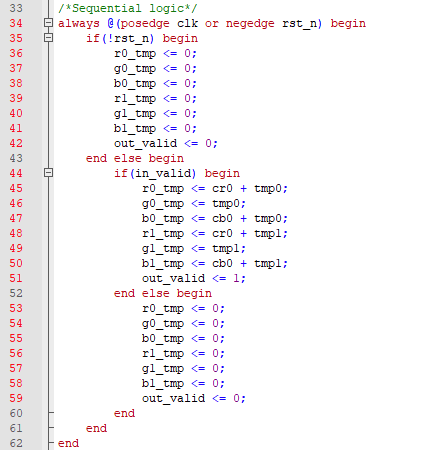
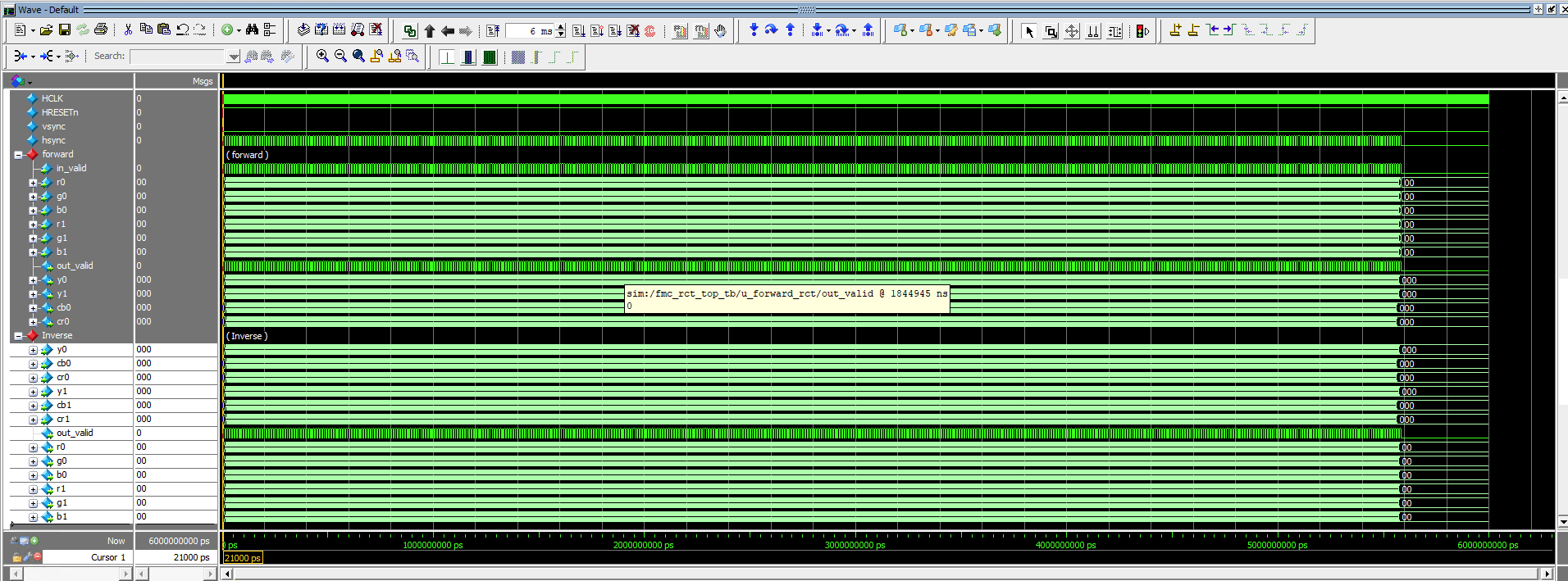


Fig. 3-2: Simulation results.

**Solution :**

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**Problem 4 (2p) (Optional): Bonus**

* Explain why the output images of Problems 1 and 3 are similar but not identical.
* Guess the motivation to use the RCT forward and inverse modules in Problem 3.

Solution :

1. It’s because we use only first pixel data of original pixel in RCT forward, which will lead to the leakage of the image data. However, since the adjacent pixel data have similar data with origin, the output image seems similar.
2. During RCT forward, we handle a half of the total image data. It will reduce the time of transmitting image data from the sensor to the display, so we can have more efficiency contrast to the data transmission without RCT forward and inverse.