

# Experiment 2 - VGA Controller

Group 4

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**Abstract**— In this experiment we used VGA output of a DE1 FPGA to show visual data. In order to reach this goal, we made a VGA controller and used MIF files to store image.

**Keywords**— VGA, VGA controller, FPGA, MIF, image.

## I. VGA STANDARDS

In order to use VGA port to transfer visual data, we need at least 5 signals: three colour signals for red, green, and blue signals in RGB standard,  $h\_sync$ , and  $v\_sync$ . Based on display's resolution, all these signals should have proper value on each time to show the correct picture.

Picture below shows the suitable values for a 640x480 px display, which we used in this experiment.

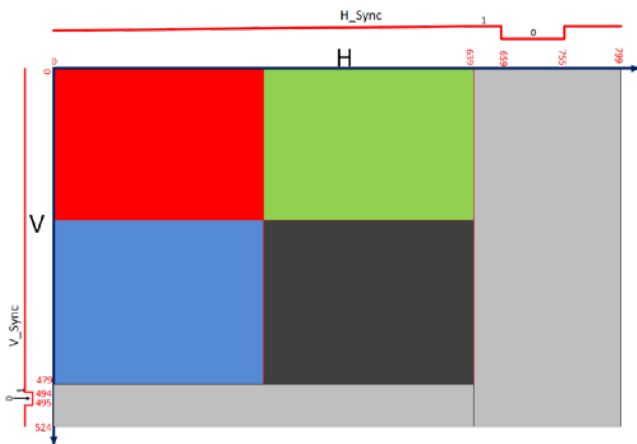


Fig. 1 640x480 VGA signals

## II. VGA CONTROLLER

It's usual to use a VGA controller to calculate value of signals mentioned before. We designed a VGA controller in Quartus II and implemented it on a DE1 FPGA. We, also, used a clock divider to convert 50 Hz clock of FPGA to 25 Hz

clock with is operational in showing visual data using VGA port.

In order to test the designed controller, we used FPGA to show a 4-cell-table on the display, coloured with red, green, blue, and white colours. Next picture shows the result.



Fig. 2 Coloured Table

## III. TILING PICTURE

In the next step, we showed a picture on the screen. We used a picture of logo of University of Tehran which was available on CECM in MIF format for this purpose.

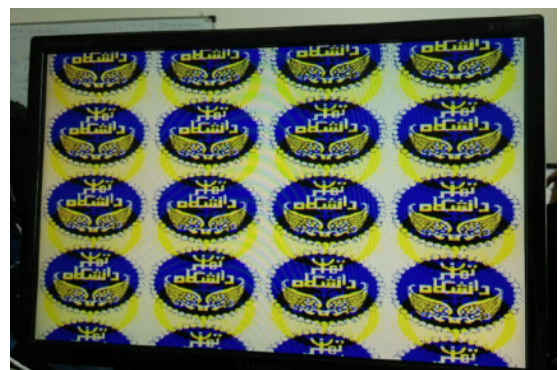


Fig. 3 Image in Tile Mode

We used a ROM to store MIF file on FPGA, and changed VGA controller of the previous part so that it reads visual data from that ROM.

We wanted to tile a 640x480 screen with a 160x120 picture, so we should calculate which point of the picture stored in MIF file should be presented on each pixel of display. So that image data is stored in MIF file in a sequential order, we used the following function:

$$((x - (\left\lfloor \frac{x}{160} \right\rfloor * 160)) * 120) + (y - (\left\lfloor \frac{y}{120} \right\rfloor * 120))$$

The final result could be seen in the Fig 3.

#### IV. CENTRED PICTURE

In the final step, we changed the VGA controller in a way that shows only one 160x120 px image in the centre of screen. This work could be done using formula bellow:

*for*  $240 < x < 400, 180 < y < 300 : (x - 240) * 120 + (y - 180)$

The final result was following picture:



Fig. 4 Image in Centre Mode

#### V. FURTHER WORKS

Using same methods, it's possible to show any visual data on screen using VGA port of FPGAs. FPGAs, also, have got ability to show texts on screen using given "font".

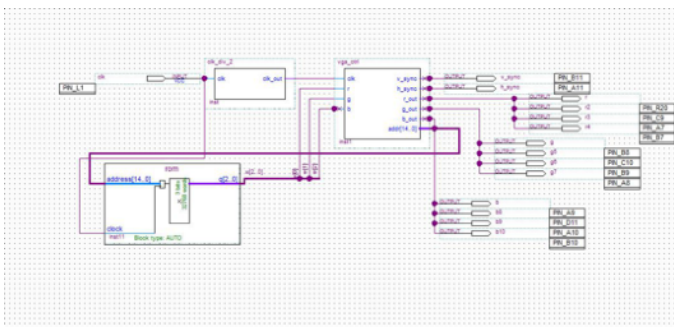


Fig. 5 VGA Circuit