# VGA Card

Ahish Deshpande, *2018102022*
Shivansh, *2018102007*

***Abstract*—A VGA Card is a device which converts the pixel data (or bitmap) to a time-synced signal that VGA monitors can understand, thus acting as an interface between the data source and monitor.**

***Keywords—VGA, graphics rendering, time-synced signal, bitmap, interface***

## I. Introduction

In order for us to be able to implement the VGA card ourselves, it is very important to understand how the VGA cable interfaces with the monitor. The VGA cable is a 15 pin cable, carrying RGBHV signals(Red, Green, Blue, Horizontal Sync, Vertical Sync). The monitor can be visualized as a grid of pixels, the number of rows and columns of which, are decided by the resolution of the monitor, which in our case is 640x480. Each pixel in this grid can display a single colour, represented by its RGB value. Thus, VGA displays images on a monitor by sending these RGB values for each pixel in the grid, serially to the monitor.

Here we take the example of CRT Monitors since they are easier to visualize. Though, all VGA monitors work in a similar way. Internally, a CRT monitor has an electron gun that fires the required colour onto the screen, according to the RGB value it receives as input. The gun moves from left to right, displaying the required colour onto the screen, line by line. Since the monitor has no memory, the RGB values for each pixel have to be sent serially, as the gun fires them onto the screen. To ensure calibration and proper synchronization, two signals, namely, horizontal sync, and vertical sync are used. These signals are timed in such a way, so as to allow the monitor's internal components enough time to be ready to begin a new line or frame. These timings are standardized and are defined in the standards for VGA monitors.

After thorough research, we realized that timing the signal accurately is of utmost importance in order to achieve the desired output on the monitor. This makes the role of the horizontal and vertical sync very significant. The horizontal sync is used to define/synchronize the beginning of a new line on the display, while the vertical sync is used to define/synchronize the beginning of a new frame. Each of these syncs consist of three parts themselves — Front Porch, Pulse, Back Porch.

The polarity of the pulse is used to convey the resolution of the image currently being sent to the monitor. Both these syncs are active low for a 640x480 screen resolution.

## II. Design

The circuit majorly comprises of two parts:

### A. Counter

Counter is one of the most essential parts of the project since the entire timing signal is generated in accordance with the RGB values of specific pixels, which are iterated over by the counter. The counter iterates over all the pixels on the screen and sets the values of Horizontal Sync, Vertical Sync, as per VGA standards. A counter can be implemented by connecting flip-flops in a serial fashion, with clock input of the next flip-flop as the output of the current flip-flop.

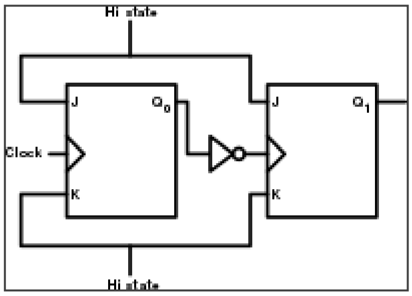


*Image source : wikipedia.org*

### B. Comparator

Another important part of the project are comparators. The circuit comprises of multiple comparators for assigning RGB outputs for different pixel ranges. On every iteration of pixel counter, comparators check if the pixel lies in a particular range and assigns RGB values for that range accordingly. A comparator can be implemented by simple combinational logic, checking each bit of the number, starting from the most significant bit.

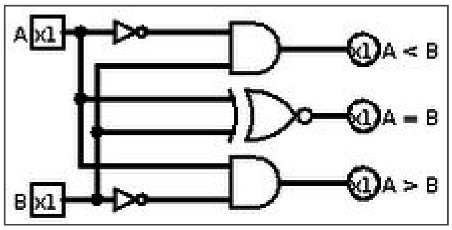


*Image source : wikipedia.org*

## III. Result

The VGA card that we have developed, is able to display the input image onto a monitor, through the FPGA board.

Following are the Area and Power reports:

TABLE I. Area

| Module | Tool Used | |
|---|---|---|
| | Genus(μm²) | Innovus(μm²) |
| Pre-optimization | 1069 + 981 = 2050 | 1069.4997 + 980.9424 = 2050.3921 |
| Post-optimization | 1010 + 928 = 1938 | 1030.1409 + 948.3957 = 1978.5366 |

TABLE II. Power

| Module | Tool Used | |
|---|---|---|
| | Genus(mW) | Innovus(mW) |
| Pre-optimization | 0.1965 | 0.1493 |
| Post-optimization | 0.1819 | 0.1459 |

## IV. Conclusion

An optimized VGA card, able to display the given input on the monitor, was implemented using both FPGA and ASIC flows.

### A. *Abbreviations and Acronyms*

VGA – Visual Graphics Array

FPGA – Field Programable Gate Arrays

ASIC – Application Specific Integrated Circuit


## Acknowledgment

We would like to thank Professor Azeemuddin Syed, for guiding us throughout the project, and enriching us with the basic concepts required for the same. We would also like to thank the TA's, Mayank Awasthi and Kunal Wadhwani, for their never-ending support, and help in clearing our doubts.


## References


[1] https://electronics.howstuffworks.com/tv.htm

[2] http://tinyvga.com/vga-timing

[3] https://computer.howstuffworks.com/monitor.htm