Final Practical Work Electronics III

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November 19, 2018

1   Summary

In this work we were asked to implement a precise chronometer, digital electronics, and a VGA screen of 640 pixels wide and 480 pixels in height. We were provided with a Cyclone IV Field Programmable Gate Array, also known as FPGA, and we had to create the digital logic inside using Verilog Hardware Descriptive Language. The implementation of this chronometer is explained in detail in the following sections.

2   How VGA Works

The functioning of the VGA protocol is very simple, as shown in Figure 1, we only have to analyze 5 wires, the h_sync or also known as Horizontal Synchronization, is the cable we use to send a clock with the period such that the horizontal printing (in one line) on the screen happens 1 time per period, and the v_sync or Vertical Synchronization, is the equivalent for the the vertical lines. It's important to clarify that the clock in v_sync is much slower tha the h_sync. The R, G and B wires correspord to the Red, Geen and Blue colors of the pixel to print. So, if we call T_H to the h_sync period and T_V to the v_sync period, to reference a single pixel as line-column, the formulas are the following:

$$Line = \frac{T_V}{480} * (time\, h_{sync}\, is\, on) \tag{1}$$

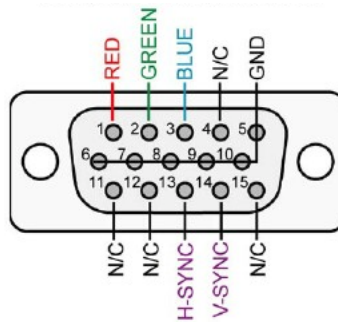$$Column = \frac{T_H}{640} * (time\, v_{sync}\, is\, on) \tag{2}$$

Figure 1: VGA Pins

3   Implementation

To implement the chronometer, we follow the diagram shown on Figure 2, we used a h_sync and v_sync generator module, a Screen Positioning Module, a Time Counter Module, a Timer Module and a binary to a 7 segments display module.

Figure 2: Implementation Diagram

3.1   H_sync and V_sync generator module

3.2   Screen Positioning Module

For this module, we received the same signals sent to the VGA (h_sync and v_sync), the BCD digits of the hours, minutes and seconds counted, and a clock working at the same speed as the h_sync clock for each pixel. The outputs of this module, were connected to the H_sync and V_sync Generato Module, and this are the R , G and B colors of the VGA pixels.

3.2.1   Operation

The operation for this module is pretty straight foward, by knowing the h_sync and the v_sync signals, and having the same clock as the h_sync generator, it determines at each moment in wich pixel it is working on. To do this, it utilizes the equations (1) and (2), and by knowing the position, it devides the screen in quadrants for each digit of the chronometer. Whenever it detects that it is on a digit quadrant, it uses the NumTo7Seg module to convert the correspond digit to a series of 7 bits, as if it where a 7 segment display, and by knowing each pixel, it determines which pixel it has to print in white, and which in black.
Finally, it feedsback the H-sync and V_sync Generator module with the colors processed in this module.

3.3   Time Counter Module

3.4   Timer Module