# VLSI Based Implementation of a digital Oscilloscope

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***Abstract*— In today's fast-paced world, engineers need the best tools available to solve their measurement challenges quickly and accurately. There are many types of oscilloscope available in the market. The main types of oscilloscopes are analog oscilloscope, digital oscilloscope and PC based oscilloscope. From which the digital oscilloscope are widely used now a days due there accuracy portability, high speed, high resolution, data storing capability etc. here we provide an alternative solution which is basically a digital oscilloscope with almost all the control options which any standard digital oscilloscope has. It has basically three large blocks, first is the ADC part which has the analog to digital IC which is controlled by the STK500 AVR kit. Second is the oscillator control part which is implanted on the FPGA Spartan 3 kit. It has the entire storage element and the user input control and driver part of IC and VGA. The third large block is display device which is a CRT monitor along this the LEDs and seven segment display part on FPGA is also used to display information. So this is a cheap alternative to expensive oscilloscopes; using a VGA display and a simple mouse interface, a user can use this scope to look at and measure signals up to about 80 MHz if an extra high frequency clock will provide to the design.**

***Keywords- ADC(Analog To Digital IC), FPGA Spartan 3 kit, VGA Display.***

## I INTRODUCTION

This digital oscilloscope provides a cheap alternative to expensive oscilloscopes; using a VGA display and a simple mouse interface, a user can use this scope to look at and measure signals up to about 80Mhz. this kind of scope would be ideal for hobbyists and students looking to learn and debug circuits. Development is based on the Spartan III Starter Kit from Xilinx. The ADC is simply controlled by an MCU (another starter kit: the ATK400 from Atmel) but will soon be controlled by the FPGA (to achieve the faster speeds).
In the future, schematics and PCB layout binaries will be available.

### 1. Features

- Timescale selection
- Selectable trigger (Rising, Falling / Normal, Single, Auto)
- Horizontal and Vertical position offsets
- Grid Display On/Off/Outline
- Semi-standard Oscilloscope look and feel
- VGA display; drives a standard computer monitor
- PS/2 Mouse User Interface
- 9-bit input data width
- Developed specifically for the Spartan III development kit from Xilinx.

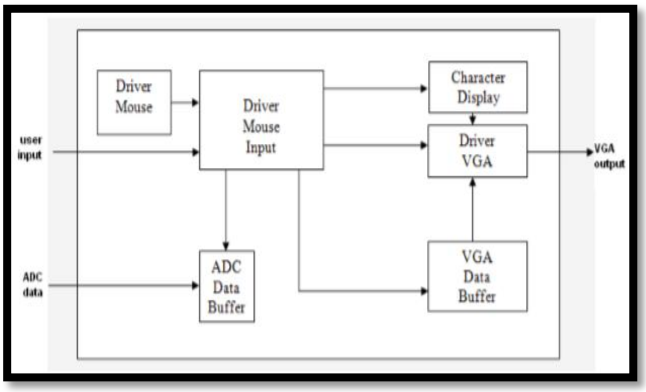


Fig 1: Diagram of Digital oscilloscope

### 2) Logical diagram:

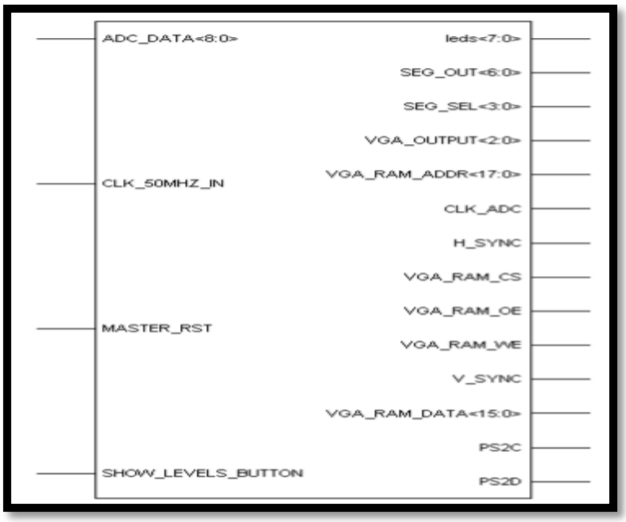


Fig 2: Block diagram of Digital oscilloscope

| SIGNAL | DIRN | DESCRIPTION |
|---|---|---|
| ADC_DATA | I/P | This is the port ,where the 8 bit ADC output is applied |
| CLK_50MHZ_IN | I/P | This is the global clock which this block take from the Spartan 3 FPGA kit |
| MASTER_RST | I/P | It is the synchronous master reset which clear the data store data and make the block in initial condition |
| SHOW_LEVELS_BUTTON | I/P | This is the input select bit from which the horizontal and vertical levels shown on monitor. |
| SEG_OUT | O/P | This is the signal which give the information on 7 segment display on FPGA spartan3 kit |
| SEG_SEL | O/P | This is the signal by which this block select the particular segment |
| VGA_OUTPUT | O/P | This is the RGB signal through which the waveform is shown on VGA monitor. |
| VGA_RAM_ADDR | O/P | This is the address of VGA RAM in which the VGA data is store. |
| CLK_ADC | O/P | It is the clock signal, which is selected according to the sampling speed at which this block receives the data. |
| H_SYNC | O/P | This is the horizontal synchronizing signal for the VGA. |
| VGA_RAM_CS | O/P | This is the signal to select/Enable the VGA RAM. |
| VGA_RAM_OE | O/P | This is the signal which enables the output from the VGA RAM. |
| VGA_RAM_THIS BLOCK | O/P | This is the signal which enables to write in the VGA RAM. |
| V_SYNC | O/P | This is the vertical synchronizing signal for the VGA. |
| VGA_RAM_DATA | O/P | Data stored in RAM to display on monitor |
| PS2C | O/P | This is the signal which is used as the mouse clock used to synchronization of mouse interfacing. |
| PS2D | O/P | This is the mouse output data through which the coordinate of mouse is shown on CRT monitor |

**3) Functional Description**:
The digital oscilloscope processes the digital data and shows it on the VGA. This is thus have three large block, these are: 1. ADC converter 2. Display device 3. controller part (FPGA part)

**ADC converter**:
This block has an analog to digital IC to convert the input analog signal into its equivalent digital Signal. The ADC is simply controlled by an MCU (another starter kit: the ATK500 from Atmel) but will soon be controlled by the FPGA (to achieve the faster speeds). The digital data from ADC then goes to the FPGA Spartan 3 kit

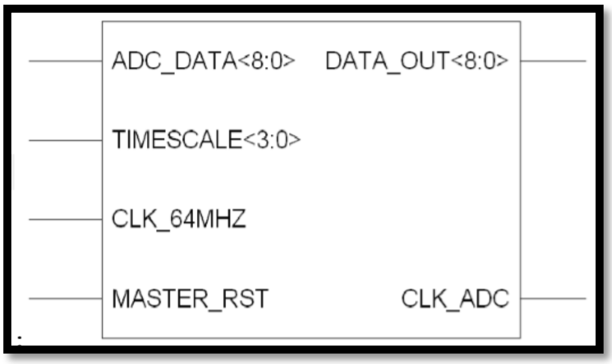


Fig 3: Block diagram of ADC Driver part

**Display (CRT) Monitor**:
This is the display devise at which the signal waveform is displayed .in this project I use the CRT monitor as display device.

**FPGA Spartan Kit Block:**
In this block the digital data is processed and synchronizing with ADC IC this block is very important and has many other processing blocks which are: ADC Data Buffer: This block has buffer the data so that the continuous waveform can be seen on VGA. It also has the time scale option so that the data can be read from the RAM at different frequency speed according to the user or signal.

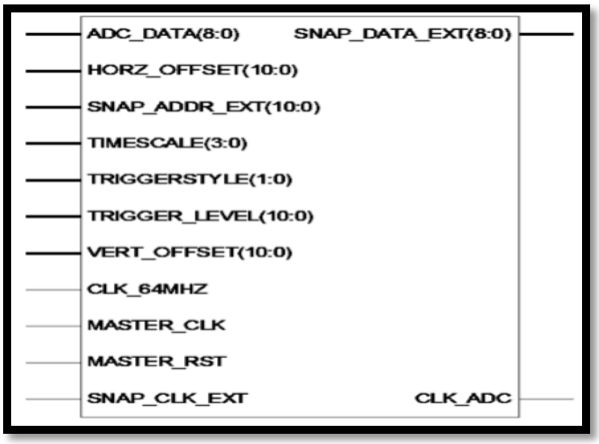


Fig 4: Block diagram of ADC Data Buffer Part

**Character Display Driver**:
The signal is display on VGA. But some information is given on the seven segment display about the signal and the working mode thus the character display part is used for this purpose.

**Mouse Driver**:
The user define values are needed to control the oscilloscope such as time scale, vertical offset, triggering style etc. thus a input device is needed to give the input in This project this block use mouse as PS2 format to give user input.


Fig 5: Block diagram of Mouse Driver Part

**VGA Driver**:
The output is shown on the VGA. Thus this block need the VGA driver to control the CRT monitor and show the wave for on the monitor. So this block have to generate some signals as vertical synchronizing and horizontal synchronizing for scanning and RGB for color except this there are many other character and user line which divide the screen for measuring purpose thus this block have to also generate these fixed lines.

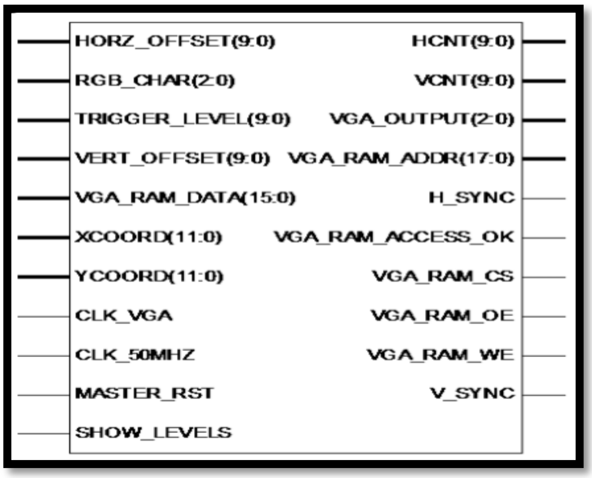


Fig 6: Block diagram of VGA Driver Part

**Seven Segment Driver**:
The analog to digital converted data can also see on FPGA board this is done by seven segment display present on Spartan 3 kit. The digital data is shown on two seven segment block in hexadecimal format.

**VGA Data Buffer**:
The signal which is shown on VGA display is stored in RAM in digital from. Thus for continuous viewing of the waveform it is necessary to store the data and retrieve it time to time. This is done by this block in this block there RAM is built in FPGA and data is stored in it.

**Mouse user Input Driver**:
In this oscilloscope the input is given by mouse so this block is control the user input and gives the signals to display and control the waveform showing on the VGA display.

**DCM (Digital Clock Manager)**:
The function of this block is to control the clock and removes the problem of clock skew.

## II. SYNTHESIS REPORT

Device utilization summary: Selected Device: 3s200ft256-4

| | | |
|---|---|---|
| Number of Slices: | 710 out of 1920 | 36% |
| Number of Slice Flip Flops: | 358 out of 3840 | 9% |
| Number of 4 input LUTs: | 1308 out of 3840 | 34% |
| Number of IOs: | 76 | |
| Number of bonded IOBs: | 76 out of 173 | 43% |
| Number of BRAMs: | 4 out of 12 | 33% |
| Number of MULT18X18s: | 2 out of 12 | 16% |
| Number of GCLKs: | 7 out of 8 | 87% |
| Number of DCMs: | 1 out of 4 | 25% |

## III. FUTURE SCOPE

The purposed design is having great future possibility. Following are the some feature that can be added in this design

- FFT display
- Measurement Display (amplitude, frequency)
- Cursors
- Vectors
- Multi-channel display (up to 8)
- Channel Math
- UART or USB computer communication (data export)

## IV. CONCLUSION

The usefulness of an oscilloscope is not limited to the world of electronics. With the proper transducer, an oscilloscope can measure all kinds of phenomena. Oscilloscopes are used by everyone from physicists to television repair technicians. An automotive engineer uses an oscilloscope to measure engine vibrations. A medical researcher uses an oscilloscope to measure brain waves. The digital oscilloscopes are generally having very high costs. The proposed design provides a cheap alternative to expensive oscilloscopes; using a VGA display and a simple mouse interface, a user can use this scope to look at and measure signals up to about 80Mhz.this kind of scope would be ideal for hobbyists and students looking to learn and debug circuits.

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