DESIGN AND DEVELOPMENT OF DIGITAL CONTROLLER FOR GROUND BASED RADIOMETER USING FPGA

PROJECT SUMMARY

by

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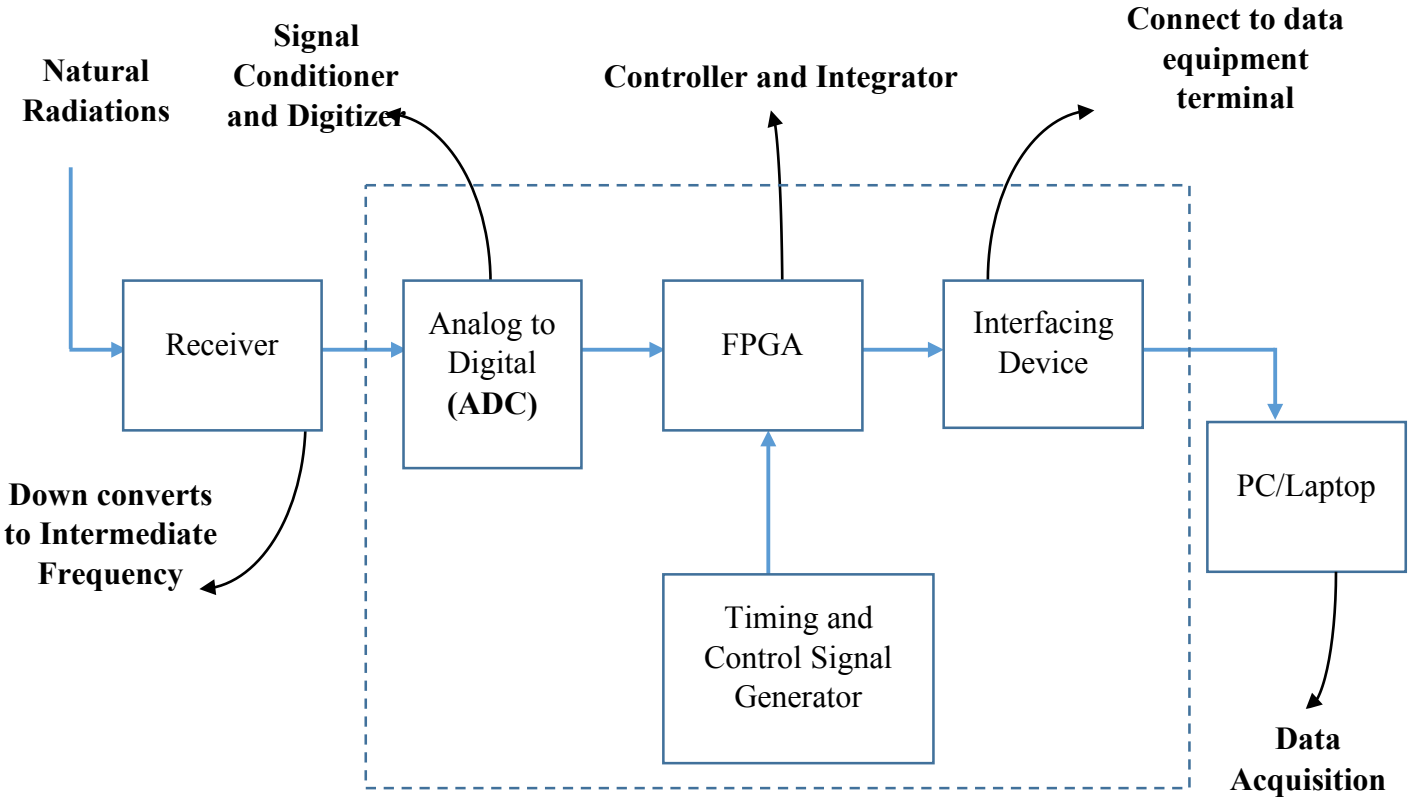
1. Abstract

In our day to day life, we are surrounded by numerous natural radiations present in the environment. The natural radiations are the result of emissions from resources like land, forests, rivers, oceans, deserts, etc. The study of these radiations plays an important role in climate predictions. Ground Based Radiometer (GBR) is a passive sensor which detects the natural emissions occurring in the environment and measures their intensity. Embedded Controller consists of a Digital Controller and Analog Front End (ADC). Digital Controller is a key block which performs functions like Control Signal Generation, Data Acquisition, Data Processing and Telecommand/Telemetry Interfacing. The end results of Digital Controller is used for weather forecast, agriculture, water resource management and disaster alerts.

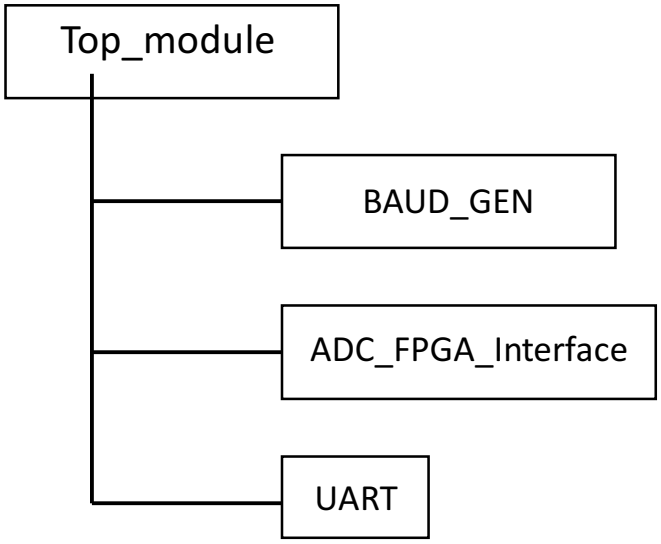
2. Functional Block Diagram

- Key components of Embedded Controller are FPGA(Xilinx DS557- Spartan 3AN), Analog Front End(Texas Instruments-ADS1278(24-bit, Delta-Sigma ADC)), Baud Rate Generator module for timing and control signal generation and RS-232 interface used to connect system output to PC(USB terminal).
- The Embedded Controller is shown by the highlighted portion in the figure below.



3. Implementation

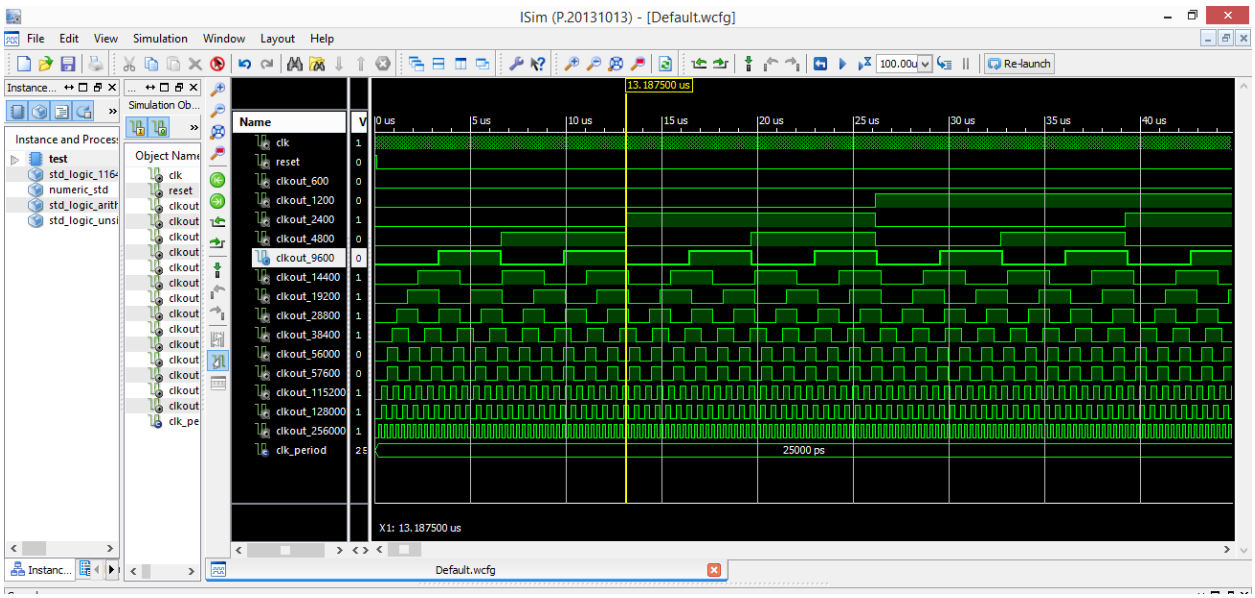
➢ Modules Hierarchy



3.1 Baud-Rate Generator

Generalized Baud Rate Generator module is created for generating different baud rates. Baud Rate Generator is used to provide the clock frequency to the UART Transmitter and UART Receiver. It is developed to set the 9600 baud rate.

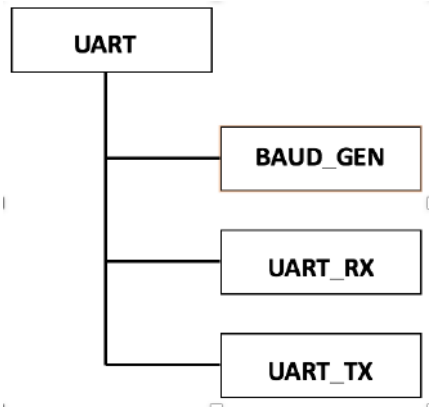
Count = (clock frequency/ baud rate*32)



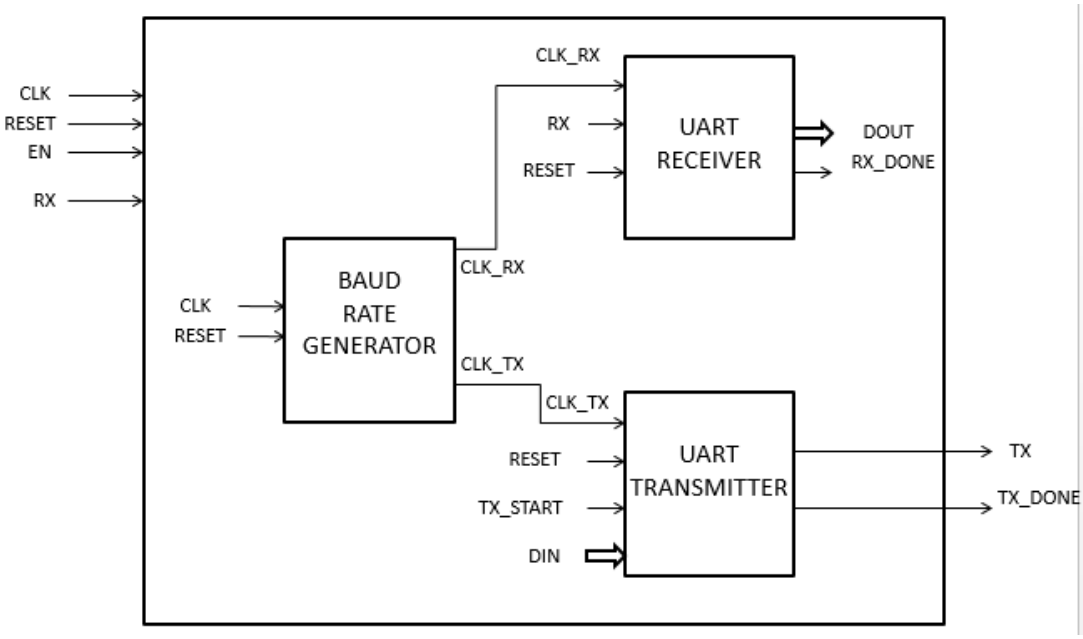
The above simulation shows different Baud-Rate signals as clock signal outputs of the Baud-Rate Generator module.

3.2 Universal Asynchronous Receiver/Transmitter(UART)

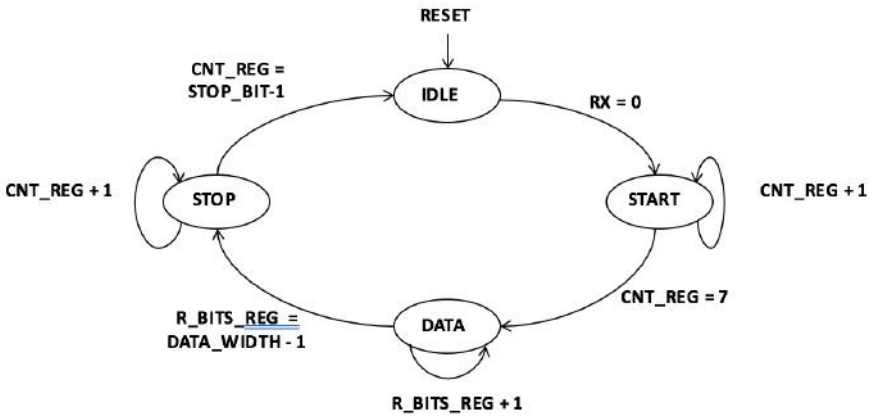
3.2.1 Modules Hierarchy



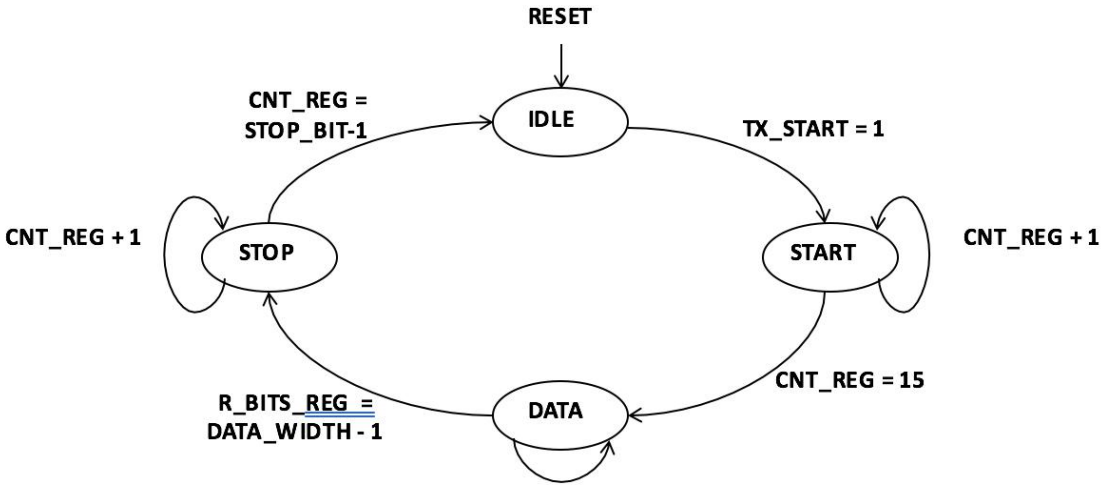
3.2.2 UART Block Diagram



3.2.3 Finite State Machine Diagrams

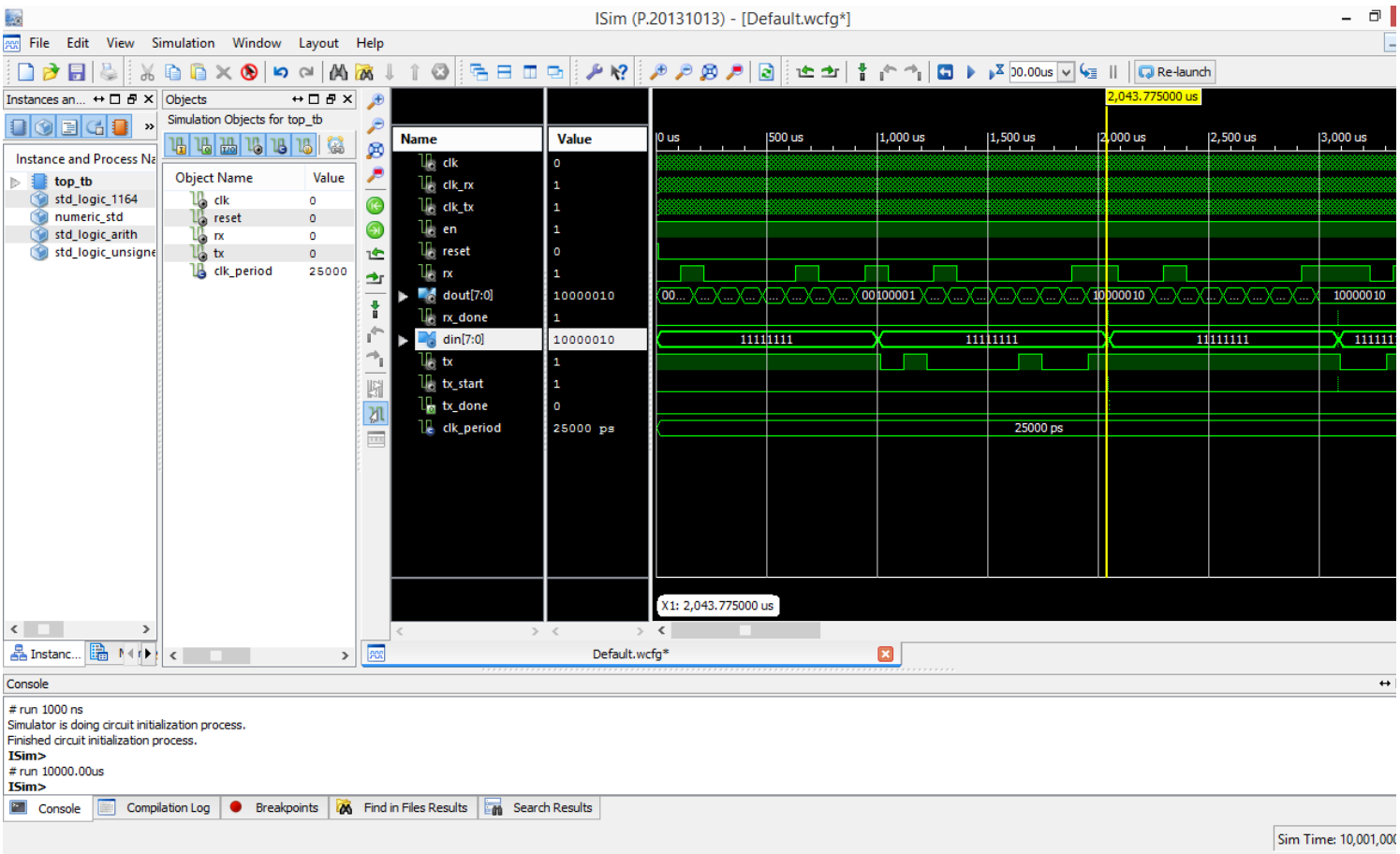


UART Receiver FSM



UART Transmitter FSM

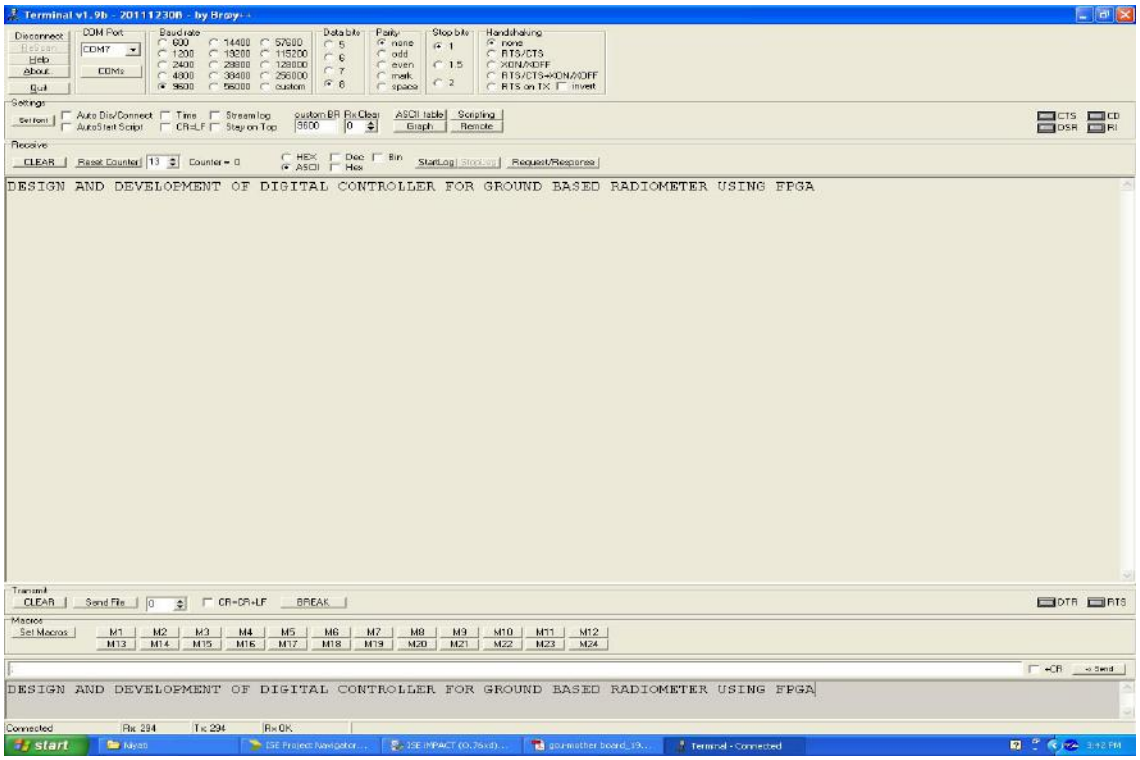
3.2.4 ISE Simulator Result



The simulation shows the function of 8-bit UART transmitter and receiver. 8-bit data is given to UART receiver as input (rx). The received data (dout) is then given to UART transmitter as input (din) and data is transmitted as output signal (tx).

3.2.5 UART Closed-loop Test

- Terminal software is used to check the synchronization between UART transmitter module and UART Receiver module.
- Data is transmitted from terminal software which is received by GBR Board(Receiver module). Data is then transmitted back to terminal from board(UART_TX module).

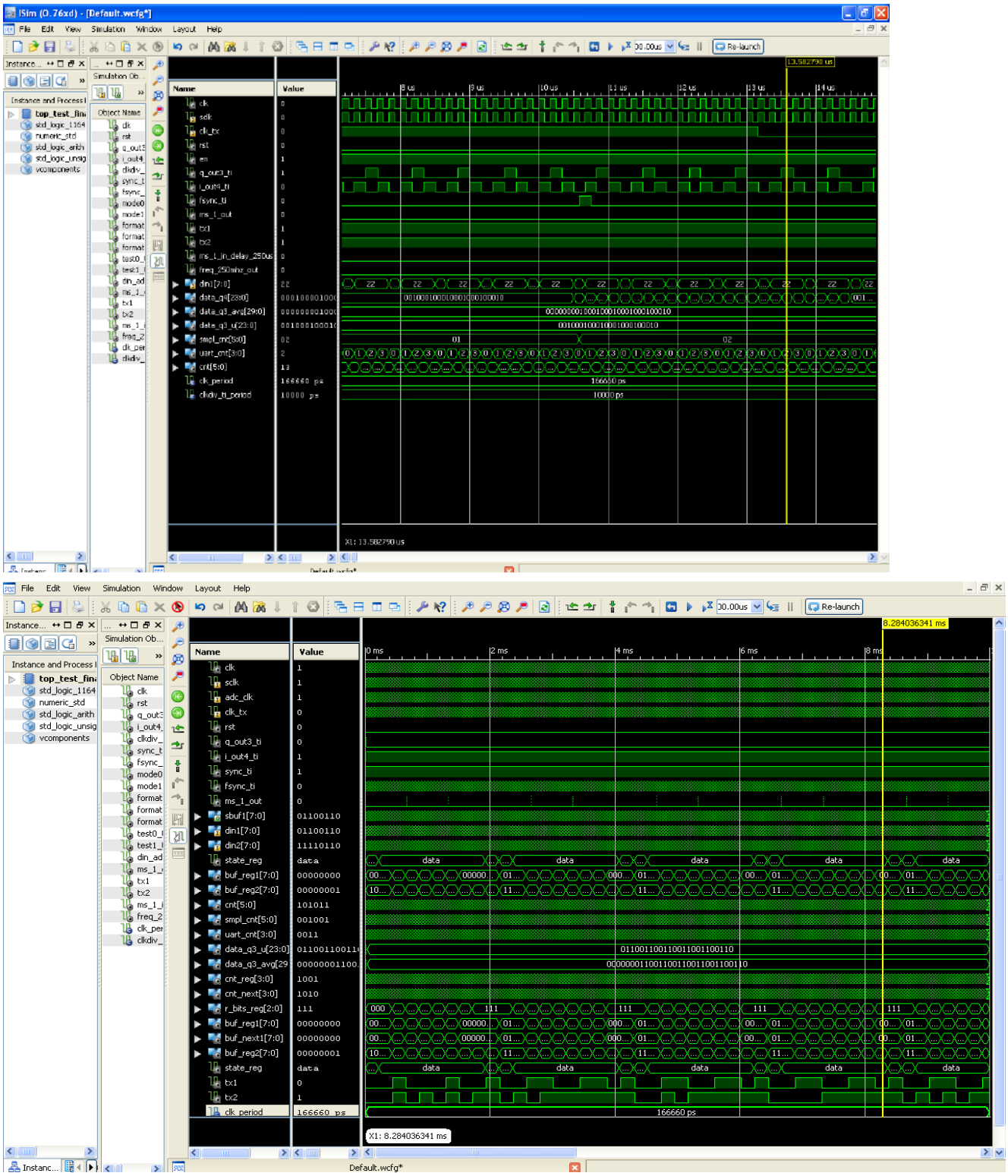


3.3 ADC-FPGA Interface

- ADS1278(Delta-Sigma ADC) would be working on Low-power mode and frame sync interface is used for extracting data.
- The ADS1278 requires following input signals to give the correct output

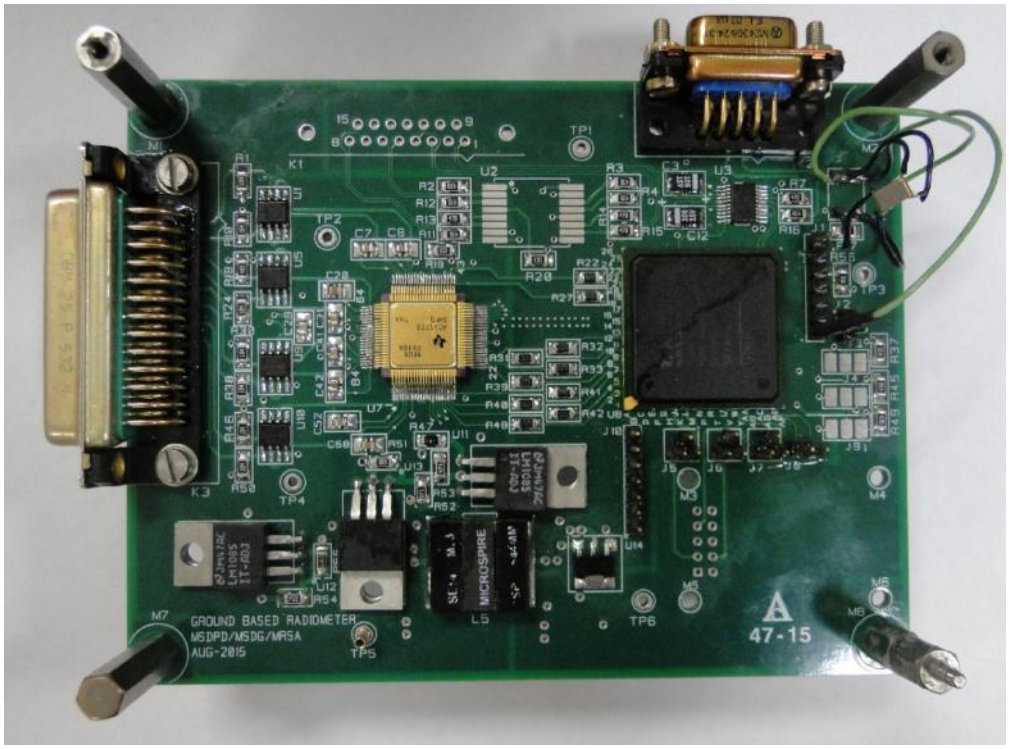
▪ ADC_clk	– 13.5 MHz	▪ Format1	-‘0’
▪ Sclk	– 13.5 MHz	▪ Format2	-‘1’
▪ Mode0	-‘0’	▪ Din	-‘0’
▪ Mode1	-‘1’	▪ Sync	-‘1’
▪ Format0	-‘1’	▪ Test0	-‘0’
▪ Format0	-‘1’	▪ Test1	-‘0’

ISE Simulator Result:

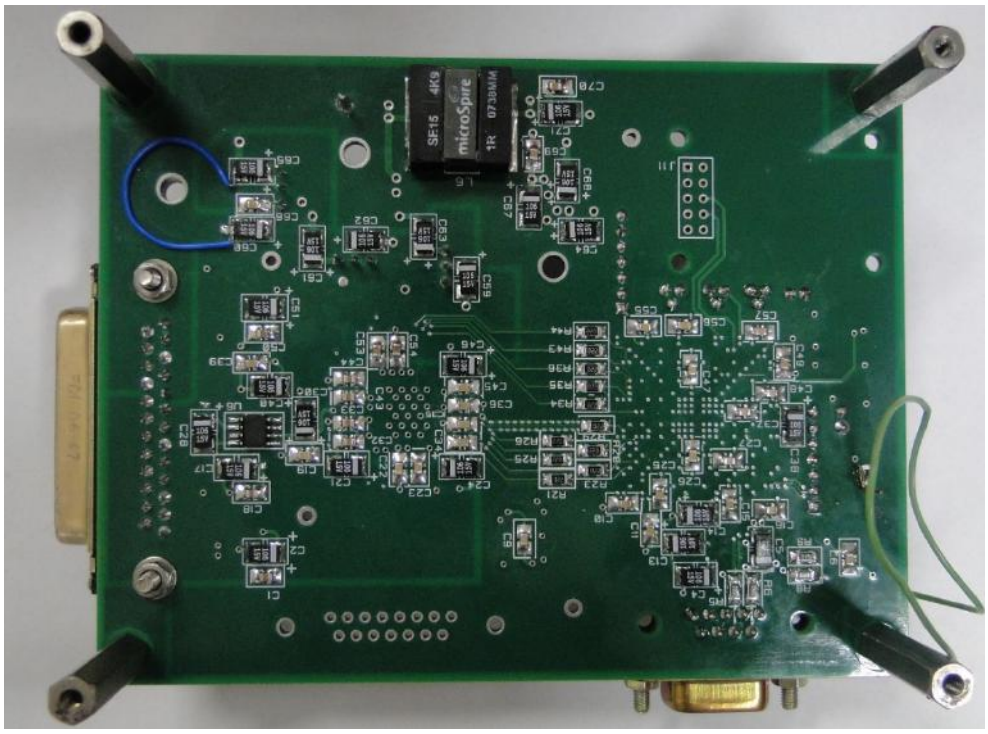


Shown above are top module simulations which contains ADC input and controlling signals, ADC-FPGA interfacing signals, FPGA output signals and the RS232 interface signals to obtain output through terminal software.

4. GBR Board



GBR Board Top Side

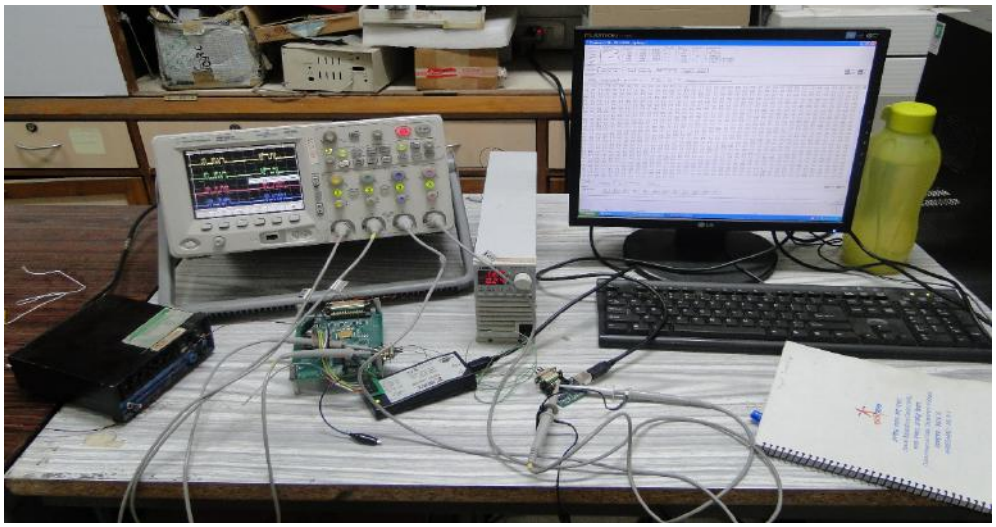


GBR Board Bottom Side

5. Implementation

5.1 Test Setup

- The board is supplied with +12 V supply using Lamda source
- The ADC is supplied with variable analog supply using DC source.
- The oscillator is set to measure the terminal output for multiple channels.
- The JTAG programmer is connected to the board and Pc as shown in the figure.
- The RS-232 male connector of board is connected to the Rs-232 female connector of module.
- The baud rate is set to 9600 by setting appropriate transmitter clock.



5.2 Output theoretical Calculation

Step Width = Max voltage / (2^n)

Step width = 5 V/ (2^24) = 0.298 uV.

$$\frac{Resolution\ of\ the\ ADC}{System\ Voltage} = \frac{ADC\ Reading}{Analog\ Voltage\ Measured}$$

For Vin = 4 V

ADC Reading = 4 V / 0.298 uV = Hex-CCD0E2 (13422818.79)

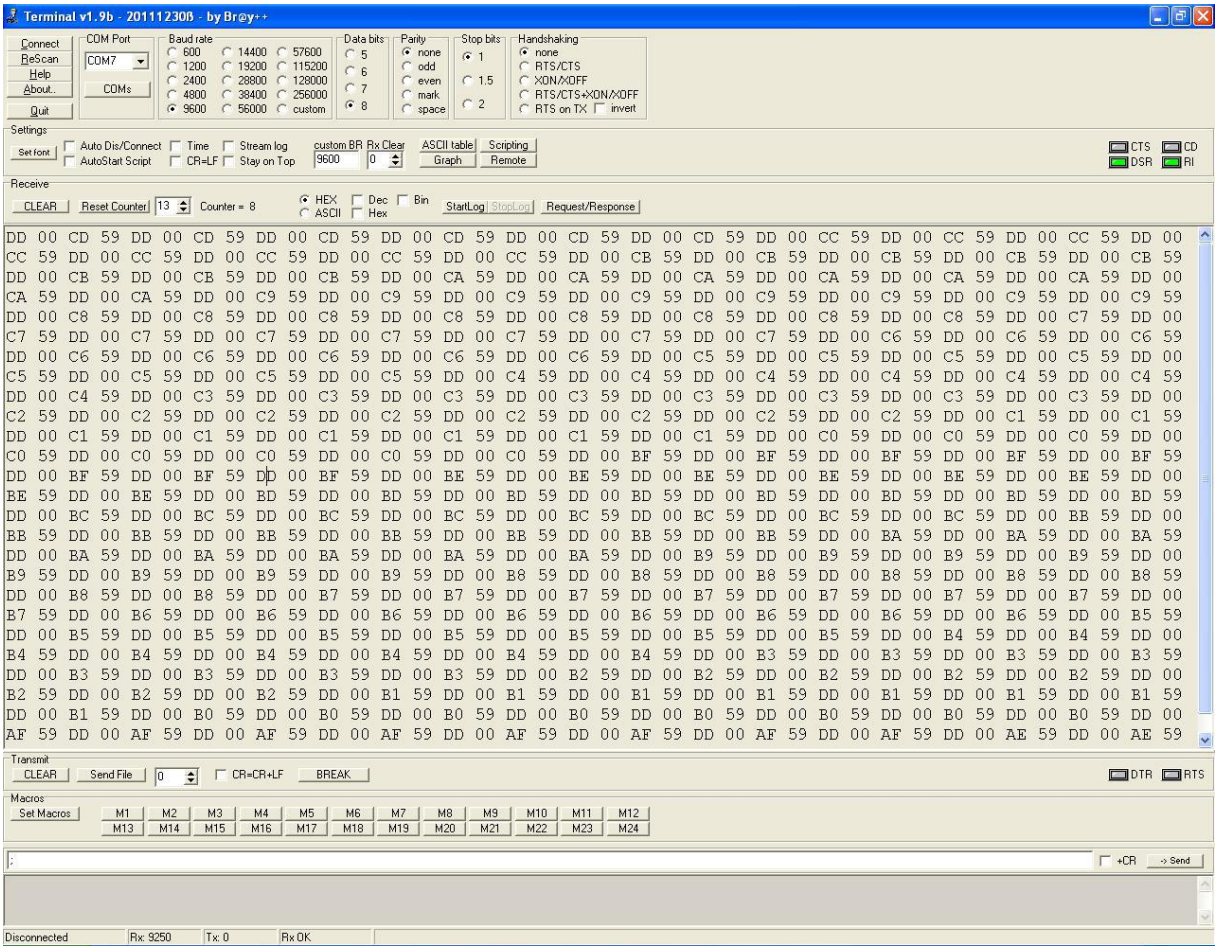
Practical Result

For Vin (Analog Supply Voltage) = 4 V

Voltage measured at ADC input pin = 3.99092 V

ADC Reading = 3.99092 V / 0.298 uV = Hex-CC59DD (13392349.69)

5.3 Terminal Output



6. Conclusion

A Digital Controller for Ground Based radiometer (GBR) was designed, fabricated and tested for acquiring and processing analog signals and providing digital output through UART interface.