FPGA Implemented on TDC: Improving its Resolution

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Keywords

- FPGA
- TDC
- Improving Resolution
Keywords

FPGA

- Field-Programmable-Gate-Array
Keywords

TDC

- Time-to-Digital-Converter
- Electronic instrument
- Converts events, time → digital representation
- Measures time interval

Introduction - Methods - Discussion - Conclusion - Future Work - Appendix
What are some possible causes of delay and how can high-resolution TDC be implemented in FPGA?
Flow Diagram of Data Collecting Process

Start → Pulse Generator

Wire 1 → No Delay → Tektronix Oscilloscope

Wire 2 → 20ns delay

Tektronix Oscilloscope → TDC Implemented in FPGA → Collect raw data

TTree.h → ROOT → Histogram.jpg

TDC_Trial1.txt → TDC_DeltaT1.c
Pulse Generator & Delay Module
Flow Diagram of Data Collecting Process

Start → Pulse Generator

Wire 1 → Tektronix Oscilloscope → TDC implemented in FPGA → Collect raw data

20ns delay

Wire 2

TTree.h → ROOT → Histogram.jpg

TDC_Trial1.txt → TDC_DeltaT1.c
Tektronix 640S
TDC Implemented on FPGA

- TDC implemented on FPGA
- Logic Fan
Readable Data

- 8 and 12 indicate the gate number
- $C = 12$ in hexadecimal
- 1500 ~ 2000 hits
```cpp
#include <TTree.h>
#include <TCanvas.h>
#include <TStyle.h>

void DNLPlot1()
{
    //gROOT->Reset();

    TTree *MyTree = new TTree("MyTree","analyseddata");
    MyTree->ReadFile("data3.txt","TBin1:ch2:Nevt:Nevt2");
    TCanvas *c1 = new TCanvas();
    TH1F *TestPic = new TH1F("TestPic","TDC DNL",256,0,256);
    MyTree->Draw("TBin1>>TestPic");

    //MyTree->Draw("hits");
}
```

- Set x bound
- Title, legend
Results

Time Difference 20 nsec

TestPic

Entries: 1477
Mean: 22.39
RMS: 0.0771

Time Difference 20 nsec

TestPic

Entries: 1479
Mean: 22.39
RMS: 0.07379
Time Difference 20 nsec

- Entries: 1477
- Mean: 22.39
- RMS: 0.0771
Discussion

- environmental factors
  - Heat
    - 0°C to 80°C
    - Doesn’t vary much
  - Voltage
    - ±5% of normal supply voltage
Application

- PET Scan
- Radioactive Isotopes
  - Carbon-11 (20min)
  - Nitrogen-13 (10min)
  - Oxygen-15 (2min)
  - Fluorine-14 (<2hr)
- Emit gamma rays
- (emit positrons when they decay)
- High resolution TDC
- Detectors
- Can have more accurate location
Conclusion

- Resolution of 80ps
- Environmental factors
- Device quantization error
- Event → Binary Code
Future Work

- Resolution better than 60ps
- New architectural design configuration
- Efficient program to generate data
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Appendix


Questions?
Question

- MRI
  Anatomic imaging
- PET
  how organs and tissues function
  Evaluate medical condition