Overview

Signals are picked up on four channels from two horns, and are recorded by the Acqiris Digitizer. The signals from the four channels are sent to the Polarizer, which converts these signals into circular polarizations. The Polarizer outputs the polarized signals into the Tunnel Diode, RC Circuit, Power Amplifier, and into the Trigger. Waveforms recorded by the Acqiris will be referred to as the "raw data."

Polarizer polarizes the raw data from the four channels into RCP/LCP for Horn1 and RCP2/LCP2 for Horn2. RCP/LCP and RCP2/LCP2 then go through the tunnel diode (with minimum output voltage 900mV/mW), then through the RC circuit (r=100 ohms, c=75pF), then through the Power Amplifier (RFx10). The output from the Power Amplifier will be referred to as the "amplifier output."

The time at which the trigger went off, which will be referred to as the "trigger time," is determined by binary outputs produced by the four amplifier outputs. If an amplifier output reaches the threshold, then the binary output is set to "high" for 30nsec. This period where the binary output remains high when the threshold is crossed will be referred to as the "trigger window." If three out of four amplifier outputs all reach a "high" at the same time, then that time is determined to be the trigger time.

By using several sets of different parameters for testing purposes, we arrived at the conclusion where applying an additional sqrt(2) gain for Horn2, and changing the trigger window to 35 nsec gave us the most optimal results. Section Testing includes the different testing procedures and results in details.

Matlab Demonstration

These are the Matlab demonstrations using the event "/raid/ANITA-lite/flight/usbdata/acq_data/run269/hd1072136125581.dat".
Raw data recorded at the Acqiris:

Polarized data produced by the polarizer:

Tunnel diode output, calculated by using $V_o=900P$ as specified from Advanced Control Components:

RC circuit output, calculated by using

$$V_{rc(i)}=V_o(i) + A(i) \cdot \exp(-dt / \tau)$$

where $A(i) = V_{rc(i+1)} - V_o(i)$:
Amplifier output, calculated by using $V_{amp}=V_{rc} \times \sqrt{10}$:

Amplifier output superimposed with the threshold level, which for this event is equal to 340.8 mV:

Binary outputs produced to calculate the trigger time. Output remains high for 30 nsec once the threshold value is crossed:
Binary sum produced by adding the four binary outputs. If 3 out of 4 channels cross the threshold at the same time, meaning if the binary sum = 3, trigger is set. In this example, trigger time=259 nsec:

**Testing**

This is a series of testings for the trigger times generated approximately from timestamp 2.51e6 to 2.65e6 by using different parameters.

1. \( V_0=900 \text{P}; \) \( R_C=7.5 \text{ nsec} \). Trigger time is set to -1 if threshold was not reached. A very high percentage of events did not reach the threshold (newtrigtimeList_r100.txt):
2. $V_o=900\text{P}$, $R_C=3.75\text{ nsec}$. Percentage of events that did not reach the threshold was still high
(newtrigtimelist_r50.txt):

3. $V_o=1100\text{P}$; $R_C=7.5\text{ nsec}$. Percentage of the events that did not reach the threshold decreased, but
still not low enough (newtrigtimelist_v1100.txt):
4. \( Vo=1100P; \) \( RC=7.5 \text{ nsec} \). An additional \( \sqrt{2} \) gain for Horn2 was applied. Very few events did not cross the threshold (newtrigtimelist_temp.txt):

5. \( Vo=900P; \) \( RC=7.5 \text{ nsec} \). No additional \( \sqrt{2} \) gain for Horn2. Trigger window was changed from 30 nsec to 40 nsec. Although the percentage of events that did not cross the threshold was lower than when the trigger window was 30 nsec, but it was still high. From this we can determine that the additional \( \sqrt{2} \) gain for Horn2 was a leading factor to produce optimal results (window40b.txt):
6. $V_o=900P$, $RC=7.5$ nsec. Additional $\sqrt{2}$ gain for Horn2. Trigger window=35nsec. Only 4% of the data did not reach the threshold, which is lower than the result from Test 4 (window35.txt):

**Conclusion**

Although the set of parameters used in Test 4 produced a satisfactory result, it consisted of parameters that were slightly different from the actual physical system parameters. The actual physical system parameters consist of:

- $V_o=900P$, $RC=7.5$ nsec

while the parameters used in Test 4 consist of:

- $V_o=1100P$, $RC=7.5$ nsec, and an additional $\sqrt{2}$ gain for Horn2

which means the output of the tunnel diode was increased by a factor of 1.4, which may be too big of a change.

The additional $\sqrt{2}$ gain was applied to Horn2 since most of the events that did not reach the threshold had very low signals from Horn2. These low signals from Horn2 were the leading factor to why most of
the events did not trigger.

This is the result generated for the entire set of data using the parameters from Test 6, which consist of: $V_0=900\text{P}$, $RC=7.5\text{ nsec}$, an additional $\sqrt{2}$ gain for Horn2, and trigger window=35nsec. The total number of events is 107944, and only 6470 events (6% of the entire data set) did not cross the threshold value:

This is the result generated after removing the events that did not trigger and selecting only the stable operation periods: The mean of the trigger times is 250.3 nsecs and the spread of the distribution is 8.885. These numbers show that the model is producing a plausible result.
This is a plot for the relative threshold, which is the ratio of threshold value to Vrms of the noise from 50 nsec to 200 nsec. This result shows that it is unlikely for the noise to reach the threshold value, and that we are in fact triggering the actual signal.
These results are produced from a model that takes the raw data from the Acqiris and integrates these data backwards from the Polarizer to the Trigger. Some power may have been lost as the signals were being recorded by the Acqiris, which may lead to the 6% data that did not trigger. Further testings are of course essential for more accurate results, but the results presented in this document are currently the most optimal results we have.

**Appendix**

**How-To**

All the files are located on beauty:/home/nancy/anita.

Plots from Matlab Demonstration were produced by running `writeup.m`, which calls `frealconvplots.m` to generate plots from Acqiris (raw data), Polarizer, tunnel diode, RC circuit, and amplifier. Plots of binary outputs are also generated from `writeup.m`. If plots for another event are needed, simply change the pathname for that specific event. `frealconvplots.m` is essentially the same as `frealconv.m` except it outputs all the internal parameters needed to generate plots from every stage of the system.

`frealconv.m` models the system from Acqiris to the Power Amplifier, if any parameters for the system need to be changed, simply edit `frealconv.m`.

`digitalout.m` models the binary output. If trigger window needs to be changed, simply edit `digitalout.m`.

To generate a list of trigger times either for the entire set of data, or for a specified range of data, run
trigtimelist.m, and specify a .txt file for the list output.

To generate a list of ratios of Vrms to threshold value either for the entire set of data, or for a specified range of data, run rmsratio.m, and specify a .txt file for the list output.

To generate a list of filenames for events that did not trigger, run findnottriggered.m, and specify an input .txt filename.

Matlab .m Files

digitalout.m
Function that outputs the binary output of a recorded waveform compared against the threshold value.

ffindfilename.m
Function that outputs the entire filename for a specific waveform.

findnottriggered.m
Outputs a list of filenames for the recorded waveform that did not reach the threshold value. Calls ffindfilename.m.

findthr.m
Function that outputs the correct threshold value at bin number.

findthr_utc.m
Function that outputs the correct threshold value at utc(timestamp).

frc.m
Function that models the correct RC circuit algorithm.

frealconv.m
Function that models a recorded waveform through the polarizer, tunnel diode, RC circuit, and amplifier, and outputs the final waveform outputted by the amplifier.

frealconvplots.m
Function that generates outputs of Polarizer, tunnel diode, RC circuit, and amplifier. Only used in writeup.m to generate plots as seen in Matlab Demonstration.

frms.m
Function that outputs the RMS value of noise before trigger point.

ftrigtime.m
Function that outputs the true time when trigger went off. If 3 out of 4 channels reach threshold value, then trigger is set. Calls frealconv.m, digitalout.m.

inbetween.m
Function that outputs a 1 if the input number is in between 2 other specified numbers; output=0 otherwise.

isodd.m
Function that outputs a 1 if the input number is odd; output=0 otherwise.

loop.m
Loops through the entire set of recorded data and outputs a specified value.
polarize.m (From Ped)
Function that converts linear into circular polarizations.

rawAnitaLoop.m (From Ped)
Function that loops over raw anita data.

readRawAnita.m (From Ped)
Function that reads raw anita event and returns event structure.

removezeros.m
Function that removes rows in a matrix if that row contains zeros.

rmsratio.m
File that computes Vrms/threshold for entire set of data.

timestamp.m (From Ped)
Function that converts raw time variable into timestamp.

trigtimelist.m
Generates a list of true times when the trigger went off over the entire set of recorded data.
Calls timestamp.m, trigtimem, removezeros.m.

wave.m
Applies ft to a recorded waveform.

writeup.m
File that produced plots as seen in Matlab Demonstration.
Calls frealconvplots.m.

Matlab .mat Files

correct_thr.mat
Matrix that contains the threshold values matched with event timestamps.
[utc rcp lcp rcp2 lcp2]

newfile.mat
Matrix that contains a list of all waveform events, all have length(ev.wv)==1024

.txt Files

hk1_thresholds_fix.txt (from Ped)
Threshold info. Note, these timestamps are not matched with event timestamps. See correct_thr.mat for the threshold values matched up with event timestamps.

newtrigtimelist_all.txt
Trigger times for the entire data set.
Vo=900P; RC=7.5 nsec
newtrigtimelist_r100.txt
Trigger times from approximately 2.51e6 to 2.65e6.
Vo=900P; RC=7.5 nsec.

newtrigtimelist_r150.txt
Trigger times from approximately 2.51e6 to 2.65e6.
Vo=900P; RC=11.25 nsec.

newtrigtimelist_r50.txt
Trigger times from approximately 2.51e6 to 2.65e6.
Vo=900P; RC=3.75 nsec.

newtrigtimelist_temp.txt
Trigger times from approximately 2.51e6 to 2.65e6.
Vo=1100P; RC=3.75 nsec; additional sqrt(2) for Horn2

newtrigtimelist_v1000.txt
Trigger times from approximately 2.51e6 to 2.65e6.
Vo=1000P; RC=7.5 nsec.

newtrigtimelist_v1100all.txt
Trigger times for the entire data set.
Vo=1100P; RC=7.5 nsec

newtrigtimelist_v1100.txt
Trigger times from approximately 2.51e6 to 2.65e6.
Vo=1100P; RC=7.5 nsec.

rawFlightList16.txt
List of all waveform events.

rmsratio.txt
Vrms values from 50nsec to 200 nsec / threshold value for entire data set.

window35all.txt
Trigger times for the entire data set.
Vo=900P; RC=7.5 nsec; trigger window=35 nsec; additional sqrt(2) for Horn2.

window35.txt
Trigger times from approximately 2.51e6 to 2.65e6.
Vo=900P; RC=7.5 nsec; trigger window=35 nsec; additional sqrt(2) for Horn2.

window40b.txt
Trigger times from approximately 2.51e6 to 2.65e6.
Vo=900P; RC=7.5 nsec; trigger window=40 nsec

window40.txt
Trigger times from approximately 2.51e6 to 2.65e6.
Vo=900P; RC=7.5 nsec; trigger window=40 nsec; additional sqrt(2) for Horn2.