Mountain Range Card Operating Manual

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I. Purpose

The mountain range card is used to set the triggering pattern used for displaying beam data, resembling a mountain range, on an oscilloscope. Various parameters including beam sync offset, the turns delay, type of machine, and the number of traces can be set remotely. An LCD screen is provided to show the current values of these parameters. As an added convenience, there are three different ways to start triggering the data to be displayed on the scope.

Figure 1 The Mountain Range Card.

II. Setup

The basic connections required to operate the mountain range include a signal for the Beam Sync Input and a sine wave signal for the 53MHz CLK Input. A sine wave is preferred for the 53MHz CLK Input, but it can be any signal that has zero crossings, as long as it meets the specifications given in the electrical characteristics section. A triggering method to start the mountain range process for the card is also needed. The three startup methods available are the manual trigger button, the external triggering signal, and a remote trigger. An Ethernet connection is attached to the card to allow remote triggering and changes to the settings. With these three connections, any feature on the card is accessible and settable.

An example setup is given in section 3 of the appendix. Using this setup, the extra bsync trig, dac out, and bsync out outputs can be used for troubleshooting the card.

III. Operation

a. Altera

The altera is used to process the 53MHz Clk and the Beam Sync inputs, to create the output signals of the mountain range card. The procedure starts with the 53MHz clock. The beam sync pulse is synchronized with the 53MHz clock, and then used as an indicator for the beginning of one revolution around the ring. The offset pulse signifies the time to delay after a beam sync pulse before sending out a beam sync trigger. The time is measured in 53MHz clock cycles, so an offset of 943.396ns would mean delaying the beam sync trigger for fifty 53MHz clock cycles after a beam sync pulse because one 53MHz clock cycle is the same as 18.868ns. To obtain the beam sync signal, the 53MHz clock is divided by the number of buckets in the ring, whether it is the Tevatron, the Booster, or the Main Injector. The turns delay pulse delays the beam sync trigger by the user specified number of revolutions around the ring. Once all the timing requirements are set, the scope triggers start to fire, after receiving a start trigger. After each beam sync trigger, a new scope trace is offset above the old scope trace. The tables below list the different parameter types and the ranges of value for each machine. The first table shows the initial settings of the mountain range card if no modifications to the parameters have been made.

During each bsync trigger, data is taken and displayed on the oscilloscope for that time. This is repeated continuously until reaching the number of triggers set by the user is reached. Looking at the scope, one will see several sets of data all plotted one above the other, giving the illusion of a mountain range. An illustration is provided in figure 2. This mountain range plot is for the booster with the following settings: the DAC delay is 838 buckets, the turns delay is 7 revolutions around the ring, the offset is set to 5 buckets, and the number of scope traces is set to 63, which makes the DAC increment value 4.

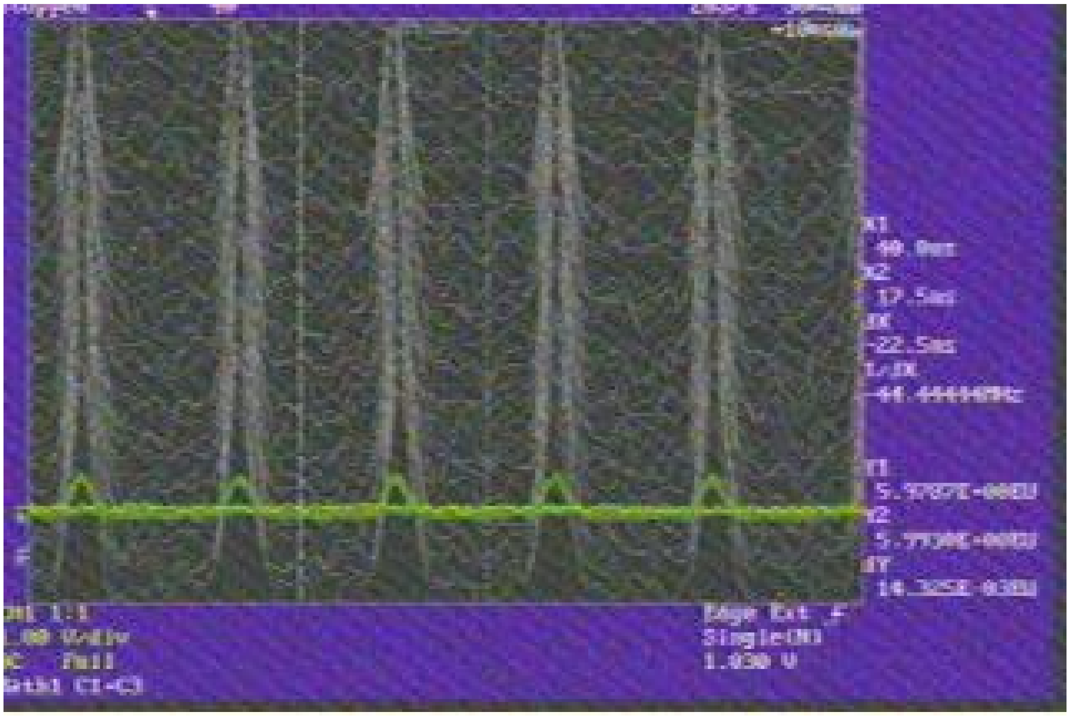

Figure 2 An example of a mountain range plot.

Initial Settings	
Offset	**5**
Turns Delay[2]	**1**
Number of Traces	**20**
DAC Incr Value	5
DAC Delay	**1613**

Table 1 The initial settings of the mountain range card are based on the Tevatron.

TEVATRON		
Offset	**0-1113**	
Turns Delay	**1-65535**	
Number of Scope Traces	**1-65535**	
DAC Increment Value [2]	**25**	**255/num of traces**
DAC Delay	**1613**	

Table 2 The Tevatron parameter settings and values.

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[1]The DAC increment value is set to 25 whenever the number of traces is less than or equal 10. As long as the value is between 11 and 256, then the DAC increment value is 255 divided by the number of traces.
[2] Although turns delay is set to one, the actual delay will be one and half time around the ring because the DAC Delay value is set to 1613 which is about one and half buckets.

BOOSTER		
Offset	**0-588**	
Turns Delay	**1-65535**	
Number of Scope Traces	**1-65535**	
DAC Increment Value [1]	**25**	**255/num of traces**
DAC Delay	**838**	

Table 3 The Booster parameter settings and values.

MAIN INJECTOR		
Offset	**0-84**	
Turns Delay	**1-65535**	
Number of Scope Traces	**1-65535**	
DAC Increment Value [1]	**25***	**255/num of traces**
DAC Delay	**122**	

Table 4 The Main Injector parameter settings and values.

b. **Rabbit**

The Rabbit module is used to initialize the two LCD's, the Rabbit ports, and the Altera ports and registers. It is also needed to receive and transmit commands, given by the user via an Ethernet connection. The program inside the Rabbit module checks to see which parameters have been chosen to be changed by the user, and then performs the necessary steps to set them accordingly. The scheme is pretty simple; each time a data packet is received, it checks each setting individually in the following order: offset with respect to beam sync, turns delay with respect to beam sync, number of scope traces to display and then the DAC delay with respect to beam sync. The DAC increment value is automatically set when the number of scope traces is set. Once the settings have been made, the module waits for the start trigger command to begin the mountain range process described in the Altera section. Another option is to save the current settings of the card. If this option is chosen all the recent changes will be saved to an EEPROM and becomes the default values on power up.

IV. Timing Diagrams

The timing diagram in figure 3 uses the Tevatron ring as an example. The number of buckets per beam sync pulse is 1113. The offset pulse triggers exactly two 53MHz clock

[1] The DAC increment value is set to 25 whenever the number of traces is less than or equal 10. As long as the value is between 11 and 256, then the DAC increment value is 255 divided by the number of traces.

pulses after beam sync. . The turns delay pulse is triggered every other offset pulse. Here, the trigger would fire off after every other turn around the ring and two 53MHz clock pulses after beam sync.

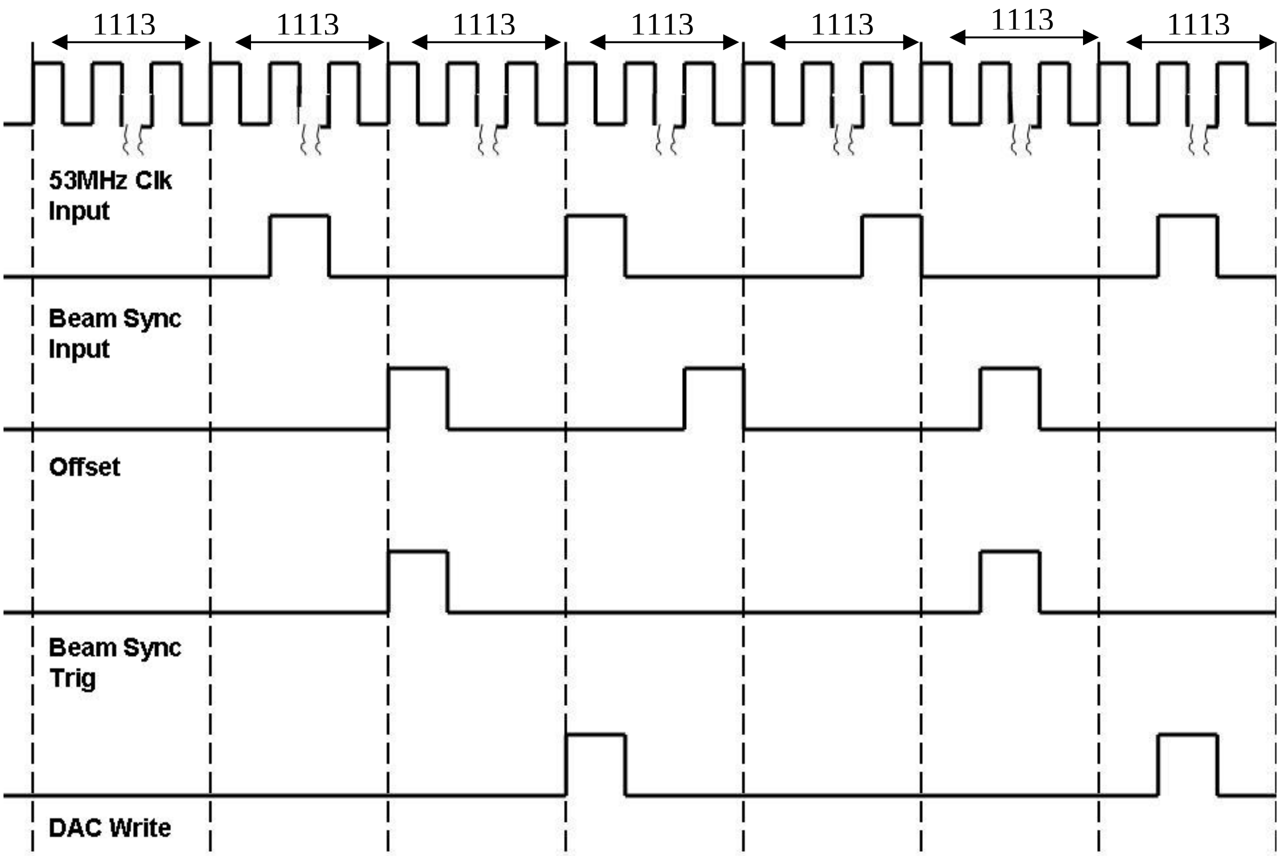

Figure 3 Timing diagram for the mountain range.

The mountain range has to be triggered between beam sync pulses to make sure there are no jumps in the data on the scope display. If the mountain range is triggered to early or to late there will be significant jumps at each DAC level on the scope. In figure 3, the DAC write pulse is only high between beam sync pulses in the timing diagram. Each time the DAC write pulse is sent out, a new level of data will be displayed on the scope after receiving the next start trigger.

V. I/O Descriptions

a. <u>53MHz Clock Input</u>: (Input) This signal is the clock that synchronizes the mountain range card. It represents the buckets in the various machines that use the mountain range card. There is a comparator at the front end of this input, so the clock input must have zero crossings. A sine wave or an AC coupled square wave will work.

b. Beam Sync Input: (Input) A TTL signal that is synchronized to the beam revolution frequency for a given machine. Each pulse marks one turn around the ring.

c. DAC OUT1: (Output) The output of the DAC.

d. DAC OUT2: (Output) The output of the DAC.

e. BSYNC OUT1: (Output) This signal is the result of synchronizing beam sync with the 53MHz clock.

f. BYSNC OUT2: (Output) This signal is the result of synchronizing beam sync with the 53MHz clock.

g. BSYNC Trig1: (Output) The timing trigger with respect to beam sync after the offset and the turns delay values have been assessed. This signal is connected to the scope trigger.

h. BYSNC Trig2: (Output) The timing trigger with respect to beam sync after the offset and the turns delay values have been assessed. This signal is connected to the scope trigger.

i. Start Trig: (Input) An external signal that can be used to fire off scope triggers to display the data rather than using the push button switch on the front panel or firing off the trigger remotely.

j. Manual Trigger: (Input) An external push button switch used to fire off scope triggers to display the data. This is another method that can be used to trigger the scope, rather than using an external signal or triggering remotely.

VI. Electrical Characteristics

53MHz: Amplitude ±5V
Input Voltage Range -2.5V to 5V
Input Resistance 50_
Operating Point 700mV p-p (0 dbm)
Max Frequency 53 MHz

BSYNC OUT1: High level 4V min
Low level 1.5V max
Impedance Drive 50_ min

BSYNC Trig1: High level 4V min
Low level 1.5V max
Impedance Drive 50_ min

APPENDIX

1. **Design**

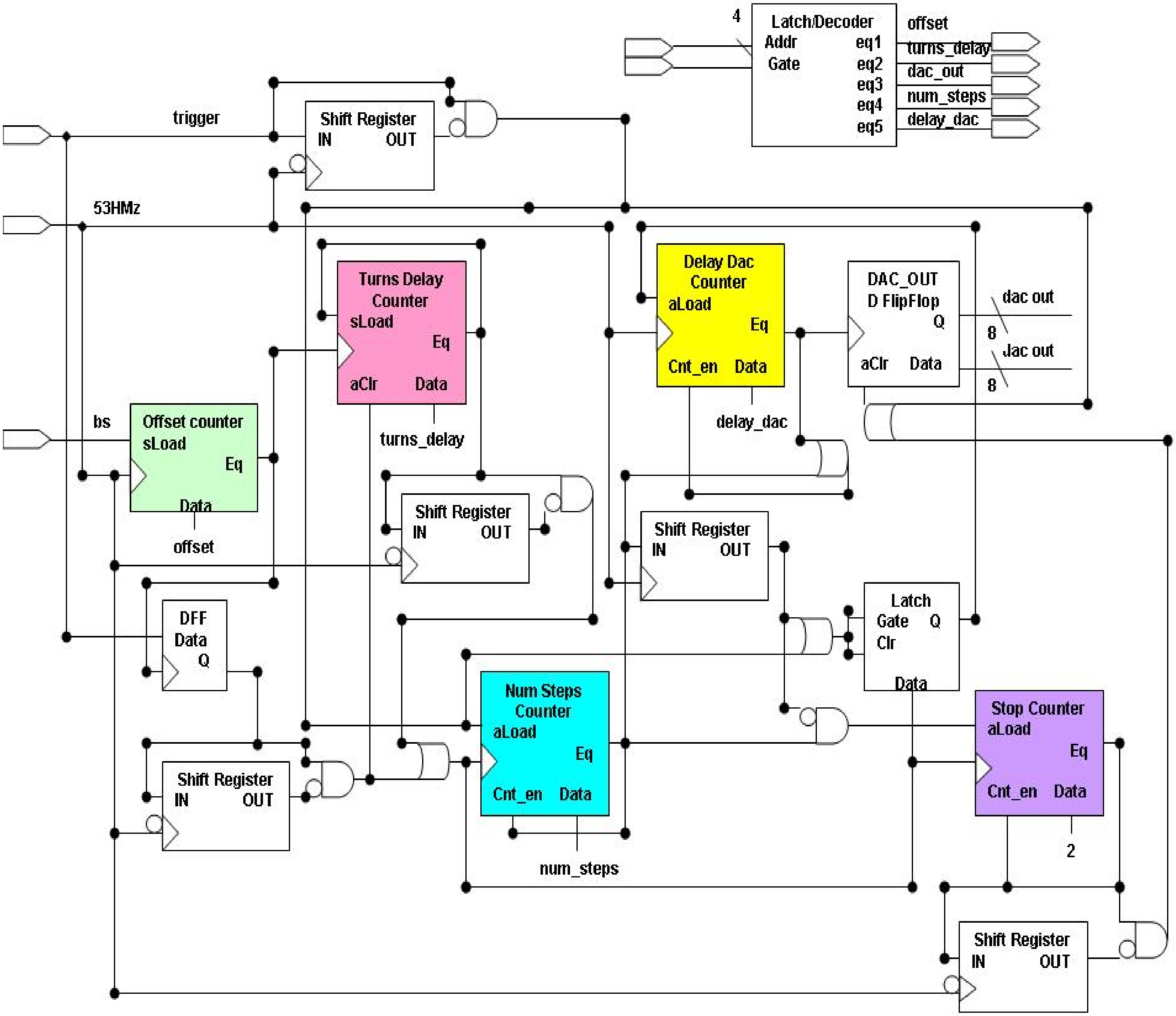

Figure 4 Schematic of the logic inside the Altera chip.

In figure 4, the 53MHz clock and the trigger signal are inputs to the Altera chip. The bs signal is beam sync, which is synchronized with the 53MHz clock signal before it actually enters the offset counter (shown in light green). Beam sync is the reference point for the beginning of each turn around the ring. Each time a beam sync pulse is detected, the offset counter is loaded and counts down until it reaches zero. Offset is the number of buckets to delay the beam sync pulse by. A pulse is then sent out to clock the turns delay counter. This pulse represents one complete turn around the ring. Turns delay is the number of turns around the ring to delay the beam sync pulse by. The turns delay counter (shown in rose) counts down by one each time it receives a pulse from the offset counter, causing it to skip one turn around the ring after each count. Hence the term turns delay. Once, the counter reaches zero, it reloads the turns delay value and starts the same process over again. The D flip-flop is used to find the first pulse from the offset counter that occurs after the rising edge of the trigger input. The shift registers combined with the logic gates used in the design are to shorten the time length of the pulses.

Number of steps is the number of DAC steps of data to be displayed on the scope. The number of steps counter (shown in turquoise) keeps track of the number of DAC steps that have yet to be displayed on the scope. When all the steps have been displayed, the counter sends out a pulse that is then shifted by one 53MHz clock period so that the gate of the latch doesn't close prematurely before the last trigger input pulse is sent out. The delay DAC is the DAC write delay, its counter (shown in yellow) is used to count the number of 53MHz clock pulses with respect to beam sync before a DAC write trigger is fired.

The DAC out flip-flop holds the DAC increment value, the number to increase each DAC step by before displaying it on the scope. The stop counter (shown in lavender) generates a stop pulse two pulses after the shortened offset pulse is asserted, the pulse resulting from the shift register after the offset counter. It clears the DAC out so that its value is zero when the next trigger comes in.

The latch part of the latch/decoder is used to store the value of the address from the Rabbit only when writing to the Altera chip to ensure that the correct address is being decoded. The decoder is needed to determine how to process the data from the Rabbit module. Using the representation in figure 4; when the address of the Rabbit is equal to one, the data from the rabbit is stored in the offset register. When the address equals three, the data is stored in the register for DAC out. The illustration given in figure 4 above demonstrates how things work. In the actual design, DAC out is eight bits. Offset, turns delay, number of steps, and DAC delay are all sixteen bit outputs.

2. Block Diagrams

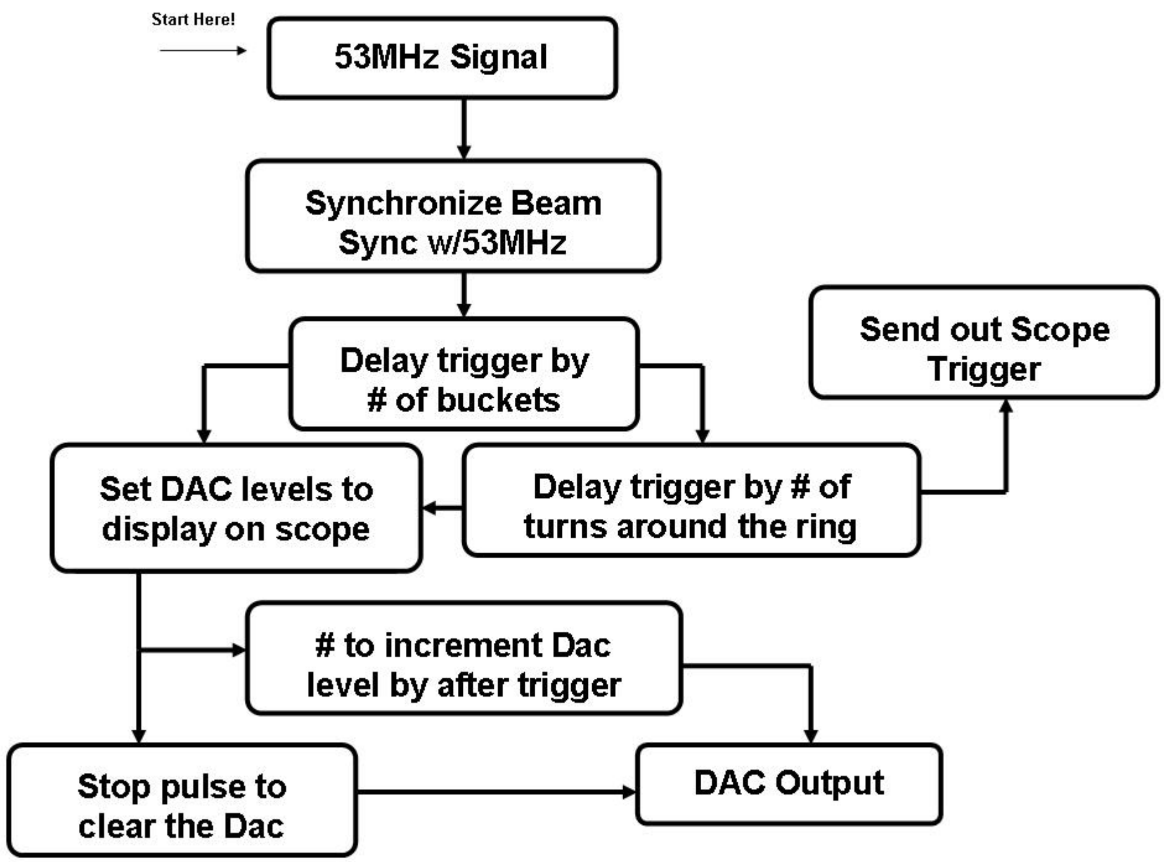

Figure 5 Block diagram of how Altera works inside the mountain range card.

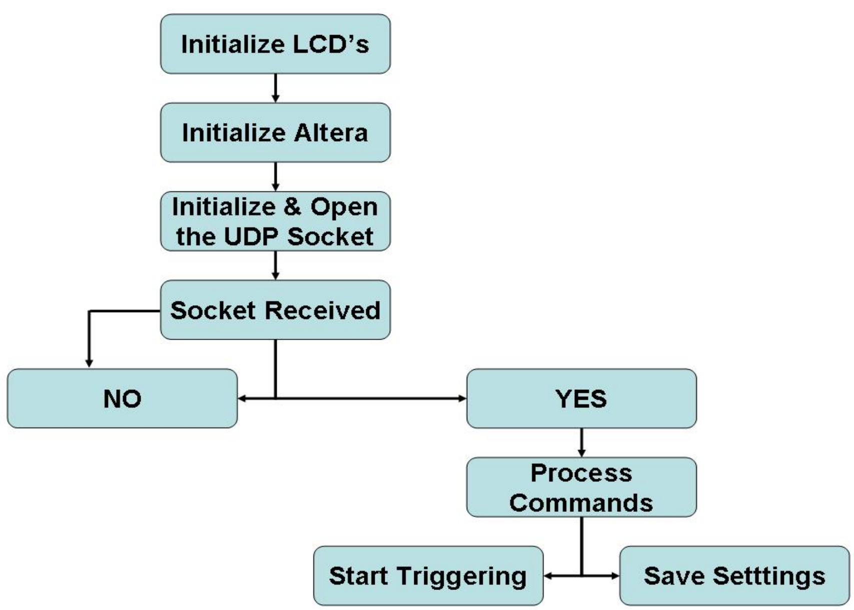

Figure 6 Block diagram of the program inside the rabbit module.

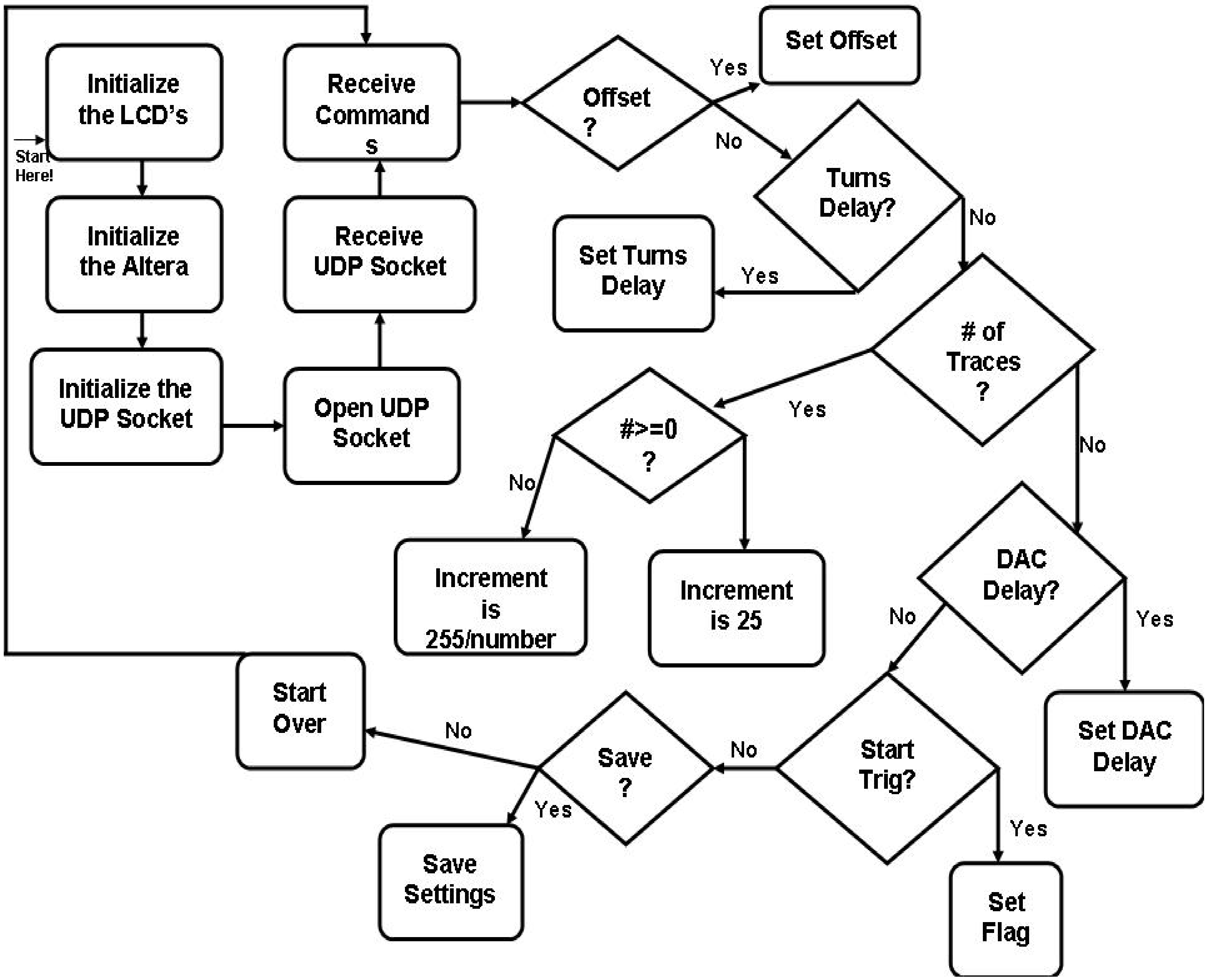

Figure 7 Process for setting parameters in the rabbit module.

3. Example Connection

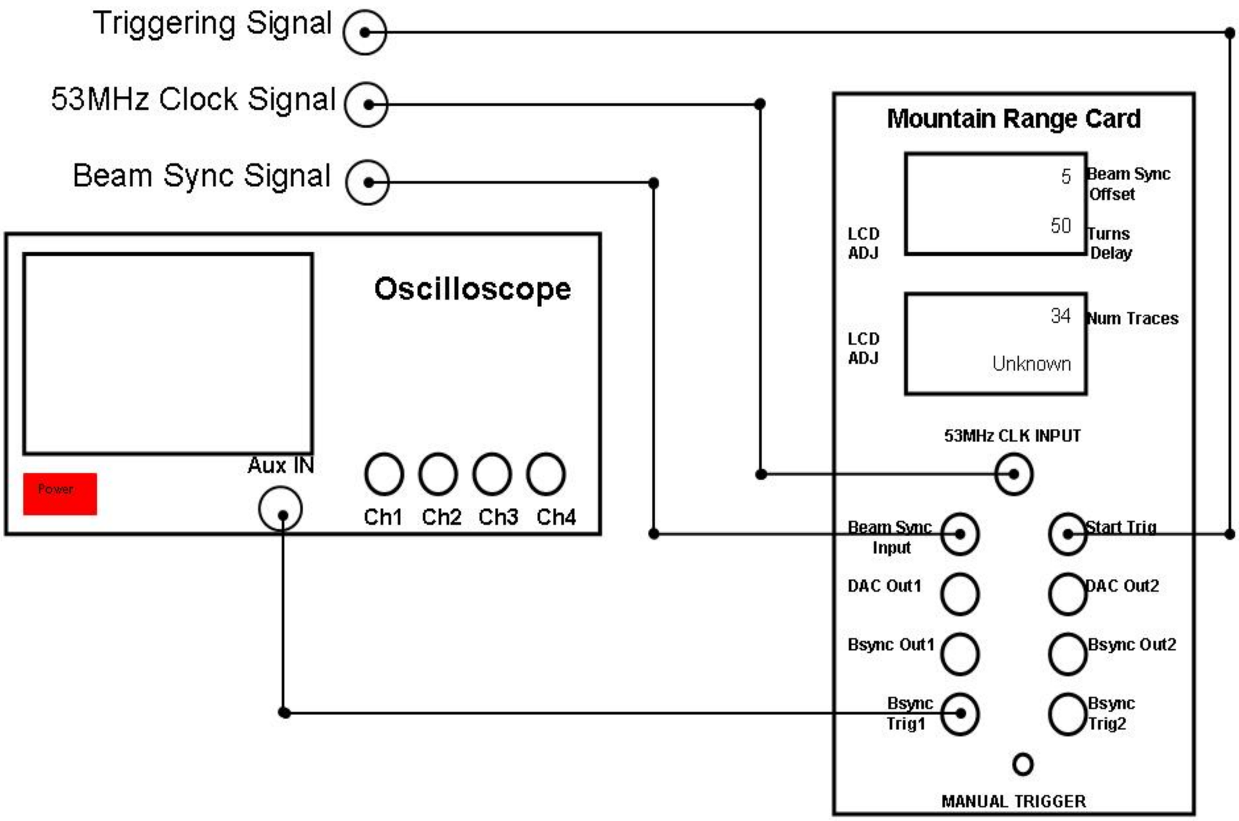

Figure 8 Connection diagram for the basic setup**.**

Figure 8 shows the basic connections for the mountain range card to the oscilloscope. The 53MHz Clock, Triggering, and Beam Sync signals are all external signals generated by the user. For the purpose of demonstration, a few parameters have been set to show what they look like when they are displayed on the LCD screen. The DAC Out and Bsync Out outputs can be viewed by connecting any of the outputs to an open channel on the oscilloscope. The manual trigger push button switch is located at the bottom of the mountain range card, and the other external trigger is underneath the 53MHz clock signal. It is called start trig. To use the push button switch, just push it each time a trigger is desired.