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FPGA IMPLEMENTATION OF CALIB_IO, WAVE AND CLOCK GENERATION MODULES FOR GRAIN SORTING MACHINE

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Abstract
The color sorting machines inspect grains by means of sensors and remove contaminants by a short burst of compressed air by using the color difference. Grain Sorting machines are successfully being used in the rice milling industry for long time. The color sorters are used in the grain cleaning to remove unwanted materials like dust particles, black tip, burnt, other discolored grains and other inner contaminants. Today's advanced color sensors are robust, compact, requires less maintenance and consumes very little energy. Hence, these color sensors can be considered for inclusion in any modern grain cleaning plant. This paper aims to develop Calib_IO, Wave Generation and Clock Generation modules for grain sorting machine to remove unwanted materials like dust particles, black tip, burnt, other discolored grains and other inner contaminants and to increase its processing speed. Clock generation module is designed using Quartus II software and is implemented in Cyclone IV E (FPGA KIT) that incorporates compact color sensors for sorting grains.

Keywords:
Sorting Grains, Color Sorting Machines, Calib_IO, Wave Generation, Clock Generation

1. INTRODUCTION

All forms of grains are harvested and are processed in edge plant. Edge of grains continuously ends up in some grains being broken. Quality factors are associated with grain length, stickiness, aroma, texture, and flavour. Within the gift grain handling system, grain sort and quality are speedily assessed by visual scrutiny. This analysis is tedious and time overwhelming. Also, the choice taken by human inspectors could also be settled by external factors like temporary state, revenge, bias or human psychological limitation. This will be overcome by exploitation grain sorting machine. "Food processors are trying to induce as shut as potential to 100% discrimination of undesirable foreign and demanding defects" Sorting of merchandise could be a terribly tough process. Continuous manual sorting creates consistency problems. Purpose of this model is to style and implement a system that mechanically separates merchandise supported their color.

Grain processing begins in a milling plant, where the harvested grains run through a production line where the grain is dried, de-stoned, husked and shelled. It is then taken to the sorter machine. At this point, the grain mixture will travel by elevator belt into a hopper on the top of the machine, from which it will flow down chutes (16, 20, 32, 40 and 63) in the sorter, streamlining their flow so that they may be scanned by the sensor. The moment the camera detects any defects, the camera instructs ejectors fitted in the machine to open the nozzle. The nozzle is connected to the valves containing compressed air. This air is then used to shoot out the defected material from the input rice. The types of defects in rice include black tipped and partially black tipped.

Color sorters employed in assembly lines to spot and classify merchandise by color. The objectives of their usage embrace to visualize the standard of merchandise, facilitate sorting and packaging, assess the equality of merchandise in storage and to observe waste merchandise. Color sorters separate things by their colours, sleuthing the colour of things that pass before them, and victimization mechanical or gas ejection devices to divert things whose color don't fall inside the suitable vary or that area unit desired to create a separate cluster from the remainder. Color sorters area unit principally employed in sorting grain (agricultural products). The rice sorting business is that the initial huge market, the rice sorting technology is per the colour variations of rice (husked paddy) materials, employing a high-resolution CCD optical sensing element to separate totally different stones, black rice, etc. it's the ultimate step when sharpening rice with a rice power tool. The second sorting market is in use for coarse cereals, like wheat, corn, peanut, totally different types of beans, benne seeds, etc. Sorting machines improve product quality and add social advantages.

2. LITERATURE REVIEW

Hazrataii and Mir-Nasiri [1] have projected a machine-controlled Pepper Sorting Machine (APSM) for industrial application. The look consists of many mechanical and electrical parts like motors, a microcontroller, soul mechanism, suction tube, belt and machine. Additionally, a framing crane is employed so as to maneuver the suction pipe across the belt to the precise position of the defective pepper. The most purpose of this style is to automatize the sorting procedure for pepper trade and to optimize its work potency.

Robert Singh and Chaudhury [2] designed a grading system for fallen rice mistreatment neural network. Rice sorting in high-speed is required for the mass cargo. However, the popularity performance of the standard sorter is not quick enough for the dealing volume involved. In a very standard rice sorter, if the rice rate exceeds a couple of thousands [kg/h], the popularity proportion is below ninetieth and recognition ability is not secured [12]. Here a brand new system for the rice grading mistreatment the neural network was planned that showed the effectiveness of the planned methodology by simulation with real rice knowledge, like the conventional rice and broken rice. Moreover, extraction formula, which may sample one grain or rice among an oversized amount of rice in a very single image frame, was conjointly planned what is more, a paradigm system was developed for rice grading, and showed its performance and effectiveness [13].

Gan and Zhao [3] have planned an effective defect review methodology for digital display mistreatment active contour model. Visual defects in liquid show pictures typically seem as low distinction and blurred contour while not distinct intensity distinction from their encompassing region. Besides, the background is sometimes intensity the irregularity. These properties create the machine vision review extraordinarily exhausting [7]. This paper presents a good machine vision review methodology employing a native active contour model to sight defects with completely different brightness levels furthermore as numerous sizes and shapes. A changed native binary fitting model that is powerful to initial contour is developed to extract defect boundary [8]. Meanwhile, an easy preprocessing theme is given to compensate the disadvantage of the two-phase active contour model for investigating objects with wide brightness levels [14].

Harshavardhan et al. [4] have planned a neural network motor assisted machine vision system for sorting pomegranate fruits was planned. Sorting is a crucial step in process and packing lines of pomegranate fruits. Presently pomegranates are sorted into quality classes manually [6]. However manual sorting poses issues like tiresomeness, low accuracy, judgment etc. Moreover, manual sorting isn't suggested for export quality fruits. Thus a machine vision system is needed so as to type the pomegranate fruits.

Savakar [9] is geared toward developing a strong non-destructive methodology to type pomegranates mistreatment moving ridge options and Artificial Neural Network (ANN) coaching [11]. Experiments were conducted to coach ANN and calculate the performance supported abstraction and moving ridge options severally. Network performance is analyzed supported the parameters like Sensitivity, specificity, accuracy, mean sq. error and Receiver in operation Characteristic (ROC) curve. The results of experimentation showed that the performance of ANN was high once moving ridge options were used for coaching as compared to the abstraction domain options. Queiroz and Braun [5] have planned a classification of rice look quality supported color embedding into unsmooth grey pictures mistreatment machine vision method, during this method of rice grain edge, rice grains are sorted by size into several classes purchasable at completely different costs. By observation on "small broken", that may be a [10] low-quality class of sorted result, it conjointly found that it composes of serious amounts of dearer rice grains. It conjointly evaluates broken rice grains so as to form higher benefit from its higher quality portion by image analysis [6]. The formula here categorizes "small broken" into four types: tiny broken, broken, huge broken and head rice, that are categories delineate by the Department of Rice, Thailand. Least-Square Support Vector Machine (LS-SVM) with Radius Basis operate (RBF) kernel is employed as a classifier within the formula. The accuracy of the formula is 98.2%.

3. PROPOSED WORK OF GRAIN SORTING MACHINE

This section deals with the design of proposed grain sorting machine using calibration input output and clock generation modules.

3.1 CALIBRATION INPUT OUTPUT MODULE

The first process to be done is the calibration input output module, this process is used for calculating the reference value and also to set the tolerance value. The grain sorting machine consists of chutes (16, 20, 32, 40 and 63). The second process to be done is the wave generation module, the wave generation module is used for positioning the on and off time period of the clock. The third process to be done is the clock generation module. After the completion of all the modules, they are combined together as a single module and implemented in hardware. (FPGA Kit named Cyclone IV E).

Mono chromatic 2048 Pixel High Speed CCD cameras with excellent scanning rate. Double Vision Scanning System to discover the slightest distinction upto 0.1mm. Specially customized lenses to identify pin point images. In a grain sorting machine, grains drop onto and slide down an anodized aluminum chute. The purpose of the chute is to separate the grains and provide a controlled distribution. At the bottom of the chute the grains are examined optically and contaminants or defective grains are removed from the stream by jets of air.

The machine has the ability to sort low quality grain which contains a large element of contaminants such as husk. The husk is extremely abrasive and this, along with other factors, can lead to a reduction in the life of the chute by wear of the surface.

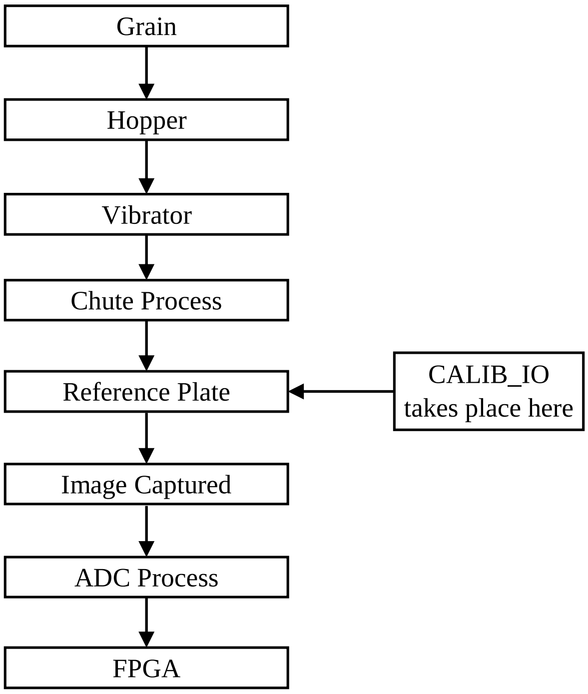

Fig.1. Flow chart of Grain sorting machine

The Fig.1 shows the process of grain sorting machine, first the grain is inserted in to the hopper, hopper is a container for a loose bulk material such as grain or rock typically one that tapers downwards and is able to discharge its contents at the bottom. Then again the grain flow through the vibrator, the vibrator tray which is used for getting high quality sorting of grain, the flow of grain is maintained uniformly. The vibrator works consistently when the voltage is high or low. The purpose of Chute is to separate the grains and provide a controlled distribution at the bottom of the chute the grains are examined optically and contaminants or defective grains are removed from the steam by gets of air. The grain passing through the inspection area is very closely scanned by the camera for any impurity.

The tolerance value is set. Grain enters the machine through the input hopper and is vibrated towards the anodized aluminum chute (16, 20, 32, 40 and 63) along a tray. The grain drops off the edge of the tray onto the chute and slides down. The chute has the effect of separating the grains so they arrive at the end in a continuous stream. The calibration process starts it is used for calculating the reference value at the end of the chute there is a detector head consisting of a number of cameras. An image is taken of each grain as it passes the head. The image is quickly processed and compared to a reference standard that is used to accept or reject the grain. A series of air jets controlled by high speed poppet valves are used to blow the defective grains or contaminants out of the stream.

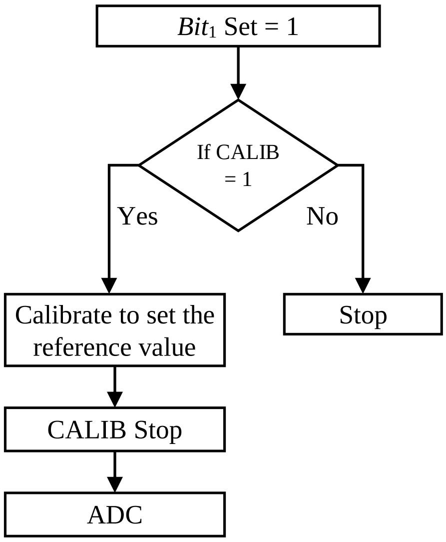

Fig.2. Flowchart of calibration process

The Fig.2 shows the flow diagram of calibration process, If the Bit_1 SET = 1 the value is 1 then the signal becomes high the calibration process starts to calculate the reference value and if the Bit_1 SET = 0 the value is 0 then the signal becomes low the calibration process will not takes place it stops the process.

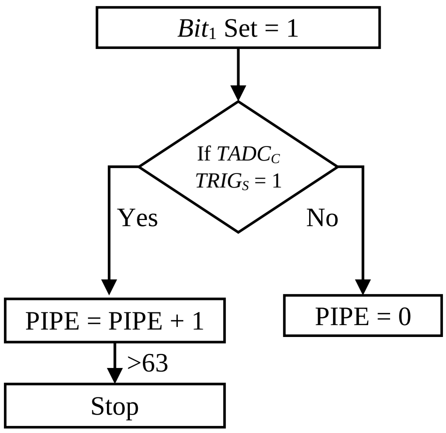

Fig.3. Flow diagram of the chute process

The Fig.3 shows the chute process of the grain sorting machine, here the tolerance value is set, when Bit_{set} = 1, the $TADC_C$ $TRIG_S$ = 1 the signal becomes high and then the chute process starts it fills the chute till 63, the pipe here denotes the chute, once the chute is filled with the rice the calibration process started, it calculates the reference value, if $TADC_C$ $TRIG_S$ = 0 the signal becomes low and the process will not run.

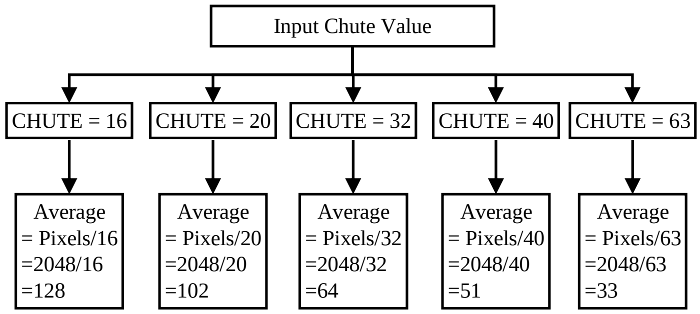

Fig.4. Chute value calculation

The Fig.4 shows the chute value calculation, the input chute value is given (totally five chute values are present namely as 16, 20, 32, 40 and 63). The average value can be calculated as total pixels (i.e. 2048) divided by the chute value.

$$Average\ value = pixels/chute\ value$$

The wave generation module has the following components that are to be present in it. Counter, three Comparator and AND operation. The counter is a digital device and the output of the counter includes a predefined state based on the clock pulse application. The output of the counter may be wont to count the amount of pulses. The comparator is a device that compares two voltage or current and output a digital signal indicating which is larger.

3.2 CLOCK GENERATION

Given, in data sheet, the following specifications, which are listed below:

- Total time period = 268μs
- On-time is 256μs
- Off time is 12μs
- Given, Frequency = 50MHz
- Time period for one cycle = 1/50MHz = 20ns
- On-time period = 256μs/20ns = 12800
- Total time period = 268μs/20ns = 13400
- Off-time period = 13400-12800 = 600.

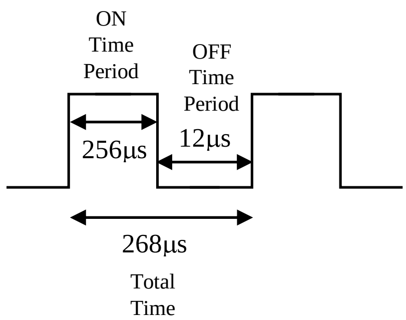

Fig.5. Generated clock signal

The Fig.5 shows the generated clock signal, the positive edge of the clock is called as ON time period and the negative edge of the clock is called as OFF time period of the clock signal. The ON time period ranges from 0 to 12800 and the OFF time period ranges from 12800 to 13400. The wave generation module is use for calculating the ON and OFF time period of the clock signal.

Total time period is to be taken is 268µs, on time period of the clock is 256µs and then the off time period of the clock is 12µs. The given frequency is 50MHZ. Time period for one cycle is calculated as 1 divided by 50MHZ so the value is 20ns. The ON time period can be as calculated as follows.

ON time period of the clock is 256, it can be given as ON time period = 256µs/20ns = 12800. So the on time period ranges from 0 to 12800. The OFF period can be as calculated as follows.

Off time period of the clock is 12µs, it can be given as OFF time period = 12µs/20ns =13400. So the off time period ranges from 12800 to 13400.

The comparator process consists of three types it can be as given below:

- The value of comparator A is assigned as 0
- The value of comparator B is assigned as 12800
- The value of comparator C is assigned as 13400

The wave generation module is done using the AND operation. The AND operation is used for denoting the position 1 and position 2 of the clock signal. Position 1 is 256µs (0 to 12800) and position 2 is 12µs (12800 to 13400). The position 1 denotes the on time (256µs) period of the clock signal and it ranges from 0 to 12800. The position 2 denotes the off time (12µs) period of the clock signal and it ranges from 12800 to 13400. This is the use of AND operation. $A \geq B$ (A is the value of counter output i.e. 0 to 13400), assign B as 0.

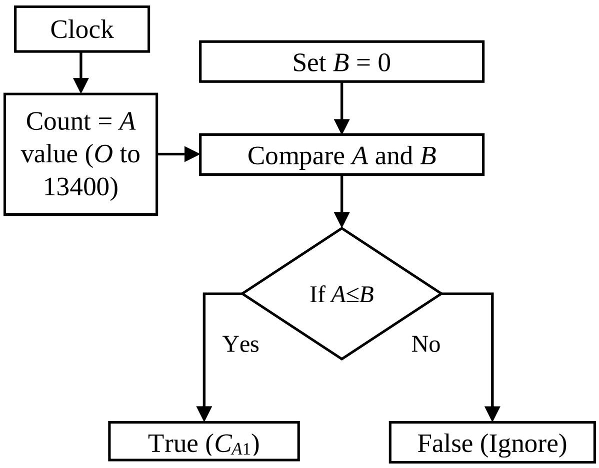

Fig.6. Comparator *A* process

The Fig.6 shows the comparator A process, where the counter output value ranges from 0 to 13400. Assign B value as 0 compare A and B if the value of A is greater than or equal to B then the process is true and it is denoted as C_{A1}, if the value of A is not greater than or equal to B then the process is ignored. Checks if $A \geq B$ or $A \leq B$; (A is the value of counter output i.e. 0 to 13400), Assign B as 0 to 12800.

The Fig.7 shows the comparator B process the counter output value ranges from 0 to 13400 the value of B is assigned as 12800. Now the value of A and B is compared and it checks the condition $A \geq B$ OR $A \leq B$, if A is greater than or equal to B the process becomes true and the value is saved as C_{B1} and if the value of A is less than or equal to B again the process becomes true and it is saved as C_{B2}. In comparator C process, assign B = 13400.

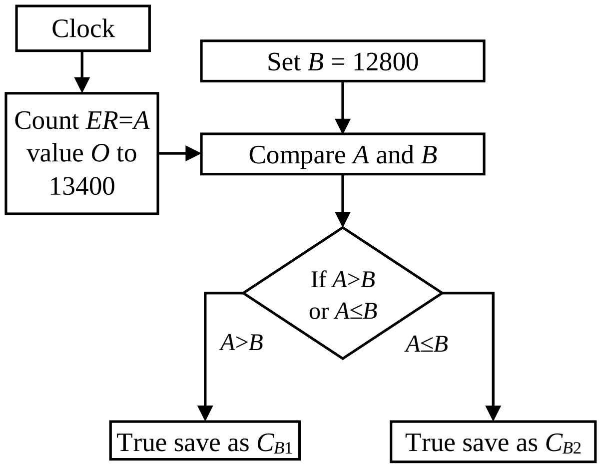

Fig.7. Comparator *B* Process

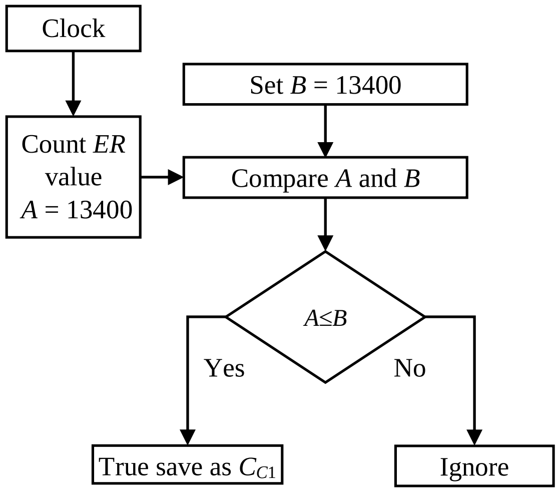

Fig.8. Comparator *C* process

The Fig.8 shows the comparator C process here the value of A is assigned as counter output value and it ranges from 0 to 13400, the value of B is set as 13400 compare A & B if the value of A is less than or equal to B then it is true and saved as C_{C1} if it is not true then the value gets ignored. The AND process for the position 1 process is described in Fig.8, which denotes the ON time period.

The Fig.9 shows the AND operation takes the input as C_{A1} and C_{B1} and it checks for the conditions, if the output value becomes 1 then it denotes the position 1 and it ranges from 0 to 12800 and if the output value is not equal to 1 then it gets ignored. The AND process for the position 2 process is described in Fig.9, which denotes the OFF time period.

The Fig.10 shows the AND operation takes the input as CB2 and CC1 and it checks for the conditions, if the output value becomes 1 then it denotes the position 2 and it ranges from 12800 to 13400 and if the output value is not equal to 1 then it gets ignored. All the modules are grouped together into a single module in the clock generation module.

The KLI-2113 Image device could be a high dynamic vary, multispectral, linear CCD image device ideally suited to stern color scanner applications. The imager consists of 3 parallel 2098-element photodiode arrays-one for every primary color. The KLI-2113 device offers high sensitivity, a high rate, low noise, and negligible lag. Freelance exposure management for every channel permits color reconciliation at the side. CMOS-compatible five V clocks, and single twelve V_{DC} provide area unit all that area unit needed to drive the KLI-2113 device, simplifying the planning of interface physics.

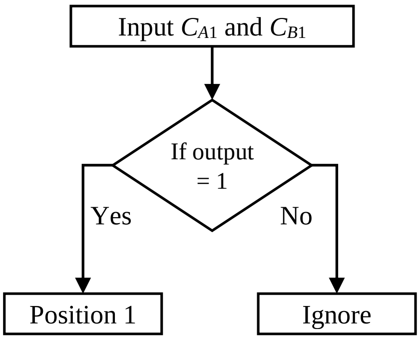

Fig.9. AND operation for position 1

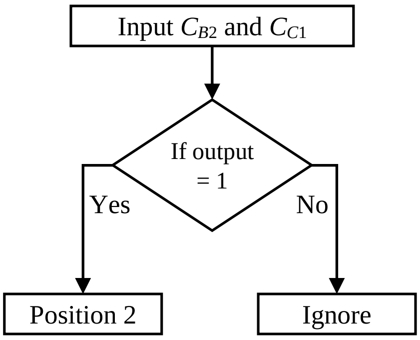

Fig.10. AND operation for position 2

All the modules area unit designed and compiled victimization the Quartus II software system that is a multiplatform style setting that simply adapts to your specific style desires.

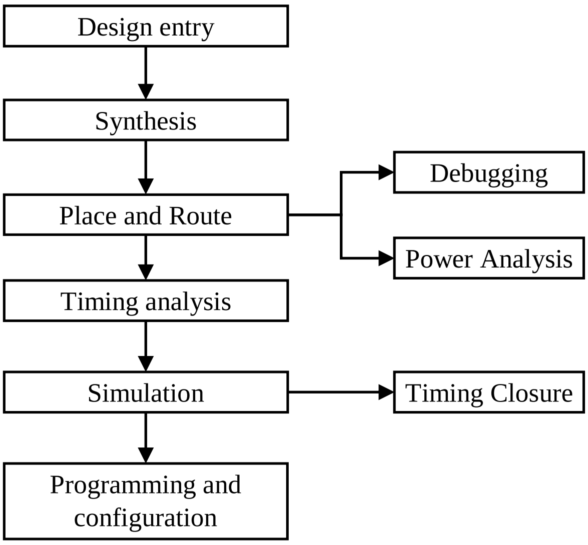

Fig.11. Design flow of the Quartus software

It is a comprehensive setting for system-on-a-programmable-chip (SOPC) style. The Quartus II software system includes solutions for all phases of FPGA and CPLD style. In addition, the Quartus II package permits you to use the Quartus II graphical programme and command-line interface for every section of the planning flow. The study uses one in all these interfaces for the complete flow, otherwise you will use totally choices at different phases. Its features are High Resolution, Wide Dynamic Range, High Sensitivity and High Operating Speed.

In addition, the Quartus II software system permits you to use the Quartus II graphical computer programme and command-line interface for every part of the look flow. You can use one among these interfaces for the complete flow, otherwise you will use totally choices at different phases.

4. RESULTS AND DISCUSSION

The RTL schematic of overall grain sorting machine is shown in the Fig.12, it consists of all the six modules such as calibration input output, wave generation, clock generation.

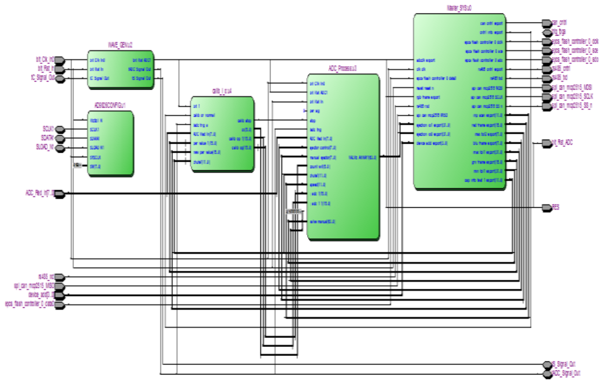

Fig.12. RTL schematic of the overall grain sorting machine

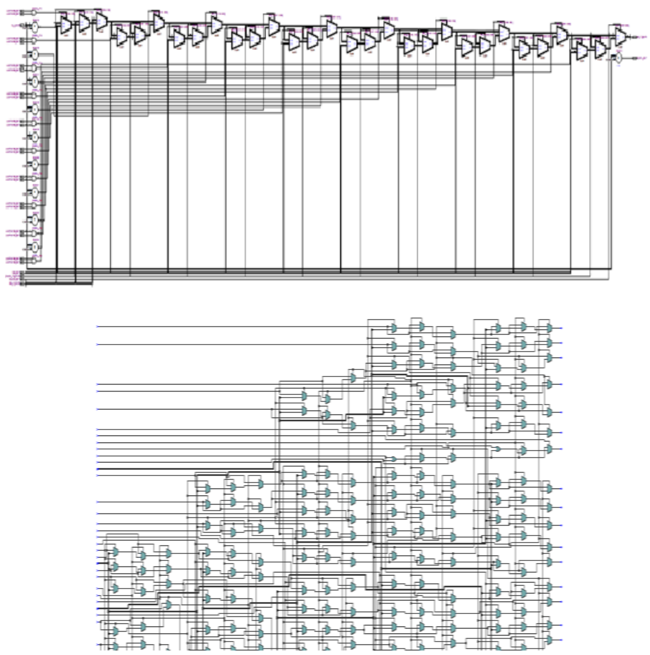

Fig.13. RTL schematic of the calibration input output process for grain sorting process

The Fig.13 shows the RTL schematic of the calibration input output process for grain sorting process, the calibration input output process is used for calculating the reference value.

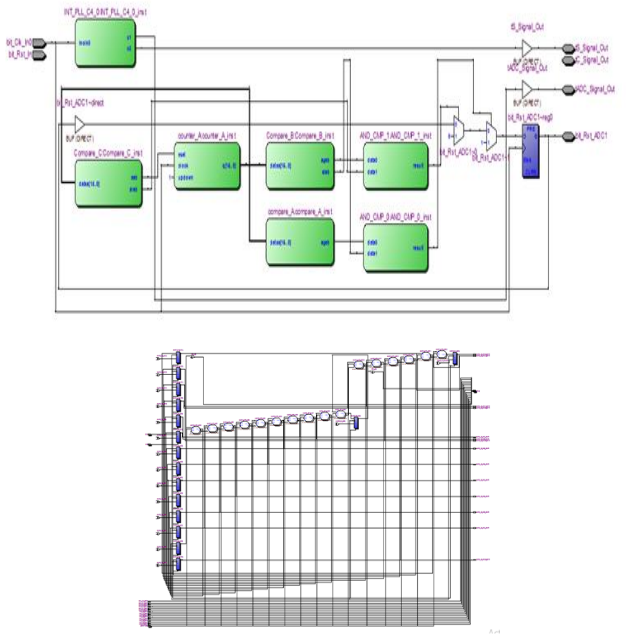

Fig.14. RTL schematic of the wave generation process

The Fig.14 shows the represents of RTL schematic of the wave generation process, in this it consists of comparator *A*, comparator *B*, comparator *C* and AND operation, which is used for positioning the ON and OFF position of the clock signal.

Fig.15. Hardware implementation of the sorting machine

The Fig.15 shows the Hardware implementation of the sorting machine, in this it consists of Cyclone IV FPGA, Digital Storage Oscilloscope (DSO) and power supply that are to be present in it, a digital storage oscilloscope is an oscilloscope which stores and analyses the signal digitally rather than using analog technique.

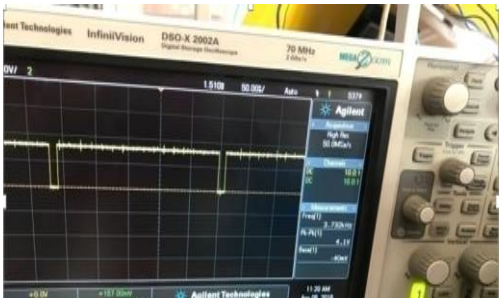

Fig.16. Clock Generation of the Grain Sorting Machine

The Fig.16 shows the Clock Generation of the Grain Sorting Machine, here the input is given as the 8MHz.

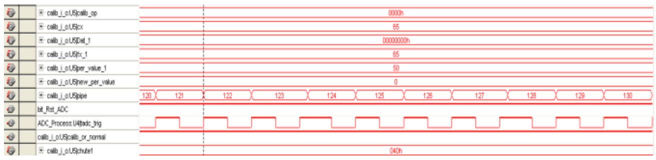

Fig.17. Output waveform of the grain sorting machine

Here the chute value is set as 50 then the rice gets flows through the machine the calibration input output process starts, which is used to calculate the reference value and it also denotes the maximum and minimum tolerance value, once the calibration input output module stops the ADC module get start.

The below images shows the rice sorting process, first the rice is inserted into the machine it is then flow into the vibrator it fills the rice into the chute. The chutes ranges as 16, 20, 32, 40 and 63 the rice gets detected by the camera and at last it detect whether the given is defective or non-defective one.

Fig.18. Inserting rice into the machine

Fig.19. Rice flows into the vibrator

The Fig.18 and Fig.19 shows that the rice is first inserted in to the machine then it may flows in to the vibrator.

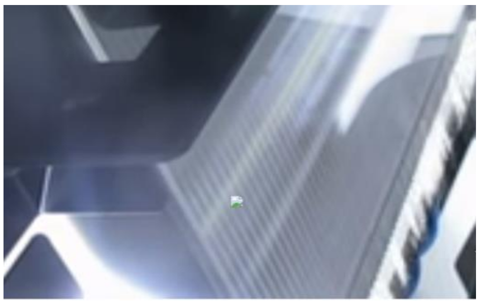

Fig.20. Chute process till 63

The Fig.20 shows the chute process, there are totally five types of chute to be present range: 16, 20, 32, 40 and 63 where the rice flows in it. In existing grain sorting machine there are only upto 40 chutes but in the proposed grain sorting machine the chute range is extended to 63, so the speed of the grain flow can be increased.

Fig.21. Separating defective and non-defective rice

The Fig.21 shows the separating process which is used for detecting whether the given rice is defective or non-defective.

5. CONCLUSION

This paper has described about the design and development of calibration input-output module, wave generation and clock generation modules for an automated grain sorting machine. The grain sorting machine can be used for categorizing the grain as defective, partially defective and non-defective. These three modules has been integrated with other modules of the grain sorting machine in the industry and has been found to be functioning successfully. This process can be extended for coffee, nuts and oil crops using this color sorter.

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