Automated Rubber Seed Clones Identification Using Reflectance Sensors With FPGA

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Abstract - ***This paper outline the study on automated rubber seed clones identification using reflectance sensors with FPGA. The main objective of this project is to create an intelligent identification system using reflectance sensors interfaced with Altera DE2 application board. To measure the average voltage level of the rubber seed clone, the reflectance sensor used the amount of reflected light from the seed surface as the sensing variable. There were five types of clones from the same species of rubber seed were used as samples for this project. The samples were RRIM2006, RRIM2025, RRIM2016, RRIM2009 and PB360. Three reflectance sensors were installed on the model to send different values of data to the application board. The data was represented by the intensity of light reflected from the rubber seed surface. From the input data, the FPGA board can differentiate the types of seed based on the data store in the FPGA lookup table. Microsoft Office Excel was used to analyze the average ADC value that was converted from the wavelength of light reflectance taken from 60 samples readings of five difference clones. Analysis results were shown in terms of data and graph where the ADC values of each type of clone were different. Results of findings have sown evidence that the brightness of brown colour on the front surface of the clone seed can be used to classify the types of rubber tree clones.***

Keyword: reflectance sensor, FPGA, Altera DE2, rubber seed, RRIM 2000 series.

I. INTRODUCTION

Latex is an important economic resource for the world, especially in Malaysia. Lots of studies have been carried out to improve the quality of latex production in the rubber tree. In Malaysia, there are more than 30 clones of the rubber trees, producing a clone of so many that cause difficulties to farmers and agriculture officers in identifying the rubber seeds clone. Rubber seeds have different patterns on the surface, for a qualified rubber seed clone inspector it is easy to identify the difference in the pattern of clones by simply observing the surface of seeds. However, these methods are time consuming, lower percentage of accuracy and high cost to train new rubber seed clone inspector to identify rubber seed clones.

Previously, the best rubber series clone was recognized based on a range of reflectance of wavelength, shape and texture of the rubber series seeds through the image processing and wavelet technique that were introduced by the Muhammad Fauzie et al [1][2][3][4].

In this project, improvement was made where reflectance of light from the rubber seed surface was used to identify the clone type. The factor that influenced the amount of light reflected was the brightness of surface material who reflected the visible light.

Figure 1and 2 show the overview of the rubber seed clones identification.

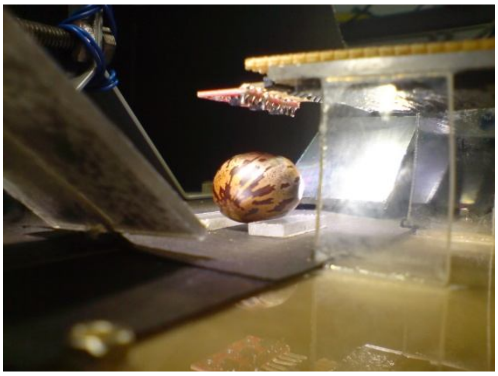

Figure 1: Rubber seed clone with reflectance sensor

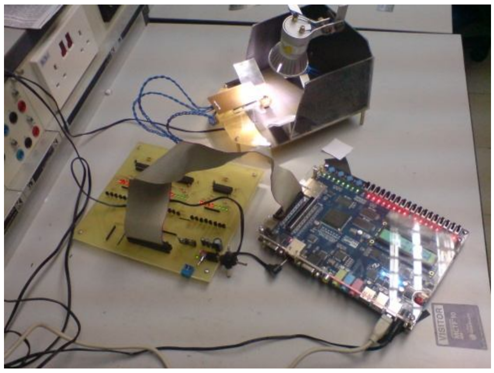

Figure 2: Hardware setup

A. FPGA – FIELD PROGRAMMABLE GATE ARRAY.

FPGA is an integrated circuit that contains many (64 to over 10,000) identical logic cells that can be viewed as standard components. Each logic cell can independently take on any one of a limited set of personalities. The individual cells are interconnected by a matrix of wires and programmable switches. A user's design is implemented by specifying the simple logic function for each cell and selectively closing the switches in the interconnect matrix. [8, 9]

The logic cell architecture varies between different device families. Generally speaking, each logic cell combines a few binary inputs (typically between 3 and 10) to one or two outputs according to a Boolean logic function specified in the user program. The cell's combinatorial logic may be physically implemented as a small look-up table memory (LUT) or as a set of multiplexers and gates. LUT devices tend to be a bit more flexible and provide more inputs per cell than multiplexer cells at the expense of propagation delay. [8, 9]

Field Programmable means that the FPGA's function is defined by a user's program rather than by the manufacturer of the device. A typical integrated circuit performs a particular function defined at the time of manufacture. In contrast, the FPGA's function is defined by a program written by someone other than the device manufacturer. Depending on the particular device, the program is either 'burned' in permanently or semi-permanently as part of a board assembly process, or is loaded from an external memory each time the device is powered up. This user programmability gives the user access to complex integrated designs without the high engineering costs associated with application specific integrated circuits. [8, 9, 10]

By individually defining the many switch connections and cell logic functions would be a difficult task. Fortunately, this task is handled by special software. The software translates a user's schematic diagrams or textual hardware description language code then places and routes the translated design. Most of the software packages have to hook to allow the user to influence implementation, placement and routing to obtain better performance and utilization of the device. [8, 9]

The main advantage of FPGA compared with a microcontroller is, FPGA is performing parallel instruction processing. All logic functions are executed simultaneously resulting high speed system rather than a microcontroller which is executing line by line regardless of how fast the controller is.

B. ALTERA DE2 APPLICATION BOARD.

Altera DE2 application board is mainly for development and education. This board contained Altera Cyclone II FPGA model EP2C35F672C6 operates at 50 MHz. This board equipped with USB blaster on board for programming the FPGA and several input output port such as RS232 transceiver, IrDA transceiver. Although this application board has a variety of I/O, unfortunately it is a lack of analogue to digital converter. [11]

Hence, an external analogue to digital converter (ADC) is needed to feed the seed's data from the sensor. Based on the application board specification, this board will recognize logic 1 at 3.3V and logic 0 at 0V. So, the ADC board will convert the analogue signal and do a logic level converter for logic 1, which is from 5V to 3.3V. [13]

The ADC board will feed 24 bit data, which are every sensor, will produce 8 bits of data. From ADC board to the application board, it will interface via expansion I/O port on the application board.

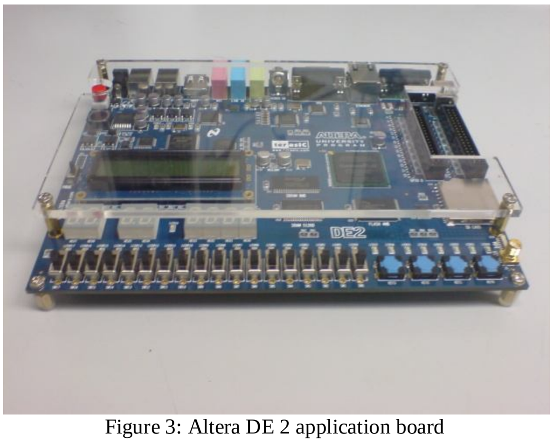

Figure 3: Altera DE 2 application board

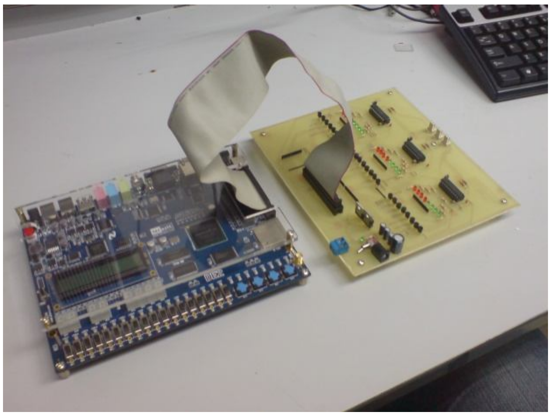

Figure 4: ADC board interface with Altera DE 2 board

C. Clone characteristic

Figure 5 shows the types of rubber seed clones that were used as samples for the identification.

(a) RRIM2009 (b) RRIM2006 (c) RRIM2016

(d) RRIM2025 (e) PB360

Figure 5: Types of rubber seed clones

A. RRIM2009 (recommended): The seed is small, smooth and shining with light brownish seed coat. It has square to slightly rounded shape. Overall growth and seed production of this clone is good. This is the best type of clone and was recommended for both latex and timber production [1][2].

B) RRIM2006: The seed feature and size of this clone are similar to RRIM2009 but the RRIM2009 is brighter compared to this clone. Overall growth and seed production of this clone is good. This clone also recommended for both latex and timber production [1].

C) RRIM2016: The seed features of this clone are most similar to the RRIM2009, but it has square shaped of seed. Overall growth and seed production of the clone is very good. This clone was also recommended for latex and timber production [1, 2].

D) RRIM2025: The seed is small, smooth and shining with dark brownish seed coat. It has square to slightly rounded shape. Overall growth and seed production of this clone is good. This is the also best type of clone and was recommended for both latex and timber production [1].

E) PB360: The seed size of this clone is medium. It was a smooth and brownish seed coat. The shape is square to slightly rectangular. The colour is brighter compared with other clones. This clone is not commercialized for production but used as a sample in research of rubber seed clones.

II. METHODOLOGY

Figure 6 shows the process involved in development of the rubber seed identification.

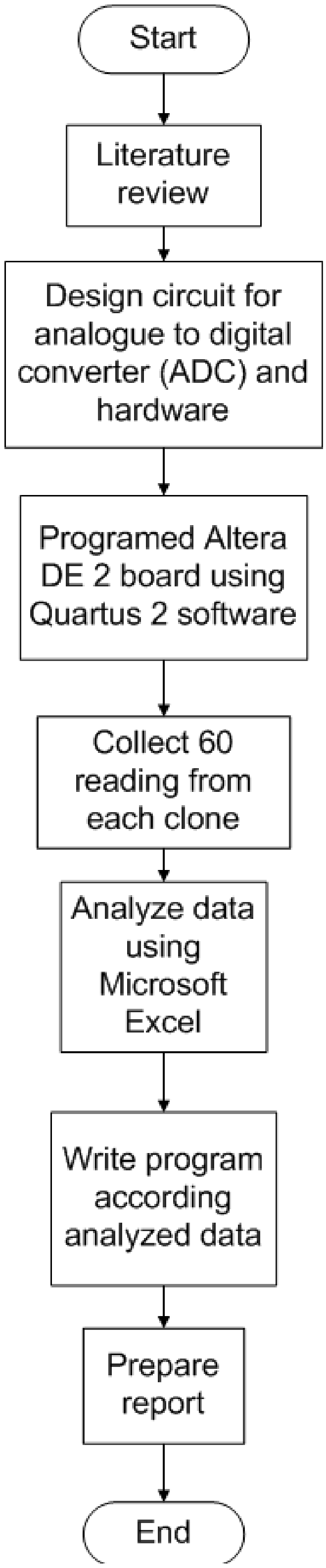

Figure 6: Methodology Flowchart

A. *Hardware Design*

In hardware design, there were 2 important components that were considered which include the sensors, external ADC. Figure 7 shows the process flow of the hardware design.

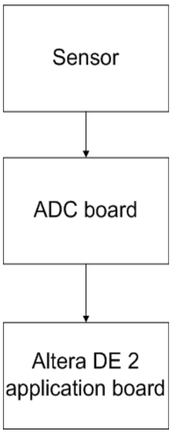

Figure 7: Methodology flowchart

The completed hardware design is shown in figure 8. ADC0804CN was used as the external ADC for input data to the Altera DE 2 application board and was interfaced with three reflectance sensors QTR-1A. The sensors were used to measure the total amount of light reflected from the rubber seeds surface in the form of analogue value. So using ADC 0804CN, the analogue value was converted to digital value in 8 bit resolution for each sensor, and it feed to the application board.

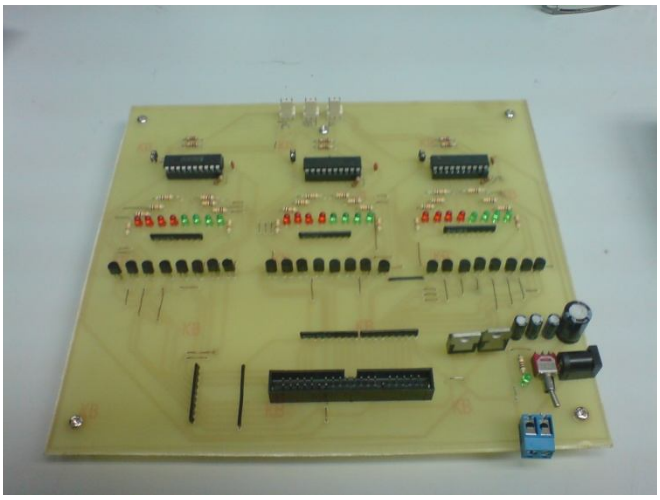

Figure 8: ADC board

The QTR-1A IR sensor carried a single infrared LED and phototransistor pair. The phototransistor was connected to a pull-up resistor to form a voltage divider who produced an analogue voltage output between 0 V and VIN (which was typically 5 V) as a function of the reflected IR. Lower output voltage was an indication of greater reflection. Figure 9 shows the QTR-1A sensor [12].

Figure 9: QTR-1A sensor

B. *Experiments*

The maximum light of reflection was very important when readings were taken during the experiments. The sensors were arranged in parallel, to get three different readings from the top (sensor A), middle (sensor B) and bottom (sensor C) and being tested with white surface and black surface to ensure functionality for each sensor. Every sensor is connected with individual ADC chips and produces 8 bit resolution output and feed to the application board.

The sensors continuously scanned the sample, and the ADC was set to self clocking and continuously converting the input from the sensor [ADC datasheet].

Figure 10: ADC value in hexadecimal

The scanning process was done at the Advanced Signal Processing (ASP) and Robotic Laboratory of Faculty of Electrical Engineering in UiTM Shah Alam. The black background was chosen to prevent any reflected light from environment light. During scanning, only upper surface of seed clone will be scanned. This is because on the below surface there is a dent. So it will influence the result of the data since the surface at below is not linearly flat. The scanned light reflectance information was extracted using Altera DE 2 board that was programmed to display the data when a button is pressed. The data was arranged in the Microsoft Office Excel and was used as statistical measurement to represent the average reflectance of wavelength using a graphical method. As for graphical method, a test was designed to study the difference in ADC value for each clone. The range of the ADC value was used to create the programming to differentiate each clone.

III. RESULT AND DISCUSSION

Graphs in figure 11, 12, 13, 14 and 15 were plotted from the experiment results undertaken for five different clones. 60 readings were taken for each of RRIM2006, RRIM2025 RRIM2016, RRIM2009 and PB360.

Figure 11, 12, 13, 14 and 15 shows the ADC value from three sensors, sensor A, sensor B and sensor C. The ADC values were obtained from 60 samples of readings.

A. RRIM2006

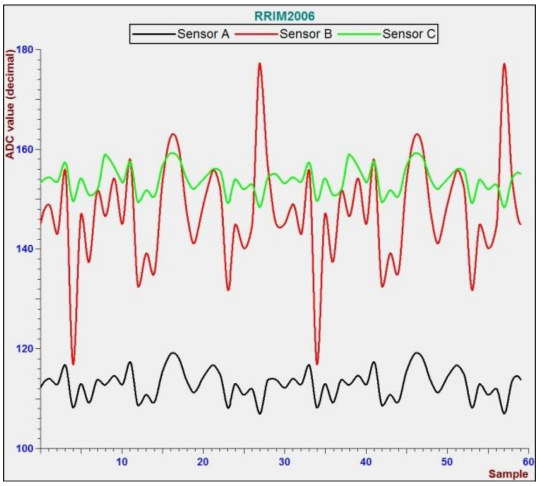

Figure 11: RRIM2006

B. RRIM2025

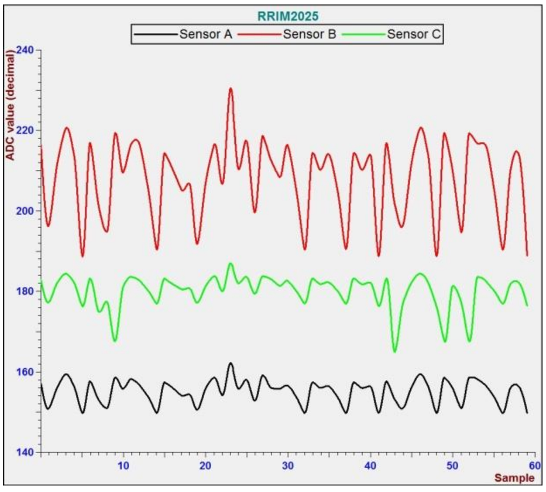

Figure 12: RRIM2025

C. RRIM2016

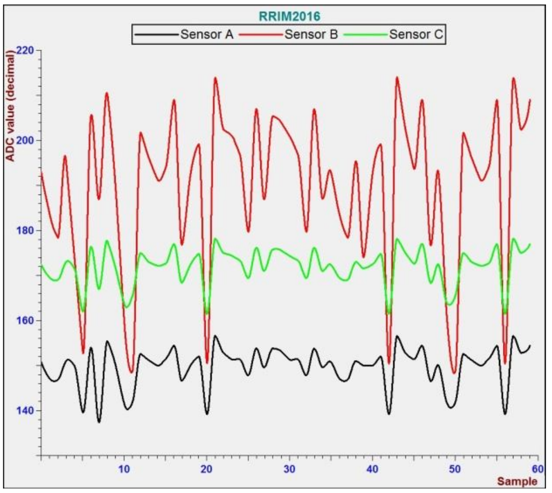

Figure 13: RRIM2016

D. RRIM2009

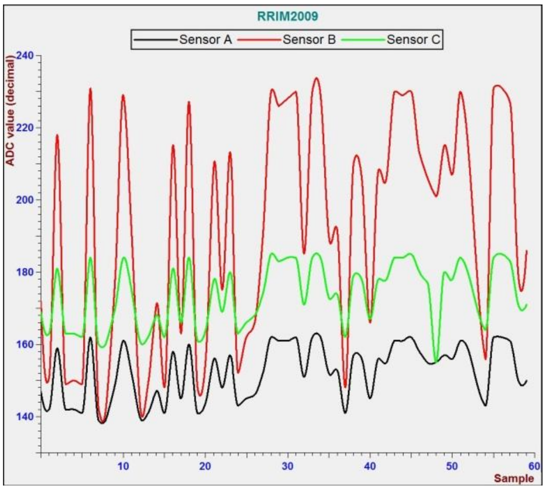

Figure 14: RRIM2009

E. PB360

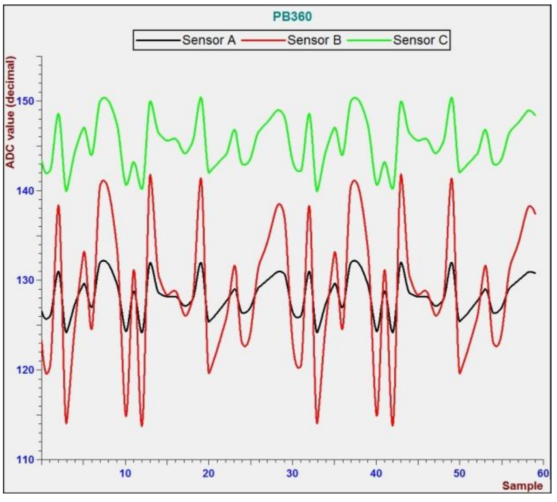

Figure 15: PB360

These experiments were performed to collect frequencies of wavelength were reflected. In orders to records the necessary range of average ADC value, all the possibilities had taken. Table 1 shows the average ADC value of rubber seeds clone.

Clone	Average					
	Sensor A		Sensor B		Sensor C	
	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal	Hexadecimal
RRIM2006	112.9467	70	150.6467	96	153.84	99
RRIM2025	155.52	9B	209.1917	D1	179.8333	B3
RRIM2016	149.44	95	189.5467	BD	171.8333	AB
RRIM2009	156.4444	9C	202.6667	CA	174.3333	AE
PB360	129.5556	81	132	84	145.3	91

Table 1

Figure 14, 15 and 16 show three different graphs plotted on the difference of voltage reading for 5 clones taken from three different sensor, namely sensor A (top sensor), sensor B (middle) and sensor C (bottom).

F. Sensor A (top sensor)

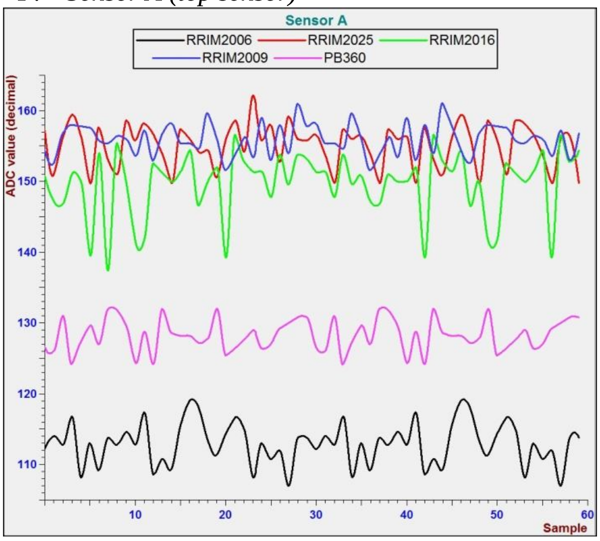

Figure 16: Sensor A (top sensor)

Table 2, 3 & 4 shows the summarization of the graph plotted in Figure 14, 15 and 16 respectively. It depicted the ADC value range for 5 different clones.

Clone	ADC range value	
	Decimal	Hexadecimal
RRIM 2006	102 - 119	66 - 77
RRIM 2025	139,5 - 165,5	8B - A5
RRIM 2016	124 - 151,5	7C - 97
RRIM 2009	139 - 162	8B - A2
PB 360	80 - 98	50 -62

Table 2

G. Sensor B (middle sensor)

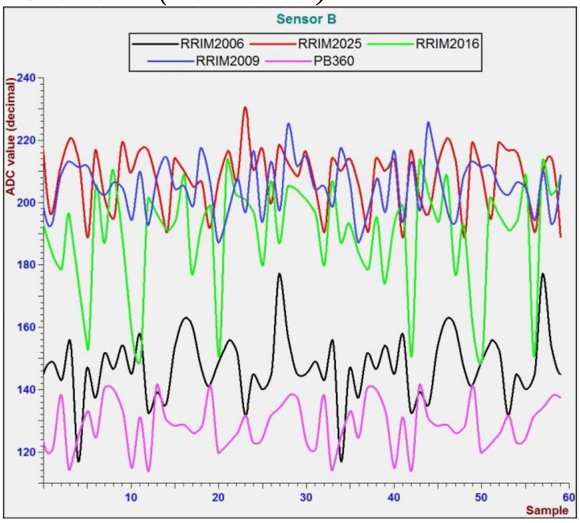

Figure 17: Sensor B (middle sensor)

Clone	ADC range value	
	Decimal	Hexadecimal
RRIM 2006	118,5 - 158	76 - 9E
RRIM 2025	169 - 191,5	A9 - BF
RRIM 2016	114,5 - 167,5	72 - A7
RRIM 2009	142 - 167,45	8E - A7
PB 360	66 - 124	42 - 7C

Table 3

H. Sensor C (bottom sensor)

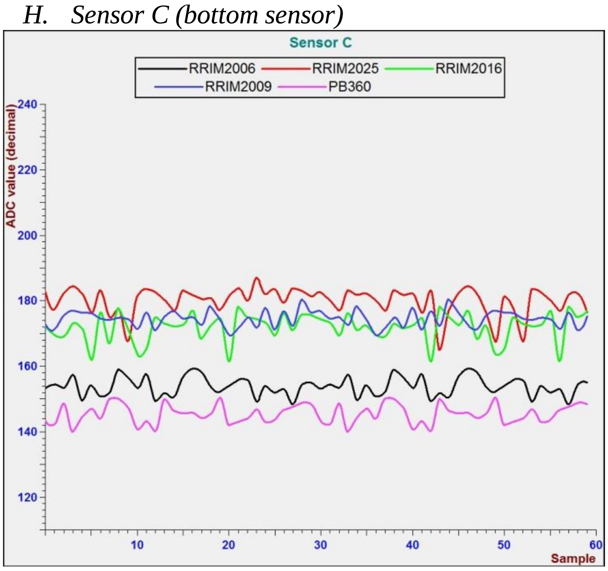

Figure 18: Sensor C (bottom sensor)

Clone	ADC range value	
	Decimal	Hexadecimal
RRIM 2006	145,5 - 161,5	91 - A1
RRIM 2025	104 - 136,5	68 - 88
RRIM 2016	160 - 170,5	A0 - AA
RRIM 2009	155 - 184	9B - B8
PB 360	137 - 161	89 - A1

Table 4

Table 5 shows the ADC value range tabulate from the data for five types of rubber seed clones. Based on the table, for sensor A, clone PB360, RRIM2006 and RRIM2016 have own ADC value range, which is it does not overlap with other clone’s range. However, for clone RRIM2009 and RRIM2025, their range is overlapped with other's range. For sensor B, for clone PB360, RRIM2016 and RRIM2006, their ADC value range is also overlapped with each other's range. In contrast, for clone RRIM 2009 and RRIM 2025, they have their own ADC value range. For sensor C, only RRIM2025 had own ADC value range, but for others clone their ADC value range is overlapped with each other's range.

Based on that condition, it is possible to FPGA to differentiate those clone. Because, it is only having one value range that is does not overlapped among those clone and for the rest of range is for verification for that clone. This is shown in the table for clone RRIM2006. For sensor A, it has own range value, which is does not not overlapped with other clone ranges, but for sensor B and C, it seems it range is overlapped with clone RRIM2016 and 2009. Figure 19 shows an example for two types of clones RRIM2025 and RRIM 2006.

Clone	Range					
	Sensor A		Sensor B		Sensor C	
	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal	Hexadecimal
RRIM 2006	102 - 119	66 - 77	118,5 - 158	76 - 9E	145,5 - 161,5	91 - A1
RRIM 2025	139,5 - 165,5	8B - A5	169 - 191,5	A9 - BF	104 - 136,5	68 - BB
RRIM 2016	124 - 151,5	7C - 97	114,5 - 167,5	72 - A7	160 - 170,5	A0 - AA
RRIM 2009	139 - 162	8B - A2	142 - 167,45	8E - A7	155 - 184	9B - B8
PB 360	80 - 98	50 -62	66 - 124	42 - 7C	137 - 161	89 - A1

Table 5

(a) Result obtained for RRIM2025

(b) Result obtained for RRIM2006

Figure 19: Example result display

IV. CONCLUSION

A. *CONCLUSION*

There were five types of rubber seed clones namely PB360, RRIM2009, RRIM2011, RRIM2016 and RRIM 2025 were tested to observe the differences in terms of maximum percentage reflectance of wavelength. Data extracted from the hardware design were analyzed using statistical method. From the observation, it was found that the surface of rubber seeds had different reflection percentage. By taking a significant difference on the 3 surface areas, the process of differentiation was more accurate. The ADC value ranges of PB360, RRIM2006 and RRIM2016 clones were distinctive compared to RRIM2009 and RRIM2025 clones where the ADC value ranges was closer to one another. Therefore, it can conclude that by analyzing the surface area of rubber seeds, the rubber seeds can be classified according to its type.

B. *FUTURE RECOMMENDATION*

In the future, another research will be carried out to enhance the technology of classifying the rubber seed clones. Other studies suggested on the rubber seed clone include distinguishing the shape and density of clones. The analysis by absorbent is also recommended to improve the effectiveness of the model. Plus, it is recommended that to use the internal ADC unit compare with external ADC unit. Because the internal ADC unit is more accurate and noise free compared with external ADC unit.

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