DEVELOPMENT OF AN EXPERT ELECTRONIC SYSTEM FOR THE MONITORING AND CONTROL OF PESTS IN A RICE PLANTATION IN NIGERIA

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ABSTRACT

Rice farmers over the ages have struggled to increase production using the manual process they know of to prevent the inversion of their farm plantations from pests such as birds. In this paper, the development of an expert electronic system for the monitoring and control of pests in a rice plantation in Nigeria, has been realized. The systems functionality and sensitivity is realized by the inclusion of a microcontroller that is embedded in the system. This microcontroller interfaces with a sensor to detect and hence monitor the plantation and then sounds the alarms to scare away the pests. In this system, there are four different sounds and there are sounded randomly so that the pests does not become used to it.. This system is powered by a 12V, 7.2Ah rechargeable deep cycle battery which is recharged by a 20W solar panel. The results showed that the system did actually control the presence of pests in the rice plantation.

Keywords: *Expert System, Monitoring and Control, Pests, Rice Plantation*

INTRODUCTION

It is a commonplace knowledge that Nigeria economy once depended solely on the oil and gas for sustainability. By then, the Gross Domestic Product rose because of the export rate of the petroleum products. This lasted for several years in Nigeria. But now, the reverse is the case. Oil and gas is no longer yielding enough income for Nigeria to maintain the sector let alone sustaining the national economy. The Refineries are in devastated conditions and produce from the sector has not been used to build new refineries. More so, since its discovery in 1956 and more especially, since 1970 when its price was on the upward trend, the oil and gas has contributed to the economy of Nigeria. However, it is a known fact across the globe that for a country to attain growth and development, its economy has to be diversified. Following the sudden fall in the price of oil by more than 50% since June 2014 when it was $115 a barrel, after five years of stability, it is a well-known fact that Nigeria's continuous large earnings or revenue from this sector has been impossible. Since then, there has been undependable proceed from oil and gas and for several months in 2017, Nigeria's crude declined from an average of 2.1 million barrels per day to as low as 0.9 million barrels per day. According to the report from Vanguard Newspaper on January 10 2017, the Nigerian National Petroleum Corporation, NNPC, disclosed that from August 2015 to July 2016, it remitted $48.99 million to the Federation Account from crude oil export sales, compared to $607.83 million remitted between December, 2014 and July, 2015.

As a matter of fact, there is an urgent need for the Nigerian government to begin to look into agriculture so as to attain solid economic growth. Even when oil was producing great yield, the money realized was being utilized in the procurement of goods and services including its raw materials and processing abroad. This in turn does not build the GDP of a nation. Exports goods contribute immensely to the development of a nation's economy. Agriculture seems to be the saving grace in terms of exportation. Nigeria is blessed with the natural resources and climatic/environmental factors. Nigerian leaders have discovered this and the government is gradually utilizing the rich potentials of agriculture to build back the economy.

Rice production is a major area of agriculture that can earn Nigeria a mind-blowing revenue. Rice is being consumed in every part of the world so it has the prospect of being exported to different countries if production is increased. One huge factor militating against the increased production of rice is prevalence of Pests which birds and other rodents.

RELATED WORKS

According to Miranda et al (2014), detection of pests in the paddy fields is a major challenge in the field of agriculture, therefore effective measures should be developed to fight the infestation while minimizing the use of pesticides. The techniques of image analysis are extensively applied to agricultural science, and it provides maximum protection to crops, which can ultimately lead to better crop management and production. Monitoring of pests infestation relies on manpower, however automatic monitoring has been advancing in order to minimize human efforts and errors. This study extends the implementation of different image processing techniques to detect and extract insect pests by establishing an automated detection and extraction system for estimating pest densities in paddy fields. Experiment results shows that the proposed system provides a simple, efficient and fast solution in detecting pests in the rice fields. The study according to

Samantha and Ghosh (2012) is concentrated to eight major insect pests based on the records of tea gardens of North Bengal Districts of India. The authors apply correlation based feature selection for the feature extraction and reduction, and incremental back propagation neural network as the neural network algorithm used for classifications.

Al-Saqer (2012) developed a neural network-based identification system for pecan weevils. Image descriptors was used as input in the neural network to recognize the pecan weevil.

Kowsalya and Karthigha (2015) proposed different techniques which will be useful for the farmers to automate the irrigation system and to reduce the human work. Patil et al (2014), Dharrao et al (2015), Milind and Bhaskar (2014) and Nikolidakis et al(2015) all proposed different ways of automating the agricultural system but their works didn't include the automatic control of birds proposed in this paper.

Soe et al (2008) designed a microcontroller based control system for automatic grain inspection. The abstraction of their paper is to contribute and apply the advanced control technique for rice and other grains inspection. Meanwhile this is done after harvest is made so the effects of pests on the grains would affect the percentage product from their automatic inspection design.

The petroleum industry has assumed a primate position in the Nigerian economy accounting for 80% of the nation's GDP in the recent times (Lukeman, 2003). The industry has also pushed Nigeria to the forefront of the global industry, making the country the 6th largest exporting and 7th largest producer of oil in the world. Revenue from petroleum sector comprising export earning, petroleum profits tax and royalties has grown steadily over the years. Between 1970 and 1998, earning from oil rose from 75.3% to a peak of 84.1% of the total federally generated revenue (CBN, 1998). Also, IMF estimates showed, Nigeria's earnings from crude oil increases from US $8,500 billion in 1989, and to $10.600 billion in 1990. "By 1995, these earnings had declined to $7,001 billion and declining further to $5.276 billion in 1998. However, crude oil prices have increased steadily in the new millennium following the implementation of strict production quotas imposed by OPEC on member-countries to stem the flow of excess crude oil in the global marketplace. As a result of the dominant role played by the oil sector in the nation's economy, economic performance has been linked to oil prices in the past three decades" (Aigbedion and Iyayi, 2007). This rather unenviable development has inspired the current administration to diversify the nation's economy away from its dependence on crude oil by harnessing natural gas, bitumen and other solid minerals. In year 2000, thanks to the oil windfall, the growth rate of oil GDP improved by 4.8 % compared with the previous year. The unexpected boom in the international market helped to propel the growth performance of the entire economy (UNECA, 2005). Oil prices rose from $18.00 a barrel in 1999 to $28.00 in 2000. Also, OPEC quota for Nigeria increased from 1.885 million barrels a day in March to 2.033 million in April, 2,091 million in July, 2,157 million in October and 2,178 million in

November. Of the total daily production, around 1.88 million barrels a day were exported from 1.66 million in 1999. Although oil is largely an enclave sector in Nigeria, having a few forward and backward linkages with the rest of the economy, however, it remains a decisive force for economic performance. Its impact is transmitted through the income effect, mediated through public spending and imports. In recent times, oil GDP is clearly more volatile than non-oil GDP. Due to the volatility of oil prices, the sector often experiences rapid growth in value added on year followed by an equally rapid decline in the next, with the trend usually reflected in volatile growth for the economy as a whole. The increase in gas utilization stems from the commencement of exportation of Liquefied Natural Gas (LNG) by the third train of the NLNG in 2002, and the Liquefied Petroleum Gas (LPG) in April 2003 (Ibiyemi 2004). A versatile, non-renewable natural resource, crude oil is a highly demanded commodity in both rich and poor countries, providing about 50% of the global energy requirements (Anyanwu et al., 1997, Igbatayo, 2004). After many glorious years of enjoying the benefits of a robust and high crude oil price, the Nigerian economy is currently teetering on the edge of depression, mainly due to faulty planning and the short-sightedness of the country's leadership.

Nigeria's current economic woes was primarily kick-started by the petroleum sector, which was and is still the major source of foreign exchange earnings for the country and a major driver of the economy. The economic crisis was triggered by a sharp decline in the prices of crude oil in the international market, as well as by the crisis in the Niger Delta, which brought about a sharp drop in Nigeria's crude oil and gas output. These twin problems of low oil price and low output, forced down the country's foreign exchange earnings, reduced the country's revenue, engendered a devaluation of the naira due to scarcity of foreign exchange and also brought about a general hike in the prices of goods and services, starting with the hike in the prices of petrol.

According to Uwakonye (2006), the oil economy of Nigeria is very important to the country, but the people of Nigeria still suffer from a corrupt government. Despite the revenues being brought in from oil exports, the Nigerian government still holds a large unemployment rate and a high poverty rate.

Diversification through Agricultural Production

"Nigeria operates mono commodity (petroleum) based economy. She just extracts the oil for export. The generated revenue is not effectively invested on diversification of the economy to develop a robust and stable economy. This is due to some socio-political challenges that border on individual interests and poor socioeconomic orientations that militate against industrialization of the economy. The situation exposes the nation to both economic and socio-political instability as the economy fails to accommodate wide spectrum of people and sustain the basic needs of the populace. Nigeria should pragmatically address the challenges of poor industrialisation to diversify her economy." (Anyaehie and Areji, 2015).

According to Omorogiuwa et al (2014), Nigeria is on its way to modern development. Branding itself as the "giant of Africa", the country now needs to prove its potential by raising its standards to a level with other fast developing economies of the world.

According to Ayodele et al (2013), to move forward, the country must increase the low productivity of current agricultural companies, engage competition within the agricultural sector, develop domestic policies and increase funding. According to the research conducted by Adams (2014) on ways in which diversification into agriculture can impact Nigeria economy, it was deduced that agricultural production contributes to economic development through: Employment generation 71%, provision of food 76%, Foreign exchange earning 32%, Poverty reduction 34% and Provision of raw materials 28%. The results of the assessment revealed that there is a relationship between agriculture and economic development. Figure 2.1 shows the ways in which diversification into agriculture can impact Nigeria economy.

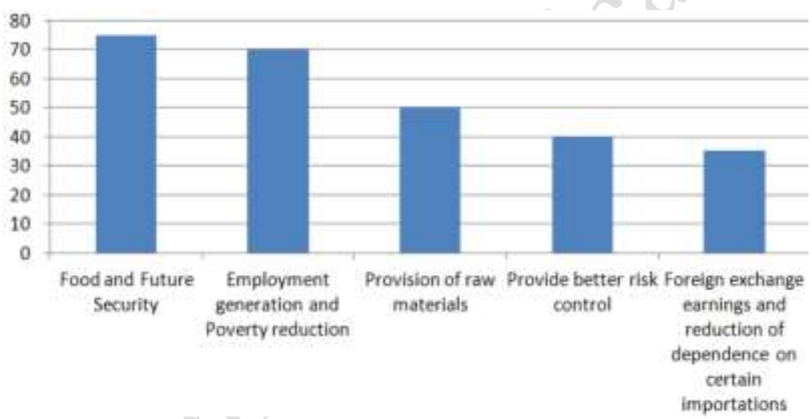

Fig. 2.1: Ways In Which Diversification into Agriculture can Impact Nigerian Economy (ADAMS, 2016)

Diversification refers to a strategic direction that takes companies into other products and/or markets by means of either internal or external development.

- Related diversification: This occurs when a company develops beyond its present product and market whilst remaining in the same area.
- Backward diversification: This is when activities related to the inputs in the business are developed.

- Forward diversification: This refers to development into activities which are concerned with a company's output.
- Horizontal diversification: This occurs when a company develops interests complementary to its current activities. For a company may integrate its activities to include all aspect of the value chain; design, manufacture, market and distribute.

SYSTEM ARCHITECTURE AND DESIGN

The conventional local method used in the prevention of attacks on rice farm by predatory birds, is the use of a scare crow. However, this research work takes this form of attack prevention, to the next level. This will make the system more effective, efficient and more reliable. Sensors will be used in the detection of the presence of birds, and to activate loud sounds in other to scare them away, when the birds are detected.

Birds are smart and just a stereotype sound may not be enough to scare them off especially over a long period of time. To this effect, four different form of alarming or sound system will be used, which are: Buzzer, Car horn, Dc powered siren and a recorded Hawk sound.

DESIGN STEPS

The design step involved in the development of a system that will prevent a piece of rice farm from being attacked by birds will be such that the system will be aimed to operate on a 12volts power supply system which will be obtained from a rechargeable deep cycle battery which will be powered or recharged by the use of solar panels.

The system is an embedded one in the sense that it will have at least one programmable integrated circuit, in this case, the 8052 microcontroller will be used which is programmed using assembly language. This microcontroller is programmed to receive signals from motion sensors and activate one of the four alarm unit incorporated in the system. The program will be such that a different sound will be activated each time the sensors detects a new predator. The selection process for the sound activated is random so that the birds do not detect a pattern to this choice.

For the alarm system, four different alarm units are used. An alarm unit will be activated each time a predator is detected. When the next predator set is detected, a different alarm is sounded. For instance, when the birds are detected at first, the HORN is sounded. The next time the birds are detected, the SIREN is sounded and so on. The other of sequence on which alarm is activated the next time birds are detected, is random. The 8052 will be thus programmed.

The proposed power source will be obtained from a 20W solar panel and a 12V battery rated 7.2Amps hour. The microcontroller and other digital integrated circuit will use 5 volts for their operation and as such, a voltage regulator will be used to regulate the 12 volts power supply, to 5V. The block diagram of the design is shown in the figure below.

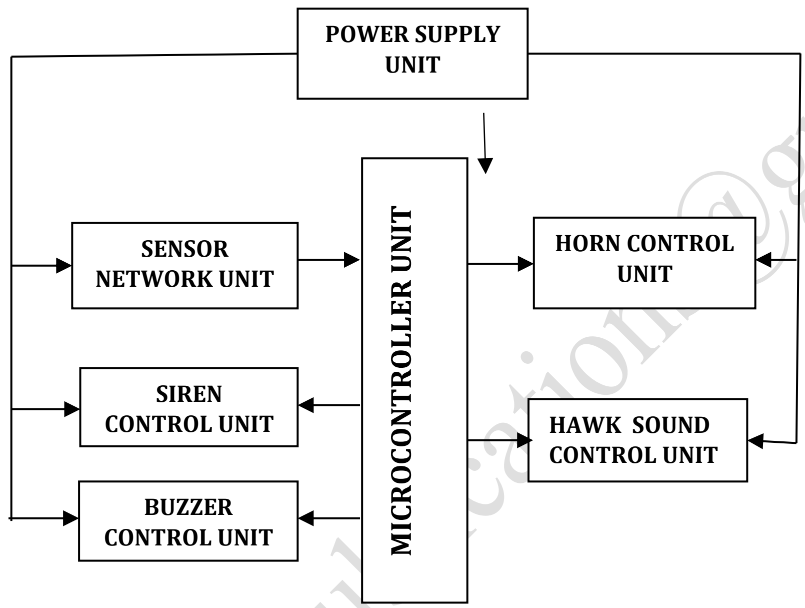

Fig. 3.1: BLOCK DIAGRAM

THE DESIGN OF THE POWER SUPPLY UNIT

This is the circuit that will supply power to the full system. The system requires two distinct voltage levels which are 5 volts dc and 12 volts dc. These two distinct voltage level will be obtained from a deep cycle rechargeable battery which will be charged with a solar panel.

The circuit diagram is as shown below

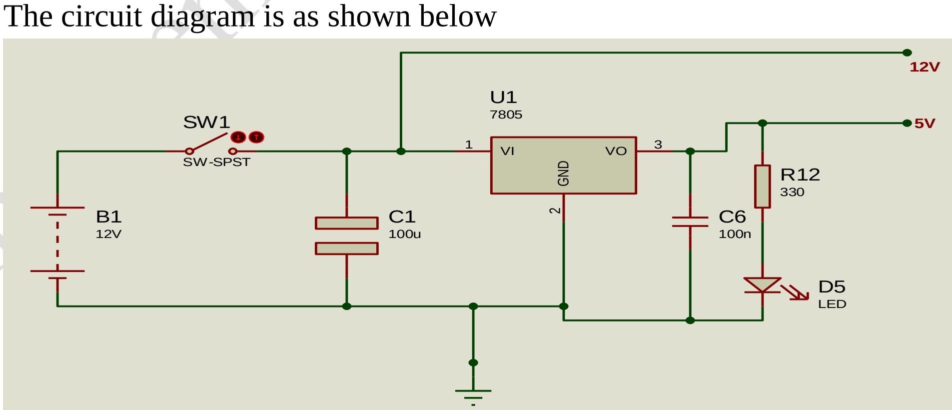

Fig. 3.2: The Power Supply Circuit

U1: This is the voltage regulator.
Regulator specifications:

- Maximum input voltage = 30V
- Maximum output voltage = 5.5V
- Operating temperature = 0%- 150%

For effective Voltage regulation, the minimum input voltage should be:

$$V_{min} = V_{out} + V_{ref} \quad (1)$$

Where: V_{min} – Minimum input voltage; V_{out} – required output voltage = 5V; V_{ref} – Datasheet Stipulated reference voltage = 3V

$V_{min} = 5 + 3 = 8V$

The output voltage after the capacitor is 13.70V. This is enough to supply the minimum input voltage of 8 volts. Therefore, the voltage regulator could be comfortably used. The regulator chosen is : U_1 = 7805

C_2 is a transient capacitor. The rating is stipulated in the 7805 voltage regulator's data sheet as 0.1uF.

This capacitor helps for smoothening of the output from the voltage regulator. It is also to prevent spikes in the DC output voltage waveform in the event of transient disturbances. It is known as a buffer capacitor whose value is gotten from the data sheet of the regulator.

Current limiting resistor calculation:

$$R_1 = \frac{V_S - V_D}{I_D} \quad (2)$$

$R_1 = \frac{5-2}{10 \times 10^{-3}} = 300\Omega$; $R_1 = 330\Omega$(nearest preferred value)

Light emitting diode characteristics:
Forward current = 10×10^{-3}A to 20×10^{-3}A; Voltage drop = 2V

DESIGN OF THE SENSOR NETWORK

This is the circuit that the system uses to sense the presence of the pest animals. It is based on a set of motion detector sensors that are placed in strategic positions all around the piece of farm land. The circuit diagram for the sensor network is as shown below

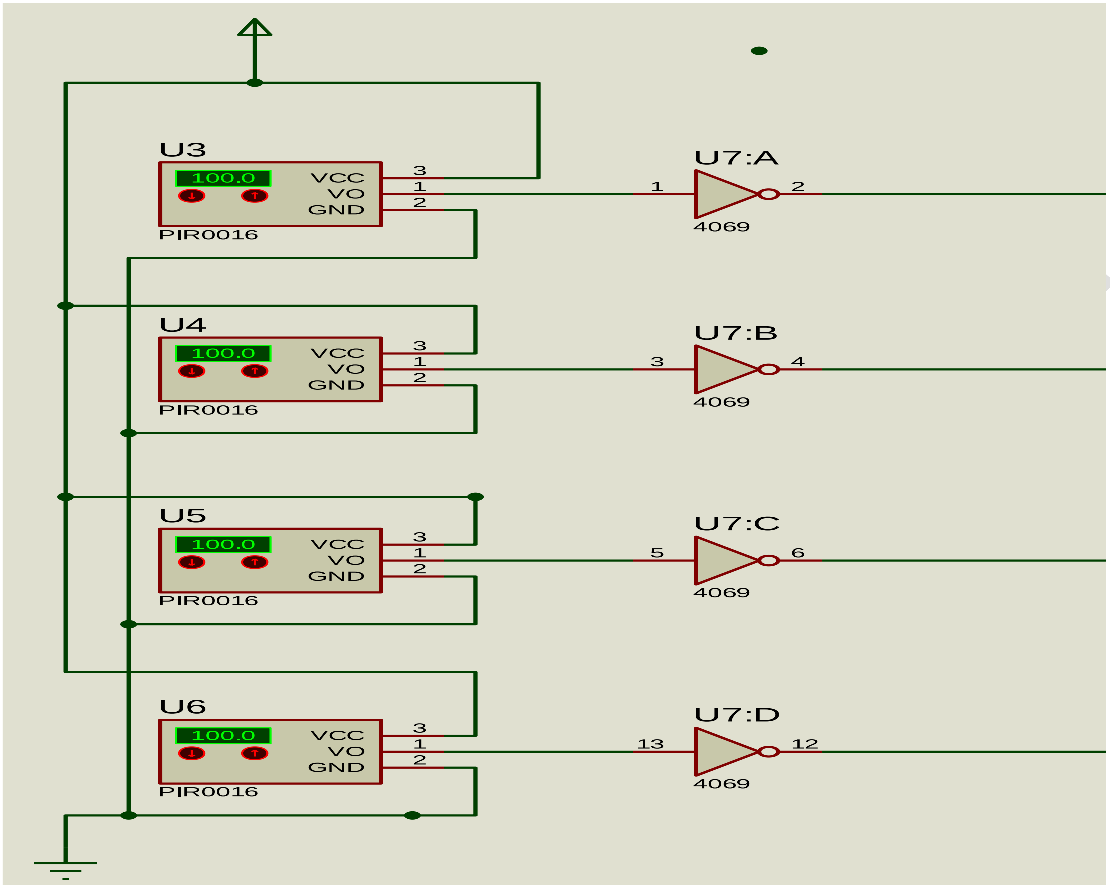

Fig. 3.3: The Sensor Network Circuit

The motion sensors that were used for this circuit was the PIR0016 motion sensor that will produce a low signal when the air space around it is calm, but will produc a monostable paulse high signa when it detects motion. The duration of the high paulse is predeterimed by the variable resistor embedded into the module of the sensor. The output of the sensors were sent to the microcontroller via the 4069 logic gates

THE DESIGN OF THE BUZZER CONTROL UNIT

This is one of the circuits that the system uses to repel the attack of the rice farm by the birds. This alerting circuit assists in the creation of the illusion of the presence of people in the farm so as to scare off the birds that want to feed off the rice crops.

The buzzer is being operated by an Astable mode connected multivibrator integrated circuit tagged the 555 timer and the frequency is set to one hertz. this enables the buzzer to produce an output that pulsates every second to make is produce the effect of turning on and staying on for one second, then turning off and staying off for one second, continuously

The circuit diagram is as shown below

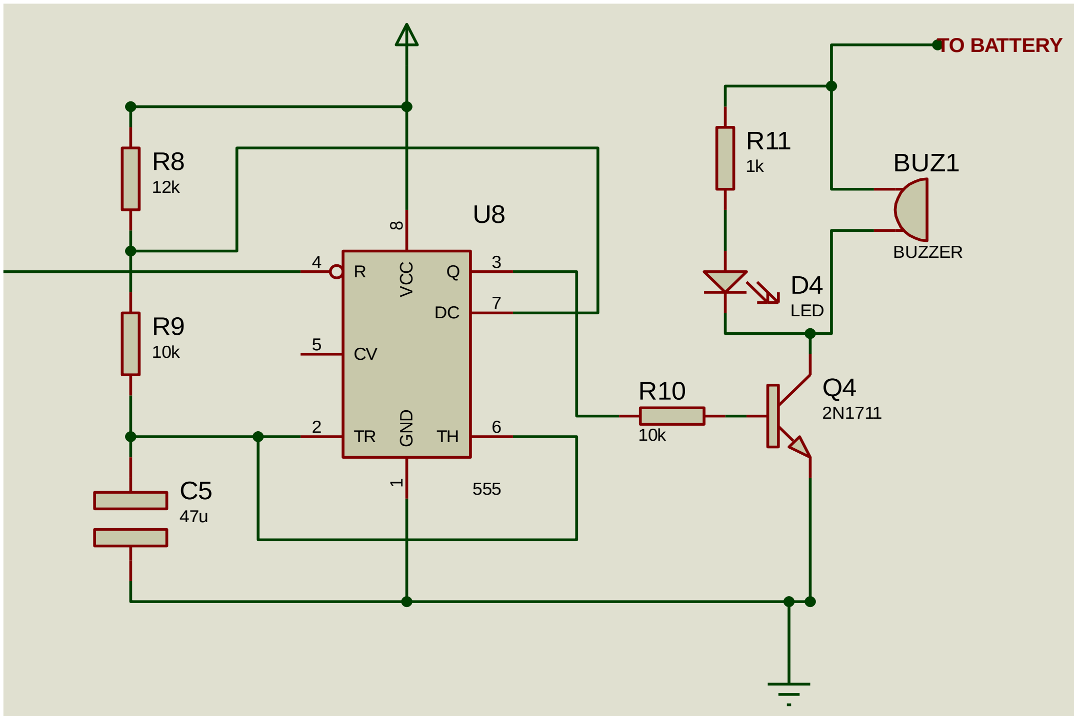

Fig. 3.4: The Buzzer Control Circuit

U_8-This is a 555 timer biased in an Astable Multivibrator mode. R_8, R_9 and C_5 are used to set the output frequency. The relationship is given thus;

$$f = \frac{1.44}{(2R_2+R_1)C_1} \qquad (3)$$

where $R_1 = R_8$; $R_2 = R_9$; $C_1 = C_5$

A frequency of 1 Hz is desired. Since we are looking for three unknown, we choose values for two and calculate for the third one. Choosing: $C_1 = 47\mu F$ and $R_2 = 10K\Omega$, and calculating for R_1 then

$$R_1 = \frac{1.44 - 2fR_2C_1}{fC_1} = \frac{1.44 - (2 \times 1 \times 10000 \times 47 \times 10^{-6})}{1 \times 47 \times 10^{-6}} = 10638.29\Omega$$

Therefore, $R_1 = 12k\Omega$ (npv)

R11 this is a current limiting resistor for the LED and the value is given as thus

$$R_x = \frac{Vs - Vir}{Iir} \qquad (4)$$

Where V_{ir} – voltage drop of the LED: 2V; I_{ir} – current of the LED taken as 10mA; V_s – source voltage.

$$R_x = \frac{12-2}{10mA} = \frac{10}{10 \times 10^{-3}} = 1000\Omega$$

Therefore: $R_{11} = 1k\Omega$

R_{10} this is the base resistor for the transistor. For effective switching, it will require the transistor to be connected in such a way as to be in the hard saturation mode. This will require the collector current to be about 10 times the base current.

$\therefore R_B = 10 \times Rc$ (5)

where $Rc = 1k\Omega$ ($R_c = R_{11} = 1k\Omega$)

$\therefore R_B = 10 \times 1000 = 10000\Omega = 10k\Omega \therefore R_{10} = 10k\Omega$

THE DESIGN OF THE HORN CONTROL UNIT

This is yet another one of the circuits that the system uses to create the illusion of the presence of an individual. This will output a loud car horn sound when the circuit is activated by the microcontroller after receiving signals from the sensor network. The horn is activated by energizing the coil of a relay thereby closing its contact. This relay is driven by a transistor.

The circuit diagram is as shown below

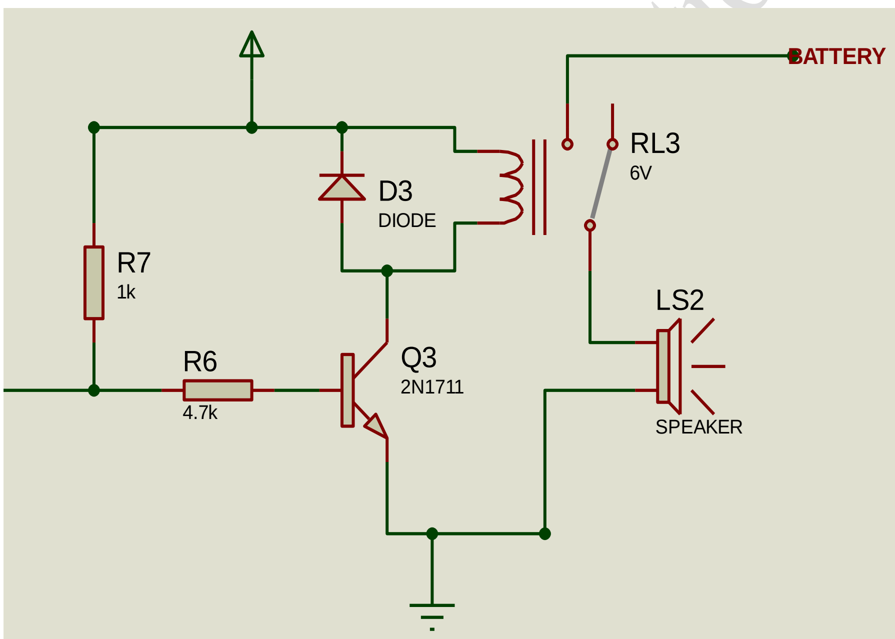

Fig. 3.5: The Horn Control Circuit

Q3: this is the switching relays. The parameters of the relays are given as:

- ✓ Coil DC volts: 6V
- ✓ Contact current 10A
- ✓ Max contact voltage 250V
- ✓ DC Coil resistance: 400Ω

@ A contact voltage of 250 volts and a contact current of 10amps, the contact of the relay has a power of:

$$P = IV \quad (6)$$

$$P = 10 \times 250 = 12500\text{watts} = 12.5\text{kW}$$

Any electrical device rated within this power could work with the circuit. The electrical power rating of a car horn to be used is rated 35watts (0.035kW). Therefore the power of the relay is adequate for its operation

R_6: This is the base resistor for the transistor. For effective switching, the collector current should be about 10 times the base current i.e. $I_C = 10 \times I_B$

Consequently, the resistors relationship will be: $R_B = 10 \times R_C$

The resistance of the relay is given as 400Ω. Thus $R_C = 400\Omega$. From the transistor switch equation, then

$$R_B = 10 \times 4000\Omega = 4000\Omega \;\therefore\; R_6 = R_B = 4.7k\Omega(\text{NPV})$$

THE DESIGN OF THE HAWK SOUND CONTROL UNIT

This is the last presence illusion based circuit that the system uses to ward off the pests. It involves the creation of the sound of the predatory hawk bird sound. The sound is recoded and replayed by a circuit which will be controlled by the microcontroller via a switching relay.

The circuit diagram is as shown below

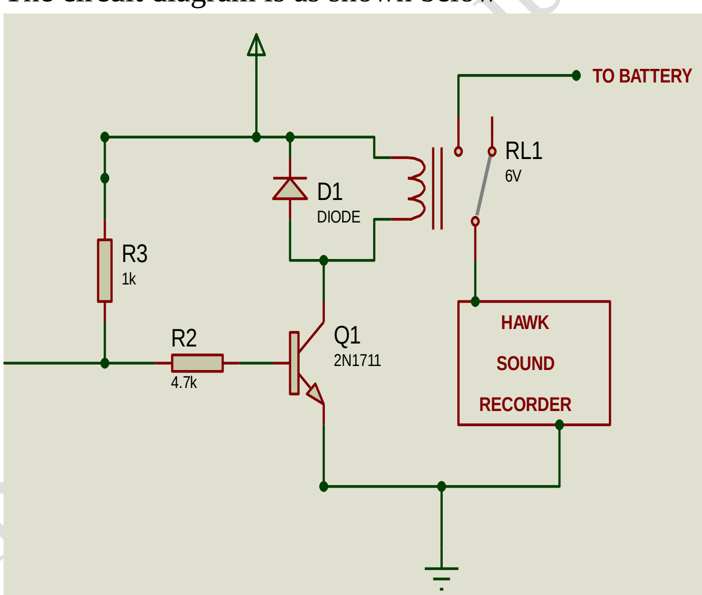

Fig. 3.6: The Hawk Sound Circuit

The electrical parameters of this switching relay circuit is the same as those of the horn control unit. The power requirements is also the same. The electrical power rating of the hawk sound recorder to be used is rated 100watts (0.1kW). Therefore the power of the relay is adequate for its operation.

R2: This is the base resistor for the transistor. It value is calculated to be the same value as R_6.

THE DESIGN OF THE MICROCONTROLLER UNIT

The microcontroller unit circuit is the heart of the project. This is where the program for the control part of the project is written and burned using assembly language and a universal programmer, respectively. The circuit diagram is as shown below

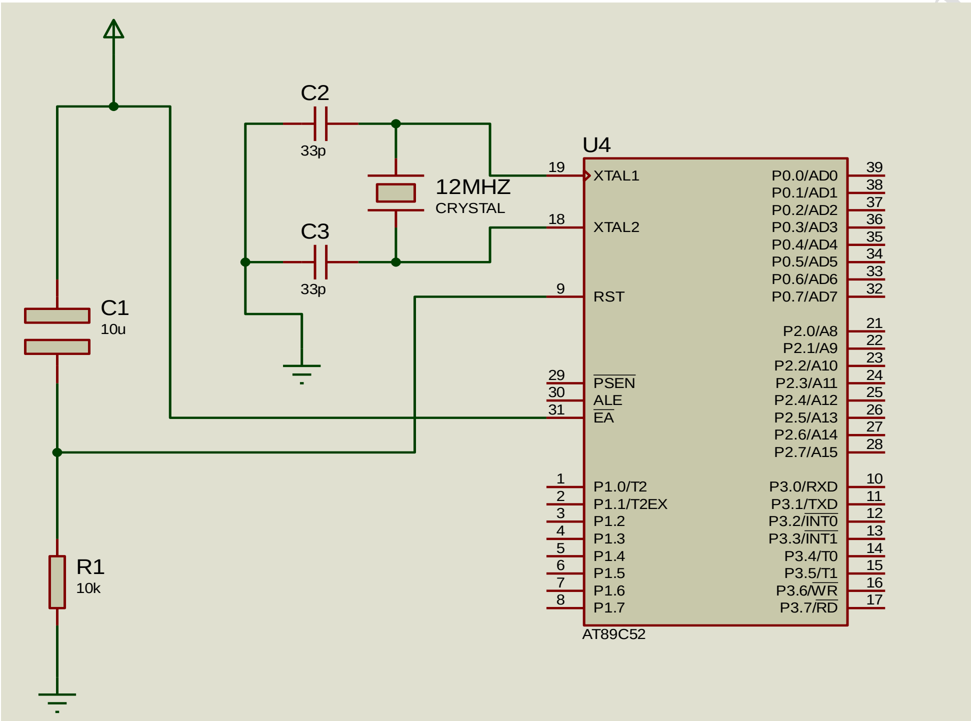

Fig. 3.7: The MicroController Circuit.

The 8052 microcontroller hardware circuit is usually a very flexible one and all the surrounding components are given a recommended range of values, by the datasheet but the actual values can be chosen by the programmer. The ranges of values given for the 8052 microcontroller hardware are as follows

- Reset capacitor: 4.7µF to 10µF
- Reset resistor: 8.2KΩ to 15 KΩ
- Crystal oscillator: 4MHz to 32MHz
- Crystal capacitors: 27pF to 47pF

The chosen values are as follows:

- Reset capacitor (C_1): 10µF
- Reset resistor (R_1): 10 KΩ
- Crystal oscillator (X_1): 12MHz
- Crystal capacitors (C_2& C_3): 33pF

THE MODE OF OPERATION

The circuit is an electronic solution to the dispelling of bird pests that destroys a rice farm plantation. The circuit comprises of four motion detectors that send signals to a microcontroller via logic gates. The circuit also has three transistor driven relays each switching ON devices that will create the illusion that humans are present, which will scare away the birds. One drives a dc power car horn, one powers a recorded hawk sound circuit while the last one controls a dc siren. The final human presence imitating circuit is an electronic buzzer. This is connected to an Astable mode connected multivibrator integrated circuit, the 555 timer. All four equipment are controlled by the microcontroller. The full circuit is powered by a deep cycle battery which is recharged by a photovoltaic cell.

The basic operation of the circuit will involve the microcontroller receiving signals from the four sensors U3 – U4 connected to it and based on the output of the sensors, control the four alerting circuits that will create the illusion of the presence of humans in the farm plantation. When no pests are detected, the motion sensors output a low signal to the microcontroller and this makes the microcontroller to deactivate the alerting circuits.

However, when the presence of bird(s) is detected, the motion sensor outputs a high pulse signal to the microcontroller. The program resident inside the ROM of the microcontroller then activates one of the alerting circuits connected to it, via the switching transistor and consequently the dc powered relay. The alerting circuits are activated at random so that the birds will not be able to detect that the whole process is mechanical and such, become used to the sequence.

DISCUSSION AND CONCLUSION

In the times before now, rice farmers and in deed, famers in general used scare crows and other manual means to scare away pests such as birds and rodents from their farms so that at the end of the day they could achieve a meaningful harvest. This local and manual process was time and energy consuming and was very inefficient in realizing the aim of scaring away the pests. The result was a wastage of harvest to the activities of these pests and a consequent loss of income which ultimately affected the volume of produce available for local consumption and for export. So if there could be a way to automate this process, production will increase and there will enough to meet the food needs of the population and also for export. This would contribute in no small measure to diversifying the economy that successive governments have tried to do over the past decade.

It is therefore concluded that through the implementation of the automatic pests control system, the major challenge in a rice plantation would be alleviated and rice production will be greatly increased to meet the ever increasing demand both locally and internationally. This will thus go on to increase the nations gross domestic product and national income. This research work focused on how to increase the production of rice by controlling the pests especially birds which is its major predator and can be adopted in the Nigerian agricultural system. Further work can also be conducted on how to automatically control the pests of some other crops like cocoa; maize and cassava thereby improve their production and affect the economy positively.

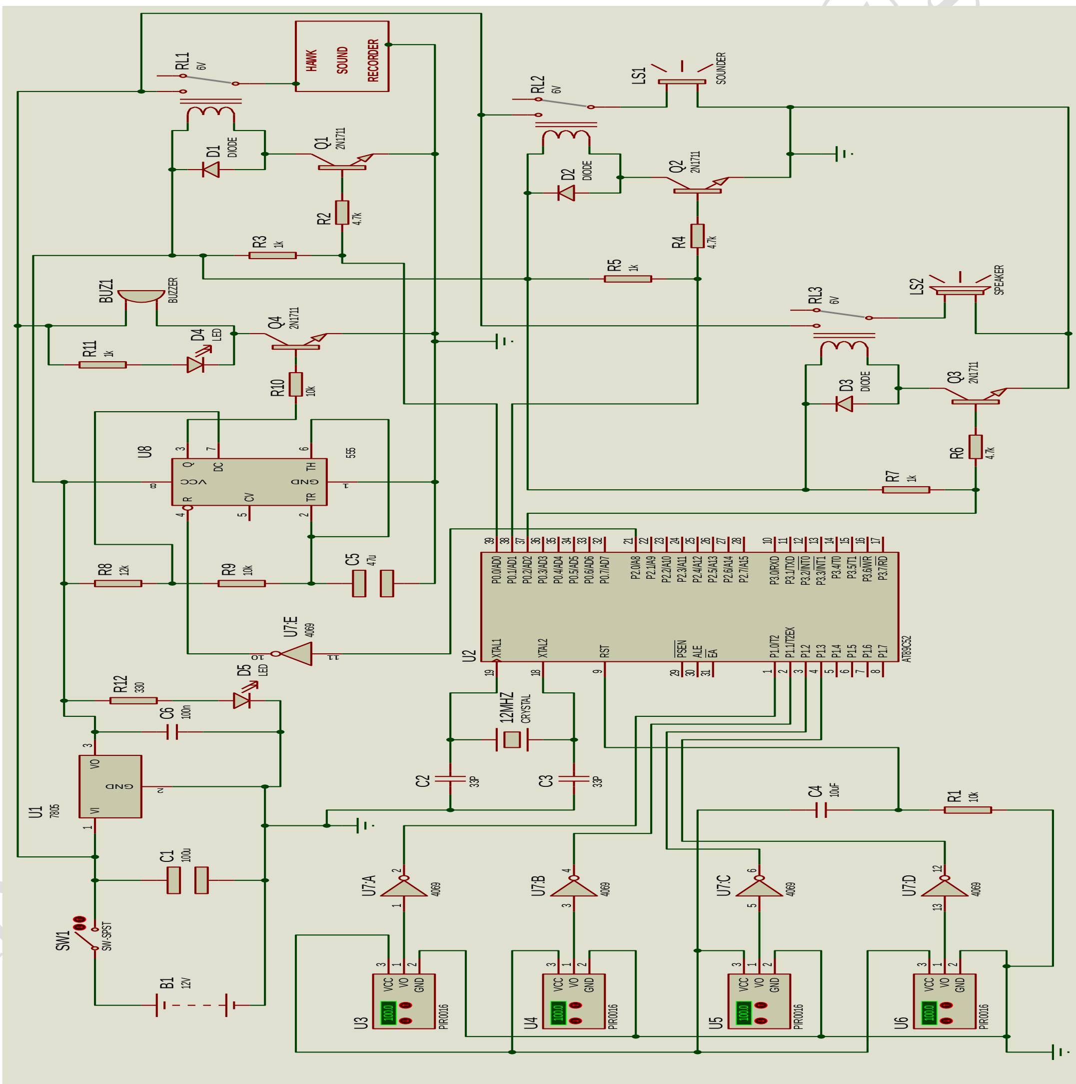

Fig. 3.8: The Complete System Circuit

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