# Development of Soil Nutrient Detection Using Microcontrollers and GPS Technology (SoilMATIC)

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# Development of Soil Nutrient Detection Using Microcontrollers and GPS Technology

**SoilMATIC**

A Design Project Proposal Submitted to the School of Engineering in Partial Fulfillment of the Requirements for the Degree

Bachelor of Science in Electronics Engineering


Asia Pacific College

by

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December 2014

**APPROVAL SHEET**

The design project entitled **Development of Soil Nutrient Detection Using Microcontroller and GPS Technology** designed by:

**James Matthew D. Wong**
**Jemanuel A. Formeloza**
**Judith Chrisitne C. Uy**

and submitted in partial fulfillment of the requirements of the **Bachelor of Science in Electronics Engineering degree**, has been examined and recommended for acceptance and approval.

**Engr. Jose Duwi Iscala**
Design Project Adviser

As oral examination panel members, we certify that the project prototype and this paper have been examined and hereby recommend to be accepted as fulfillment of the design project requirement for the Degree Bachelor of Science in Electronics Engineering.

**Engr. Einstein Yong**
Committee Chair

**Engr. Alain Bernard C. Rañola**
Lead Panelist

**Engr. Ana Antoniette Illahi**
Panel Member

This design project paper is hereby approved and accepted by the School of Engineering as partial fulfillment of the requirement for the degree of Bachelor of Science in Electronics Engineering.

**Engr. Stanley Glenn E. Brucal**
Program Director, School of Engineering

## DEDICATION

The proponents would like to dedicate this project to their families for their relentless support and encouragement especially during the most challenging days of pursuing the project. Without these people, the project could not have materialized. Not only did they provide financial assistance, but they have also showered the researchers with so much motivation and moral support.

**ACKNOWLEDGMENT**

We, the proponents, would like to thank our project adviser, Engr. Jose Duwi Iscala, who gave us knowledge and guidance that lead to the success of the capstone project. Thank you for always believing in our abilities and keeping us focused on our goals. We would also like to thank the Bureau of Soil and Water Management for providing significant techniques that served as the project's backbone and Asia Pacific College for providing the necessary tools and equipment. Lastly, we would like to send our deepest gratitude to our parents for their never ending support and love.

**ABSTRACT**

In order to optimize the land, farmers should have knowledge on how they can use its nutrient content to their advantage. To determine the nutrient content of an area, soil tests are manually done inside laboratory offices located in very few urbanized cities. In which case, farmers from far flung areas would have to ship their soil sample and wait 1 to 2 weeks before they get the test results back. Farmers also resort to using fertilizers in order to grow plants which can be harmful to the human body. The researchers wanted to incorporate innovation to the process of soil testing by creating an automated machine that can determine the soil's Nitrogen, Phosphorus, Potassium content, and ph level and use these data to suggest the best crop/s that can be planted in the area thus minimizing the use of fertilizers. Manipulation of color sensor and motors became possible by combining microcontrollers to the system. The researchers have gone through project construction and calibration process to ensure the functionality of the system. By collating all the recorded test and evaluation results, the proponents were able to verify that the system is able to perform the soil testing process with minimal user intervention and still provide accurate results. Improvements on internet virtual mapping can also be done in the future in order to provide soil analysis data to the public.

Keywords: nutrient contents, soil testing, virtual mapping, soil analysis, color sensor

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# Chapter I

# THE PROBLEM AND ITS BACKGROUND

## 1.1 Introduction

Precision agriculture has been pursued by so many agriculturists nowadays in order to aid in the heightening of crop productivity in a specific region. Its application ranges from a site-specific farm management to extensive geo-mapping. Engineering methodologies were adopted in order to address the pressing problems of soil-crop mismatch that results to non-optimized use of soil.

Site-specific management especially for farmers tilling their land requires soil testing which is necessary to determine the nutrients and some essential parameters present in it. As a basic component of soil testing, nutrient determination is usually carried out in an off-site testing laboratory. However, conventional soil nutrient detection methods are reliable, but are time-consuming, complex and expensive.

Up to this day, a manual soil test kit which is being offered by the Bureau of Soils and Water Management (BWSM) is still used by some farmers especially in areas near Manila. Some farmers in the far-flung areas are not even given the chance to use such kit and they still have to go to regional offices of the bureau to have their soil samples tested. Sadly, some regional offices do not have basic soil testing equipment and manual soil test kit supplies.

## 1.2 Background of the Study

Successful crop production is dependent upon effective nutrient management that includes identifying nutrient deficiencies and excesses. Thorough soil testing provides an opportunity to check the soil nutrient account which is critical for developing an efficient agricultural management plan for a specific land.

It has been eminent that the crop production index of the Philippines has dropped from year 2000 up to present. This trend only shows the negligence and lack of support to

the largest income generator of our country which is agriculture. To address the decrease in crop productivity, further push for research and development of new and technological methods are greatly needed.

The soil is the basic component in order to grow a crop. But before this, one must know if the soil would be fit to grow a specific crop. One's knowledge of the basic soil properties such as its pH, nitrate content, phosphorus content and potassium content would help him determine the right crop to grow along with the right fertilizers to be used. This would make him a wise farmer and a good manager of his land that will somehow help him in increasing productivity of his land.

In this study, the proponents have developed a prototype which enables detection of nutrients from a soil sample and also suggest a crop based on the results of the soil test. This prototype aids farmers to further know the properties of the soil they till without going to urban laboratories which might be too far from them thus enabling them to conveniently maximize their land.

## 1.3 Objectives of the Study

### 1.3.1General Objective

The proponent's main objective is to design a microcontroller-based prototype that detects the presence of nutrients such as Nitrogen, Phosphorus, Potassium, and pH level of a soil sample and also suggest a possible crop that will match with the soil being tested.

### 1.3.2Specific Objectives

This project aims to:

- Use a microcontroller to automate the staining of the soil samples placed in test tubes.

- Design a separate microcontroller-based color sensing module to detect the presence of soil nutrients (nitrogen, potassium and phosphorus), and pH level by sensing the resulting color of the samples after staining with chemicals; after which the prototype will suggest possible crop/s to be planted.
- Display the warning messages, time, and results using an LCD display.
- Develop a provision in the prototype that will enable the user to save the results (in text file) of the soil test through a flash drive or an SD card.

## 1.4 Significance of the Study

- To the Future Researchers

Having such kind of study will open up the horizons of the researcher of further determining problems especially in agronomy which can be solved through engineering methods. This is an opportunity for the researcher to consider agriculture as a field where he can utilize his skills and knowledge in order to help increase awareness of the need for more and intensive research studies to heighten farm productivity.

- To the Academe

A school whose nature is business and IT would most likely dive into fields of improving technology; miniaturizing gadgets, compacting different peripherals into one device, automating control and related processes, and the like. However, such focus would leave other fields behind depriving them to further improve in their expertise and widen their knowledge in the use of technology. It is deemed beneficial for the academe to consider fields like agriculture and agronomy because this would open opportunities for the students to use engineering methodologies in order for them to think and design new ways to innovate manual farming and other related procedures or processes.

- To the Government

One aspect of a nation's growth is its agricultural status. It has been known to many that the Philippines was once the rice granary of Asia. But for the past few years, the country has been importing rice from Asian countries which at that time has insufficient knowledge on rice productivity. Learning such situation, this study would leave a message to the government that it is not yet too late to welcome such studies which aim to improve productivity in the agricultural sector. This study, which the proponents present, gears to provide the government agency concerned (Department of Agriculture) on crop productivity an avenue to further pave its way to fulfill its task of improving farmers' education and productivity.

Also, the government can fund on producing this project and distribute it to regional offices which cannot afford to have a sophisticated and expensive laboratory equipment to conduct soil testing.

- To the Farmers

Investing on technological devices would not be as easy especially for farmers earning a little from their produce. However, considering the product of this research would help the farmers get the most of their lands by choosing the right crops for them to plant. Also, this would open an avenue for them to have this interest in learning soil science in a manner that is neither too complicated nor sophisticated to them. This study aims to ease the burden of complex soil testing by providing rural laboratories with a reliable and automatic kit which will determine a soil sample's nutrient contents.

## 1.5 Scope and Delimitations

### 1.5.1 Scope

- Dispensing and swirling of chemicals will be done by the system.

- The color sensing module used in this prototype will determine its nitrate, phosphorus, potassium concentration, and detect the pH level of the soil sample through its resulting color. The module conducts detection of the sample individually.
- The LCD will display the nutrient concentration after each sample is being tested and after all the four stages of the test are done, a PC based system will enable the user to generate the possible crop/s that best suit the land.
- This study is based on the procedures of manual soil testing as done by the BWSM which includes the chemicals being used to stain the soil sample.

### 1.5.2 Delimitations

- Parameters such as temperature, salinity, and other quantities are not being tested by this system.
- The prototype cannot automatically rearrange the samples. Samples have to be complete and follow the sequence of testing: Potassium, pH Level, Nitrate, and Phosphorus.
- Refilling of solutions has to be done manually.
- Wrapping of the stirrer with foil used for phosphorus testing has to be done manually.
- Swirling of chemical using a foil-wrapped stirrer used for phosphorus testing has to be done manually.
- The prototype will be practically appreciated by farmers whose crops are included in the major and priority crops which are stated in the Crop Production Survey of the Bureau of Agricultural Statistics and the Fertilizer Recommendations for Different Crops by the Bureau of Soils and Water Management. Thus, the two (2) crops that will be suggested by the system are limited to what was enumerated in the survey.

### 1.6 Conceptual Framework

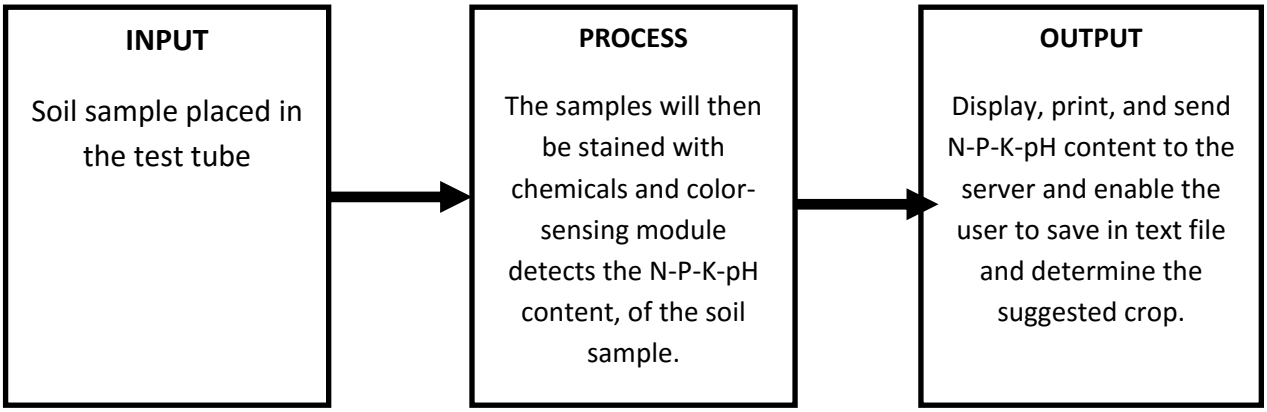



Figure 1.1 Block Diagram of Conceptual Framework

The system is best described by Figure 1.1 above. The system will need to obtain approximately 0.1ml of soil sample placed in a test tube. A marker is usually seen in test tubes provided by the Bureau of Soils and Water Management. The process for each stages of the test will be done separately starting first with the potassium, pH level, nitrogen, and phosphorus.

Each sample would undergo procedures depending on the parameter to be tested. Soil pH, potassium, and nitrogen tests involve staining while phosphorus involves staining and some additional procedures.

Results of the sensor section will be forwarded to the data section which will display the findings to the LCD display and then print it. The data composed of the nutrient level, latitude, longitude, and date will be sent to the computer server. Through these acquired data, the pc based system will show the map where the soil testing took place. The user has now the ability to save the results in text file and enter the data to determine the possible crops that would optimize the nutrients in the land.

**1.7 Definition of Terms**

| | |
|---|---|
| Brom Cresol Green (BCG) | A pH sensitive dye used for colorimetric detection usually intended to specify pH level from 4.0 to 5.2. |
| Brom Thymol Blue (BTB) | A pH sensitive dye used for colorimetric detection usually intended to specify pH level from 6.0 to 7.6. |
| BWSM | Bureau of Soils and Water Management |
| Chemical Staining | The process of dispensing liquid solution onto the soil and allowing it to chemically react by swirling. |
| Chlor Phenol Red (CPR) | An indicator-dye that changes color from dark yellow to violet depending on the pH level from 5.0 to 6.0. |
| Dispenser | Composed of syringes and motors that are dedicated to release a specific amount of chemical solution into the soil sample. |
| Platform | A rotating surface that holds the test tube during the chemical staining process. |
| Soil pH | A measure that defines the soil's level of acidity or basicity. |
| Soil Test | A process where indicator dye and elements such as Potassium, Nitrogen, and Phosphorus are chemically stained on the soil in order to determine its nutrient and acidity level. |

## Chapter II

## REVIEW OF RELATED LITERATURE AND STUDIES

Agriculture in the Philippines has been very vital in the State's economic growth. With the advent of new techniques and technologies on farming, soil cultivation, and other relevant activities, Filipino farmers and fisher folks have made a significant step to contributing revenue to the State.

Given that the country is an archipelagic state, up to this time vast farm lands can still be seen especially in the provinces. According to Briones, for agricultural output to grow, there should be a significant increase of resources into agriculture by farm area expansion1. However, it is observed in the dailies that subdivisions keep on sprouting in so many areas that were once planted with crops. Such is observed especially in Antipolo City where establishments, residential and commercial, are being built in the area.

Thus, information on land use must be further pursued by legitimate authorities with the help of non-government organizations.

### 2.1 Soil Productivity

The concern on soil productivity has been a concern in the Philippines since 1930 according to the FAO report. This is in contrary with the agricultural upsurge that country was known for especially in rice production.

According to the Department of Environment and Natural Resources, 75% of agricultural lands are susceptible to soil erosion. This is because of the increasing conversion of lands for either residential or commercial usage.

Table 2.1. Areas used for agricultural and non-agricultural uses in the Philippines: extent of degradation by major island and by slope

| Island/ slope | Land used for agriculture (in '000ha) | | | Land used for other uses (in '000ha) | | |
|---|---|---|---|---|---|---|
| | Moderate to Severe | None to Slight | Total | Moderate to Severe | None to Slight | Total |
| **Luzon** | | | | | | |
| 0-8% | 814 | 3,277 | 4,091 | 276 | 948 | 1,224 |
| > 8% | 626 | 1,277 | 1,903 | 4,288 | 2,634 | 6,921 |
| Total | 1,440 | 4,554 | 5,994 | 4,564 | 3,582 | 8,146 |
| **Visayas** | | | | | | |
| 0-8% | | 610 | 610 | 200 | 200 | 401 |
| > 8% | 501 | 183 | 684 | 1,120 | 653 | 1,773 |
| Total | 501 | 793 | 1,294 | 1,320 | 854 | 2,174 |
| **Mindanao** | | | | | | |
| 0- 8% | 2,053 | 1,412 | 3,465 | 771 | 511 | 1,282 |
| > 8% | 1,815 | 200 | 2,015 | 3,358 | 79 | 3,438 |
| Total | 3,868 | 1,612 | 5,480 | 4,129 | 590 | 4,720 |
| **Philippines** | | | | | | |
| 0- 8% | 2,867 | 5,299 | 8,166 | 1,248 | 1,660 | 2,907 |
| > 8% | 2,942 | 1,660 | 4,602 | 8,765 | 3,367 | 12,132 |
| Total | 5,809 | 6,959 | 12,767 | 10,013 | 5,027 | 15,039 |

(Source: Crop Development and SoilConservation Framework for Luzon, Visayas, and Mindanao Islands. Management and Evaluation Division (ALMED), Bureau of Soils and Water Management (BSWM), 1990.)

Widespread land conversion leads to erosion thus increases impractical usage of land. Such practice according to environmentalists, conversion of agricultural land especially forests is the cause of flashfloods because less trees and crops get to hold and sip water. In addition, nutrients are flushed away with the eroded soil.

## 2.2 Crop Productivity in the Philippines

Facing the concerns on decreasing land area to be used for agricultural purposes, farmers must learn how to maximize their available land to further increase productivity. Briones and Habito told in their publication that there was an observed fast growth rate in the 1960s and slowed down in the 1970s as the Green technology diffused and neared 100% adoption. However, rice in particular showed increase in growth in the 1980s and slowed down again even up to the present. Other crops followed similar pattern like corn except that its yield growth is fairly steady.

Table 2.2. Yield Growth for Major Crops, Annual Average by Decade, 1961-2003

| | 1961-1970 | 1971-1980 | 1981-1990 | 1991-2003 |
|---|---|---|---|---|
| **Rice** | 4.3 | 2.6 | 3.3 | 1.2 |
| **Corn** | 3.2 | 1.5 | 2.8 | 2.8 |
| **Coconuts** | -2.6 | 1.7 | 4.9 | 2.8 |
| **Sugarcane** | 0.1 | 0.8 | 2.8 | -0.8 |
| **Bananas** | 1 | 13.4 | -2.5 | 3.1 |

(Source: FAOStat 2004)

On a closer look, only corn and sugarcane have undergone production declines from 1992 to 2003 while the rest maintained a decent pace. We take the example of rice production which from 9.5 million metric tons it rose to 14 million metric tons.

Table 2.3. Production, Area, and Yield, Major Philippine Crops, 1992-2003

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Production ('000 mt)** | | | | | | | | | | | | |
| Rice | 9,513 | 9,434 | 10,541 | 10,541 | 11,284 | 11,268 | 8,554 | 11,787 | 12,389 | 12,955 | 13,271 | 14,031 |
| Corn | 4,619 | 4,798 | 4,129 | 4,161 | 4,345 | 4,332 | 3,823 | 4,585 | 4,511 | 4,525 | 4,319 | 4,478 |
| Coconut | 9,384 | 11,328 | 11,207 | 12,183 | 11,937 | 13,708 | 12,806 | 12,142 | 12,995 | 13,208 | 13,683 | 13,700 |
| Sugarcane | 28,856 | 29,748 | 26,694 | 24,590 | 26,592 | 26,813 | 26,287 | 23,780 | 24,491 | 28,541 | 27,203 | 25,865 |
| Banana | 3,005 | 3,069 | 3,283 | 3,499 | 3,312 | 3,774 | 3,493 | 4,571 | 4,930 | 5,061 | 5,264 | 5,500 |
| **Area ('000 ha)** | | | | | | | | | | | | |
| Rice | 3,237 | 3,282 | 3,652 | 3,759 | 3,951 | 3,842 | 3,170 | 4,000 | 4,038 | 4,065 | 4,046 | 4,094 |
| Corn | 3,482 | 3,149 | 2,692 | 2,736 | 2,729 | 2,726 | 2,354 | 2,642 | 2,510 | 2,487 | 2,395 | 2,485 |
| Coconut | 3,077 | 3,075 | 3,062 | 3,064 | 3,149 | 3,314 | 3,731 | 4,091 | 3,119 | 3,120 | 3,140 | 3,140 |
| Sugarcane | 356 | 384 | 402 | 375 | 396 | 352 | 344 | 314 | 395 | 387 | 384 | 391 |
| Banana | 321 | 326 | 332 | 322 | 327 | 338 | 328 | 372 | 328 | 387 | 390 | 400 |
| Total | 10,473 | 10,216 | 10,139 | 10,256 | 10,551 | 10,573 | 9,927 | 11,419 | 10,391 | 10,445 | 10,356 | 10,510 |
| **Yield (kg/ha)** | | | | | | | | | | | | |
| Rice | 2,939 | 2,874 | 2,887 | 2,804 | 2,856 | 2,933 | 2,698 | 2,947 | 3,068 | 3,187 | 3,280 | 3,427 |
| Corn | 1,327 | 1,524 | 1,533 | 1,521 | 1,592 | 1,589 | 1,624 | 1,735 | 1,797 | 1,820 | 1,803 | 1,802 |
| Coconut | 3,050 | 3,684 | 3,660 | 3,976 | 3,791 | 4,136 | 3,432 | 2,968 | 4,167 | 4,234 | 4,358 | 4,363 |
| Sugarcane | 81,109 | 77,467 | 66,463 | 65,556 | 67,213 | 76,177 | 76,504 | 75,763 | 62,013 | 73,738 | 70,888 | 66,135 |
| Banana | 9,349 | 9,428 | 9,887 | 10,867 | 10,131 | 11,155 | 10,658 | 12,282 | 15,007 | 13,094 | 13,499 | 13,750 |

(Source: FAOStat 2004)

In terms of land use, one can observe in Table 2 that there are years that area will increase slightly then decrease slightly, having a variation of slight increase and decrease trend from which a conclusion maybe be drawn that most agricultural lands are being maintained to be of such purpose. It is only for banana that its land area kept an increasing behavior from 1992-2003.

## 2.3 The BSWM and Soil Profiling

The Bureau of Soils has completed Soil surveys in the Philippines. Bureau of Soils is an agency of the Philippine government under the Department of Agriculture responsible for advising and giving assistance on matters relative to the utilization of soils as an important agricultural resource. The soil properties of texture, structure, depth, permeability and chemistry are the important roles in irrigation management. Table 2.4 shows the level of nutrients needed to grow specific plants.

Table 2.4 Nutrient Level for Common Plants

| **VEGETABLES** | **pH** | **N** | **P** | **K** |
|---|---|---|---|---|
| Cabbage | 6.5 | high | high | present |
| Mongo | 6.0 - 6.9 | low | mid | present |
| Tomato | 5.5 - 7.5 | mid | mid | present |
| Eggplant | 6.0 - 7.0 | mid | high | present |
| Onion | 5.5 - 7 | mid | mid | present |
| Garlic | 6.8 - 7.2 | mid | mid | present |
| Peanut | 6.2 - 6.5 | high | mid | present |
| Sitaw | 6.8 | low | mid | present |
| **ROOT CROPS** | | | | |
| Camote | 5.8 - 6.2 | high | low | present |
| Cassava | 5.5 - 6.5 | low | high | unavailable |
| **FRUIT CROPS** | | | | |
| Banana | 5.0 - 5.5 | high | low | present |
| Pineapple | 4.5 - 5.5 | high | high | present |
| Mango | 5.5 - 7.5 | mid | high | present |

## 2.4 Demand and Usage of Fertilizers

According to FAO in its report for the year 2000, from 1993 world population of 6 billion, it will increase to 7 billion by year 2020, thus, having the need for more food production. Up to 90% of this increase should come from fields which are already under cultivation. However, most farmers are only small-scale ones which even comprise the rural sector of a State.

To achieve increase in food production for a fast increasing population would certainly need for the usage of fertilizers which according to the same FAO report could increase crop yields in a double or even triple manner. However, it is hard to estimate exactly how mineral fertilizers contribute to the increase in agricultural production. It is because of many important factors arising.

Table 2.5. Fertilizer: Supply and Disposition by Year and Item (Unit: metric tons, P - Preliminary)

| | Production | Imports | Supply | Local Sales | Exports |
|---|---|---|---|---|---|
| 2008 | 287105 | 1512245 | 1799350 | 678544 | 7258 |
| 2009 | 196095 | 1733728 | 1929823 | 173929 | 160182 |
| 2010 | 182549 | 1970489 | 2153038 | 331219 | 322593 |
| 2011 | 614499 | 1610308 | 2224807 | 629295 | 191930 |
| 2012P | 314461 | 1575621 | 1890082 | 822256 | 173827 |

(Source: Fertilizer and Pesticides Authority, Philippine Statistics Authority)

Considering that most farmers come from rural areas, sometimes it hampers them to purchase fertilizers because of their limited income. Furthermore, it also hampers increase in their crop productivity. In fact, there is no trend whether increasing or not in terms of supply and local sales. In the next table, the prices of fertilizer per 50 kilos are shown.

Table 2.6. Fertilizers: Dealers' Prices by Region and by Province (Unit: Pesos per 50 kilograms)

| | | Annual | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| CENTRAL LUZON | Ammophos (16-20-0) | 1577.84 | 1029.47 | 872.58 | 1013.7 | 1080.5 | 1087.27 |
| | Ammosul (21-0-0) | 900.51 | 585.92 | 519.92 | 678.54 | 781.52 | 744.4 |
| | Complete (14-14-14) | 1599.85 | 1110.35 | 1023.78 | 1127.53 | 1203.2 | 1189.04 |
| | Urea (45-0-0) | 1493.03 | 905.65 | 932.85 | 1177.53 | 1239.58 | 1105.99 |
| CALABARZON | Ammophos (16-20-0) | 1623.39 | 1216.86 | 1008.51 | 1091.1 | 1229.19 | 1229.1 |
| | Ammosul (21-0-0) | 888.69 | 735.3 | 610.02 | 678.45 | 819.78 | 828.61 |
| | Complete (14-14-14) | 1498.28 | 1225.86 | 1109.92 | 1203.61 | 1317.19 | 1292.68 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Urea (45-0-0) | 1493.4 | 1050.01 | 973.18 | 1180.08 | 1304.12 | 1234.65 |
| MIMAROPA | Ammophos (16-20-0) | 1609.24 | 1194.44 | 1024.54 | 1116.12 | 1234.99 | 1192.48 |
| | Ammosul (21-0-0) | 915.41 | 748.59 | 658.94 | 724.77 | 829.47 | 802.92 |
| | Complete (14-14-14) | 1667.23 | 1233.51 | 1123.09 | 1228.18 | 1312.87 | 1270.48 |
| | Urea (45-0-0) | 1586.53 | 1072.79 | 1007.54 | 1259.3 | 1369.03 | 1236.03 |

(Source: Bureau of Agricultural Statistics, Data based on BAS Weekly Cereals and Fertilizers Price Monitoring covering 5 dealer-representatives per province)

A 50-kilo bag of fertilizer would sometimes be enough for just a hectare. It means that if one would have over a hectare, he or she has to spend more. Such situation is a common concern of famers. That is why this leads to the proposition of making farmers know more of their land, its properties or nutrients, to know what crop best fits their farm land, thus minimizing the use of fertilizers.

**2.5 Soil Test Kit**

The soil test kit is a complete package of soil testing which uses simple colorimetric chemical analyses in which chemical reagents are made to react with a soil sample in a test tube to give a characteristic color depending on the amount of available nutrients in the soil. The colors produced are then matched with a standard color chart which rates whether the soil is slow, medium, or high in available nitrogen, phosphorus or potassium. Also determined in similar manner is soil pH or acidity.

The soil test kit also is cheap, quick, handy and easy to use. It does not require sophisticated laboratory instruments and specialized training for the user. Soil testing can be done right in the field and results are obtained within the hour. It is, therefore, a useful tool to farmers and extension workers who, oftentimes, need immediate answer to the question of what kind and amount of fertilizer to use for a crop grown in a particular soil.

The soil test kit is a product of research from the Department of Soil Science, University of the Philippines at Los Baños in cooperation with the National Food and Agricultural Council.

**2.6 Soil Nutrients**

- Nitrogen

  This is an integral part of all protein nutrients, and one of the main elements required for plant growth and photosynthesis. This makes up 1 to 4 percent of dry matter of the plant. In most conditions, availability of nitrogen that can be used is the factor that mostly limits high growth. The crop absorbs nitrogen by taking in ammonium or nitrate through its root system. The plant will then use nitrogen as a building block to produce protein in the form of enzymes.

- Phosphorus

  Phosphorus is necessary for strong growth. This makes up 0.1 to 0.4 percent of the dry matter of the plant and plays a key role in the transfer of energy. Insufficient phosphorus in the soil will cause crops to be undersized or small. The plant uses phosphorus as well for photosynthesis and energy or nutrient transport.

  Not enough supply can cause green & purple discoloration, sagging, small fruits and flowers. When phosphorus is added to the crops, it can establish a strong root base and produce strong all through the growth season.

- Potassium

  Potassium, the third of three elements in healthy soil nutrition, can greatly increase crop yields. It makes up 1 to 4 percent of the dry matter of the plant. It helps in water absorption and retention. Potassium also induces plants to have strong roots, tough stems, and healthy full grown crops that have longer shelf life.

  Potassium comes naturally in two forms, one is able to be absorbed by the plant, while the other is not present to the plant. Many crops depend on abundant supply of potassium so they must rely on fertilizers and soil amendments to add to the

potassium that is present in the soil. Agricultural products which contain potassium are water soluble, allowing it to be absorbed by crops in through the nutrient rich soil.

- Soil pH

Soil pH is a measure of the degree of acidity or alkalinity. A pH of 7 is neutral. The lower the pH (below 7) the more acidic the soil is. On the other hand, the higher the pH (above 7) the soil becomes more alkaline.

It is important to know the pH of a soil because the availability of most nutrient elements for plant growth and occurrence of toxicities of elements is related to soil pH. Most plant nutrients are in readily available form at soil pH ranging from 5.5 to 7.0, hence, most plants prefer to grow within this range. However, nutritional disorders usually appear when pH values become higher or lower. The following shows the nutritional disorders observed in relation to soil pH.

| | |
|---|---|
| Lower than 5.0: | Deficiencies of phosphorus, calcium, magnesium, potassium and molybdenum |
| | Toxicities of aluminum, iron and manganese. |
| Higher than 7.5: | Deficiencies of phosphorus, iron, potassium and zinc |
| | Toxicity of boron |

**2.7 Soil Analyzers and Microcontrollers**

The use of microcontrollers in today's industry has been a trend especially for enthusiasts who aim to develop newer and simpler systems that will improve efficiency in work whether in a manufacturing or laboratory setup.

The use of microcontrollers has been a project in India where almost 80% of their citizens depend on the agricultural sector. Most of them are involved in production based on land while a small percentage depends on life on sea.

The Atmel's AVR Atmega16 was used in one project conducted by Mohammad Khan and Rashid Mustafa which focused on getting an accurate pH result on the soil

sample. The project mainly used the concept of analog to digital conversion which is common to most microcontrollers nowadays. This process is called upon when device is faced with analog signal and has to interpret this into something digital wherein only 1 and 0 are being considered.

According to the Bureau of Soils in an interview, they are already being offered devices or equipment from India which is almost the same with SoilMATIC, however it is expensive for them to buy and is not ideal for distribution to regional offices to start catering soil samples from far flung areas.

**2.8 GPS Assisted Soil Analysis**

It is one of the practices in agriculture to have a regular monitoring of a farm land – nutrients, crop production and the like. On the advent on new technological advancements, some farmers have resorted to seek assistance to attain efficiency in farm work. This is what is presently called as precision agriculture.

Precision agriculture has been employed by farmers to ensure that they keep track on their farmlands. The commonly used tool for this query is the GPS wherein at the end they generate a summarized report on the status of portions of land they own. However, there was no documented account that there was an entity who introduced virtual mapping of farmlands. They may have employed the assistance of GPS but most farmers according to Crozier and Heiniger comply with the manual procedures and tabulation of results. Another is, the practice has been tested already for years spent on field calibration trials with crops grown on selected, uniform, and small land areas

**2.9 Relevance of the Study**

The following literature included in this study has been carefully selected by the researchers so as to induce better understanding of the project versus the current trends or even similar studies conducted in the Philippines or in other countries. The following results can be drawn from the conduct of the Review of Related Literature:

- There is no existing study in the Philippines about further improving the present manual procedures on Soil Testing which has been used since the time of the former President Marcos.

- According to an interview with the Laboratory Technician of the BSWM, they have been considering purchasing a similar unit abroad but still opted to continue with the present practice in the hope that a group of Filipino students would choose to deal with Pedology (study of soil).

- She added that the unit they were able to encounter in India may be "a step advanced" compared to this study but too expensive for the Bureau to purchase especially that if the unit will be distributed to regional offices plus the technical support or assistance they can get is their concern.

- It was found out that there is a similar project or study being conducted in India. It was observed as well in further research conducted that the main focus of electronics engineering in their country is to help improve their agricultural sector aside from medicine and health care.

- Precision agriculture has been a practice in the field of soil monitoring and economics however this only included the use of GPS to generate a listing or a summarized report of status of soil samples from a certain land area.

Furthermore, it will be noticed that the Chapter II of this study was not anymore divided into related literature and study because each section of this chapter does not only come from a single source but rather a consolidated content coming from both literature and study made by various local and international organizations where each is stated in the bibliography of this study.

# Chapter III

# METHODOLOGY

## 3.1 Project Design

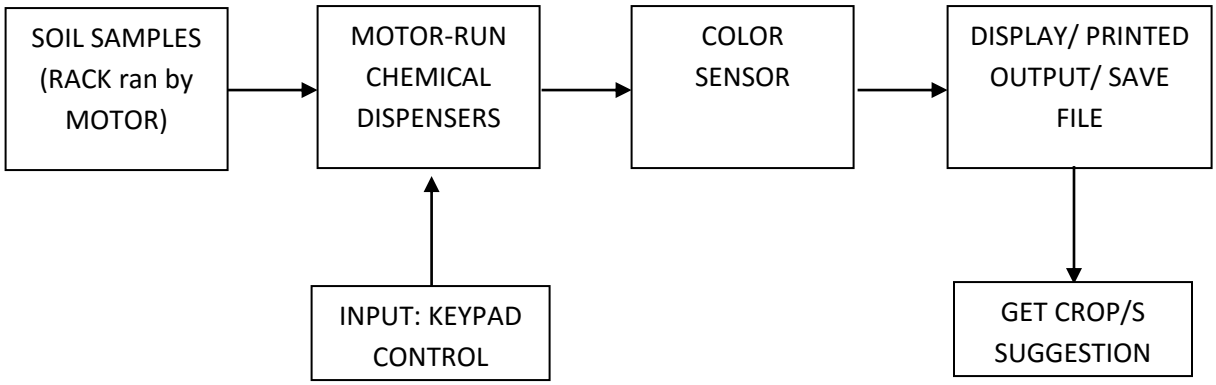



Figure 3.1 Block Diagram of Project Design

A microcontroller will control each dispenser to stain the soil sample. After the chemical staining process, the color sensing module will determine the nitrate, phosphorus, and pH content of the soil through the detection of the RGB content of the soil sample while potassium is quantified by detecting a yellowish layer on top of the solution. Another microcontroller will show the result in the LCD screen and print a copy of the data. The device will also give the user an option to store the data to either an SD card or flash drive and afterwards, acquire the crop suggestion.

### 3.1.1 Hardware Design

The prototype contains a color sensing module, microcontrollers, a backup battery, a total of 10 motors, a GPS and GSM module,. The microcontroller manipulates the motors of the syringe allowing them to dispense and refill chemical solutions. Also, the microcontroller is used to command the stepper motor beneath

the platform to revolve multiple times in order to position the soil sample under the designated hose/s. With the integration of microcontrollers, the researchers were able make all the components function harmoniously in a timely manner.

To let the user communicate with the microcontroller, an LCD screen and a keypad were installed in front of the prototype. The LCD displays the status of the project whether it is on standby, in the middle of a test, or if the test procedure is finished. A 12-volt rechargeable battery was installed to supply power to all the components especially during field testing.

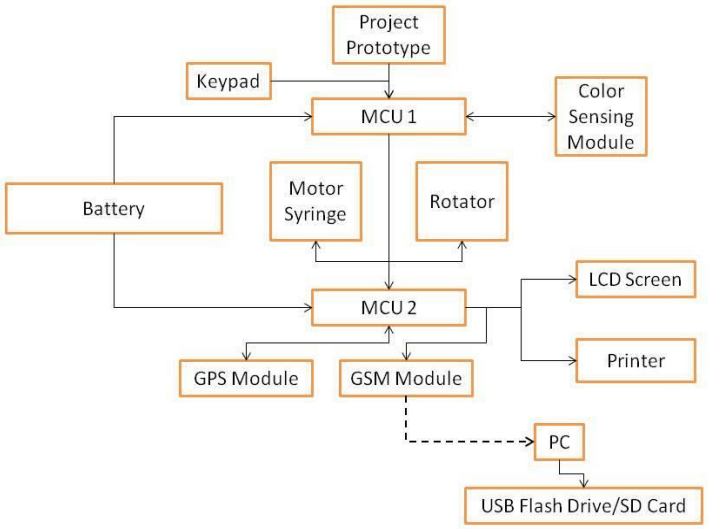



Figure 3.2 Hardware Design Layout

The color sensing module was calibrated by the researchers to detect the colors base on the color chart. A couple of manual testing has been done to adjust the readings of the color sensing module.

### 3.1.2 Software Design

Figure 3.3 illustrates how the system works internally. After the user selects the nutrient from the menu, the motors on the platform and syringes are triggered to perform the chemical staining and swirling process. Separate soil samples

undergo individual procedures until the pH, nitrogen, potassium and phosphorus nutrient data are obtained through the use of a color sensing module.

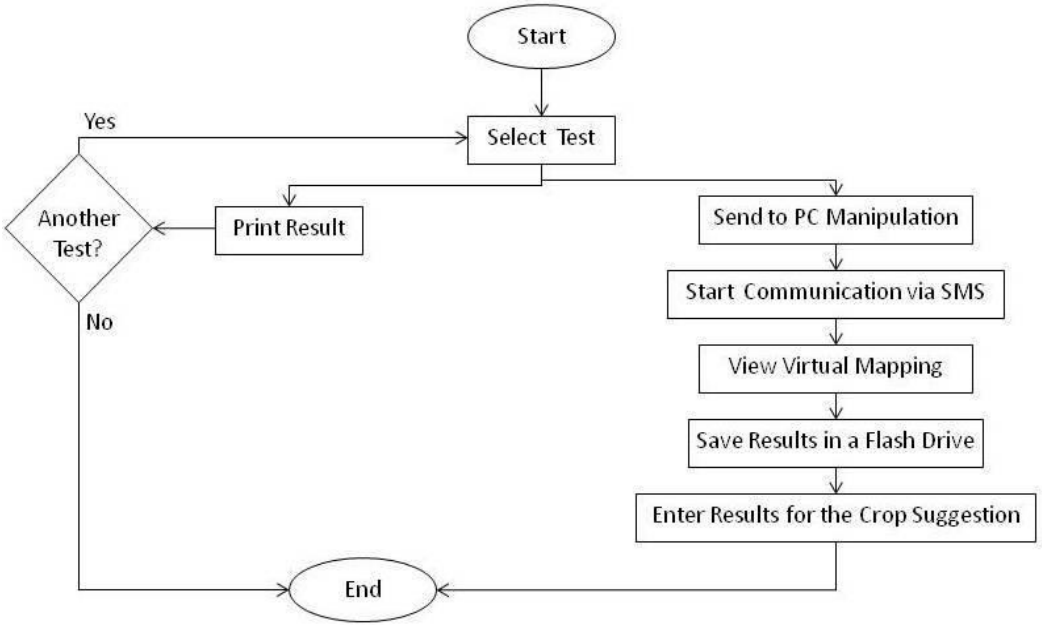



Figure 3.3 Simplified Flowchart of the Program

Each result is displayed in the LCD, and printed out. At the same time, the GSM sends the data to the computer where the user can view the tabulated results with its geographical location. The user can choose to save the results in a flash drive and also generate the crop/s suggestion by inputting all the gathered data.

## 3.2 Project Development

This section emphasizes the highlight of the activities starting with the designing stage, assembly, calibration, and up to the implementation phase. Some problems and remedies encountered during construction are also included.

### 3.2.1 Design and Implementation Process

#### 3.2.1.1 Designing

The researchers started with conceptualizing the hardware of the system. On the third week of June 2014, the placement of components within the chassis where considered. The design of the prototype is enclosed so that no ambient light might affect the reading and calibration of the color sensor. Also, it was decided that the syringes be held on a horizontal orientation doing away with the vertical orientation so as not to consume much space. The horizontal orientation made the design more compact rather than being a tall, tower-type design which on the perception of the researchers is not practical especially during field usage. The horizontal orientation also made the syringes lay on a stack-style manner having five syringes on top and four syringes below. A tight hose was used to enclose the adaptor of the syringe and connecting it to a slot on top of the platform. The researchers also created schematic plans for the relay circuitry, as shown from Appendix A, and how it can be conveniently connected to the syringe motors. Also, the researchers came up with a circuitry design for the stepper motor at Appendix A which was used for the rotating platform. Also, the researchers have constructed source codes shown at Appendix B for the microcontrollers to manipulate the electrical components of the system.

#### 3.2.1.2 Prototyping

During the prototyping stage, the researchers used steel angles to construct the foundation of the chassis and then enclosed it using sintra boards. Also, wallpaper was wrapped around the entire chassis for finishing with additional labelling.

The color sensor shown at Figure 3.4 was carefully placed on one side of a compartment where the test tube can be easily inspected for acquiring the RGB color value. During the last week of June, series of tests were done to determine the most appropriate vertical and horizontal position of the sensor where it can produce precise results.

Figure 3.4 Color Sensor

During the last week of July 2014, the optical sensor was omitted since the color sensor can already perform the same task of detecting a yellowish layer for the potassium test. Through this technique, the researchers were able to reduce the number of microcontrollers to be used in the project.

The platform that holds the soil was originally designed to be stationary while the hoses are placed on a rotating disk. But during the second week of June 2014, the design was found to be ineffective due to limited hose movements that may end up tangled. As a solution, the platform was placed on top of a stepper motor and the hose are held in place just above the test tube.

Figure 3.5 Redesigned Platform and Rack

Figure 3.5 shows the revision to the design of the platform. This alteration allowed more accurate circular movement because the test tubes can be placed exactly below the desired hose. The rotation of the platform also satisfied the swirling process for chemical staining. The sequence of rotation is also being dictated by the microcontroller as shown in the circuit from Appendix A.

On the last week of June 2014, the researchers proceeded with integrating the LCD and printer to the system. It was of the utmost importance that the system displays the correct results so the researchers had to produce a series of sample print out results to see if it is in-sync with the LCD and if both outputs are readable. During the first week of July 2014, it was decided that the SD/flash drive ports need to be combined with PC interface since the microcontroller from the project has limited memory capacity.

The first plan was to use solenoid pumps to dispense the chemical solution as this device can provide higher accuracy. However, most of the pumps available in the market are too large and expensive which is impractical. As an alternate, the researchers opted to combine DC motors and syringes in order to dispense the desired amount of liquid into the soil sample. Figure 3.6 shows how the plunger of the syringe was attached to multiple gears that are controlled by a DC motor.

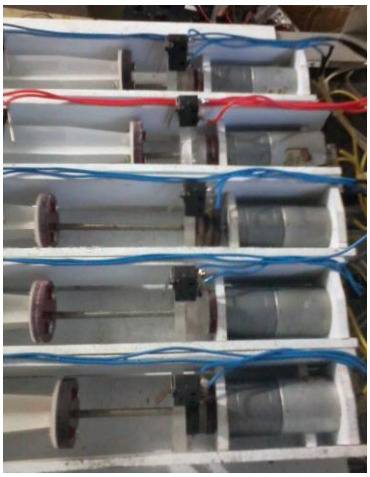


Figure 3.6 Syringes with Motors

As the DC motor rotates clockwise, the gear pushes the plunger forward which forces the liquid out of the hose and into the test tube. On the other hand, the counter clockwise motion of the motor pulls the plunger and creates a suction which is useful in refilling the hose with more chemical solution. Limit switches were installed on the barrel and the plunger's top in order to trigger the dc motor to turn on/off. However, to avoid air gaps on the dispenser's hose, the limit switches on top of the plunger were moved closer to the barrel of the syringe. The

schematic of this circuitry is shown at Appendix A where researchers integrated microcontrollers to send series of commands to the motors.

During the third week of July 2014, multiple tests were made to measure the amount of liquid that is being dispensed within a specific amount of time. This procedure was done to make sure the system releases only the necessary amount of chemicals per test. The major components of the project such as LCD, printer, keypad, motors, and sensors were individually integrated to the microcontrollers to allow the researchers to test if each component is functioning as expected and also for easier troubleshooting.

Next activity was the integration of GSM and GPS to the project. In order to create virtual mapping, the researchers added a GSM module to send the acquired test results to a computer via SMS. This data also includes the longitude and latitude coordinates where the test was done which is provided by the GPS antenna. The schematic diagram of both the GSM and GPS is shown at Appendix A, where the researchers added buffer circuit which avoids possible damages on the IC chips. With the coordinates sent by the project, the pc user can see the map location by clicking on any data from the table as shown below in Figure 3.7.

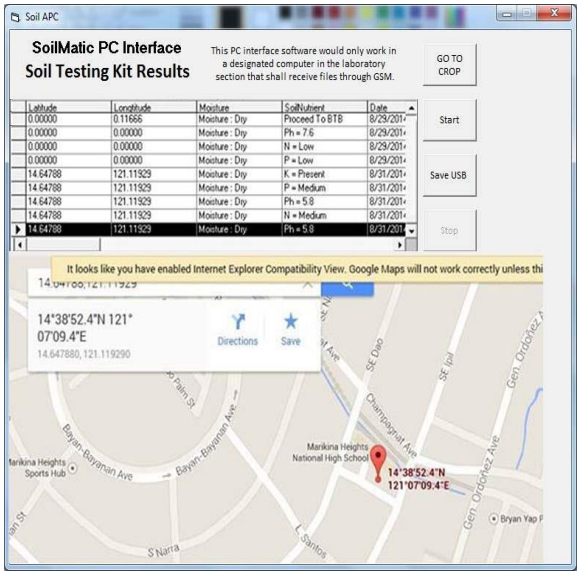



Figure 3.7 Mapping and Tabulated Results

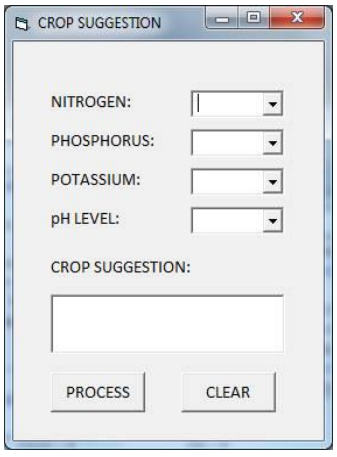



Figure 3.8 Crop Suggestion Tool

Figure 3.8 shows how the user can determine the suggested crop by inputting all the four nutrient levels. PC interface is composed of these two systems which are all constructed through visual basic programming which can be seen from Appendix B.

### 3.2.1.3 Data Gathering

To acquire reliable information about the soil testing process, the researchers consulted lab experts in determining soil nutrient level and the proper way of conducting tests. The researchers also learned the common dilemmas that arise in this specific task. One of which is the lack of facilities in rural areas. During the planning phase, the researchers studied the procedures and conditions emphasized in the Soil Testing Kit manual at Appendix L provided by the Bureau of Soil and Water Management (BSWM) which was used as the skeletal concept of the project. During the first week of July 2014, calibration procedures on the sensor were conducted to ensure the accuracy of the system.

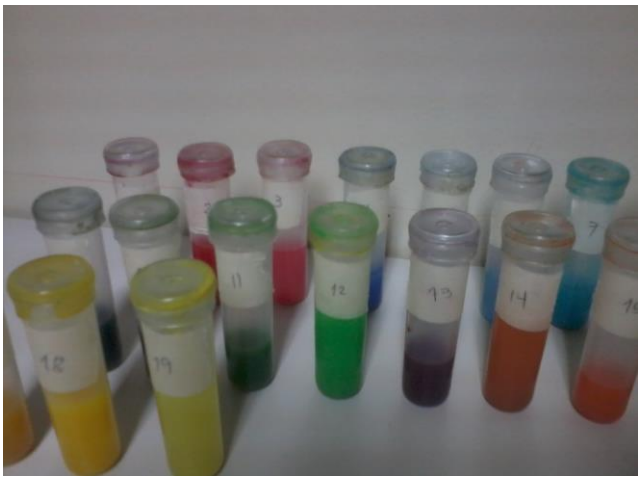


Figure 3.9 Color Samples

Figure 3.9 shows the stack of color samples that were used to measure all the possible RGB value from each shade of color. With this method, the researchers were able to determine the color range for all the nutrient levels in each test.

During the first and second week of July 2014, the researchers gathered multiple soil samples from Parañaque and Marikina which are necessary for conducting multiple manual and SoilMatic testing.

#### 3.2.1.4 Implementation

The project was formally endorsed to the Bureau of Soils and Water Management last July 30, 2014. At the same time lab experts also conducted manual testing. The results gathered by lab experts where compared to the data acquired from the SoilMATIC test which proved the accuracy of the system. The project was also tested for field usage specifically in Marikina area during the last week of August 2014. Through the projects back up battery, the researchers were able to conduct a series of tests and acquire matching crop suggestion with the actual plants found in the field.

## 3.3 Testing and Operation Procedures

### 3.3.1 Testing Procedure of Each System Block

On the conduct of test per system block, all tests were done with the aid of Zilog Development software. Sample codes were used to test if all the elements in the project are working based on how it is meant to work in the project.

#### 3.3.1.1 LCD, Printer

This test is done to determine if the LCD and printer can produce correct and readable results.

Step 1 : Turn on the system.

Step 2 : Press the pound (#) key.

Step 3 : Place a soil sample on the platform

Step 4 : Press number 2 and 1.

Step 5 : Observe if the LCD screen displays the status of the test.

Step 6 : Wait for a few minutes until the result is displayed on the screen.

Step 7 : Check if the printer was able to produce a readable copy of the result.

#### 3.3.1.2 Color Sensor

The color sensor's main purpose is to attain the RGB value from a test either N, P, K, or pH. To test the accuracy of the sensor, the researchers created color samples of each color shade and place it in front of the sensor, in which case, the dispensers need to be empty.

Step 1: Turn on the system.

Step 2: Press the pound (#) key.

Step 3: Place color sample on the platform.

Step 4: Press number 2 and 1.

Step 5: Observe and record the result from the LCD.

#### 3.3.1.3 Dispenser

The correct dispensing of chemical solution plays an important role in successfully detecting the nutrient level of the soil. Thus, the researchers allotted a lot of time in calibrating the movement of the motors attached to the syringes.

Step 1: Press and hold the number 0 and turn on the system.

Step 2: Place an empty test tube on the platform and place it under the first hose.

Step 3: Press number 1 to select the first syringe.

Step 4: Observe if the plunger is being pushed forward.

Step 5: Record the amount of liquid that was dispensed into the test tube.

Step 6: Press the pound (#) key. Then press number 1.

Step 7: Observe if the plunger is being pulled back. (Repeat steps 2 to 7 for all the remaining syringes)

#### 3.3.1.4 Platform

This test is necessary to determine if the platform can position the soil sample under in the desired hose.

Step 1: Turn on the system.

Step 2: Press the pound (#) key.

Step 3: Place the soil sample on the platform.

Step 4: Press number 1 to select the Potassium test.

Step 5: Observe if the soil sample is positioned under the correct hose. (Repeat steps 2 to 5 for all the remaining tests such CPR, BTB, BCG, Nitrogen, and Phosphorus)

#### 3.3.1.5 PC interface

Through PC interface, a user has the option to do the following, namely: save the result in text file, look for the location of the test through virtual mapping, and attain the suggested crop/s based on the given results.

Step 1: Turn on the system.

Step 2: Press the pound (#) key.

Step 3: Place the soil sample on the platform.

Step 4: Press number 1 to select the Potassium test.

Step 5: Observe if the soil sample is positioned under the correct hose. (Repeat steps 2 to 5 for all the remaining tests such CPR, BTB, BCG, Nitrogen, and Phosphorus)

Step 6: Click “Start” to confirm broadband connection and check if the computer received all the four test results from N,P,K,pH tests.

Step 7: Click on one of the data from the table and observe if the program shows the location of the test.

Step 8: Click on “Save USB” button and observe if a pop up screen is allowing the user to save the results in txt file.

Step 9: Click on “Go To Crop” button at input all the four nutrient level.

Step 10: Click on “Process” button and record the suggested crop.

### 3.4 Evaluation Procedure and Criteria

The accuracy of the system was assessed by conducting series of tests that were performed by the proponents and BWSM. All of these results had been documented and analyzed. The researchers also collected feedback from respondents by conducting multiple project evaluations. This is a way to verify how effective the project had been by letting the respondents rate the project in terms of certain criterial.

#### 3.4.1 Accuracy Test

Table 3.1a shows how the recorded results had been tabulated for comparison. This method made the calibrating process much more convenient for proving the accuracy of the project. To explain further, the results from the project would have to be compared to the results of the manual testing; including the actual laboratory testing conducted by the Bureau of Soils and Water Management.

Table 3.1a Comparison of SoilMATIC Results and Manual Tests

| Nutrient | Test # | SoilMatic Result | Manual Test | % Error |
|---|---|---|---|---|
| Potassium (K) | 1st test | | | |
| | 2nd test | | | |
| | 3rd test | | | |
| | **Average** | | | |

Table 3.1b shows how the researchers have created a tabulated record of the functionality of the GSM if it had successfully sent the data to the computer or not, as explained in step 6 from section 3.3.1.5.

Table 3.1b Effectivity of Sending SoilMATIC Results via SMS

| Test # | Success | Unsuccessful |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |

Table 3.1c was also used to document the system's ability to determine the best crop to be planted in an area base on the acquired soil test results. The data from the project are compared with the manual test to see if both tests provide matching results.

Table 3.1c Crop Suggestion

| Soil Sample Location | SoilMATIC | Manual | Match/Not Match |
|---|---|---|---|
| Location 1 | | | |
| Location 2 | | | |
| Location 3 | | | |

### 3.4.2 Safety

To determine the safety of the users, the respondent's will be asked to inspect the aesthetics of the entire project in terms of its outer layout, its weight, and its ability to keep the chemical solution intact. Each criterion can be rated from 1 to 4, 1 being the lowest and 4 being the highest, as perceived by the respondent. Same is true with the next sections below.

Table 3.2a Safety Survey

| | | Rating | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| a. | The design of the chassis is safe to use. (smooth surface, no sharp edges/corners) | | | | |
| b. | The project is easy to carry. | | | | |
| c. | The handling of chemicals is safe. | | | | |

### 3.4.3 Ease of Usage

This section verifies the user-satisfaction as shown on the aspects from Table 3.2 where respondents are asked to try to use the project's outer parts by going through the menu. The main concern is to identify if the system is user-friendly enough.

Table 3.2b Ease of Usage Survey

| | | Rating | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| a. | The charging port is accessible and sturdy. | | | | |
| b. | The keypad is responsive. | | | | |
| c. | The menus are easy to navigate. | | | | |

### 3.4.4 Functionality

This section verifies the efficiency of the system's outputs according to the perception of the respondents. They will be instructed to finish the soil test and also examine the project while it's performing the necessary procedures. With this method, the respondents can properly assess the entirety of the system.

Table 3.2c Functionality Survey

| | | Rating | | | |
|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** |
| a. | The results on the LCD & printer are readable? | | | | |
| b. | The project's test results are accurate? (same w/ manual test results) | | | | |
| c. | The project was able to suggest a crop. | | | | |

## 3.5 Instruments and Techniques to be Used

### 3.5.1 Instruments and Components Used

Soil Test Kit — Used to conduct manual soil tests.

Express PCB — Used to create layout for the pcb.

Express Schematic — Used to virtually simulate the circuitry of the system.

Zilog Developer Studio — Used in uploading the source codes to the project and simulating the software.

Arduino — Used to compile the series of commands for the motors.

Digital Multimeter — Used to measure the parameters (voltage/amperage) of components. It is also used in ensuring the connectivity of components.

### 3.5.2 Techniques Used

Munsell Color Chart — Aided in the calibration process for attaining the numerical RGB value of each nutrient level.

| | |
|---|---|
| NPK Staining Technique | Used as guide on the proper way of conducting the soil test. |
| Project Evaluation | Used to attain feedback from users which is necessary in determining the effectiveness of the project. |

# Chapter IV

# RESULTS AND DISCUSSION

## 4.1 Project Technical Description

This prototype is an automation of the manual soil testing procedure as currently implemented by the Bureau of Soils and Water Management. This prototype aims to advance the usage of the soil testing procedure to a more accurate reading so as to facilitate efficient choice of crops that would best fit on the land area of whose soil sample is subjected for testing. The project's system is mainly controlled by two microcontrollers. The first microcontroller is responsible for the transmission of the GSM technology, gathering the data using the GPS technology, detecting the color using the color sensing module, and printing the output of the test conducted. The 9 motors for the syringe, the rotator motor, the LCD (Liquid Crystal Display), and the keypad used for the selecting the test to be conducted are connected and controlled by the second microcontroller. The color sensor is attached in front of the project inside the testing area. This color sensor contains a LED light to determine the color of the tested soil, and the testing is enclosed so there will be no light that will interfere the color of the soil being tested. The system uses GPS technology that determines the position where the test happened. It will provide the longitude and latitude, and will be printed together with the results. The project is capable of sending the results with the use of GSM technology. The project will send a text message to a specific mobile number. The SIM card is in a broadband stick that is attached to the computer, and the computer process the received text message. The text message contains the result of the test, the GPS gathered data, and the date of the test conducted.

## 4.2 Project Structure and Organization

### 4.2.1 Integration of Software and Hardware

The project contains the GPS and GSM module that features the wireless communication of the system. These modules are installed inside the project, and they are connected to the microcontroller unit. For the GPS module, it will determine the position where the test was conducted, and the data contain the longitude and latitude. The data is needed for the virtual mapping of the system. With the use of an internet connection, the virtual map will be able to view the location. The GSM module is responsible of sending the result of the test with the data gathered by the GPS module into a mobile number.

An LCD screen is installed in front of the project to show the current state of the project. Also, a keypad is installed for the user to choose on what test should be done. For the keypad, 1, 2, 3, 4, *, 0, and # are the only buttons needed to be used in the testing part.

After the testing has been done, a printer will produce a copy of the result, and then, the GSM module will send the results in the PC, so there will be a hard copy and a soft copy of the result. The copy of the printed result contains the following: title of the project, name of the school and the group, date of the test, longitude and latitude, and the result of the test. The data that will be sent via text message includes only the longitude and latitude, date of the test, and result of the test.

There is only one sensor needed for this project. That sensor is the RGB color sensor or the color sensing module. To be able to capture the right color, the color sensor must be placed inside the project that has no light entering inside the prototype. The color sensing module has its own LED light to lights up the test tube that contains the tested soil with the chemical chosen.

In Figure 4.1, the prototype contains the microcontroller units, GSM and GPS Module, and the color sensor. In front of the project, the LCD screen, keypad, and the printer. The two microcontrollers controls all the electronics of the project.

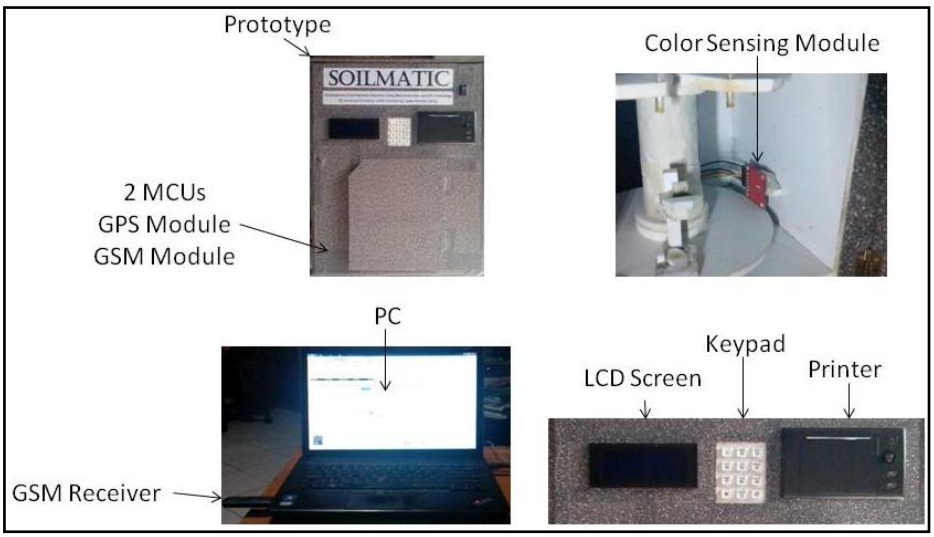



Figure 4.1 Parts of the Project

### 4.2.2 Hardware Constructions

In front of the project, there are LCD Screen, keypad, printer, and color sensing module inside the compartment. Also inside the compartment, there is a test tube rack which is attached in a rotator. At the back of the prototype, the researcher placed the GPS and GSM module near the first microcontroller unit to have a shorter wire to connect. The other microcontroller unit was placed near the motors and the electronics in front of the prototype. All the circuitry is supplied by a 12-volt rechargeable battery.


Figure 4.2 Finished Project

As seen in Figure 4.2, the parts of the project are attached to the prototype. Inside the prototype contains the two (2) microcontrollers, GSM and GPS module, and the color sensing module. The LCD, keypad and printer is seen in front of the prototype. Then, the switch of the whole system is placed on top of the printer. There is no wired connection between the prototype and the PC.

## 4.3 Project Limitation and Capabilities

### 4.3.1 Capabilities

- 100% accuracy of generating the expected output.

  The researchers have done multiple tests and calibration process to the system in order to evaluate the accuracy of results. The manual testing done by lab experts at BWSM have proved that the system can also produce the identical soil test results on the same soil sample.

- Refilling of chemicals are device-aided

  Through the use of coding in the microcontroller, the researchers have enabled the motors to rotate counter clockwise which pull syringe plunger to sip in chemicals through its hose.

- Can be used both inside the laboratory and at the field

  The system also contains a GPS antenna which determines the longitude and latitude data where the test is being done. This adds convenience in the process of gathering the test results to be used for virtual mapping. Also, the system's compact design makes it portable and easy to handle.

- The project is powered by a 12-volt rechargeable battery that can test 2-3 soil samples.

  The project is equipped with a backup battery that can supply power to the whole system for a few hours which is enough to conduct two to three tests.

### 4.3.2 Limitations

- Soil samples have to be manually put on the rack for testing.

  The user would have to place the soil sample manually so as to

- Only one (1) testing of a soil sample at a time.

  In order to avoid the contamination of chemical solutions, each stage of the soil test has to be done separately otherwise the results won't be as accurate.

- Testing time is 74 minutes up to 82 minutes.

  After observation during multiple tests, the researchers tabulated the amount of time the system needs to complete the soil tests and took the average. It would be 74 minutes if the systems detects that the pH level of the soil is within the CPR level. However, if it is lower or higher than the given range of CPR, then another test must be conducted, either BTB or BCG, in order to attain the exact acidity of the soil which makes up the maximum test duration of 82 minutes.

- No indicator that will determine if the system needed to refill the chemicals.

  The system cannot show the amount of chemicals left in the hose. However, limit switches has been placed on the syringes which acts as a trigger to the motors if the limit has been reached thus preventing the system from being damaged.

- No indicator that will show the percentage of the battery charge.

  The system does not show the battery level of the system. The project needs to be plugged into the power outlet as often as possible or during laboratory use.

- Results only follow the ones used by the Bureau of Soils and Water Management in its official reports to clients.

  The project is limited to the information gathered from BWSM in terms of its nutrient level and crop suggestion.

## 4.4 Project Evaluation

### 4.4.1 Accuracy Test

The researcher tested the accuracy of the project in doing 3 tests done by the system and done manually by the researchers in each chemical shown in Table 4.1a. From the Potassium test, 3 out of 3 tests done by the system matched the manual test result. From the pH test, 3 out of 3 tests done by the system were the same as the manual test result. From the Nitrogen test, 3 out of 3 tests done by the system were the same as the manual test result. From the Potassium test, 3 out of 3 tests done by the system is identical with the manual test result. All the tests have an average percentage error of 0%.

Table 4.1a Testing Results

| I. COMPARISON OF SOILMATIC RESULTS AND MANUAL TESTS | | | | |
|---|---|---|---|---|
| **Nutrient** | **Test #** | **SoilMatic Result** | **Manual Test** | **% Error** |
| Potassium (K) | 1st test | Present | Present | 0 |
| | 2nd test | Present | Present | 0 |
| | 3rd test | Present | Present | 0 |
| | **Average** | | | 0% |
| pH Level (pH) | 1st test | 6.8 | 6.8 | 0 |
| | 2nd test | 7.2 | 7.2 | 0 |
| | 3rd test | 7.6 | 7.6 | 0 |
| | **Average** | | | 0% |
| Nitrogen (N) | 1st test | Low | Low | 0 |
| | 2nd test | Low | Low | 0 |
| | 3rd test | Low | Low | 0 |
| | **Average** | | | 0% |

| | | | | |
|---|---|---|---|---|
| Phosphorus (P) | 1st test | Medium | Medium | 0 |
| | 2nd test | Low | Low | 0 |
| | 3rd test | Low | Low | 0 |
| | **Average** | | | 0% |

The results of the test will be used in determining the right crop to be planted in the soil being tested. For the Potassium test, if the result is present, it means that the soil can easily absorb water, and it will help the plant to have strong roots, tough stems, and longer shelf life. In pH testing, it determines the degree of acidity and alkalinity. Soil pH ranging from 5.5 to 7.0 is the readily available form for most of the plant nutrients, and most plants prefer to grow within this range. The Nitrogen test determines the capability of the soil to serve as a building block that provides protein to the plant. For the Phosphorus test, if the result is high, the soil will provide strong growth to the plant, and if the result is low, the plant will be smaller and will have discoloration and small fruits and flowers.

### 4.4.2 Effectivity Testing

The researcher tested also the effectivity of the GSM module by sending the result to the PC via text message shown in Table 4.1b. The test has been done after the Potassium test seen in Table 4.1a. From the Potassium test, 3 out of 3 were sent and received by the PC.

Table 4.1b SMS Sending Testing Result

| **II. EFFECTIVITY OF SENDING SOILMATIC RESULTS VIA SMS** | | |
|---|---|---|
| **Test #** | **Success** | **Unsuccessful** |
| 1 | 1 | 0 |
| 2 | 1 | 0 |

| | | |
|---|---|---|
| 3 | 1 | 0 |

The researcher also conducted three (3) tests to determine the effectivity of the crop suggestion software as shown in Table 4.1c. The result of the tests is based on the tests done in Table 4.1a.

Table 4.1c Crop Suggestion Testing Result

| **III. CROP SUGGESTION** | | | |
|---|---|---|---|
| **Soil Sample Location** | **SoilMatic** | **Manual** | **Match/Not Match** |
| Parañaque | Mongo and Sitaw | Mongo and Sitaw | Match |
| Marikina | Garlic and Tomato | Garlic and Tomato | Match |
| Marikina | Tomato | Tomato | Match |

In Table 4.1c, to be able to get the suggested is to input the Potassium, pH, Nitrogen, and Phosphorus tests done in Table 4.1a. As shown in Table 4.1c, the crop suggestion software has been able to match the same suggested crop done manually.

### 4.4.3 Safety Test

The researchers performed a survey to measure the safety of the project. The survey includes the following questions: 1 - The design of the chassis is safe to use (smooth surface, no sharp edges/corners), 2 - The project is easy to carry, 3 - The handling of chemicals is safe. Ten (10) respondents were able to answer the survey by rating it 1 to 4 where 1 is the lowest and 4 is the highest. All of the respondents are first time users of the project.

Table 4.2a Safety Survey Result

| | Rating | | | |
|---|---|---|---|---|
| Criteria | 1 | 2 | 3 | 4 |
| 1) The design of the chassis is safe to use (smooth surface, no sharp edges/corners) | 0 | 3 | 7 | 0 |
| 2) The project is easy to carry. | 0 | 1 | 5 | 4 |
| 3) The handling of chemicals is safe. | 0 | 0 | 1 | 9 |
| **Total Rating** | **0** | **4** | **13** | **13** |
| Points per rating | (1) | (2) | (3) | (4) |
| **Overall Points** | **0** | **8** | **39** | **52** |

$$\frac{\Sigma \text{ Overall points}}{\text{Perfect Score}} \times 100\% = \text{Total percentage} \qquad \frac{99}{120} \times 100\% = 82.5\% \qquad \textbf{Eq. 4.1}$$

The safeness of the project had been evaluated by summing the number of respondents who answered the survey rating from 1 to 4. The total score for each criterion is multiplied by the points per rating, and the overall rating will be summed up and the result is 99. It is divided by the perfect score which is 120, and will be multiplied by 100% to get the total percentage. The total percentage of the survey about the safety is 82.5%.

### 4.4.4 Ease of Usage Test

The researchers also conducted a survey about the comfortability of the user in using the project. The survey contains: 1 - The charging port is accessible and sturdy, 2 – the keypad is responsive, 3 – The menus are easy to navigate. Ten (10) respondents also answered the questions by marking it from 1 to 4 where 4 is the highest and 1 is the lowest.

Table 4.2b Ease of Usage Survey Result

| | Rating | | | |
|---|---|---|---|---|
| Criteria | **1** | **2** | **3** | **4** |
| 1) The charging port is accessible and | 0 | 0 | 2 | 8 |

| | | | | |
|---|---|---|---|---|
| sturdy. | | | | |
| 2) The keypad is responsive. | 0 | 0 | 1 | 9 |
| 3) The menus are easy to navigate. | 0 | 0 | 4 | 6 |
| **Total Rating** | **0** | **0** | **7** | **23** |
| Points per rating | (1) | (2) | (3) | (4) |
| **Overall Points** | **0** | **0** | **21** | **92** |

$$\frac{\Sigma \text{ Overall points}}{\text{Perfect Score}} \times 100\% = \text{Total percentage} \qquad \frac{113}{120} \times 100\% = 94.17\% \qquad \textbf{Eq. 4.2}$$

The ease of usage had been calculated by summing up the number of respondents who answered the survey rating from 1 to 4. The total rating for each criterion is multiplied by the points per rating, and the overall rating will be summed up and the result is 113. It is divided by the perfect score which is 120, and will be multiplied by 100% to get the total percentage. The total percentage of the survey about the ease of usage of the project is 94.17%.

### 4.4.5 Functionality Test

The researchers also did a survey about the functionality of the project. This will show that the first time users will be satisfied with the projects output. The survey contains: 1 - The results on the LCD & printer are readable, 2 – The project's test results are accurate (same w/ manual test results), 3 – The project was able to suggest a crop. Ten (10) respondents also answered the questions by rating it from 1 to 4 where 4 is the highest and 1 is the lowest.

Table 4.2c Functionality Survey Result

| | Rating | | | |
|---|---|---|---|---|
| Criteria | **1** | **2** | **3** | **4** |
| 1) The results on the LCD & printer are readable? | 0 | 0 | 3 | 7 |
| 2) The project's test results are accurate? (same w/ manual test results) | 0 | 0 | 0 | 10 |

| | | | | |
|---|---|---|---|---|
| 3) The project was able to suggest a crop. | 0 | 0 | 0 | 10 |
| **Total Rating** | **0** | **0** | **3** | **27** |
| Points per rating | (1) | (2) | (3) | (4) |
| **Overall Points** | **0** | **0** | **9** | **108** |

$$\frac{\Sigma \text{ Overall points}}{\text{Perfect Score}} \times 100\% = \text{Total percentage} \quad \frac{117}{120} \times 100\% = 97.5\% \qquad \textbf{Eq. 4.3}$$

The functionality survey had been evaluated by summing up the number of respondents who answered the survey rating from 1 to 4. The total score for each criterion is multiplied by the points per rating, and the overall rating will be summed up and the result is 117. It is divided by the perfect score which is 120, and will be multiplied by 100% to get the total percentage. The total percentage of the survey about the functionality of the project is 97.5%.

# Chapter V

# SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

## 5.1 Summary of Findings

From gathering all the test results from the project and comparing it to the manual tests, the proponents have ensured the accuracy of the project. Then, the researchers performed a survey to test the safety, ease of usage, and the functionality of the project. The overall result of each test and survey is shown under Table 5.1.

Table 5.1 Overall Results of the Tests and Survey

| Category | Acceptable Results | Test & Survey Results | Remarks |
|---|---|---|---|
| Accuracy | 80% to 100% | 100% | Passed |
| Effectivity | 80% to 100% | 100% | Passed |
| Safety Survey | 80% to 100% | 82.5% | Passed |
| Ease of Usage Survey | 80% to 100% | 94.17% | Passed |
| Functionality Survey | 80% to 100% | 97.5% | Passed |

In Table 5.1, the researchers performed three (3) tests to determine if the system will produce the correct output. The researchers also did a manual testing for the comparison of the test done by the system. The results of the tests in accuracy and effectivity can be seen in Table 4.1a, Table 4.1b, and Table 4.1c. With the comparison of the test done by the system and test done by the researchers, it is said to be 100% accurate and effective.

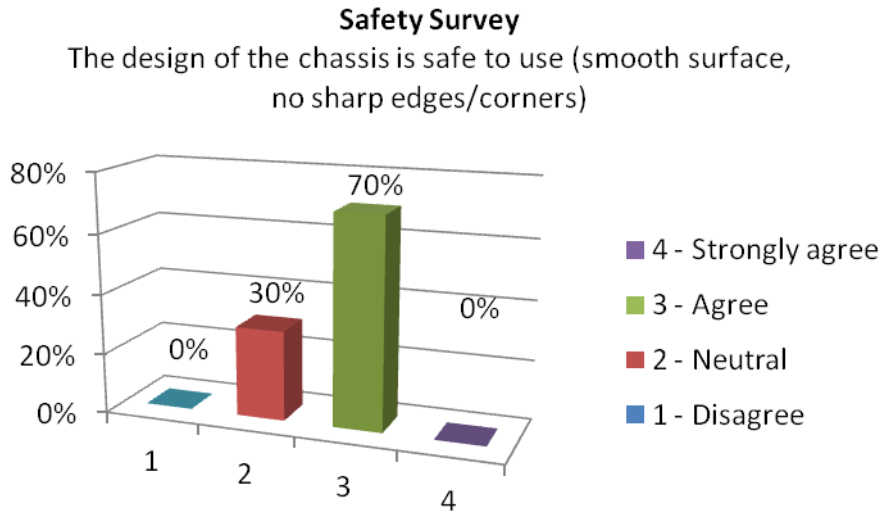



Figure 5.1 Design of the Chassis is Safe to Use Result

The respondents answered a survey to test about the safety of the project, ease of usage, and functionality of the project. The respondents are all first time users of the project.

In Figure 5.1 illustrates the results of the safety of the design of the project to the user. As expected feedback from the respondents, the design is good for the system but not excellent.

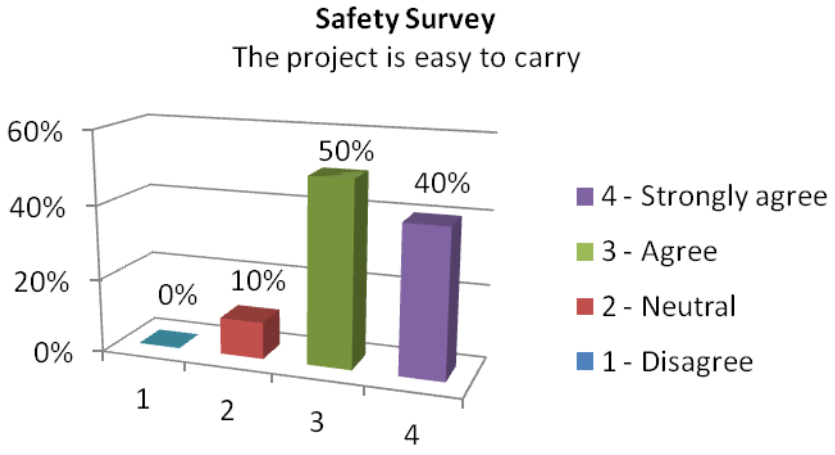



Figure 5.2 Project Is Easy to Carry Result

In Figure 5.2 shows the result of the safety if it can be easily carried by the respondent. According to the respondents, the project is slightly lighter with its size. Most

of the respondents can bring the project from one place to another.

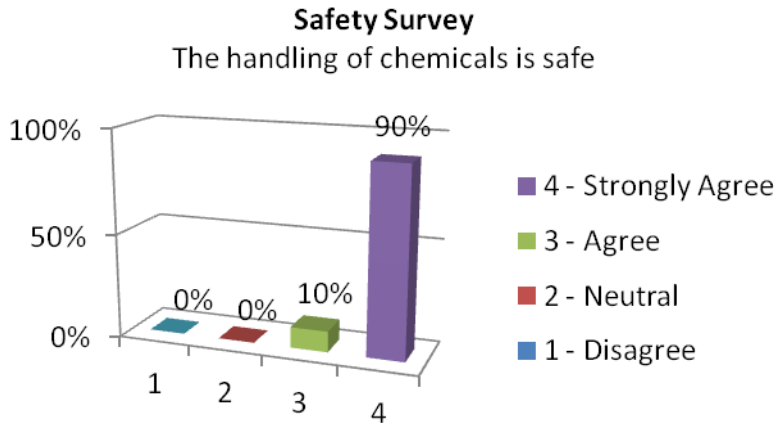



Figure 5.3 Handling of Chemicals is Safe Result

In Figure 5.3 shows the result of the safety if the handling of chemicals is safe. According to the respondents, the chemicals will have no contact with the user. Most of the respondents agreed that the project has safely handled the chemicals used in this project.

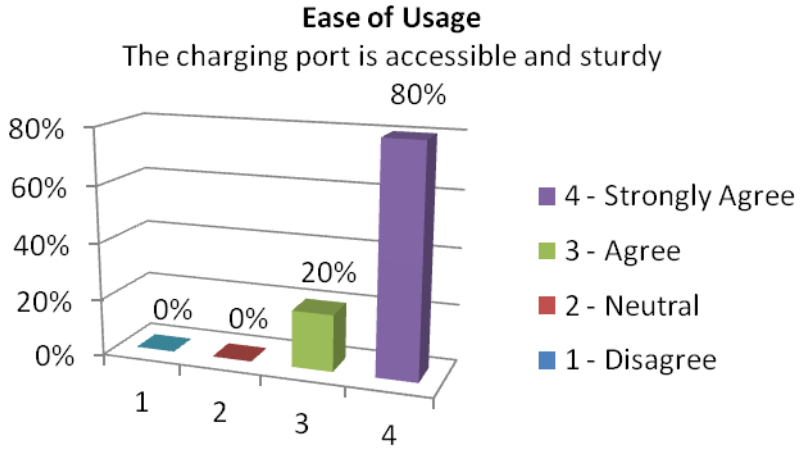



Figure 5.4 Charging Port Is Accessible and Sturdy Result

The researchers were pleased with the results of the survey shown in Figure 5.4. The respondents commented that the project can charge easily like an electronic device. Also, the respondents are well-informed of the label above the charging port. 80% of the correspondents gave the highest rating on this survey which is 4.

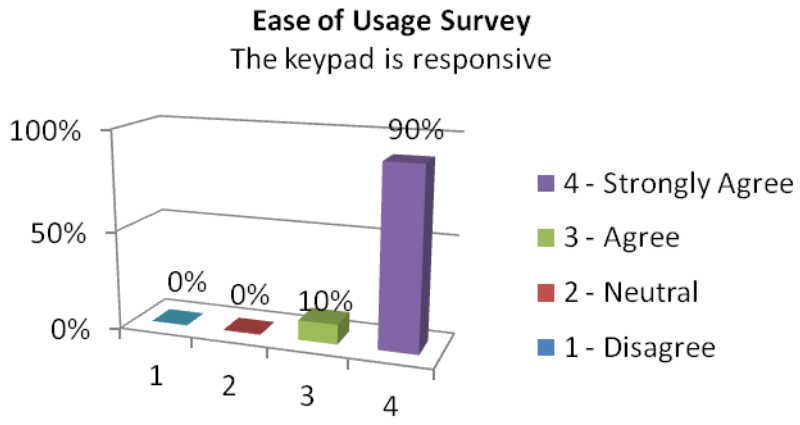
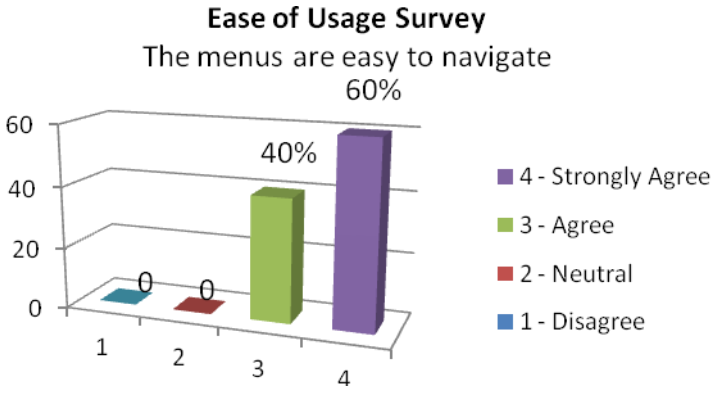



Figure 5.5 Keypad Is Responsive Result

With the first timer respondents, they were able to press the buttons in the keypad easily. 90% of the respondents easily managed to control the system and started testing. The researchers were satisfied with the comments and results given by the




respondents.

Figure 5.6 Menus Are Easy to Navigate

Once the system is turned on, the LCD screen will show the name of the project, the name of the school, and the group's name. More than half of the respondents easily saw and read the information shown in the LCD screen. The other 40% commented that the font size is slightly small but still readable.

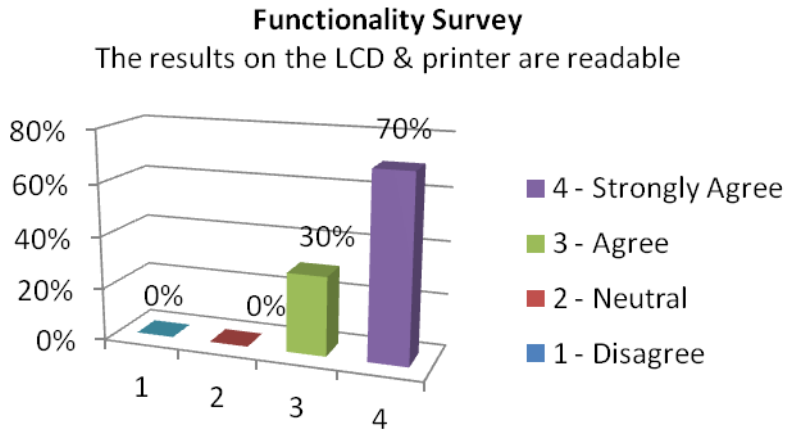



Figure 5.7 Results on the LCD and Printer Are Readable

The output of the system can be viewed in the printed result and in the LCD Screen. Most of the respondents were able to read the results clearly. 70% of the respondents are very satisfied in reading the output of the system. The results printed are very simple according to the respondents which are excellent for them.

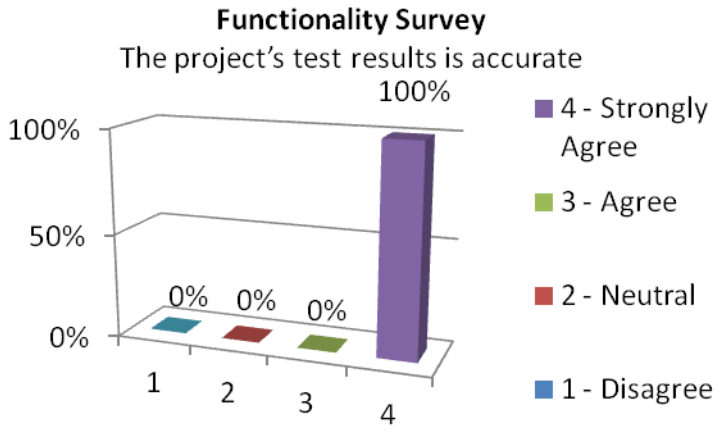



Figure 5.8 Project's Test Result Is Accurate

With the sample test done by the researchers in Table 4.1a, the respondents also got the expected results. The prefer having their test with the project than the manual test because the project will produce a hard copy and soft copy of the results.

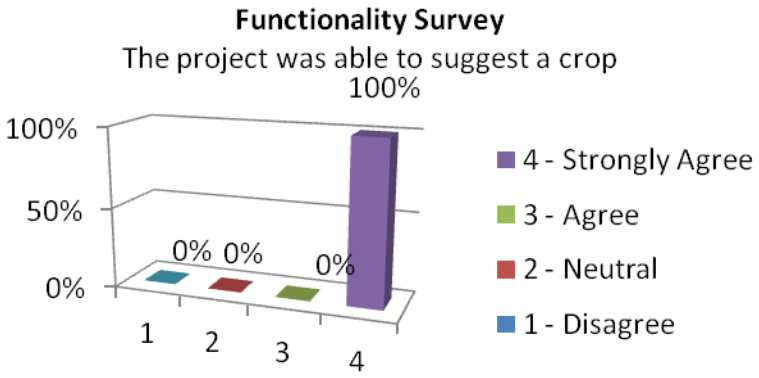



Figure 5.9 Project Was Able to Suggest a Crop

The survey result of the criterion as seen in Figure 5.9 received a perfect rating. The respondents easily determined the crop to be planted. If it is used manually, the respondent must search in a given booklet and find the result of the test and it takes time to search for the crop suggested, but with the projects capability, in a matter of seconds the respondent already know the crop to be planted.

## 5.2 Conclusions

The system was able to fulfill its objective of attaining the soil nutrient level and suggest crop/s that can be planted in an area by:

- Developing a system that can perform the chemical staining process automatically through the use of microcontroller-controlled motors.

  By attaining a passing mark on accuracy from both the testing and surveying method, as shown in Table 5.1 and Figure 5.8, it is concluded that the system can dispense the right amount of chemical solution and perform the swirling process correctly thus producing the expected soil testing results.

- Integrating a color sensing module to microcontrollers in order to determine the soil nutrient level for Nitrogen, Potassium, Phosphorus and also the pH level of soil.

  From conducting the accuracy test as shown from Table 4.1a, the

researchers have proven that the system can produce accurate soil test results. This was justified by attaining the same results as compared with the results accumulated manually by the researchers and lab experts from BWSM.

- Adding LCD and printer to the system in order to produce soft and hard copy of results.

The feedback gathered from survey respondents, as seen from Figure 5.7, justified that the system provides readable copy of results on the liquid crystal display or on the printed copy.

- Integrating GPS and GSM to communicate to the PC interface and let the user determine the geographical location and crop suggestion from a soil sample.

Through thorough evaluation process, the researchers have concluded that the system can successfully send the test results to the computer as shown in Table 4.1b where 100% sending functionality is recorded. Also, the pc interface shows the longitude and latitude location of the test site.

- Allowing the user to save the gathered data into .txt file.

Multiple tests were also done to assure that the PC interface allows the user to save the test results in text format. It was also confirmed that the file can be opened in other computers without visual basic application.

## 5.3 Recommendations

The following are further studies and improvements which may be pursued in the future:

- Create a program that can save the soil analysis data into the virtual map for public use.
- Additional solar-powered back up battery.
- More compact chassis design.
- Study on wider scope of crop suggestion.

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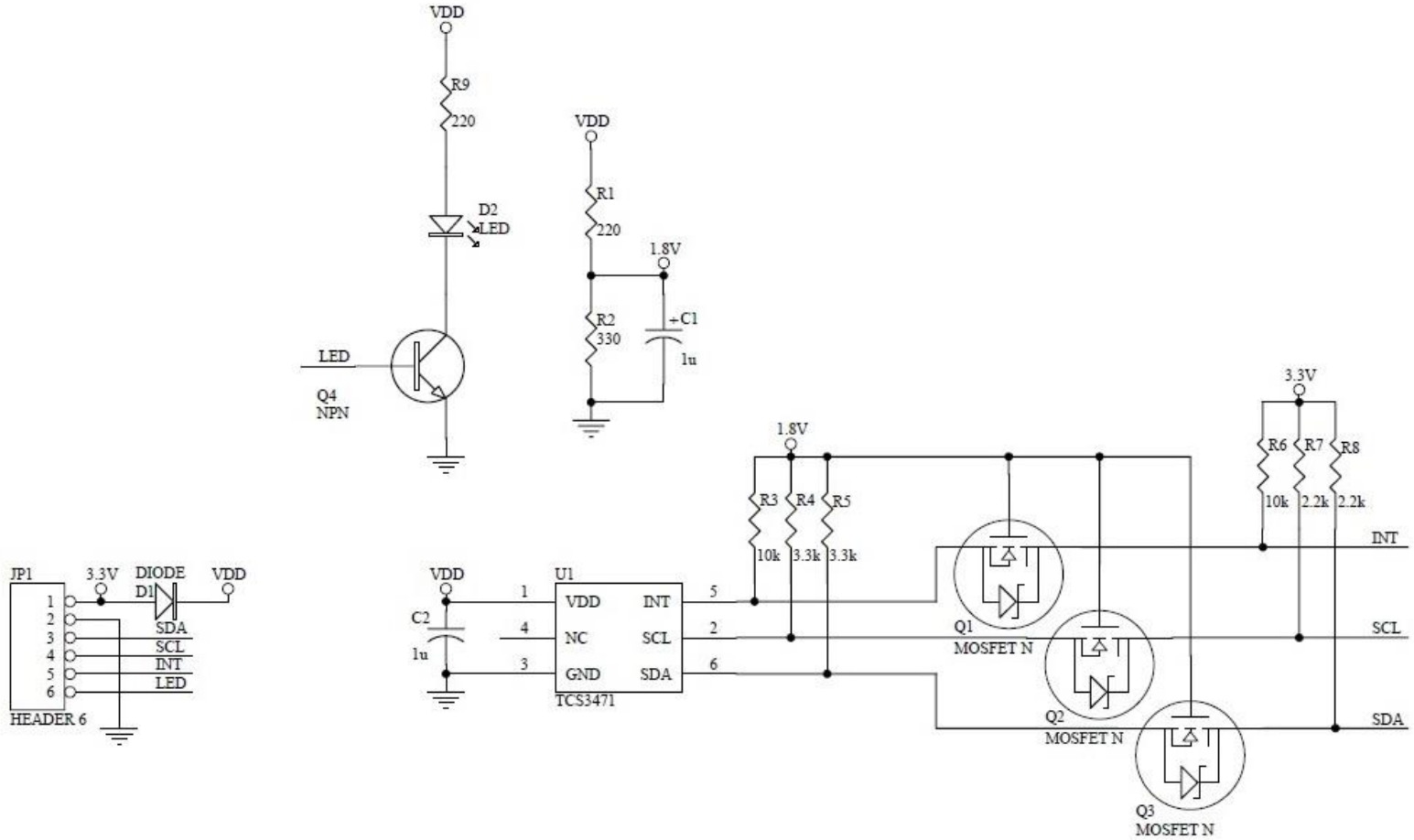
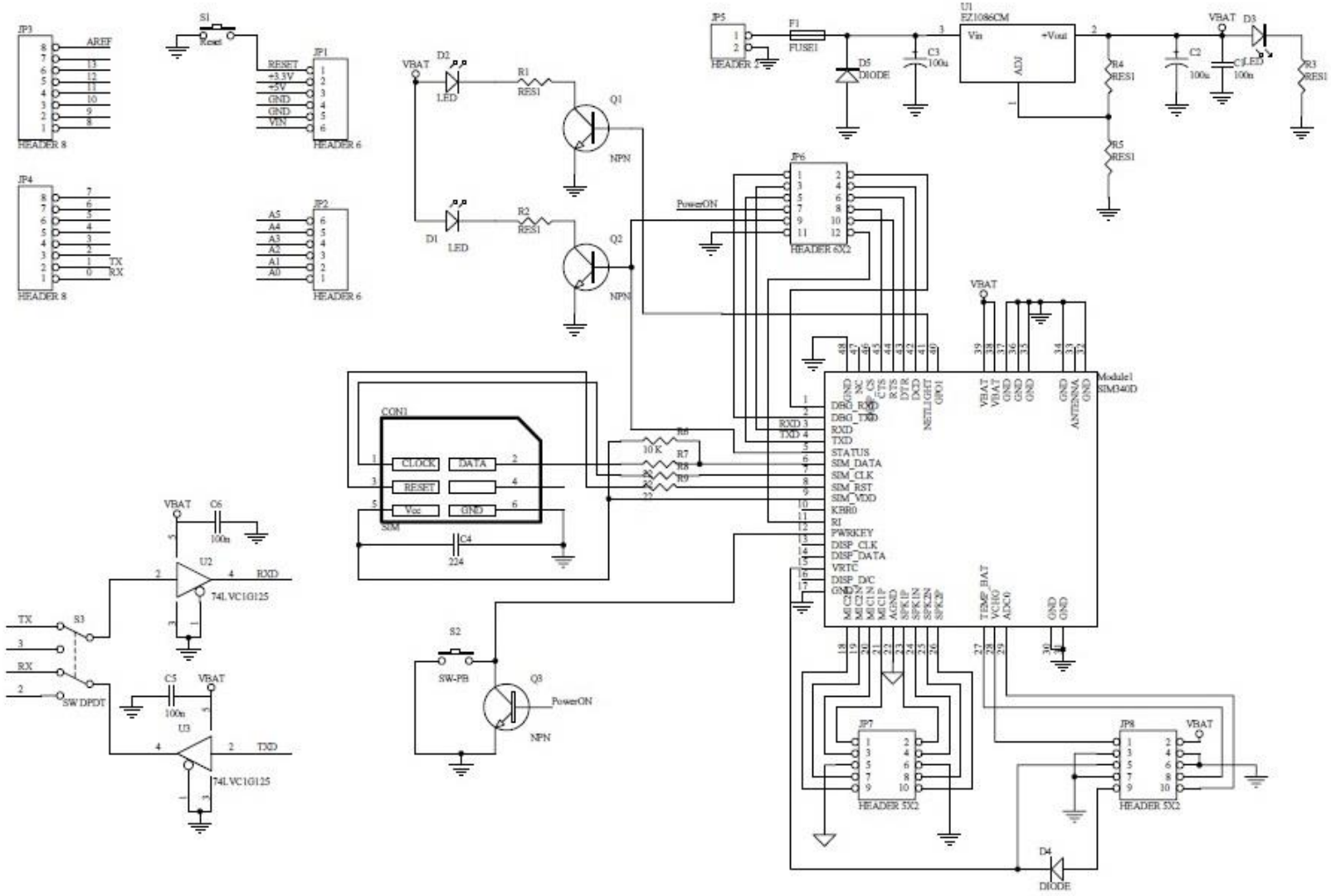
# APPENDIX A

# SCHEMATIC DIAGRAM

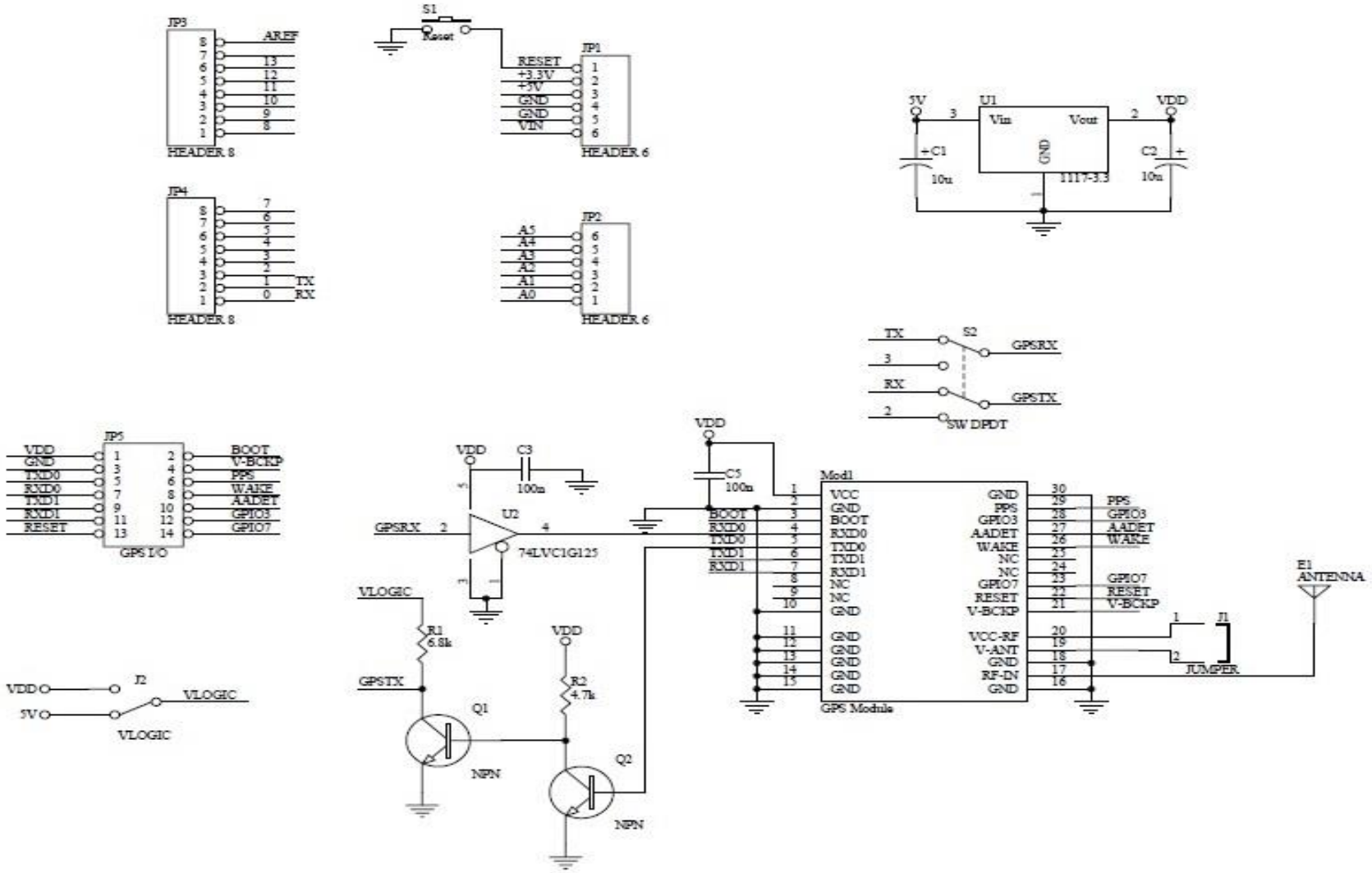
**Color Sensor Schematic Diagram**



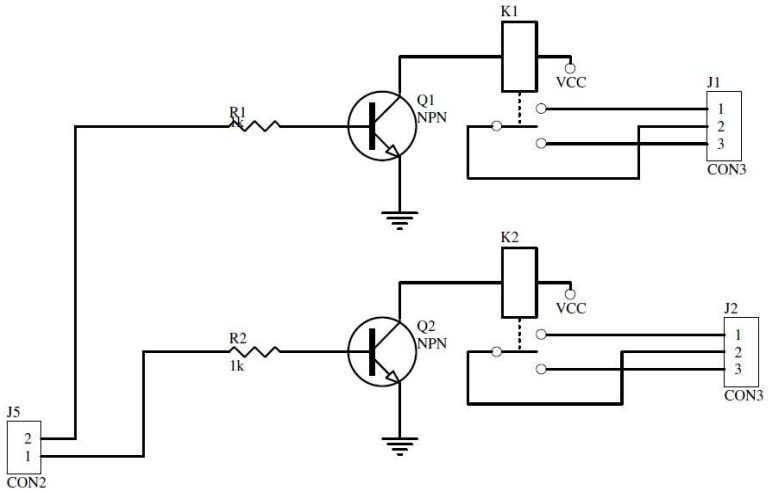
**GSM Schematic Diagram**



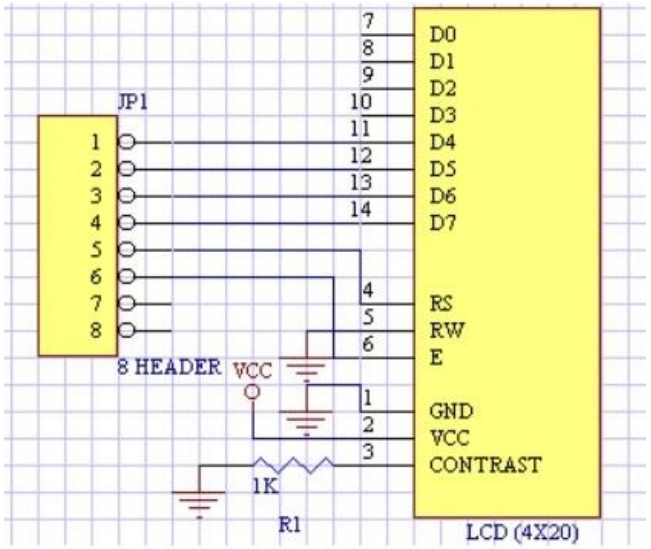
## GPS Schematic Diagram



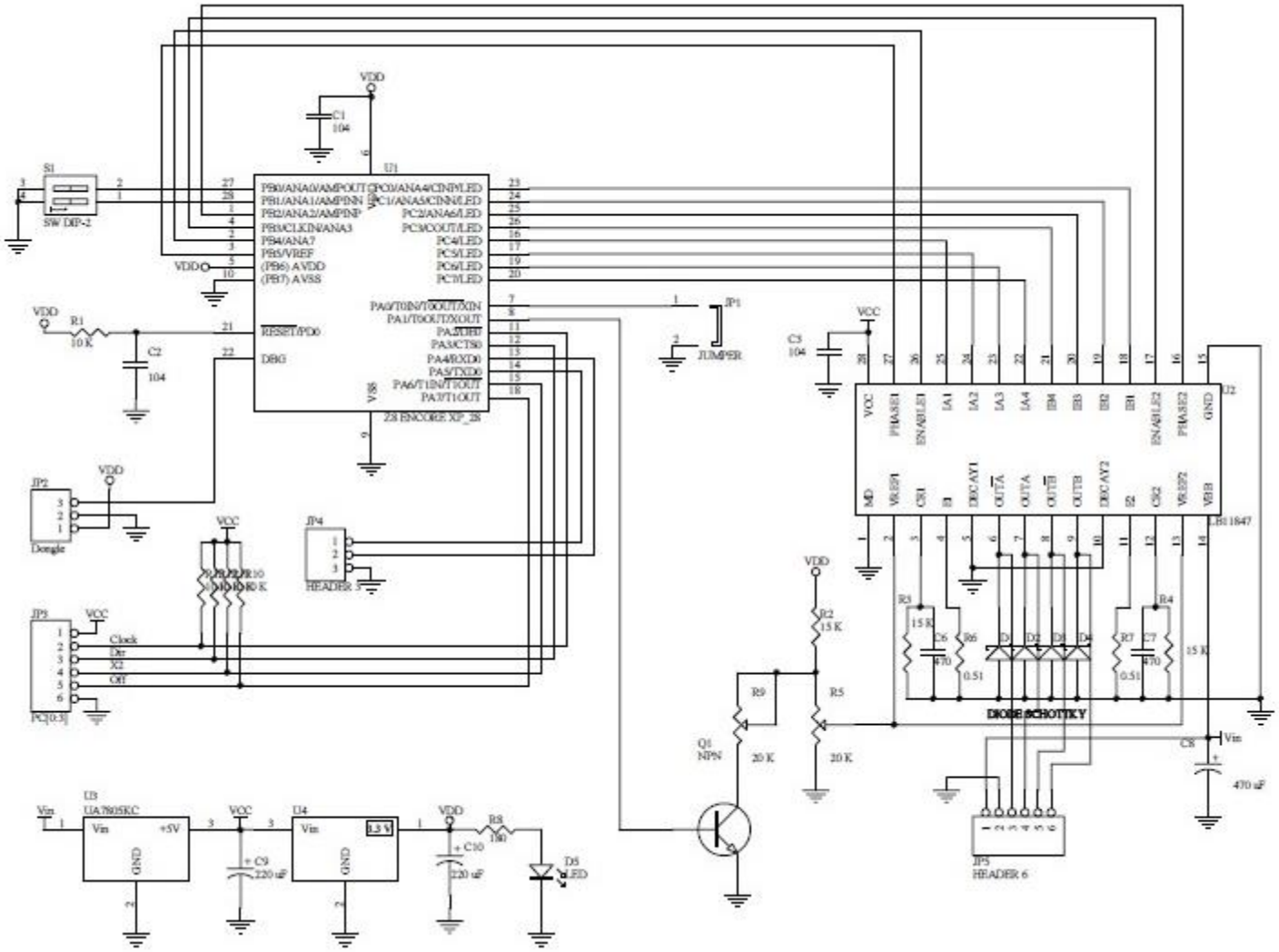
## Relay Schematic Diagram



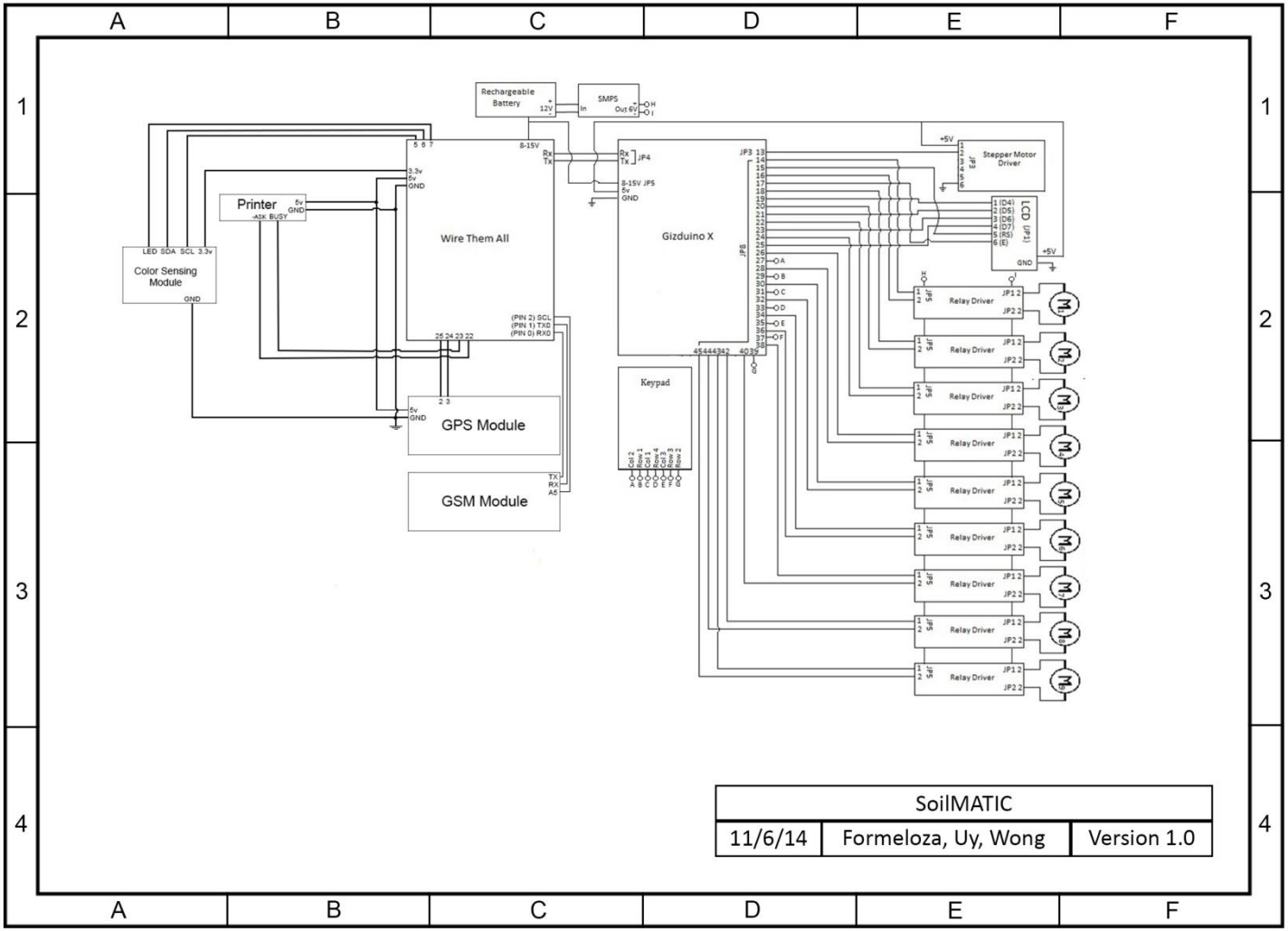

## LCD Schematic Diagram



**Stepper Motor**


VDD
C1
104
S1
SW DIP-2
U1
P00/ANA0/AMPOUT
P01/ANA1/AMPINN
P02/ANA2/AMPINP
P03/CLKIN/ANA3
P04/ANA7
P05/VREF
(P06) AVDD
(P07) AVSS
PC0/ANA4/CINP/LED
PC1/ANA5/CINN/LED
PC2/ANA6/LED
PC3/CCOUT/LED
PC4/LED
PC5/LED
PC6/LED
PC7/LED
PA0/T0IN/T0OUT/TX
PA1/T0OUT/TX
PA2/INT
PA3/CTS0
PA4/RXD0
PA5/TXD0
PA6/T1IN/T1OUT
PA7/T1OUT
Z8 ENCORE XP_28
R1
10 K
RESET/PD0
DBG
C2
104
JP1
JUMPER
JP2
Dongle
JP4
HEADER 3
R10
10 K
JP3
Clock
Dir
X2
Off
PC[0:3]
U2
LB1847
R2
15 K
R5
20 K
R9
20 K
Q1
NPN
R3
15 K
R4
15 K
C6
470
C7
470
R6
0.51
R7
0.51
D1
D2
D3
D4
DIODE SCHOTTKY
C8
470 uF
JP5
HEADER 6
U3
UA7805KC
+5V
U4
3.3 V
C9
220 uF
C10
220 uF
R8
180
D5
LED

## Wiring Map


A
B
C
D
E
F
1
2
3
4
Rechargeable Battery
SMPS
Wire Them All
Gizduino X
Stepper Motor Driver
LCD
Printer
Color Sensing Module
GPS Module
GSM Module
Keypad
Relay Driver
SoilMATIC
11/6/14
Formeloza, Uy, Wong
Version 1.0

**APPENDIX B**

**SOURCE CODES**

## Arduino

```
// include the library code:
#include <LiquidCrystal.h>
#include <dht11.h>

dht11 DHT11;



int NumIn = 20;
int NumOut = 20;
int Input[20] = {2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, A0, A1, A2, A3, A4,
A5, A6, A7};
int Output[20] = {14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42,
44, 43, 45};
int stat[20];
int debH[20];
int debL[20];
int reload = 1000;
int i;

#define CLK_STEP 13
#define SENSOR              12

char key;
byte menu;

char  Data[25] ;       // to hold incoming data
boolean DataComplete = false;  // whether the string is complete
byte count;
int Num_Steps[9] = {0, 44, 89, 133, 178, 222, 267, 311, 355};
byte mode;

// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(15, 17, 19, 21, 23, 25);

void setup(void)
{
  Serial.begin(9600);
  lcd.begin(20, 4);
  init_keypad();
  for(i=0; i<NumOut; i++)
  {
    pinMode(Output[i], OUTPUT);
  }
  pinMode(SENSOR,INPUT_PULLUP);
  pinMode(CLK_STEP,OUTPUT);
  digitalWrite(CLK_STEP,HIGH);

  key = scankey();
  if(key == '0') {
    mode = 1;        //refill mode
  }
  w8_key_release();
}

void loop(void)
{
  if(mode)
  {
  key = scankey();
  if(key == '#') {
    mode = 0;
  }
  if(key == '*') {
    Serial.print("WTV*\r");
    w8_key_release();
  }
  if(key == '0') {
    Serial.print("WTVS\r");
    w8_key_release();
//    Serial.print("WTVS\r");
  }
  if(key == '1') {
    Serial.print("WTV1\r");
    w8_key_release();
//    Serial.print("WTVS\r");
  }
  if(key == '2') {
    Serial.print("WTV2\r");
    w8_key_release();
//    Serial.print("WTVS\r");
  }
  if(key == '3') {
    Serial.print("WTV3\r");
    w8_key_release();
//    Serial.print("WTVS\r");
  }
  if(key == '4') {
    Serial.print("WTV4\r");
    w8_key_release();
//    Serial.print("WTVS\r");
  }
  if(key == '5') {
    Serial.print("WTV5\r");
    w8_key_release();
//    Serial.print("WTVS\r");
  }
  if(key == '6') {
    Serial.print("WTV6\r");
    w8_key_release();
//    Serial.print("WTVS\r");
  }
  if(key == '7') {
    Serial.print("WTV7\r");
    w8_key_release();
//    Serial.print("WTVS\r");
  }
  if(key == '8') {
    Serial.print("WTV8\r");
    w8_key_release();
//    Serial.print("WTVS\r");
  }
  if(key == '9') {
    Serial.print("WTV9\r");
    w8_key_release();
//    Serial.print("WTVS\r");
  }
  }

  if (DataComplete)
  {
    if(count == 5)
    {
      //3 motor, 4 state
      if (Data[4]=='2')
      {
        step_to_sense(SENSOR);
        step(Num_Steps[(Data[3]-1)], 0);
        Serial.print("OK\r");
      }
      if (Data[4]=='1')
        digitalWrite(Output[Data[3]-1],HIGH);
      if (Data[4]=='0')
        digitalWrite(Output[Data[3]-1],LOW);
    }
    else
    {
      lcd.clear();
      lcd.setCursor(0,0);
      count = 3;
      while(Data[count])
```

```
        {
          lcd.print(Data[count]);
          count++;
        }

    }

    clearString(Data);
    count = 0;
    DataComplete = false;
  }

  if(mode == 0)
  {
  if(menu == 0) {
    Display();
//    Read_Sensors();
    key = scankey();
    if(key == '#') {
      menu = 1;
      Disp_Menu();
      w8_key_release();
    }
    if(key == '*') {
      step_to_sense(SENSOR);
      step(380,0);
      w8_key_release();
    }
  }

  if(menu == 1) {
    key = scankey();
    if(key == '*') {
      menu = 0;
      lcd.clear();
      w8_key_release();
    }
    if(key == '1') {
//      menu = 0;
      Disp_K();
      Serial.print("WTA1\r");
      w8_key_release();
    }
    if(key == '2') {
      menu = 2;
      Disp_PH_Menu();
      w8_key_release();
    }
    if(key == '3') {
//      menu = 0;
      Disp_N();
      Serial.print("WTA5\r");
      w8_key_release();
    }
    if(key == '4') {
//      menu = 0;
      Disp_P();
      Serial.print("WTA6\r");
      w8_key_release();
    }
  }

  if(menu == 2) {
    key = scankey();
    if(key == '*') {
      menu = 1;
      Disp_Menu();
      w8_key_release();
    }
    if(key == '1') {
//      menu = 0;
      Disp_PhCPR();
      Serial.print("WTA2\r");
      w8_key_release();
    }
    if(key == '2') {
//      menu = 0;
      Disp_PhBTB();
      Serial.print("WTA3\r");
      w8_key_release();
    }
    if(key == '3') {
//      menu = 0;
      Disp_PhBCG();
      Serial.print("WTA4\r");
      w8_key_release();
    }
  }
  }
}

void step(long cnt,char dir)
{
//      pinMode(CLK_STEP,OUTPUT);
//      pinMode(DIR_STEP,OUTPUT);
      while(cnt)
      {
            digitalWrite(CLK_STEP,LOW);
            delay(5);
            digitalWrite(CLK_STEP,HIGH);
            delay(5);
            cnt--;
      }
}

//long val=200;
void step_to_sense(char pin)
{
//      pinMode(pin,INPUT_PULLUP);
//      step(100,0);
//      pinMode(DIR_STEP,OUTPUT);
      while(digitalRead(pin))
      {
            digitalWrite(CLK_STEP,LOW);
            delay(5);
            digitalWrite(CLK_STEP,HIGH);
            delay(5);
      }
      while(!digitalRead(pin))
      {
            digitalWrite(CLK_STEP,LOW);
            delay(5);
            digitalWrite(CLK_STEP,HIGH);
            delay(5);
      }
//      val=8;//for calibration to off state of DMM
      step(132,0);
}

void Display(void)
{
  lcd.setCursor(0,0);
  lcd.print("    SoilMATIC     ");
  lcd.setCursor(0,1);
  lcd.print("   Asia Pacific   ");
  lcd.setCursor(0,2);
  lcd.print("     College      ");
  lcd.setCursor(0,3);
  lcd.print("       UFW        ");

}

void Disp_Menu(void)
{
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("1. Potasium");
  lcd.setCursor(0,1);
  lcd.print("2. PH");
  lcd.setCursor(0,2);
```

```
  lcd.print("3. Nitrogen");
  lcd.setCursor(0,3);
  lcd.print("4. Phosphorus");
}

void Disp_PH_Menu(void)
{
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("1. CPR");
  lcd.setCursor(0,1);
  lcd.print("2. BTB");
  lcd.setCursor(0,2);
  lcd.print("3. BCG");
}

void Disp_K(void)
{
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("Potasium test");
//  lcd.setCursor(0,1);
//  lcd.print("2. PH");
  lcd.setCursor(2,2);
  lcd.print("please wait...");
//  lcd.setCursor(0,3);
//  lcd.print("4. Phosphorus");
}

void Disp_PhCPR(void)
{
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("PH test (CPR)");
//  lcd.setCursor(0,1);
//  lcd.print("2. PH");
  lcd.setCursor(2,2);
  lcd.print("please wait...");
//  lcd.setCursor(0,3);
//  lcd.print("4. Phosphorus");
}

void Disp_PhBTB(void)
{
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("PH test (BTB)");
//  lcd.setCursor(0,1);
//  lcd.print("2. PH");
  lcd.setCursor(2,2);
  lcd.print("please wait...");
//  lcd.setCursor(0,3);
//  lcd.print("4. Phosphorus");
}

void Disp_PhBCG(void)
{
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("PH test (BCG)");
//  lcd.setCursor(0,1);
//  lcd.print("2. PH");
  lcd.setCursor(2,2);
  lcd.print("please wait...");
//  lcd.setCursor(0,3);
//  lcd.print("4. Phosphorus");
}

void Disp_N(void)
{
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("Nitrogen test");
//  lcd.setCursor(0,1);
//  lcd.print("2. PH");
  lcd.setCursor(2,2);
  lcd.print("please wait...");
//  lcd.setCursor(0,3);
//  lcd.print("4. Phosphorus");
}

void Disp_P(void)
{
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("Phosphorus test");
//  lcd.setCursor(0,1);
//  lcd.print("2. PH");
  lcd.setCursor(2,2);
  lcd.print("please wait...");
//  lcd.setCursor(0,3);
//  lcd.print("4. Phosphorus");
}

void INPUTS(void)
{
  if(digitalRead(Input[i])) {
    debL[i] = reload;
    if(debH[i] > 0)
      debH[i]--;
    else if(!stat[i]){
      Serial.print("OFF");
      Serial.print(i+1);
      Serial.print("\r\n");
      stat[i] = 1;
    }
  }
  else {
    debH[i] = reload;
    if(debL[i] > 0)
      debL[i]--;
    else if(stat[i]){
      Serial.print("ON");
      Serial.print(i+1);
      Serial.print("\r\n");
      stat[i] = 0;
    }
  }

  i++;
  if(i >= NumIn)
    i = 0;
}

/*
 SerialEvent occurs whenever a new data comes in the
 hardware serial RX.  This routine is run between each
 time loop() runs, so using delay inside loop can delay
 response.  Multiple bytes of data may be available.
 */
void serialEvent() {
 while (Serial.available()) {
  // get the new byte:
  char inChar = (char)Serial.read();

  if(count == 0 && inChar != 'W')
    continue;
  if((count == 1 && inChar != 'T') || (count == 2 && inChar != 'A')) {
    clearString(Data);
    count = 0;
    continue;
  }
  // add it to the inputString:
  if (inChar == 123) {
  //  digitalWrite(led, HIGH);
    DataComplete = true;
    return;
  }
  if(count < 19 && DataComplete == false) {
    Data[count] = inChar;
```

```
    count++;
   }
   // if the incoming character is a newline, set a flag
   // so the main loop can do something about it:
  }
}

void clearString(char *strArray) {
  int j;
  for (j = 25; j > 0; j--)
    strArray[j] = 0x00;
}

/*
Alexan Keypad
1   2   3

4   5   6

7   8   9

*   0   #

C2  R1  C1  R4  C3  R3  R2
*/

unsigned char keydeb = 100;
unsigned char n;
int ROW1 = 29;
int ROW2 = 39;
int ROW3 = 37;
int ROW4 = 33;
int COL1 = 31;
int COL2 = 27;
int COL3 = 35;
////////////////////////////////////////////////////////////
// Initialize ports. Add other ports initialization as may be
// necessary
void init_keypad(void)
{
   pinMode(ROW1, INPUT_PULLUP);
   pinMode(ROW2, INPUT_PULLUP);
   pinMode(ROW3, INPUT_PULLUP);
   pinMode(ROW4, INPUT_PULLUP);
   pinMode(COL1, OUTPUT);
   pinMode(COL2, OUTPUT);
   pinMode(COL3, OUTPUT);
}

char scankey(void)
{
   digitalWrite(COL1, HIGH);     //
   digitalWrite(COL2, HIGH);     //
   digitalWrite(COL3, HIGH);     //
   digitalWrite(COL1, LOW);     //enable first column
//   delay(1);
   if(!digitalRead(ROW1)) return '1';
   if(!digitalRead(ROW2)) return '4';
   if(!digitalRead(ROW3)) return '7';
   if(!digitalRead(ROW4)) return '*';
   digitalWrite(COL1, HIGH);     //disable 1st column
//   delay(1);
   digitalWrite(COL2, LOW);     //enable 2nd column
//   delay(1);
   if(!digitalRead(ROW1)) return '2';
   if(!digitalRead(ROW2)) return '5';
   if(!digitalRead(ROW3)) return '8';
   if(!digitalRead(ROW4)) return '0';
   digitalWrite(COL2, HIGH);     //disable 2nd column
//   delay(1);
   digitalWrite(COL3, LOW);     //enable 3rd column
//   delay(1);
   if(!digitalRead(ROW1)) return '3';
   if(!digitalRead(ROW2)) return '6';
   if(!digitalRead(ROW3)) return '9';
   if(!digitalRead(ROW4)) return '#';
   digitalWrite(COL3, HIGH);     //disable 3rd column
//   delay(1);
   return 'E';              //no keypress
}

void w8_key_release(void)
{
   for(n=0;n<keydeb;)
   {
                if(scankey() == 'E')
        n++;
      else
        n=0;
   }
}
```

## Zilog

```
#include <ez8.h>
#include <stdio.h>
#include <stdlib.h>
#include <gps.h>
#include <string.h>
#include <SIM900.h>
#include <softwareserial.h>
#include <TCS3471.h>
#include <uart1.h>
#include <wire.h>
#include <wta.h>
//ENDHEADER - DONT REMOVE THIS COMMENT
float lat=0,lon=0,speed=0;
char date[30];
char time[30];
char datasms[300];
char msggps[150];
extern char ringflag;
char inboxNum=0;
char vrs[10];
color_t color_detected;
char U1buffer[U1BUFFERSIZE];
extern Uart1 Serial1;
char hasreplyMCU=0;
char soilNutrient[50];

//ENDVARANDCONST - DONT REMOVE THIS COMMENT
int pos=7;
char readInbox(char *cell,char *msg,char inboxNum)
{
                if(strstr(msg,"LINEON"))
                {

                }
                if(strstr(msg,"LINEOFF"))
                {

                }
                delSms(inboxNum,2);
                return 0;
}
void sms_rx(void)
{
                inboxNum++;
                if(inboxNum==3)
                                inboxNum=1;
                ReadSms(inboxNum,1);
                delay50Ms(4);//200ms
}
char datasend[200];
char datasendcolor[200];
char num;
void CW(int X)
{
   X = X - 1;
   X = X * 2;
```

```
   sprintf(datasend,"WTA%c1%c", X + 1, 123);
                SendUART1(datasend);
   delayms(50);
                sprintf(datasend,"WTA%c0%c", X + 2, 123);
                SendUART1(datasend);
}
void CCW(int X)
{
   X = X - 1;
   X = X * 2;
   sprintf(datasend,"WTA%c0%c", X + 1, 123);
                SendUART1(datasend);
   delayms(50);
                sprintf(datasend,"WTA%c1%c", X + 2, 123);
                SendUART1(datasend);
}

void Position_step(int X)
{
   hasreplyMCU = false;
   sprintf(datasend,"WTA%c2%c", X , 123);
                SendUART1(datasend);
   while (hasreplyMCU == false);
}

void OFF(int X)
{
   X = X - 1;
   X = X * 2;
   sprintf(datasend,"WTA%c0%c", X + 1, 123);
                SendUART1(datasend);
   delayms(50);
                sprintf(datasend,"WTA%c0%c", X + 2, 123);
                SendUART1(datasend);
                delayms(50);
}
rom char K_txt[]="MOT8 CW,DEL 4500,MOT8 BW,DEL 400,MOT8
STOP,DEL 1000,MOT9 CW,DEL 2800,MOT9 BW,DEL 400,MOT9
STOP,S,S,S,S,S,S,S,S,S,DEL 180000,S,S,S,S,S,S,S,S,S,DEL 300000,MOT4
CW,DEL 3600,MOT4 BW,DEL 400,MOT4 STOP,DEL 120000";
rom char CPR_txt[]="MOT1 CW,DEL 2900,MOT1 BW,DEL 400,MOT1
STOP,S,S,S,S,S,S,S,S,S,DEL 120000,S,S,S,S,S,S,S,S,S,S,S,S,S,DEL
300000";
rom char BTB_txt[]="MOT2 CW,DEL 2900,MOT2 BW,DEL 400,MOT2
STOP,S,S,S,S,S,S,S,S,S,DEL 120000,S,S,S,S,S,S,S,S,S,S,S,S,S,DEL
300000";
rom char BCG_txt[]="MOT3 CW,DEL 2900,MOT3 CW,DEL 400,MOT3
STOP,S,S,S,S,S,S,S,S,S,DEL 120000,S,S,S,S,S,S,S,S,S,S,S,S,S,DEL
300000";
rom char Nitrogen_txt[]="MOT6 CW,DEL 4700,MOT6 BW,DEL
400,MOT6 STOP,DEL 200,S,S,S,S,S,S,S,S,S,S,DEL
300000,S,S,S,S,S,S,S,S,S,S,S,DEL 1800000";
rom char P_txt[]="MOT5 CW,DEL 4600,MOT5 BW,DEL 400,MOT5
STOP,DEL 200,MOT7 CW,DEL 1100,MOT7 BW,DEL 400,MOT7 STOP,DEL
800,S,S,S,S,S,S,S,S,S,S,S,DEL 180000,S,S,S,S,S,S,S,S,S,S,DEL
300000,S,S,DEL 360000";

rom char K1_txt[][30]={"R682,G489,B581,150,100,60",""};

rom char
CPR1_txt[][30]={"R882,G587,B587,31,13,6","R602,G440,B567,50,50,50,
","R589,G368,B476,17,3,5","R539,G385,B496,40,50,80"};


rom char
BTB1_txt[][30]={"R743,G609,B581,6,5,2","R558,G446,B528,3,3,2,","R56
3,G424,B541,55,30,40","R513,G491,B743,3,3,10","R499,G397,B566,4,4,
4"};

rom char
BCG1_txt[][30]={"R558,G446,B528,3,3,2","R506,G426,B511,2,3,4,","R51
6,G414,B511,2,3,4","R483,G376,B580,3,6,9"};

rom char
Nitrogen1_txt[][30]={"R536,G394,B502,45,45,50","R599,G490,B563,9,1
0,9,","R561,G476,B541,6,10,7"};

rom char
P1_txt[][30]={"R630,G555,B756,12,16,23","R537,G481,B834,5,11,40,","
R524,G399,B521,30,30,30"};

rom char K[][30] = {"K = Present", "K = Unavailable"};
rom char CPR[][30] = {"Proceed To BCG", "Ph = 5.4", "Ph = 5.8",
"Proceed To BTB"};
rom char BTB[][30] = {"Ph = 6.0", "Ph = 6.4", "Ph = 6.8", "Ph = 7.2", "Ph =
7.6"};
rom char BCG[][30] = {"Ph = 4.0", "Ph = 4.4", "Ph = 4.8", "Ph = 5.2"};
rom char Nitrogen[][30] = {"N = Low", "N = Medium", "N = High"};
rom char P[][30] = {"P = Low", "P = Medium", "P = High"};
char IsInBetween(long min_ , long max_ , long val_)
{
   if ((val_ >= min_) && (val_ <= max_) )
                return true;
        else
                return false;
}

char process_auto(int cnt)//cnt = user selection()
{
static char ret_proc[50];
char strbuf[30];
int R1_=0,G1_=0,B1_=0;  //sensor aquired value(TMS)

int R,G,B;                                      //base of color

int RR1,GG1,BB1;                //base-offset
int RR2,GG2,BB2;                //base+offset

//example(red) base=150,offset=35 then R=150,RR1=115,RR2=185

//example(green) base=155,offset=35 then G=155,GG1=120,GG2=190

//example(blue) base=160,offset=35 then B=160,BB1=125,BB2=195


//this routine select template base on cnt
//and check to see if R_ is inbetween RR1,RR2
//                                              AND  G_ is
inbetween GG1,GG2
//                                              AND  B_ is
inbetween BB1,BB2
// if three condition are all true then
// ret value is greater than 0(1..num_template)

char ret;                                       //not equal to 0 if
found in template
char num_sample=0;              //num_sample as per template
rom char * str[5]=0;    //pointer to template array
//On Error GoTo err
        ret_proc[0]=0;
        switch(cnt)
        {
    case  1:
                                        //fname = "K"
                                        str[0]=K1_txt[0];
                                        num_sample = 1;
                                        break;
    case  2:
                                        num_sample = 4;
                                        for (ret=0;ret!=
num_sample;ret++)

        str[ret]=CPR1_txt[ret];
                                        //fname = "CPR"
                                        break;
    case  3:
                                        num_sample = 5;
```

```
                                        for (ret=0;ret!=
num_sample;ret++)

                str[ret]=BTB1_txt[ret];
                                        //fname = "BTB"
                                        break;
        case  4:
                                        num_sample = 4;
                                        for (ret=0;ret!=
num_sample;ret++)

                str[ret]=BCG1_txt[ret];
                                        //fname = "BCG"
                                        break;
        case  5:
                                        num_sample = 3;
                                        for (ret=0;ret!=
num_sample;ret++)

                str[ret]=Nitrogen1_txt[ret];
                                        //fname = "Nitrogen"
                                        break;
        case  6:
                                        num_sample = 3;
                                        for (ret=0;ret!=
num_sample;ret++)
                                                str[ret]=P1_txt[ret];
                                        //fname = "P"
                                        break;
                }



   for (ret=0;ret!=num_sample;ret++)
                {
        getCSV_FlashString(0, ',', str[ret] ,strbuf);
        R = atoi(strbuf+1);
        getCSV_FlashString(1, ',', str[ret] ,strbuf);
        G = atoi(strbuf+1);
        getCSV_FlashString(2, ',', str[ret] ,strbuf);
        B = atoi(strbuf+1);
                        delayms(500);//james mod of delay b4
reading color sensor
                        //Command9_Click aquire color here b4
processing
        color_detected=TCS3471_getColor(5,6,7,true);
                        //R1_ = getCSV(0, ",", Text1 & "")
        //R1_ = Mid(R1, 2)
        //G1_ = getCSV(1, ",", Text1 & "")
        //G1_ = Mid(G1, 2)
        //B1_ = getCSV(2, ",", Text1 & "")
        //B1_ = Mid(B1, 2)
                        R1_=color_detected.RED;
                        G1_=color_detected.GREEN;
                        B1_=color_detected.BLUE;

        getCSV_FlashString(3, ',', str[ret] ,strbuf);
                        RR2=R+atoi(strbuf);
                        getCSV_FlashString(3, ',', str[ret] ,strbuf);
                        if (R>=atoi(strbuf))//vb code doesnt have this..
update it
                                RR1=R-atoi(strbuf);
                        else
                                RR1=R;

                        getCSV_FlashString(4, ',', str[ret] ,strbuf);
                        GG2=G+atoi(strbuf);
                        getCSV_FlashString(4, ',', str[ret] ,strbuf);
                        if(G>=atoi(strbuf))
                                GG1=G-atoi(strbuf);
                        else
                                GG1=G;

        getCSV_FlashString(5, ',', str[ret] ,strbuf);
                        BB2=B+atoi(strbuf);
                        getCSV_FlashString(5, ',', str[ret] ,strbuf);
                        if(B>=atoi(strbuf))
                                BB1=B-atoi(strbuf);
                        else
                                BB1=B;



     if ((IsInBetween(RR1, RR2, R1_) == true) && (IsInBetween(GG1,
GG2 , G1_ ) == true) && (IsInBetween(BB1, BB2, B1_) == true) )
          return  ret;

   }
   //If process_auto = "" Then process_auto = -1
   //Exit Function
//err:
 //   MsgBox "Error in " & fileName & ret & ".txt"
                return 0;// no template match found
}

void ExecScript(char cnt)
{
int x=0;
rom char * str=0;
char str_data[20];
int mot,last_pos=0;
long dels;

   switch(cnt)
                {
     case 1:
                                        //fname = "K.txt"
                                        str=K_txt;
                                        break;
     case 2:
                                        //fname = "CPR.txt"
                                        str=CPR_txt;
                                        break;
     case 3:
                                        //fname = "BTB.txt"
                                        str=BTB_txt;
                                        break;
     case 4:
                                        //fname = "BCG.txt"
                                        str=BCG_txt;
                                        break;
     case 5:
                                        //fname = "Nitrogen.txt"
                                        str=Nitrogen_txt;
                                        break;
     case 6:
                                        //fname = "P.txt"
                                        str=P_txt;
                                        break;
   }
    while(1)
                {
                        getCSV_FlashString(x,',',str,str_data);
                        if (str_data[0]==0) break;
     if (strstr(str_data, "MOT") )
                        {
                                if (str[4]==' ')//If Mid(X(a), 5, 1) =
" " Then
            mot=str_data[3]-0x30;//mot = Mid(X(a), 4, 1)
          else
            mot = ((str_data[4]-0x30)*10)+(str_data[5]-0x30);//mot =
Mid(X(a), 4, 2)

          if(strstr(str_data, "CW"))
                                        {
                                                if(last_pos!=mot)
                                                {


                Position_step (mot);//position test tube b4 dispense
```

```
            last_pos=mot;
                                                }
        CW (mot * 1);

                                        }
      if(strstr(str_data, "BW"))
        CCW (mot * 1);
      if(strstr(str_data, "STOP"))
        OFF (mot * 1);
    }
    if(str_data[0]=='S')
                        {
                                Position_step (1);
                                delayms (10);
    }
    if(strstr(str_data, "DEL"))
                        {
      dels = atol(str_data+4);//Mid(X(a), 5)
      delayms( dels * 1);
    }
                        x++;
            }
}


{
static char hasprint_flag=0;
            SendUART1(datasend);
            delay(500);

            if(!hasprint_flag)
            {
                        virtualRsOut(23,"ASIA PACIFIC COLLEGE \n");
                        virtualRsOut(23,"SCHOOL OF ENGINEERING
\n\n");
                        virtualRsOut(23,"  SOIL TEST RESULTS
\n\n\n");
                        sprintf(datasend,"DATE: %s","08/06/14");
                        virtualRsOut(23,datasend);

            getGPSparam(25,&lat,&lon,&speed,date,time);
                        sprintf(datasend,"LON: %0.5f
LAT:%0.5f\n\n",lon,lat);
                        virtualRsOut(23,datasend);
                        virtualRsOut(23,datasend);
                        hasprint_flag=0x1;
            }
            sprintf(datasend,"%s\n",soilNutrient);
            virtualRsOut(23,datasend);

            //sms sending
            sprintf(datasms,"%0.5f,%0.5f,%s,%s,%s",lon,lat,date,soilNu
trient);
            SendSms("09201676153",datasms,7);
}




void GetSoilGrade(int num,int valret)
{
            char datasendx[20];
  if (num == 1)
            {
                        getCSV_FlashString(0,',',K[valret],datasendx);
                        sprintf(datasend,"WTA%s%c", datasendx,
123);
            }
  if (num == 2)
            {

            getCSV_FlashString(0,',',CPR[valret],datasendx);
                        sprintf(datasend,"WTA%s%c", datasendx,
123);
            }
  if (num == 3)
            {

            getCSV_FlashString(0,',',BTB[valret],datasendx);
                        sprintf(datasend,"WTA%s%c", datasendx,
123);
            }
  if (num == 4)
            {

            getCSV_FlashString(0,',',BCG[valret],datasendx);
                        sprintf(datasend,"WTA%s%c", datasendx,
123);
            }
  if (num == 5)
            {

            getCSV_FlashString(0,',',Nitrogen[valret],datasendx);
                        sprintf(datasend,"WTA%s%c", datasendx,
123);
            }
  if (num == 6)
            {
                        if (valret != 0)
                        {

            getCSV_FlashString(0,',',P[valret],datasendx);
                                    sprintf(datasend,"WTA%s%c",
datasendx, 123);
                        }
                        else
                        {
                                    sprintf(datasend,"WTATemplate
Error%c",  123);
                        }
            sprintf(datasendcolor,
"WTA%04d:%04d:%04d%c",color_detected.RED,color_detected.GREEN,
color_detected.BLUE,123);           //james mod remove
            SendUART1(datasendcolor);



                                                                  //jmes
mod removed
            delayms(2000);




            //james mod remove
            strcpy(soilNutrient,datasendx);
            SendUART1(datasend);

}
char valret=0;
char atmel[20]="";
char fetchUart1(char *m)
{
            strcpy(atmel,m);
            if (m[0]!=0 )
            {
                        if((m[0]=='O')&&(m[1]=='K'))
                                    hasreplyMCU = true;
            }
            return 1;//clear buffer:return 0 dont clear buffer
}
void dispColorSoil(void);
void Automation(void)
{
static char dir=0;
static char mot=0;
```

```
		//WTA1 = Select 1,WTA2 = Select 2 up to WTA7 = Select 7
		if(atmel[0]!=0)
		{
			if (strstr(atmel,"WTA"))//If (InStr(1, str,
"WTA") <> 0) Then
			{
				num = atmel[3]-0x30;
				atmel[0]=0;
				ExecScript (num);
				Position_step(pos);
				//dispColorSoil();
					//testing remove this
after calibration purposes
				//delayms(200);
						//enable
this after calibration
				valret = process_auto(num);
			//enable this after calibration
				GetSoilGrade (num, valret);
			//enable this after calibration
				print_result();
			}
			if (strstr(atmel,"WTV"))
			{
				if(atmel[3]=='*')
					dir^=1;

		if((atmel[3]>='0')&&(atmel[3]<='9'))
				{
					mot=atmel[3]-0x30;
					if(dir)

		CCW(mot);
					else

		CW(mot);
				}
				if(atmel[3]=='S')
					OFF(mot);
				memset(atmel,0,9);
			}
		}

}

//ENDROUTINE - DONT REMOVE THIS COMMENT
void Wiring(void)
{
		WTAWire();
		uart1Wire(fetchUart1,9600,U1BUFFERSIZE,13);//replace
fetchUart1 to 0 if Poll method
		SIM900Wire(2);
		SIM900IsrWire(readInbox);


}
void dispColorSoil(void)
{
			//Position_step(pos);
			TCS3471_setup(5,6,7,ENABLELIGHT);
			//print_result();
			atmel[0]=0;
			while(atmel[0]==0)
			{
				delayms(300);

		color_detected=TCS3471_getColor(5,6,7,true);
				sprintf(datasend,
"WTA%04d:%04d:%04d%c",color_detected.RED,color_detected.GREEN,
color_detected.BLUE,123);
				SendUART1(datasend);

			}
}
void main(void)
{
		Wiring();
		TCS3471_setup(5,6,7,ENABLELIGHT);
		color_detected=TCS3471_getColor(5,6,7,true);
		while(1)
		{
			Automation();
		}
		/*
			Position_step(pos);
			TCS3471_setup(5,6,7,ENABLELIGHT);
			//print_result();
			while(1)
			{
				delayms(300);

		color_detected=TCS3471_getColor(5,6,7,true);
				sprintf(datasend,
"WTA%04d:%04d:%04d%c",color_detected.RED,color_detected.GREEN,
color_detected.BLUE,123);
				SendUART1(datasend);
			}

		GetSoilGrade(1,1);
		GetSoilGrade(1,2);

		GetSoilGrade(2,1);
		GetSoilGrade(2,2);
		GetSoilGrade(2,3);
		GetSoilGrade(2,4);

		process_auto(2);
		ExecScript(1);
		ExecScript(2);
		*/
		//Wiring();
		//x=GetDistance(14.572769, 120.985455,14.574425,
120.984529);
		//x=getAngleTwoGPSParam(14.572769,
120.985455,14.574425, 120.984529);
		//getCompassParam(27,&compass);
		while(1)
		{
			virtualRsOut(24,"Paste NMEA String \n");


		getGPSparam(25,&lat,&lon,&speed,date,time);

		sprintf(msggps,"%0.5f,%0.5f,%0.2fKnots,",lon,lat,speed);
			virtualRsOut(24,msggps);
		}
		while(1)
		{
			sms_rx();
			//SendSms("09192284345","Ok!!!",7);
		}
		virtualRsOut(24,"Adjust Freq for 9600\n");
		virtualRsInCnt(25,vrs,2);
		virtualRsOut(24,vrs);
		virtualRsInByChar(25,vrs,'\r');
		virtualRsOut(24,vrs);
		color_detected=TCS3471_getColor(18,20,21,ENABLELIGHT)
;

//ENDMAIN - DONT REMOVE THIS COMMENT
}
```

## Visual Basic

```
Public sql As String
Dim WithEvents x As Class1
Dim msgmem As Integer
Const PLATE_NUM = "KCL 923"
```

```
Private Type soildata
   data1 As String
   data2 As String
   data3 As String
   data4 As String
   data5 As String
End Type
Dim soildata As soildata
Private Sub Comm1_OnComm()
If Comm1.CommEvent = comEvReceive Then
   Text1 = Comm1.Input
   x.PushInbox Text1.Text
End If
End Sub

Private Sub Command1_Click()
Dim rs As New ADODB.Recordset
   rs.Open "Select * from data", conn, adOpenStatic, adLockOptimistic
   Set DataGrid1.DataSource = rs
End Sub

Private Sub Command2_Click()
   frmperiod.frm = 1
   frmperiod.Show vbModal, Me
End Sub




Private Sub Command4_Click()
   If soildata.data1 = "" Then
      MsgBox "Select data to save"
      Exit Sub
   End If
   fname = InputBox("Enter Filename", "Save", "Soil.txt")

   If DirExists("J:") = True Then
      If FileExists("J:\" & fname) = True Then
         MsgBox "File Exist!!!", vbInformation
         Exit Sub
      End If
      savefileStr "J:\" & fname, soildata.data1 & "," & soildata.data2 & ","
& soildata.data3 & "," & soildata.data4 & "," & soildata.data5
   Else
      MsgBox "Insert USB Flash Drive"
   End If
End Sub
Private Sub UpdateGrid()
Dim rs As New ADODB.Recordset
   rs.Open "Select * from data ", conn, adOpenStatic, adLockOptimistic
   Set DataGrid1.DataSource = rs
End Sub
Private Sub Command5_Click()
  On Error GoTo ERR
   Comm1.RThreshold = 1

   If Comm1.PortOpen = False Then
      Comm1.CommPort = txtgsmPort
      Comm1.PortOpen = True
      Timer1.Enabled = True
      Command6.Enabled = True
      Command5.Enabled = False
      Comm1.Output = "ATE0" & Chr(13)
      Msec 500
      Comm1.Output = "AT+CMGF=1" & Chr(13)
      Msec 500
      Comm1.Output = "AT+CPMS=" & Chr(34) & "ME" & Chr(34) &
Chr(13)
      Msec 1000
      UpdateGrid
   End If
ERR:
End Sub

Private Sub Command6_Click()
   If Comm1.PortOpen = True Then
      Comm1.PortOpen = FASE
      Timer1.Enabled = False
      Command5.Enabled = True
      Command6.Enabled = False
   End If
End Sub

Private Sub DataGrid1_RowColChange(LastRow As Variant, ByVal
LastCol As Integer)
'   MsgBox GoogleMapUrl(DataGrid1.Columns.Item(1),
DataGrid1.Columns.Item(2))
   WebBrowser.Navigate GoogleMapUrl(DataGrid1.Columns.Item(0),
DataGrid1.Columns.Item(1))
   soildata.data1 = DataGrid1.Columns.Item(0)
   soildata.data2 = DataGrid1.Columns.Item(1)
   soildata.data3 = DataGrid1.Columns.Item(2)
   soildata.data4 = DataGrid1.Columns.Item(3)
   soildata.data5 = DataGrid1.Columns.Item(4)

End Sub

Private Sub Form_Load()
Dim createconn As New dsnCREATE
   createconn.Test "database", "database"
   Set x = New Class1

   Connect

End Sub

Private Sub MSComm1_OnComm()

End Sub

Private Sub Timer1_Timer()
Static x As Integer
   msgmem = x
  Comm1.Output = "AT+CMGR=" & msgmem & Chr(13)
   x = x + 1
   If x >= 4 Then x = 0

End Sub

Private Sub x_raksEventsMsg(ByVal Phone As String, ByVal Message As
String, ByVal mem As Integer)
   Me.Caption = Phone & " : " & Message
   Text3 = "From :" & Phone & vbCrLf
   Text3 = Text3 & Message
   xx = Comm1.Input
   Comm1.Output = "AT+CMGD=" & msgmem & Chr(13)
   Msec 1000
End Sub
Private Sub adddata(ByVal str As String)
Dim rs As New ADODB.Recordset
rs.Open "select * from data", conn, adOpenStatic, adLockOptimistic

   rs.AddNew


   rs!Longtitude = getCSV(0, ",", str)
   rs!Latitude = getCSV(1, ",", str)
   rs_Date = getCSV(2, ",", str)
   rs!Date = Date
   rs!SoilNutrient = getCSV(3, ",", str)
   rs.Update
   rs.Close

'   rs.Open "Select * from data where date=#" & Date & "#", conn,
adOpenStatic, adLockOptimistic
   rs.Open "Select * from data ", conn, adOpenStatic, adLockOptimistic

   Set DataGrid1.DataSource = rs
End Sub
```

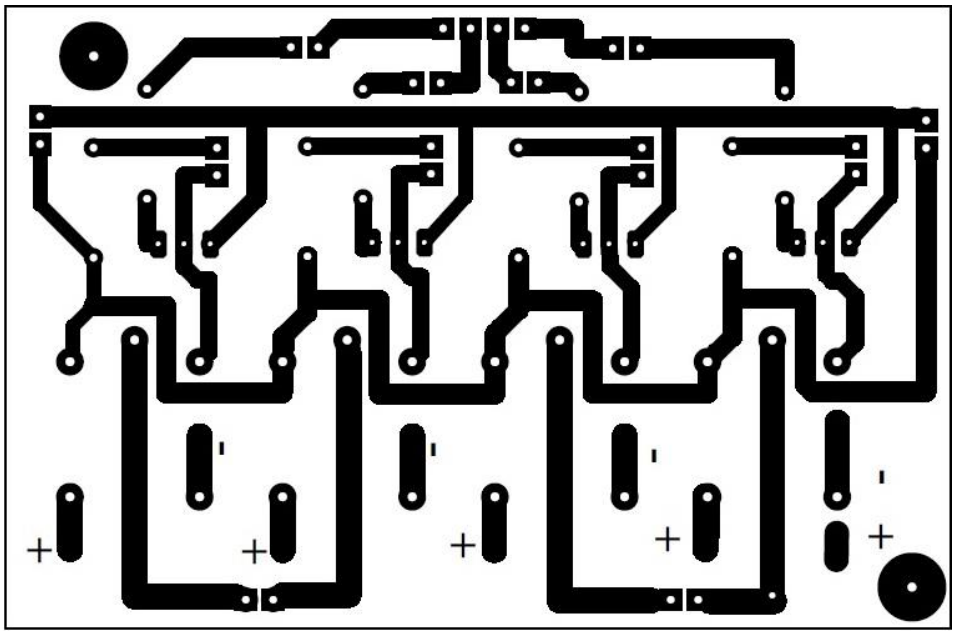
```
Private Function GetData(str As String, start_ As Integer, end_ As
Integer, char As String) As String
Dim ptr As Integer
   len_ = Len(str)
   If start_ <> 0 Then
      For ptr = 1 To len_
         If Mid(str, ptr, 1) = char Then
            start_ = start_ - 1
            If start_ = 0 Then
               start_ = ptr + 1
               Exit For
            End If
         End If
      Next
   Else
      start_ = 1
   End If
   If end_ <> 0 Then
      For ptr = 1 To len_
         If Mid(str, ptr, 1) = char Then
            end_ = end_ - 1
            If end_ = 0 Then
               end_ = ptr
               Exit For
            End If
         End If
      Next
   Else
      end_ = Len(str) + 1
   End If
   GetData = Mid(str, start_, end_ - start_)

End Function
Function GoogleMapUrl(ByVal lat As String, ByVal lon As String)
Dim str1 As String
Dim str2 As String
Dim str3 As String
   str1 = "http://maps.google.com/maps?hl=en&q="
   lat = lat & "%2C"
   lon = lon
   str2 = "&um=1&ie=UTF-8&sa=N&tab=wl"
   GoogleMapUrl = str1 & lat & lon & str2
End Function
```

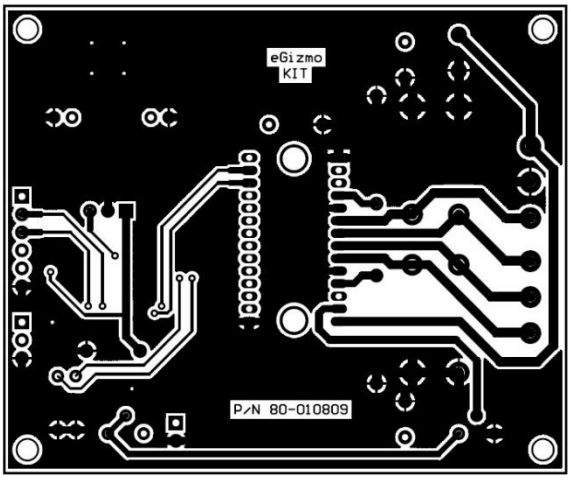
# APPENDIX C

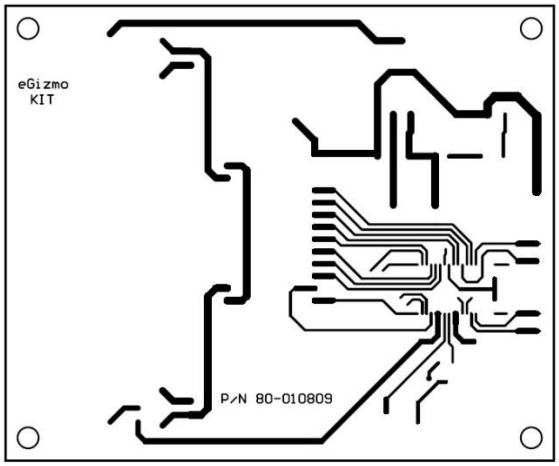
# PCB LAYOUT

**Relay PCB Layout**

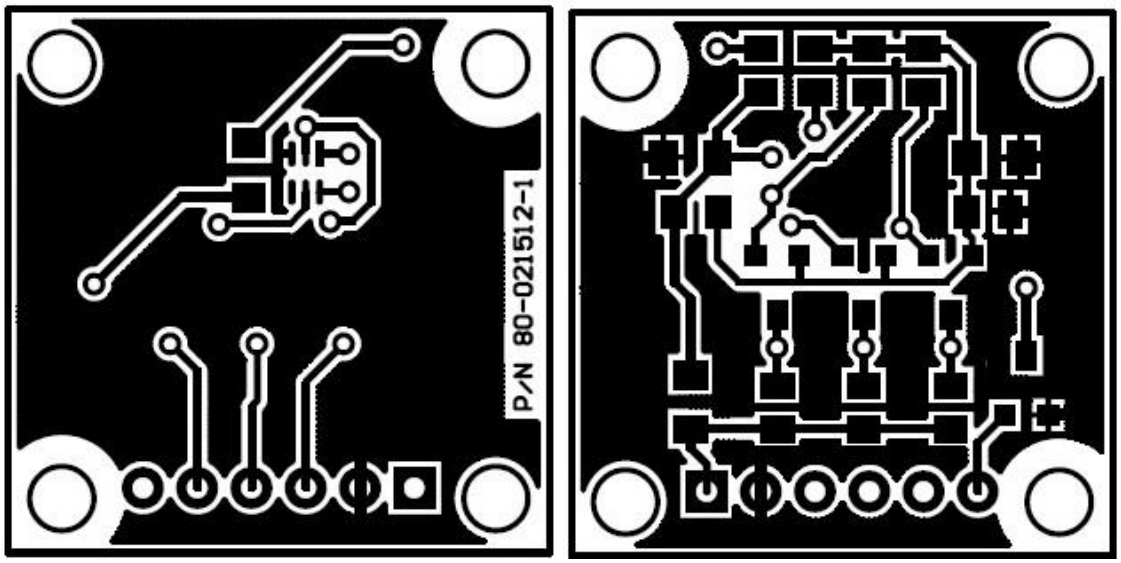


**Stepper Motor (Bottom Layer & Top Layer)**



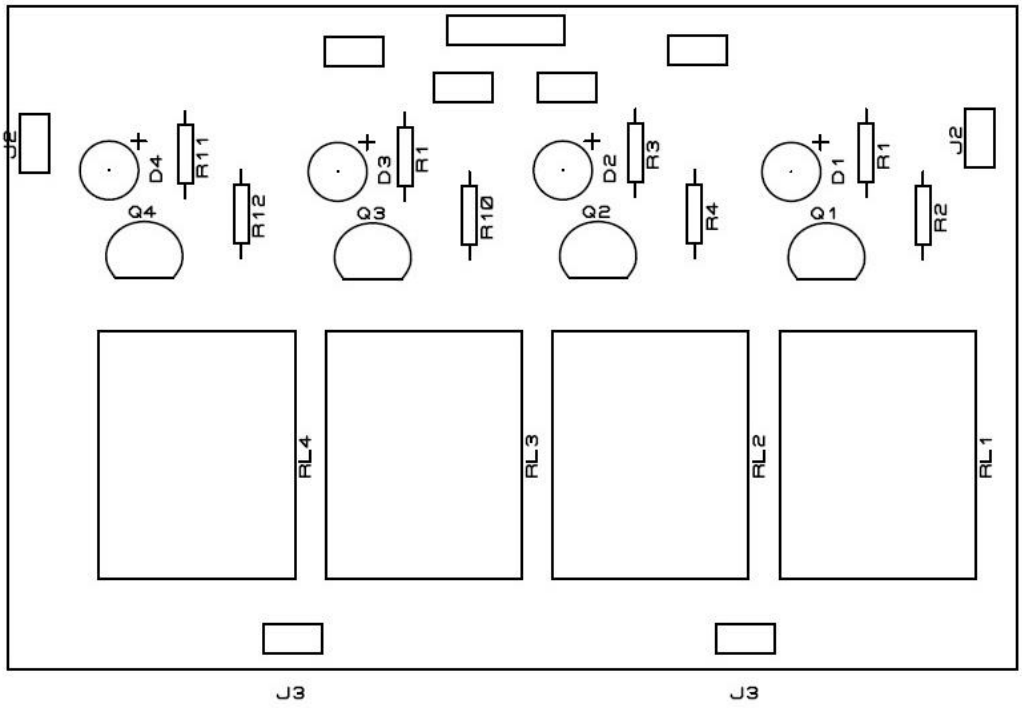
**Color Sensor (Bottom / Top Layer)**

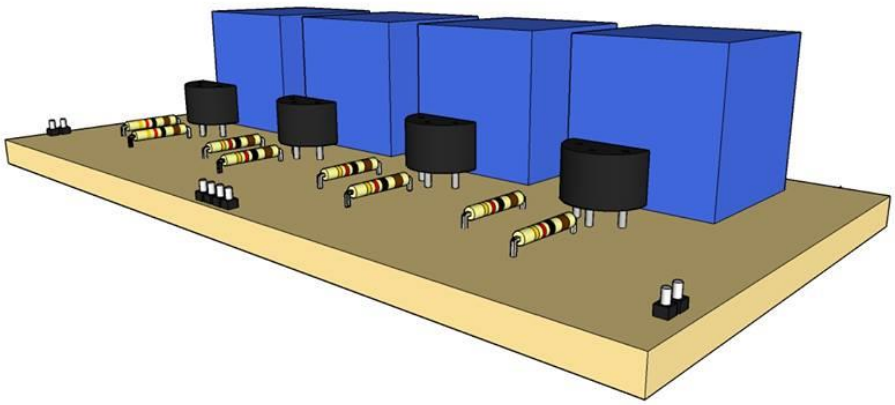


# APPENDIX D

# PCB AND COMPONENTS MOUNTING

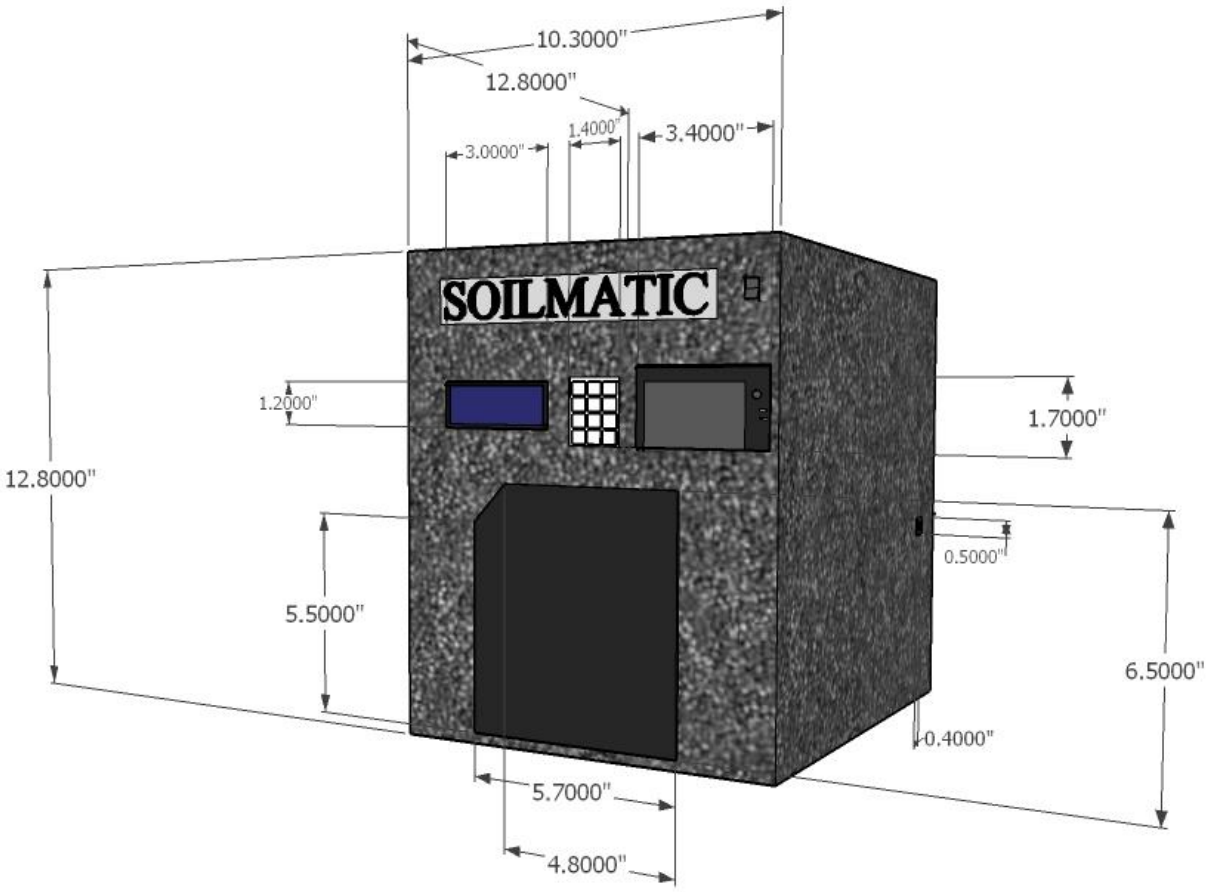
**Relay**


J2
D4
R11
Q4
R12
D3
R1
Q3
R10
D2
R3
Q2
R4
D1
R1
Q1
R2
J2
RL4
RL3
RL2
RL1
J3
J3



# APPENDIX E

# CHASSIS LAYOUT


10.3000"
12.8000"
1.4000"
3.4000"
3.0000"
SOILMATIC
1.2000"
1.7000"
12.8000"
0.5000"
5.5000"
6.5000"
0.4000"
5.7000"
4.8000"

**APPENDIX F**

**PROJECT POSTER**

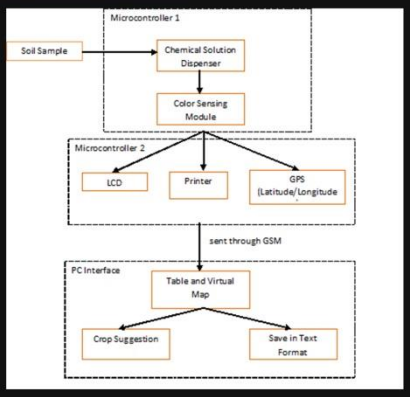
# SoilMATIC

Development of Soil Nutrient Detection Using Microcontrollers and GPS Technology

## Abstract

This prototype automates the soil testing with a GPS technology. It is equipped with color sensor that will detect the color of the tested soil sample. The result includes the latitude and longitude where the test happened, the date of the test, and the result of the test, either N, P, K, or pH. The result will be shown in the LCD screen, will be printed, and will be saved in a flash drive or SD card.


## Block Diagram




UFW

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# APPENDIX G

# PROJECT COST

**Bill of Materials**

| Main components | Quantity | Price (Php) | Total (Php) |
|---|---|---|---|
| Printer | 1 pcs | 2800 | 2800 |
| Microcontroller | 2 pcs | 790 | 1580 |
| GPS antenna | 1 pcs | 685 | 685 |
| LCD (4x20) | 1 pcs | 550 | 550 |
| GSM Module | 1 pcs | 550 | 550 |
| Syringe | 9 pcs | 40 | 360 |
| USB to UART Downloader | 1 pcs | 250 | 250 |
| Keypad | 1 pcs | 150 | 150 |
| Hose | 1 m | 55 | 55 |
| **Electronic components** | | | |
| DC Motor | 9 pcs | 250 | 2250 |
| Wires | 1 roll | 1,200 | 1200 |
| Relay | 20 pcs | 30 | 600 |
| Rechargeable 12V Battery | 1 | 550 | 550 |
| Capacitor | 20 pcs | 15 | 300 |
| PCB | 1 | 300 | 300 |
| Stepper Motor | 1 pcs | 250 | 250 |
| Resistor | 40 pcs | 2.50 | 100 |
| Limit Switch | 18 pcs | 2.50 | 45 |
| Gold Header | 40 pcs | 1 | 40 |
| Bridge Type | 1 | 15 | 15 |
| Power Switch | 1 | 15 | 15 |
| Charging Port | 1 | 15 | 15 |
| **Bolts and nuts** | | | |
| Hinge | 1 pack | 300 | 300 |
| Cable Tie | 1 pack | 90 | 90 |
| **Other** | | | |
| Soil Test Kit | 1 | 2500 | 2500 |
| Sintra Board | 1 | 300 | 300 |
| Steel Angle | 1 | 200 | 200 |
| Wallpaper | 1 | 147 | 147 |
| Super Adhesive Glue | 2 | 20 | 40 |
| | | TOTAL | 16,237.00 |

# APPENDIX H

# USER'S MANUAL

**APPENDIX I**

**DATA SHEETS**

**APPENDIX J**

**ECEPRO1 GANTT CHART**

| ACTIVITY | WEEK NO. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Basic Requirement 1) To control the staining process of the soil samples placed in test tubes with the help of microcontroller technology. | | | | | | | | |
| 1. Installing motors for test tube rotation | | | | | | | | |
| 2. Testing syringe motors for staining | | | | | | | | |
| Basic Requirement 3) Use an optical sensor to detect a distinct cloudy yellowish layer on top of the resulting soil solution which will indicate a sufficiency of potassium in the soil sample. | | | | | | | | |
| 3. Installation of optical sensor<br>- Positioning of sensor<br>- Testing | | | | | | | | |
| Basic Requirement 2) Design a separate microcontroller-based color sensing module to detect the presence of soil nutrients (nitrogen and phosphorus), and pH level by sensing the resulting color of the samples after staining with chemicals.<br>Basic Requirement 6) The prototype will adopt wired (USB) connectivity in order for the microcontrollers to communicate with each other at real time. | | | | | | | | |
| 2. Install / test Color sensing module and pH Sensor | | | | | | | | |
| 3. Calibrate color chart value | | | | | | | | |
| Specific Objective 5) Develop a provision in the prototype that will enable the user to save the results (in text file) of the soil test through a flash drive or an SD card. | | | | | | | | |
| 4. Install sd/flash drive port | | | | | | | | |
| Specific Objective 4) Display the warning messages, time, and results using an LCD display.<br>Specific Objective 7) Printer | | | | | | | | |
| 5. Synch LCD with microcontroller | | | | | | | | |
| 6. Calibrate output print out | | | | | | | | |
| Specific Objective 8) To tabulate the results in a specific area<br>Specific Objective 9) To suggest two crops that would best to be planted.<br>Specific Objective 10) Integrate GPS technology for virtual mapping. | | | | | | | | |
| 7. Gather Soil Test results from a specific area & calibrate data | | | | | | | | |
| Supplementary Requirement 2) Provide an option for PC manipulation/control of the system. | | | | | | | | |
| 8. Integrate PC assisted Calibration | | | | | | | | |
| Supplementary Requirement 1) Provide a soil moisture detector to determine the water moisture content in the soil sample. | | | | | | | | |
| 9. Add Soil moisture detection | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10. Testing and calibrating prototype | | | | | | | | |

# Appendix K

# Soil Test Kit Manual

# POTASSIUM TEST

1. Fill the test tube up to the scratch mark with soil sample.
2. Add 24 drops (or 1 ml) os solution K and 8 drops of solution K1.
3. Mix well by gently swirling the tube for-about 1 minute.
4. Repeat step 3 after about 3 minutes and let stand for 5 minutes or until the soil particles have settled at the bottom of the tube.
5. Add solution K2 as follows:

   a. slowly insert the dropper containing 0.6 ml of solution K2 inside the test tube so that its tip is about 2 cm above the solution.

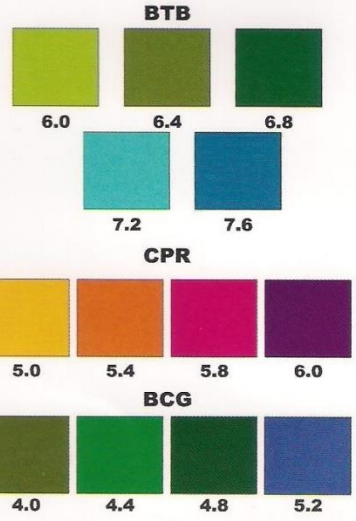
   b. slowly add 12 drops of solution K2 one drop at a time.

   c. DO NOT MIX OR SHAKE THE SOLUTION.

6. Let it stand for 2 minutes. Then observe the appearance of a cloudy yellow layer on top of the orange solution. A DISTINCT CLOUDY YELLOWISH LAYER indicates that the soil has SUFFICIENT AVAILABLE POTASSIUM. There is no need to apply potassium fertilizer.
7. If NO distinct cloudy yellowish layer appears on top of the orange solution, the soil is DEFICIENT in available potassium. Refer to the table on FERTILIZER RECO-MMENDATIONS FOR DIFFERENT CROPS.

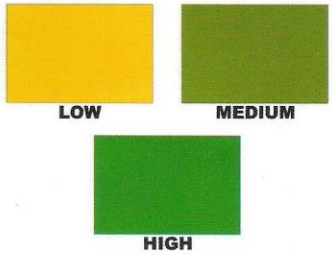
# SOIL pH

1. Fill the test tube with soil sample to scratch mark.
2. Add 12 drops of CPR pH indicator dye.
3. Mix by gently swirling the test tube 20 times.
4. Repeat step 3 after about two minutes and let the test tube stand for 5 minutes.
5. To get the pH of the soil with the corresponding color chart of pH indicator dye used.
6. If soil pH is used to or greater than 6 repeat steps 1 to 5 using BTB instead of CPR. However, if soil pH is less than or equal to 5, repeat steps 1 to 5 using BCG instead of CPR.
7. Wash test tube with tap water and then rinse with distilled water.



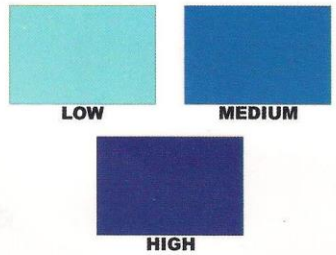

# NITROGEN TEST

1. Fill the test tube with soil sample up to the scratch mark.
2. Add 24 drops (1 ml) of solution N.
3. Mix well by gently swirling the test tube 30 times.
4. Repeat step 3 after about 5 minutes and let the test tube stand for 30 minutes.
5. Match the color of the resulting solution on top of the soil with the color chart below and take note if the soil is low, medium, or high in available nitrogen.
6. Refer to the table on FERTILIZER RECOM-MENDATION FOR DIFFERENT CROPS.
7. Wash the test tube with tap water and then rinse with distilled water.




# PHOSPHORUS TEST

1. Fill the test tube with soil sample up to the scratch mark.
2. Add 24 drops (or 1ml) of solution P and 4 drops of solution P1.
3. Mix well by gently swirling the tube for about 1 minute.
4. Repeat step 3 after about 3 minutes and let the test tube stand for 5 minutes.
5. Take one foil or tin strip and wrap it firmly at one end of the plastic stick.
6. Without disturbing the soil, stir the solution slowly with the tin strip for one minute. Repeat the step after about two minutes. (Note: The tin strip attached to the plastic can still be used for another set of four samples provided that analyses are done on the same day. Rinse the tin strip with distilled water after each analysis).
7. Match the blue color intensity of the solution with the color chart below and take note if the soil is low, medium, or high in available phos-porus.
8. Refer to the table on FERTILIZER RECOM-MEDATIONS FOR DIFFERENT CROPS.
9. Wash the test tube with tap water and then rinse with distilled water.



# APPENDIX L

# PROJECT PRESENTATION PHOTO GALLERY

(INSERT PHOTOS FROM LETS GET TECHIE AND SYMPOSIUM)

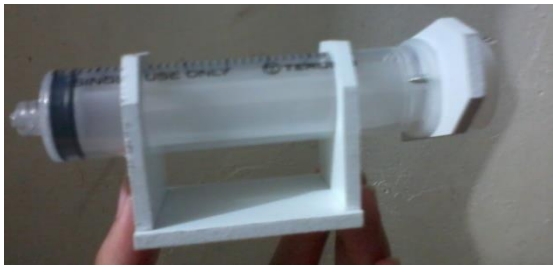
**APPENDIX M**

**ECEPRO1 PHOTO GALLERY**

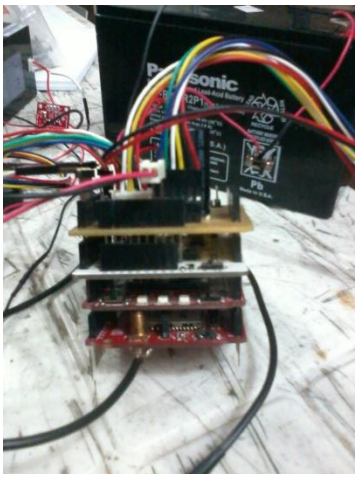
**Constructed Chassis**


**Components for Chemical Dispensing**

**Assembly of the Syringes to the Motors**



**Incorporated Microcontrollers to the System**

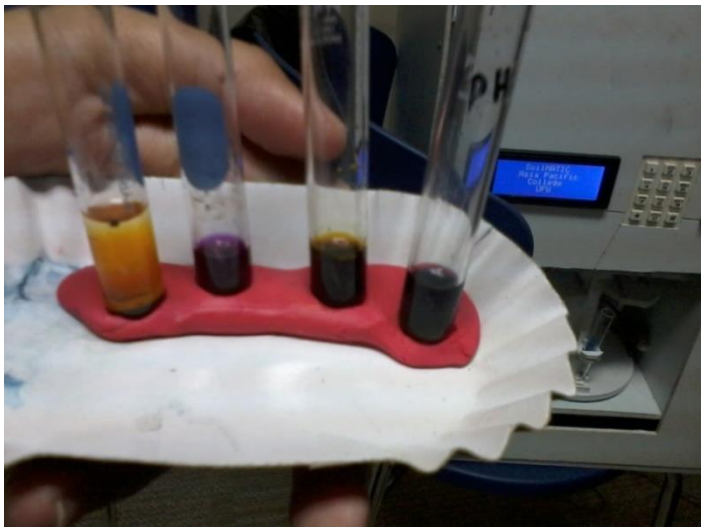


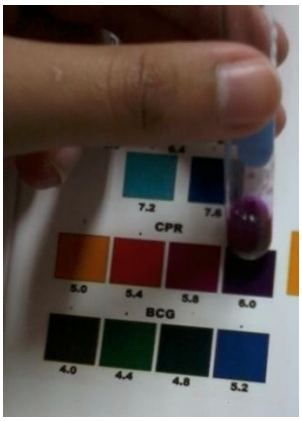
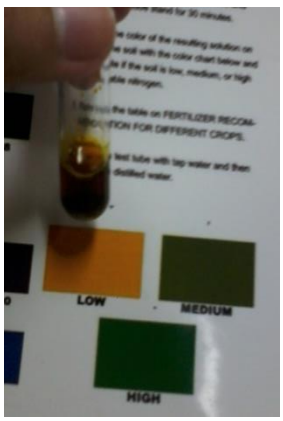
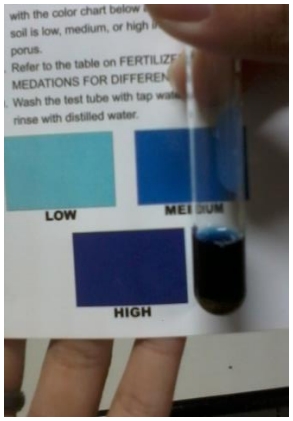
**Installed Color Sensing Module**

**Testing the LCD Screen**


**EEDPRO2 Photo Gallery**

**Testing and Calibration**




7.2
7.6
CPR
5.0
5.4
5.8
6.0
BCG
4.0
4.4
4.8
5.2

LOW
MEDIUM
HIGH

porus.
LOW
HIGH


**APPENDIX N**

**RESEARCHER'S PROFILE**

## APPENDIX O

## IEEE RESEARCH PAPER FORMAT

**(INSERT IEEE PAPER HERE)**

# APPENDIX P

# THE PROCESSOR ARTICLE

**(INSERT PROCESSOR ARTICLE HERE**

# APPENDIX Q

# SURVEY FORMS

SoilMATIC

**PROJECT EVALUATION SHEET**

This survey is conducted to rate the project SoilMATIC according to specific criterial. Simply put a check mark on the rating from 1 to 4. (1-Lowest and 4-Highest)

| | Rating | | | |
|---|---|---|---|---|
| **I. SAFETY** | **1** | **2** | **3** | **4** |
| a. The design of the chassis is safe to use. (smooth surface, no sharp edges/corners) | | | ✓ | |
| b. The project is easy to carry. | | | | ✓ |
| c. The handling of chemicals is safe. | | | | ✓ |

| **II. EASE OF USAGE** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| a. The charging port is accessible and sturdy. | | | | ✓ |
| b. The keypad is responsive. | | | | ✓ |
| c. The menus are easy to navigate. | | | | ✓ |

| **III. FUNCTIONALITY** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| a. The results on the LCD & printer are readable? | | | | ✓ |
| b. The project's test results are accurate? (same w/ manual test results) | | | | ✓ |
| c. The project was able to suggest crop/s. | | | | ✓ |

SoilMATIC

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