International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:6, No:9, 2012

Development of Greenhouse Analysis Tools for Home Agriculture Project

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***Abstract*—**This paper presents the development of analysis tools for Home Agriculture project. The tools are required for monitoring the condition of greenhouse which involves two components: measurement hardware and data analysis engine. Measurement hardware is functioned to measure environment parameters such as temperature, humidity, air quality, dust and etc while analysis tool is used to analyse and interpret the integrated data against the condition of weather, quality of health, irradiance, quality of soil and etc. The current development of the tools is completed for off-line data recorded technique. The data is saved in MMC and transferred via ZigBee to Environment Data Manager (EDM) for data analysis. EDM converts the raw data and plot three combination graphs. It has been applied in monitoring three months data measurement for irradiance, temperature and humidity of the greenhouse..

***Keywords*—**Monitoring, Environment, Greenhouse, Analysis tools

I. Introduction

NOWADAYS greenhouses are used widely and extensively by botanists, commercial plant growers, and dedicated gardeners for planting plants. Plants can be grown easily in the greenhouse due to the availability of required plant environmental conditions. It can be a potential businesses model for a new concept of home agriculture especially in tropical countries. In Malaysia each house consumes small garden or land which is very valuable if properly managed for home agriculture. One of the unique ideas to materialize the potential of home agriculture project is setting up mini greenhouse. In general a greenhouse is a building in which plants are grown. The purpose of a greenhouse is to provide a controlled environment for plants, which allows them to flourish under optimal conditions. It has a structure with different types of covering materials, such as a glass or plastic roof. Glass or plastic walls are heats up because incoming visible solar radiation from the sun is absorbed by plants, soil, and other things inside the structure. Air warmed by the heat from hot interior surfaces is retained in the greenhouse by the roof and wall. In addition, the warmed structures and plants inside the greenhouse re-radiate some of their thermal energy in the infrared spectrum, to which glass is partly opaque, so some of this energy is also trapped inside the glasshouse.

Although heat loss due to thermal conduction through the glass and other building materials occurs, net energy increases (and therefore temperature) inside the greenhouse.

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Monitoring and controlling the changes of the heat inside the greenhouse for promoting fast growth of plants is a new exploration especially for tropical climax. Apart from the above factor greenhouse in tropical countries is exclusive in minimizing the usage of pesticide chemicals which is badly harmful to human. Heavy dose of pesticide is used to prevent the plant from the insect and bugs in open plantation. Insect and bugs such as mosquito, snails, bat and etc are well known becomes the main disturbance of the plant to growth. Hence greenhouse becomes the best option to isolate the disturbance and ultimately produce healthy vegetables without chemical.

II. Home Agriculture Project

The project involves the development of modern agriculture system specifically for home user. It maximizes the small land or home garden to generate lucrative income with low cost and minimum maintenance. The system is powered through Solar for supporting all the electronic devices includes automation system, motor pump and ventilation fan. In tropical countries typically in Malaysia, medium scale greenhouse is common for planting strawberry in highland areas. Few farmers used to plant vegetables, flowers and potato. However small greenhouse for home garden is rarely seen even many houses have enough space to set up mini greenhouse. Hence this project is to explore the effectiveness of the greenhouse against tropical weather, low maintenance and side incomes generation for housewife or garden hobbyist. The project will look after all the system components include design, test, measurement and garden products.

III. Greenhouse Model

Fig. 2 shows the model of greenhouse which comprises four main components. There are Solar system, greenhouse structure, water tanks, sensory and monitoring control circuit. The details of the components are summarized in the following subsections

A. Solar System

The solar system is manned to perform as power supply for the whole system of the greenhouse.

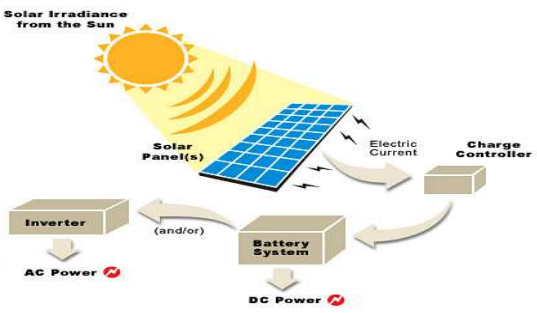

Fig. 1 Solar Power System Overview

The solar system consists of 6 photovoltaic panels with each producing 70 W. The total of power generated by the solar system would be 420 W. This power is used continuously for all the functions in the greenhouse. Part of the power which is unused is stored into DC batteries. The DC batteries are fully optimized during night time at which Solar panels are no longer productive. The complete system is illustrated in Fig. 1.

B. Green House

The proposed Greenhouse has open area of 20' x 20' which is equivalent with 400 sq. feet. The area can accommodate approximately 300 to 350 plant begs.

The greenhouse is constructed using solid metal for the main frame and coated with transparent plastic to filter out 30 % of radiated sun. Three parameters inside the green house are measured to monitor the condition against the outside weather. The three parameters being monitored are humidity, temperature and irradiance. These parameters are hourly changed according to the outside weather. For instance during day time, the temperature is slightly higher while the humidity is low.

To compensate the changes the sprinkler is activated to spray cool water. The sprinkler is placed on top of the green house for wide coverage. Once the temperature is dropped at acceptable level the sprinkler stops spraying the water. This process is continuously repeated to ensure the temperature and humidity is maintained at productive level. Third sensor is Irradiance sensor that is used to monitor intensity of light. Light is required to facilitate for photosynthesis process for plant to grow. Therefore part of the study is to explore the duration of light that make the plant to grow faster. When the light is low especially during night time, the green house is light up with full spectrum florescence light. Full spectrum florescence light has capabilities to generate all wavelengths that are useful for plant [12]. Some plants grow better when given more of a certain color light, due to the mechanism of photosynthesis.

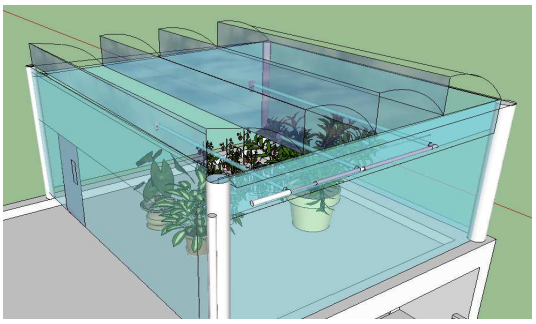

Fig. 2 Greenhouse: Tropical Design with Ventilation Roof

There are different types of greenhouse used which is depending on the nature of the location.

Simple design with flat roof is common in cool weather. The ventilation is controlled through exhaust fan.

While in tropical countries, greenhouse as shown in Fig. 2 is suitable due to the roof is triangular shape to promote air ventilation for the air circulation in the greenhouse.

C. GSM Intelligent Controlled System

Appropriate environmental conditions are necessary for optimum plant growth, improved crop yields, and efficient use of water and other resources. Automating the data acquisition process of the soil conditions and various climatic parameters that govern plant growth allows information to be collected with less labor requirements. GSM Greenhouse monitoring systems employ PC or SMS-based systems for keeping the user continuously informed of the conditions inside the greenhouse

The GSM Greenhouse monitoring systems design should be simple, easy to install, microcontroller-based circuit with the aims to monitor and record the values of temperature, humidity, soil moisture and sunlight of the natural environment that are continuously modified and controlled in order to maximize plant growth and yield.

The system communicates with the various sensor modules in real-time in order to control the light, ventilation and drainage process efficiently inside a greenhouse by actuating a sprinkler, fan ventilation, and lights respectively according to the necessary condition of the crops. An integrated Liquid crystal display (LCD) is used for real time display of data acquired from the various sensors and the status of the various devices. Microcontroller and its peripheral components becomes the main components which are easily available hence reduces the manufacturing and maintenance costs. The design is quite flexible as the software can be changed any time. It can thus be tailor-made to the specific requirements of the user.

The acquitted data which is stored in MMC is also used for monthly analysis using Environment Data Manager (EDM) [5]. EDM keeps records for all the months with the aim to investigate the climax changes throughout the year. Fig. 4, 5, 6, 7, and 8 show the graphs plotted by EDM for temperature, humidity and irradiance.

D.Environment Data Manager (EDM)

The development of Data Analysis tools involves with three main parts namely data conversion, class interfacing and graph plotting. Data conversion is a process to convert raw data which was saved in text file to database format. Class interfacing is involved with movement of data from one class to another class. Each process in Visual Studio is controlled by a class. Communication between classes is to ensure the current data or results could be shared with other class. The third component is the data analysis which involved graph plotting. There are many tools available under open source package that provide excellent graphic and features.

However nPlot tool has been applied to support for the graph analysis due to its less difficulties in getting references.

IV. EDM and The Features

The raw data saved in the text file format contains data measurement for temperature, time, date, irradiance and humidity.

The raw data was structured by frame and each frame is separated with string 'XX'. A class is designed to read the text file and convert the text into database access format. The keywords in accomplishing the conversion are shown as follow:

```
line= System.Text.Encoding.ASCII.GetString(FileUpload1.FileBytes);
   count = line.Length;          //IndexOf("XX");
    Session["Selamat"] = line;
    ar = Regex.Split(line, "XX");
```

A string 'line' is assigned to hold the whole string of text file. Each frame in the line string is split through a command called Regex and they are hold by an array 'ar'. The purpose of assigning the frame in array form is to facilitate the calculation towards actual data measurement when the column and row for each of them is known. The result of splitting the line string is shown as follow

```
XX41425316244D014E01
XX41225416244D014E01
XX41025516244F014F01
XX41425516244E014D01
```

Next process is to separate each data in each frame for actual values of dates, temperature, humidity and irradiance. All the algorithms to compute the raw data to actual reading (decimal) is integrated in a class. The computation is carried out by inserting the name of the function and the name of the class. Below shows the conversion algorithm for temperature from Hex code to actual decimal value.

```
public string Calc_Temperature(string hex)
      {
      decimal result;
      string resultS;
result=int.Parse(hex, system.Globalization.NumberStyles.HexNumber);
      if (result > 4000)
         result = result - 4000;
      else
         result = 4000 - result;
      result = result / 100;
      resultS = Convert.ToString(result); // .i  ToString.Insert(2, ".");
            if (resultS == "0" )
         result = 0;
            return Math.Round(result, 2).ToString();
   }
```

The final step for data conversion is inserting the decimal data in data access file. Two tools are used namely Sqldatasource and Accessdatasource. Both are required to establish the link between class and the data access file before using them. To recall the data, Accessdatasource is used while to insert a new data in the data access file, Sqldatasource is used.

The result after the conversion from Hex code to data access file is shown in Fig. 3.

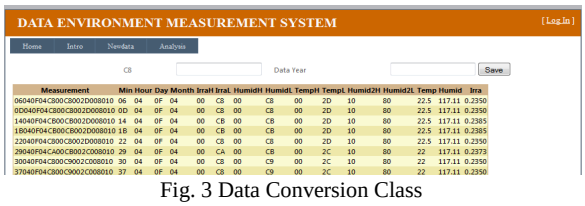

Fig. 3 Data Conversion Class

A. Class Interfacing

Visual Studio application is based on class development. Each class could be used to perform a function and they are link together through command, menu and etc. This mechanism shortens the programming development hours and help the programmer to debug the file class effectively. Among the command for effective communication between the class files, there are two techniques which are useful and unique in Visual Studio.

Data communication between classes could be carried out by using 'Session' command. For instance "Selamat" has been defined as string to hold text file which then accessible by any other class.

```
Session["Selamat"] = line;
```

Once the line string is declared upon Session command the line string can be recalled in different class file using command as follow:

```
line = (string)(Session["Selamat"]);
```

Interfacing class with other class could also be carried out using image tool. The example to execute the strategy is shown as follow;

```
this.Image1.ImageUrl = "HumidG.aspx?batchno=" + this.DropDownList1.SelectedItem.Text;
```

Image1 is placed in graphAnalysis.aspx class. It is manned to activate HumidG.aspx class once the batchno has been selected from DropDownList button.

B. NPLOT Tools

NPLOT is a tool for configuring data in a graph format. It is a free software tool for different types of platform. Immediate usage for NPLOT in Visual Studio is by copying NPLOT.dll file in bin folder. Once the file is copied all the command for NPLOT could be executed during debugging. A standard format for setting up plotting graph using NPLOT has been implemented and used [17].

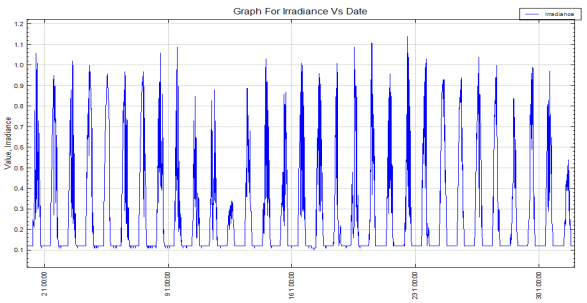

Fig. 4 Peak Irradiance Population for Jan 2012

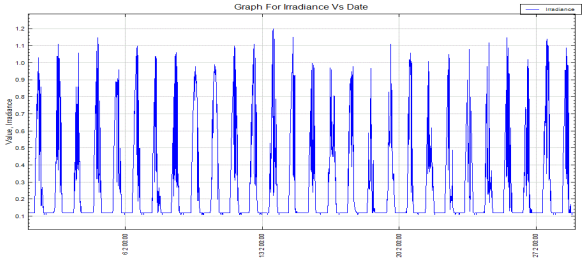

Fig. 5 Peak Irradiance Population for Feb 2012

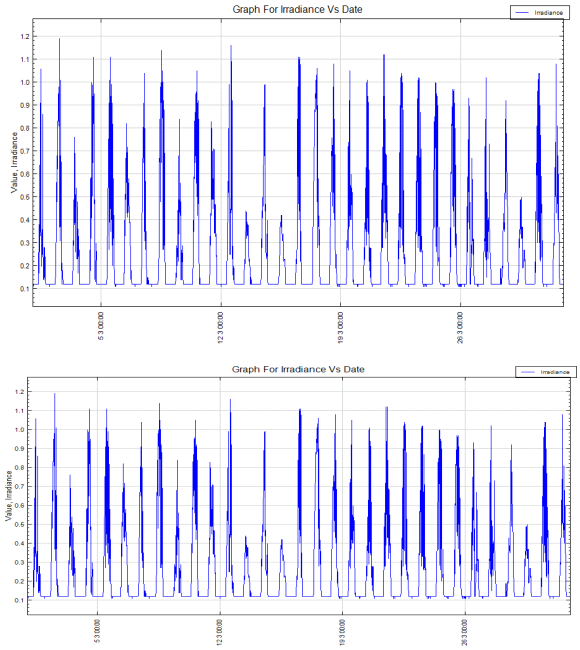

Fig. 6 Peak Irradiance Population for Mac 2012

C. Data Analysis using EDM System

Apparently the EDM has been used to analyse three month data measurement. Data measurement of the greenhouse has been carried out to study the strength of sun irradiance through-out for 3 months started from Jan 2012 till March 2012. The analysis was done by the EDM and the results are shown in Figure 4, 5, 6, 7, and 8. Figure 4, 5, and 6 show the measurement for peak irradiance from Jan 2012 till Mac 2012. Irradiance is the strength of sun intensity which is measured using Pyranometer[5].

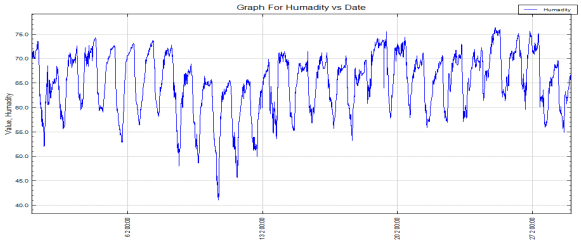

Fig. 7 Humidity Measurement for Feb 2012

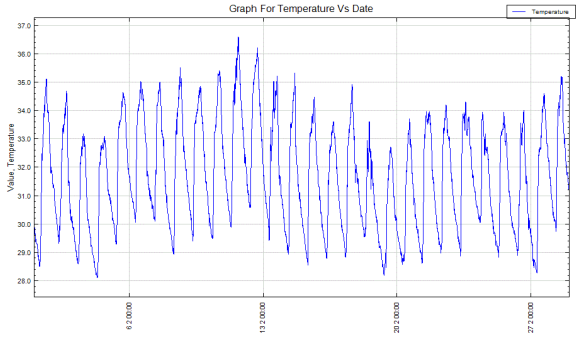

Fig. 8 Temperature Measurement for Feb 2012

The reading is in kw/m^2 with the measureable range from 0.0 kw/m^2 to 1.6 kw/m^2. Normal irradiance reading for good weather is 0.9 to1.2 kw/m^2. Reading which is beyond 1.2 kw/m^2 indicates that the weather is extremely hot. While reading that shows below 0.3 kw/m^2 indicates the weather is cloudy and raining.

Average reading for Jan and Mac are normal while in Feb the reading is consistent above 1.0 kw/m^2

Besides irradiance, the EDM is also capable to analyse humidity and temperature paramaters. Fig. 8 and 9 show the analysis graph for humidity and temperature respectively. Humidity is a percentage of water in air while the temperature is measured in Celsius. The Peak reading for humidity and temperature during day time and night time could be easily recognized through the graph. In tropical climax humidity is low (lowest 40 %) and temperature is high (highest 36.5'C) during day time while during night time humidity reading is high (highest = 76%) and temperature is low (28'C).

D. Peak Irradiance Population Analysis

The measurement data was saved in data access format. It can be easily analysed using microsoft office which provides statistical tool such as histogram, pie chart and etc.

The EDM has features to generate histogram to highlight the population of peak irradiance as shown in Fig. 9. The histogram indicates the frequency of peak irradiance from Jan to Mac 2012. In Jan the peak value is within acceptable level while in Feb the peak irradiance is slightly higher through-out the month.

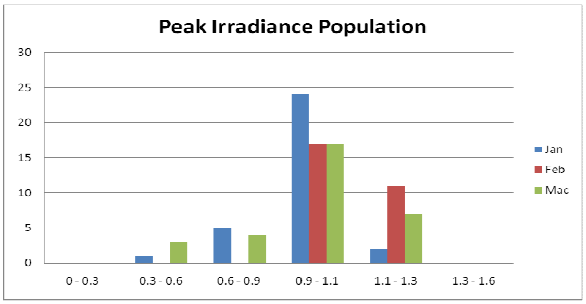

Fig. 9 Peak Irradiance Population from Jan till Mac 2012

In statistical analysis tool three patterns have been plotted as shown in Fig. 10, 11 and 12. The pattern for frequency against peak value for irradiance and humidity are similar where the values are concentrated at the lower range.

Correlation factor between them is 0.776 which indicates both have similar pattern. While for temperature the pattern is concentrated at the end of middle range. The correlation factor between temperature and irradiance is 0.426 which shows they have low interdependence against time.

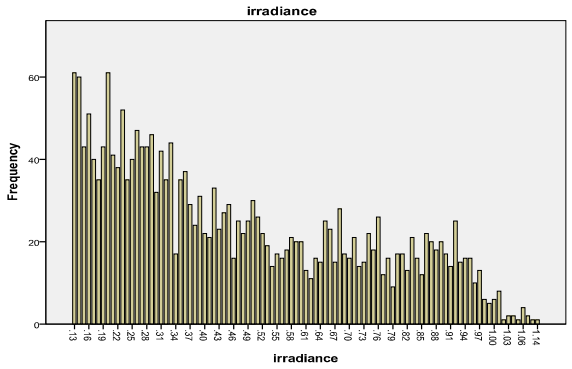

Fig. 10 Irradiance Reading for Day Time

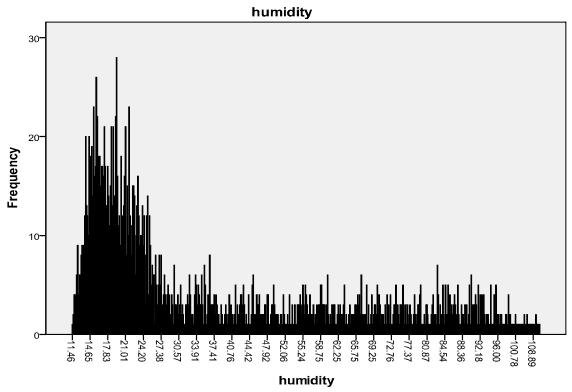

Fig. 11 Humidity Pattern against Time

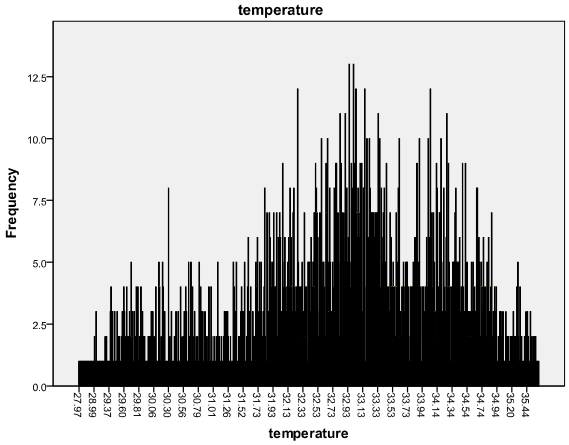

Fig. 12 Temperature Pattern against Time

V. Discussion

The main outcome of the research works is reasonably achieved with the main focus to develop data analysis tool using Visual Studio C# compiler. The tool has been applied to analyse measurement data for EDM and some interactive graphs have been plotted.

The development of the EDM is still on-going. The current stage is only activating tools for plotting the graph. The analysis tool to describe the condition of the greenhouse corresponding to the nature of the graph is in progress. The other part that is still in progress is the real time measurement and analysis.

It is reported that NPlot is capable to support the real time measurement. Nevertheless the coding has not been implemented yet by other users.

Besides irradiance, EDM is also capable to analyse humidity and temperature parameters. Fig. 7 and 8 shows the analysis graph for humidity and temperature respectively. Humidity is percentage of water in air while the temperature is measured in Celsius. The Peak reading for humidity and temperature during day time and night time could be easily recognized through the graph. In tropical climax humidity is low (lowest 40 %) and temperature is high (highest 36.5'C) during day time while during night time humidity reading is high (highest = 76%) and temperature is low (28'C).

Acknowledgement

This project is supported by STRG fund from UniKL and partly from e-science fund 01-02-13-SF0002. Special complement also goes to the team members from Teras Solution Sdn Bhd, Mr. Yassin for his knowledge and contribution towards the development of the EDM. Finally special thanks to the owner of the research station at Rawang for his willingness allowing the measurement to be carried out successfully.

References

[1] "What is the Climate, Average Temperature / Weather in Malaysia?" http://www.climatetemp.info/malaysia/. Dec 2009.
[2] Frank Bason,"80SPC Pyranometer CM21 SolData", SolData Instruments Manual
[3] Malaysian Meteorological Department, http://www.met.gov.my/
[4] R.Luharuka et al. "Design and realization of a portable data logger for physiological sensing." *IEEE Transaction on Instrumentation and Measurement*, June, 2003.
[5] R.Mukaro and X.F.Carelse. "A microcontroller based data acquisition system for solar radiation and environmental monitoring." *IEEE transaction on instrument and measurement*, Vol 4, no 6. Dec 1999. 2.
[6] M. Hilmi Fadzil S, M. Amir Abas, Samsudin A.Kadir, A. Khusairy Azim, "Improved Structure of Solar Tracker with Microcontroller based Control" *2nd International Conference on Advances in Computing, Control, and Telecommunication Technologies* - ACT 2010, Dec 02-03 2010 in Jakarta, Indonesia.
[7] M. Amir Abas, A. Khusairy Azim, M. Hilmi Fadzil, M. Dahlui, A.M.Arshad, "Portable Multi-Channel Environmental Data Measurement System for Monitoring Global Warming" *Proceeding of the 9th International Conference on Instrumentation, Measurement, Circuits and Systems*, April 10-13, 2010 Hangzhou, China pp 33-37
[8] M. Hilmi Fadzil, M. Amir Abas, A. Khusairy Hakiim, "Development of Environmental Monitoring Data Management System using OSS Python" *Proceeding of the International Conference on Electrical and Computer Engineering* April 2010, Rome.
[9] M. Amir Abas, M. Dahlui, "Investigating Ultra Violet (UV) Strength against Different Level of Altitude using New Environmental Data Management System", *International Conference on Ecosystems, Environment and Sustainable Development*, Venice 27-28 Nov 2011 (accepted)
[10] M. Amir Abas, A. Khusairy Azim, M. Hilmi Fadzil, M. Dahlui, "Monitoring the Quality of Ozone towards the Prevention of Further Global Warming" *The 2nd International Conference on Instrumentation, Control and Automation*, 15–17 Nov, 2011 Bandung
[11] M. Amir Abas, A. Khusairy Azim, M. Hilmi Fadzil, M. Dahlui, A.M.Arshad, "Portable Multi-Channel Environmental Data Measurement System for Monitoring Global Warming" Publisher: *WSEAS, Computer and Simulation in Modern Science Volume* V, April 2011, pp 102-106 (ISI Publication)
[12] http://en.wikipedia.org/wiki/Full-spectrum_light

[13] K.Rangan, T.Vigneswaran “An embedded systems approach to monitor green house” Recent Advances in Space Technology Services and Climate Change (RSTSCC), 2010
[14] Chang-Sun Shin; Yong-Woong Lee; Meong-Hun Lee; Jang-Woo Park; Hyun Yoe, “Design of Ubiquitous Glass Green Houses” Software Technologies for Future Dependable Distributed Systems, 2009
[15] Junlong Fang; Fulu Wang, “Design of Greenhouse remote monitoring system based on LabVIEW” IEEE International Conference on Computer Science and Automation Engineering (CSAE), 2011
[16] Ahonen, T.; Virrankoski, R.; Elmusrati, M.,”Greenhouse Monitoring with Wireless Sensor Network”, IEEE/ASME International Conference on Mechtronic and Embedded Systems and Applications, 2008. MESA 2008.
[17] http://www.netcontrols.org /nplot

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