Data Acquisition of Greenhouse Using Arduino

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Abstract

In this paper, the Design had been aimed data acquisition in greenhouse for multiple sensors to use data for simulation or processing to achieve the better enhancement of growth in greenhouse, this data has effect on the climate of greenhouse. Graphical User Interfaces (GUI) had been used through LabVIEW, firmware of arduino as software and arduino board and sensors as hardware. by using arduino mega board provides multiple inputs analogs and I/O digitals to made read data sensor easy to take temperature, humidity, CO2 gas, also measuring the soil moisture that needed for irrigation plants and the intensity of lights that applied for greenhouse . These factors has the major effect on increase growth plants. Greenhouse environments monitoring present difference changes to parameters, the system for this purpose had been provided and given ability to control on climate of greenhouse.

Keywords: data acquisition, arduino mega, LabVIEW, temperature, humidly, sensors

الخلاصة

تم بحث التصميم في اكتساب البيانات من مجموعة من المتحسسات الموزعة داخل البيوت الخضراء حيث تستخدم تلك البيانات في عمليات المحاكاة أو المعالجة للوصول إلى أفضل عملية أنماء داخل البيوت الخضراء من خلال توفر الظروف المناسب . برنامج اللاب فيو استخدم للمحاكاة بالإضافة إلى البرنامج المسقط على الاردوينو حيث إن استخدم كارت اردوينو ميجا يسهل ويوفر العديد من الإدخالات التناظرية بالإضافة إلى الإدخال والإخراج الرقمي والذي يجعل من قراءة الحرارة والرطوبة وباقي المتحسسات والتي له التأثير في أنبات النباتات من خلال مراقبة تلك المتغيرات حيت تعطي القدرة على السيطرة الصناعية على المناخ في البيوت الخضراء

الكلمات الدالة : اكتساب البيانات, اردوينو ميج, لاب فيو, الحرارة, الرطوبة, المتحسسات .

1.Introduction

The crop agriculture in greenhouse is higher affected by the surrounding conditions. The significant environmental factors for the quality and better productivity of the plants growth are temperature, relative humidity, Lighting, moisture soil, and the CO2 amount in greenhouse. Continuous monitoring of these factors gives relevant information pertaining to the individual effects of the various factors towards obtaining maximum crop production [J. H. Shin *et al.*, 1998].

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. [David *et al.*, 2007]. Arduino can sense the surroundings by receiving input signal from a variety of sensors and can affect its environment via controlling heater, Water pump, and other actuators. The AVR Atmega2560 on the board is programmed using the Arduino programming language (depended on Wiring) and the Arduino development environment (depended on processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, MaxMSP)

A greenhouse is seen as a multivariable process presents a nonlinear nature and is influenced by biological processes [Herrero *et al.*, 2007].The five most important parameters must be taken into consideration when design a greenhouse are temperature, relative humidity, ground water, illumination intensity and CO2 concentration. This parameters is important to realize that the five parameters mentioned above are nonlinear and extremely interdependent [Fourati *et al.*, 2007; Blasco *et al.*, 2007; Putter and J. Gouws, 1996]. the computer control system for the greenhouse involves the series steps [Melrolho, 1999]:

1. Acquisition of data through sensors.
2. Processing of data, comparing it with desired states and finally deciding what must be done to change the state of system.
3. Actuation component carrying the necessary action.

This paper describes a solution to the first part of the system. The information is obtained from multi-sensors station and is transmitted through USB port to computer.

Mahmoud presented an method for controller and monitoring, this research used microcontroller to transfer data via the RS232 port [MAHMOUD OMID, 2004].

H. Mirinejad *et al.* presented an approach for greenhouse and control system based on the (SCADA) tools, supervisory system designed and simulated to serve as a user-friendly interface with the operator[H. Mirinejad, 2008].

Anuj Kumar *et. al.* had been made an attempt to devise a DSP processor based environment monitoring system (EMS) to real time monitor the climatic parameters which, directly or indirectly, have a vital say in the growth of the greenhouse plant[Anuj Kumar *et al.* , 2010].

Kiran Sahu *et al.* had been design a simple and easy to installing by used microcontroller-based circuit to monitor and record, to achieve the maximum plant growth for greenhouse [Kiran *et al.*, 2012]

M. GUERBAOUI *et al.* proposed a contribution to the development of greenhouse manufacture in Morocco. The suggest solution include the development of an controller system, a data acquisition card PCL-812PG controlled via personal computer [M. GUERBAOUI *et al.* , 2013].

2.System Architecture

The global architecture of the greenhouse data acquisition system shows in Figure(1) below. The system design consists of two parts Hardware and Software.

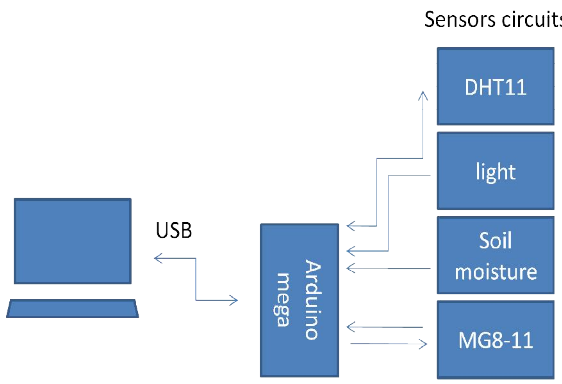

Figure (1): The global architecture

2-1 Hardware part

The core of the hardware part is the data Acquisition card that is used as a mean between PC and sensors circuit ,arduino mega 2560 r3 is used here for this purpose. The Arduino Mega 2560 is a microcontroller board use AVR ATmega2560.It has16 analog inputs pins and 54 digital input/output pins (of which 15 can be support work as Pulse-width modulation outputs).

a- Temperature and humidity sensor

Temperature and relative humidity sensor (DHT11) is multifaceted with a calibrated digital signal output features (D-Robotics, 2010), it enclose high accuracy and stellar long-term steadiness. Single-bus data form is used to communicate and synchronize control unit and DHT11 sensor. One communication handling is about 4ms. Data composed of decimal and integral portions. A entire data transmission is 40bit, and the DHT11 sends response as higher bit first. Also the time of sensor is very sensitive to distinguish zero and one bits as show in Figure(2).

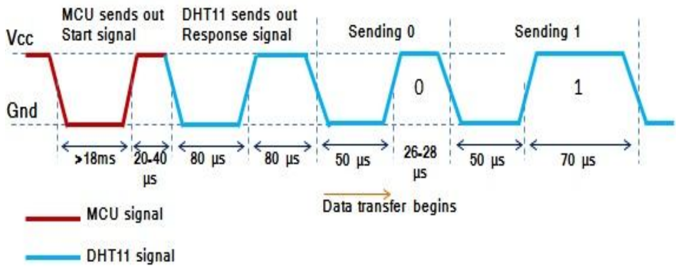

Figure (2): Timing diagram depict the protocol include in the connection between a control unit and the DHT11 sensor (D-Robotics, 2010).

Data form: 8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data + 8bit check sum. If the data transmission is valid, the check-sum should be the last 8bit of "8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data".

In the present work one of digital I/O of arduino mega is used for DHT11 sensor. By approach of a handshake the values are pulse out over the single digital line and connected GND and VCC as show in Figure (3).

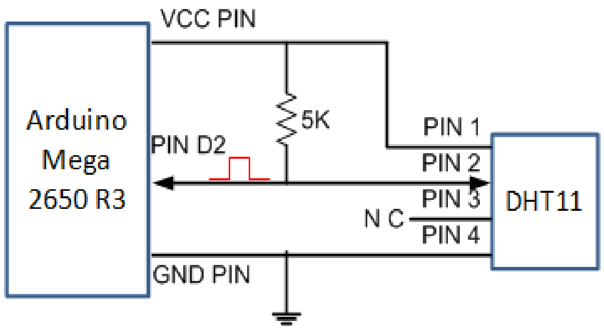

Figure (3): Typical Application Schematics

b- Soil moisture sensor

The second sensor Soil Hygrometer detection module soil moisture sensor had been used for greenhouse monitoring this module has the important benefit in process of irrigation. The sensor as show in Figure (4)

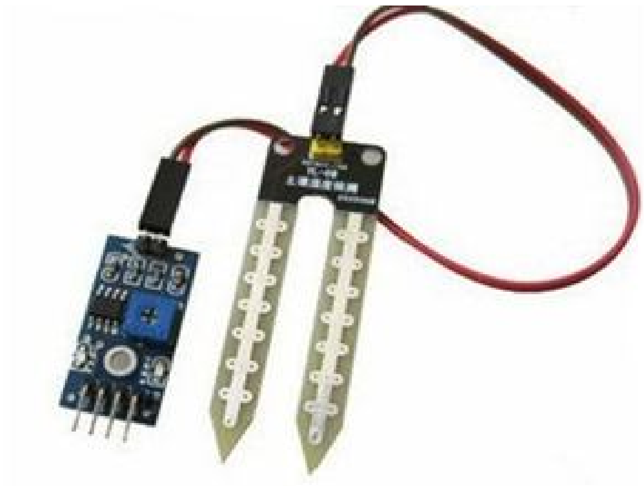

Figure (4): Soil Moisture Sensor Module

Two approach in the soil moisture, less than a set threshold value when the D0 pin output high, when soil moisture surpass the threshold value is set, the module D0 pin output low, digital outputs D0 can be directly connected with the MCU, arduino mega r3 to distinguish high and low, and thus to alarm about soil moisture. Analog output A0 connected through the A/D converter or to any pins of analog onboard, as well as use analog pins can give more accurate values of soil moisture

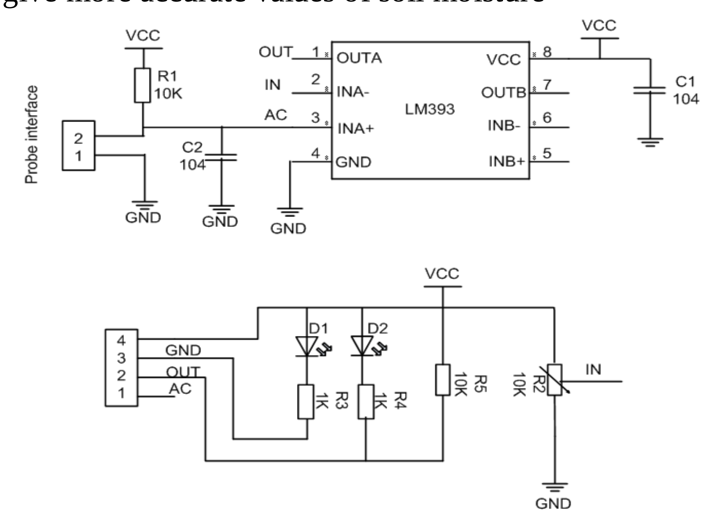

Figure (5): Soil humidity module circuit diagram

Many of these sensors can be used and distributed in greenhouse, using analog inputs for arduino mega .

c- Lighting sensor

The third sensor is Photosensitive resistance module light sensor to adjustment amount of lighting, the condition circuit is same as the soil moisture sensor shown in Figure (5) also connect to any analog input (A0-12) of arduino mega .

d- CO_2 concentration

The fourth sensors for CO_2 concentration (MG-811) ,there is an onboard signal conditioning circuit for amplifying output signal and an onboard heating circuit for heating the sensor. The MG-811 is highly sensitive to CO_2 and less sensitive to alcohol and CO. this sensor need one analog input and one digital for connect the sensor to arduino mega. Typical Application Schematics shown in Figure (7), the sensor module shown in Figure (6)

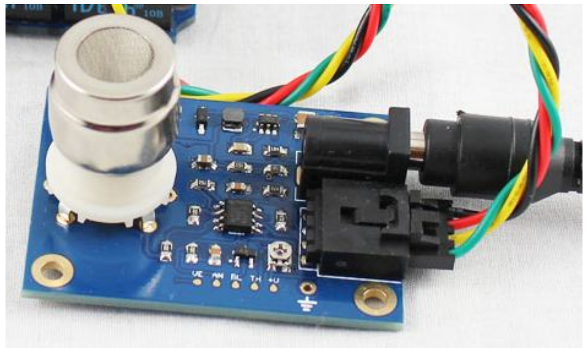

Figure (6): MG-811 CO2 sensor module

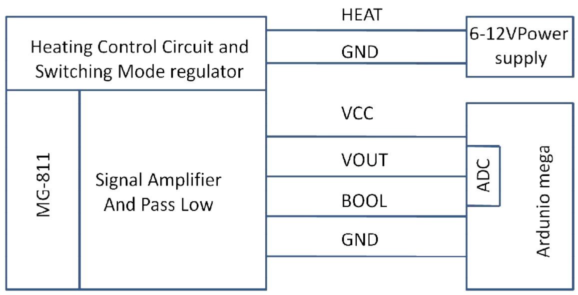

Figure (7): Typical Application Schematics

The MG-811 sensor is basically a cell which gives an output in the range of 100-600mV (400—10000ppm CO_2). The LMC662 is used as the amplifier because of its ultra-high input impedance. According to the datasheet of MG-811, this sensor require an input impedance of 100-1000Gohm

From Figure (8) we can calculate output from multiple input by gain

$$Vout= Vin *(1 + R4/R1)$$

In this specific application

$$Vout= 8.5*Vin.$$

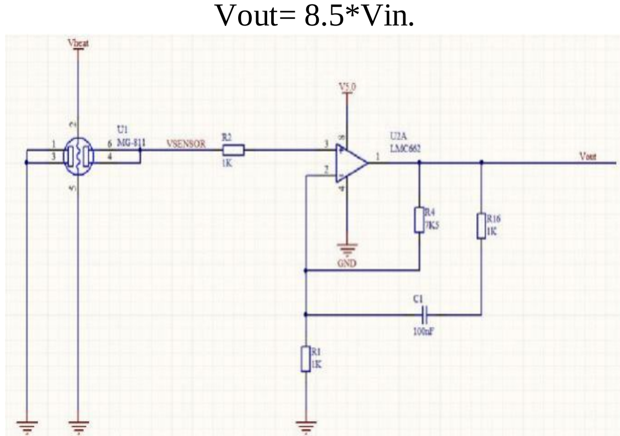

Figure (8): Signal Conditioning circuit

Also this sensor module has chip MP2359 for Switch Mode Heating Voltage Regulator of MG-811 heating circuit.

2-2 Software Part

The hardware design had been completed, the next step is to define the software part. Which is composed of two main parts, software part configuring in the arduino mega 2560 r3 (Firmware) and software for LabVIEW .

In order to interface The NI LabVIEW with arduino, the NI LabVIEW Interface for Arduino Toolkit (LIFA) support to readily interface with the Arduino board using LabVIEW. With LabVIEW toolkit data can be controlled or acquired from the Arduino board. Once the data is in LabVIEW, it will be analyzed using the hundreds of built-in LabVIEW functions, improve algorithms to control the Arduino hardware, and present the findings on a polished UI.

The LabVIEW toolskit given features :

- Easy used Arduino digital input/output , analog input, I2C, and Serial Peripheral Interface from LabVIEW.
- I/O engine sketch to load on Arduino
- communication wireless via XBee or Bluetooth.
- Loop rates: USB tethered (200 Hz) and wireless (25 Hz).
- IDE arduino sketch and LABVIEW toolkit VIs help to specification functionality.

The Firmware took from LabVIEW toolkit and upload to arduino mega using integrated development environment (IDE) arduino as shown in Figure (9).

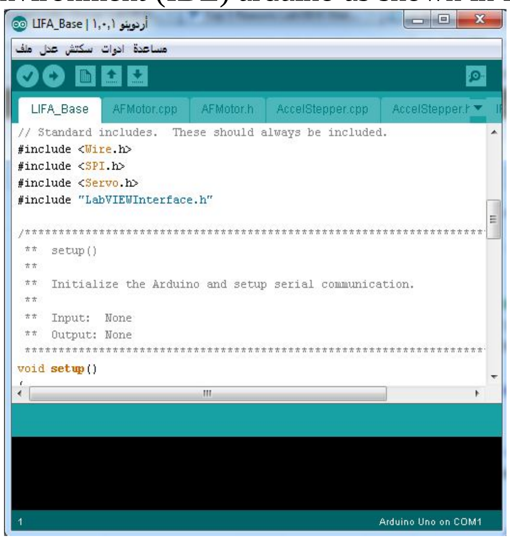

Figure (9): IDE arduino

Now the firmware wrote in C\C++ language support all sensors in the greenhouse except the DHT11 sensor because this sensor is very sensitive for time (cannot process by LabVIEW), thus we needed to edit or modified firmware by add two files to firmware one DHT11.cpp contain the main program of DHT11 sensor and declaration of parameters, DHT11.h contain process and function of DHT11 sensor, these files are called by main firmware. The software design of LabVIEW is a development environment which is the user graphical programming to interact with real world data. The block code shown in Figures (10,11,12,13) illustrate the design.

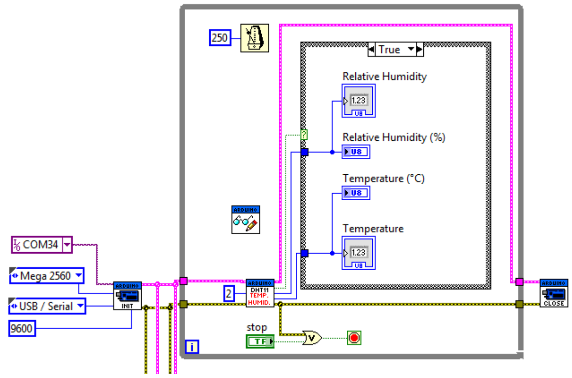

Figure (10): DHT11 sensor design

Figure (10) shows the required block code for operation DHT11 for acquisition data in greenhouse, so it is needed to define Init that includes the VISA resource (COM34), type of arduino board, type of connection (USB/serial, XBEE, Bluetooth), bate rate and at the end define close session.

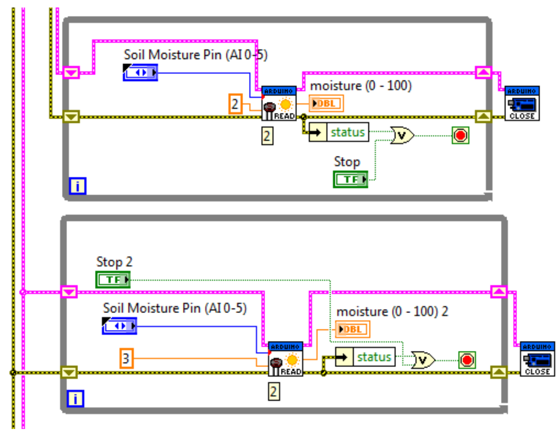

Figure (11): IDE arduino

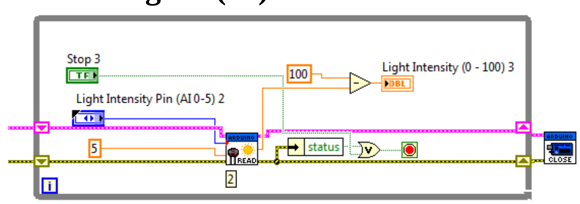

Figure (12): Light Intensity design

The Figure (11,12) shown acquisition data of light and soil moisture and final Figure shown the CO_2 concentration read from sensor

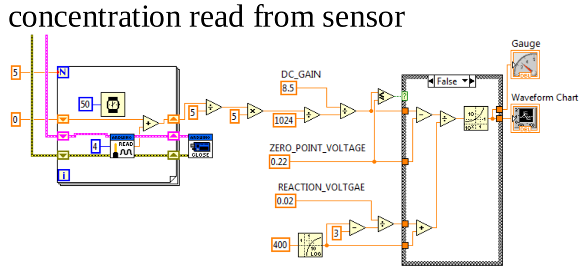

Figure (13): CO2 sensor design

3.Results and Conclusion

The system monitoring based on computer and arduino mega board given ability for data acquisition from greenhouse. The system applies for small greenhouse and the changes for many parameters had been gotten that may be process in the future in order to give appropriate action by using one of control methods .

As shown in Figure (14) had been shown the change of temperature and humidity ,that take through average half hours between each one.

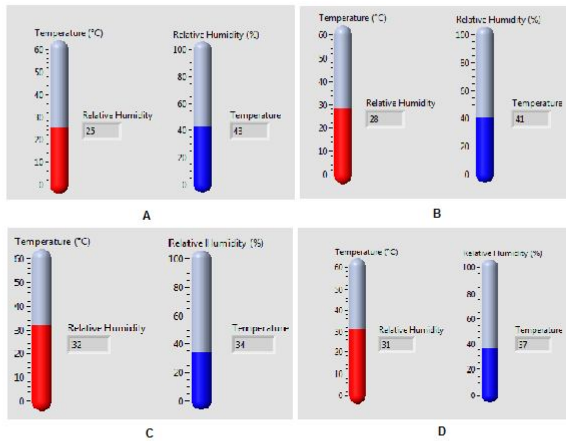

Figure (14): The temperature and humidity data measured in the greenhouse.

Figure (15) shows the measured value taken in a time period of one hour between each reading. In additional the change of light intensity and carbon dioxide in Figures (15,16),notice that the CO_2 concentration is very low because light intensity is high .

At the end, the conclusion of this paper: the acquisition data can be done using arduino mega board with the ability of increasing the size and number of greenhouses by using one board because it has multiple analogs inputs, digitals inputs/outputs in additional to other specifications

Figure (14): Soil moisture measured

Figure (15): Monitoring of light intensity

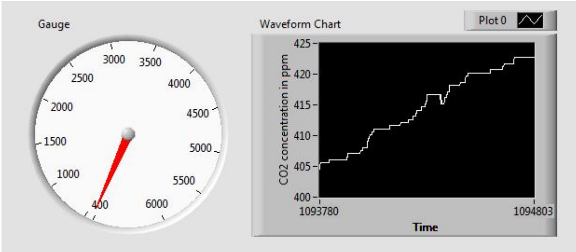

Figure (16): Carbon dioxide data monitored in the greenhouse.

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