

## **Development of Automated Agricultural Process Monitoring and Control Technology in an Enclosed System**

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**Abstract:** For proper growth of any plants various physiological and physiochemical factors are responsible like: soil moisture, atmospheric temperature, humidity, sunlight, pH of soil, nutrient and chemical balance of soil. Biologically, these parameters are in direct relation with the process of photosynthesis, which effects the total overall growth of the plant. An Attempt has been made to develop an automated system which can measure different agricultural process parameters (like temperature, soil moisture, sunlight intensity, humidity, chemical contents etc.) and control using PID controller these parameters can be remotely monitored and control. With the help of MATLAB interfaced with NI LABVIEW, virtual designs of the real time processes are simulated.

**Keywords:** DAQ, labVIEW, Matlab, multi-sensor system, SIT.

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### **I. Introduction**

There are so many engineering problems related to agriculture as stated below and lack of technical implementation at grass-root level. In this paper we intend to provide an idea that will help the farmers and the operators to receive a low cost, fully automated, user defined and eco-friendly technology that will not only save labour but also natural resources. An attempt has been made to design a VI using labVIEW and connected it to Simulink model, Matlab works [8-10]. This can work both as a simulator and in a real time (with minor changes in design) basis. In the design we will provide a complete used-defined panel that will do continuous monitoring and fully automated controlling of the set parameters. It will also provide the overall system condition as- 'good, average, worst' interfaced with an alarm system on basis of system performance. This will be achieved in real time by using integrated sensor, timer systems, NI-DAQ based on simulation interface toolkit (NI-LabVIEW software) interfaced with Simulink Matlab works [10].

#### **1.1. Problem statement**

Before starting the research work on this paper, we have personally gone to some of our regional suburbs where still farmers are using primitive methods [7] of agriculture. We have thereby found out some of the common problems that they face. In the agricultural sector there are lots of problem related to crop production. We are focusing on some of the problems significantly faced by the farmers, which are:

- a) Shortage in availability of land and water resources ;
- b) Drastic change in environmental conditions[7,5] due to Global Warming, etc. ;
- c) Unnecessary use of chemical agents (e.g. inorganic pesticides, fertilizers, etc.);
- d) Lack of information on sustainable agriculture
- e) (Overuse of land, leading to land exploitation and degradation of soil quality.)
- f) On a broader aspect for the agro-market:
- g) Production of foreign crops cannot be done here in the native farmlands ;
- h) Seasonal plants cannot be grown throughout the year[6] (e.g. Tulip cannot be grown in summer) ;
- i) High percentage of sensitive plants like Chiraita[5,6], etc. having great medicinal values is becoming extinct.

#### **1.2. Objective**

So, our vision is to develop a low cost, secured, automated online control and monitoring system for agricultural parameters and try to solve maximum problems stated. In this work we will provide solutions to the following:

- a) Unavailability of low cost automatic agricultural monitoring and control system available yet;
- b) Easy installation of equipment not readily available to the farmers;
- c) Fully automatic systems are yet not built and implemented in agricultural sectors at grass root level.

#### **1.3. Description**

Laboratory Virtual Instrumentation Engineering Workbench abbreviated as **labVIEW**, version 2012 is a project based platform. It is a graphical-based programming language developed by National Instruments. Its

graphical nature makes it ideal for test and measurement (T&M), automation, instrument control, data acquisition, and data analysis applications. This results in significant productivity improvements over conventional programming languages [8].

Simulink is an add-on toolkit for **MATLAB**, and it provides a graphical environment for the design and interactive execution of dynamic system models [2].

The user can create models in Simulink using customizable blocks. The Simulation Interface Toolkit (SIT) provides a way to create a LabVIEW user interface [10] that you can use to interact with a Simulink model. With a LabVIEW user interface, one can manipulate the model parameters and view the output data of the Simulink model immediately.

## II. Materials

The requirements for the presentation of this work are as follows:

- a) LabVIEW simulation interface toolkit(sit) version 2012,LABView 2012,ni
- b) Matlab Simulink version R2007b
- c) Sensors used

**Table shows the list of sensors and control actions for various agricultural parameters:**

Serial number	Controlling parameters	Sensor used	Controlling action
1.	Moisture of soil (%)	Moisture sensor	Sprinkler system
2.	Ambient Humidity (%)	Humidity sensor	Mist spray system
3.	Sunlight Intensity (%)	Sunshine sensor	Floodlight
4.	Ambient temperature (°C)	Temperature	Conditioner ( heater)
5.	pH of soil	pH sensor	Underground drip system
6.	Nutrient and chemical	Timer control	Drip system
7.	Organic insecticide and pesticide	Timer control	Sprinkler system

**Table 1: Sensor system and control action for various parameters [1].**

## III. Concept And Methodology

### 3.1. Simulink Model For Controlling Different Parameters

MATLAB Simulink is an effective tool for designing a virtual simulation for a real time process and it acts same as the real time process present in the real world [10]. It helps a lot to process control engineers like us to test, map and simulate a real time process in a computer before implementing the control algorithm to a real time process. In this work we are trying to map the real time process of harvesting a particular crop in virtual world and will try to control different physiological and physiochemical factors that are having direct impact on the growth of a particular crop.

In MATLAB Simulink we will code the PID control algorithms to control different process parameters such as temperature, moisture, humidity sunlight intensity and flow of chemical fertilizer and pesticides. We will also code the control algorithms to control the water level in reservoir.

LABVIEW will be used to show a virtual simulation of the entire process on front panel from where the operator cum farmer can able to see the current status of his land and can able to control different parameter which are having direct impact on the growth of the crops. Alarm systems are made to generate necessary alarm signal in case of worst scenario in order to alert the farmer about the consequences. This will provide the farmer a remote control approach to look after his land and crops. It will also increase the productivity of land though efficient control and will reduce human efforts though complete automation of the harvesting process.

As our approach is flexible the same system can be used for cultivation of different crops without any modification of the hardware only as per the crop grown the set points of different controlling parameters has to change. The LabVIEW Simulation Interface Toolkit integrates LabVIEW with the software of the Matlab works known as Simulink and Real-Time Workshop[8,10] in a way that allows us to develop, prototype, and test control systems using models developed in the Simulink simulation environment. The Simulation Interface Toolkit automatically generates labVIEW code to interface with a Simulink model resulting in a flexible and easy to use user interface. After configuring the Simulink model to communicate with LabVIEW, we can create a LabVIEW host VI that automatically a call, run, and interacts with the Simulink model.

### 3.2. Configuring the Simulink Model

To create a user interface in LabVIEW for Simulink model, we first must have a Simulink model. Before using the Simulation interface Toolkit, we must have MathLab works 6.0 or later here we are using MathLab 7.0, MathLab Simulink 4.0 or later and National Instruments 7.0 or later with Simulation Interface Toolkit here we are using LabVIEW 2012 with Simulation Interface Toolkit 2012 installed on the host computer. We can complete the following steps to build a new control system Model in Simulink.

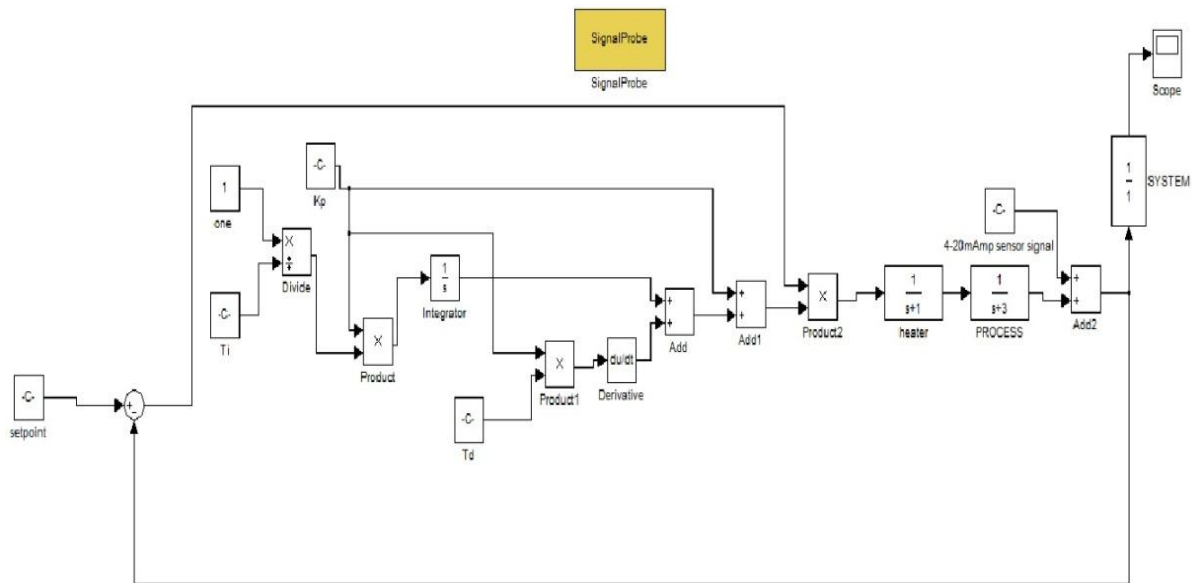


Fig 1: Block diagram of process in Simulink model

The following steps are to configure the Simulink software:

- Install the Simulation Interface Toolkit and launch the SIT Server by running Matlab in host computer. The MATLAB [11] command window displays the following message. “Starting the SIT Server on Port 6011 SIT Server started” This message indicates that the SIT Server is running.
- Enter simulink in the MATLAB command window to launch the Simulink Browser window. In a new model place the transfer function of the PID control unit and place all the required constants. Then drag the signal probe block from NI SIT Block in the model.
- Select Simulation Parameters to open the Simulation Parameters dialog box to set the simulation parameters. Reference gives a guide how to choose a Fixed\_Step\_Solver and step size. On the Solver tab type 50 (which must at least be greater than the settling time of a control system, so we can see a full step response chart of a control system.) in the stop time text box. By changing the stop time to an infinity value, the simulation runs until we stop it. Set the Type option to Fixed-step in the solver option section and type 0.1 in the Fixed-step size (fundamental sample time) text box.
- Save the model with some name. We now can create a user interface in lab VIEW for the simulink model. The model must remain fully- operational within the simulink environment.

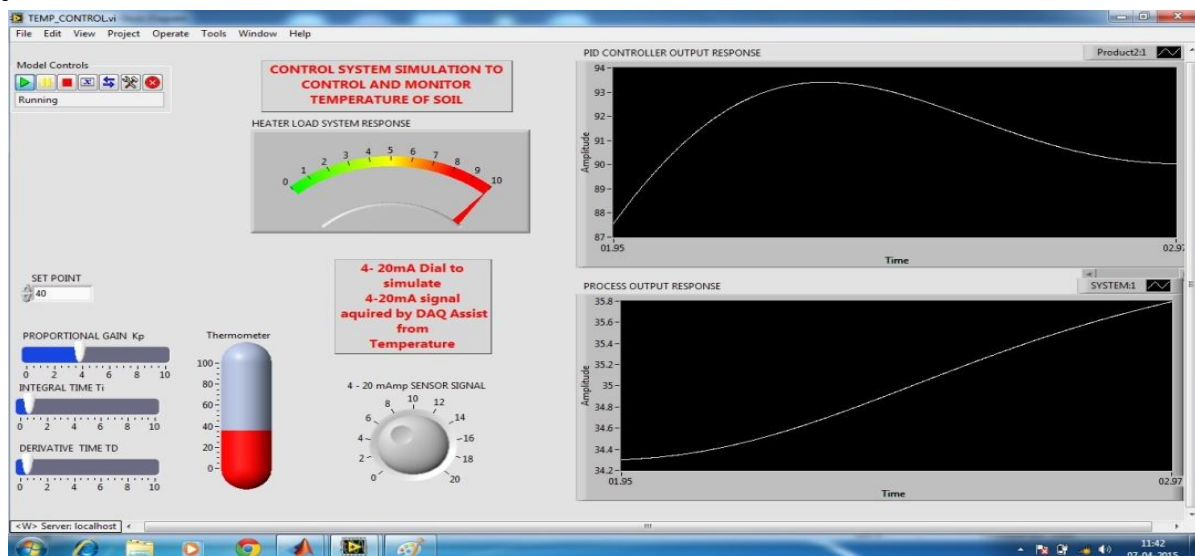


Fig 2: VI of temperature control unit

### 3.3. Creating a LABVIEW user interface

To interact with the simulink model using LABVIEW user interface, we need to create the user interface in LABVIEW. We need control for manipulating different parameters in the simulink model and indicators to display the response process (land and crops ) and different parameters such as temperature, moisture, humidity, water level etc.

We can complete the following steps to create the control and indicators that reflect the parameters and sink of the simulink model.

- Launch LABVIEW on the host computer and open a new VI. Select the required control indicator depending on the parameter and place on the front panel of the VI. Adjust the scale of the indicator as per maximum range of variation.
- Select the control buttons as per convenience to feed set points into the system and place on the front panel of the VI.
- Save the VI with some appropriate relative name.

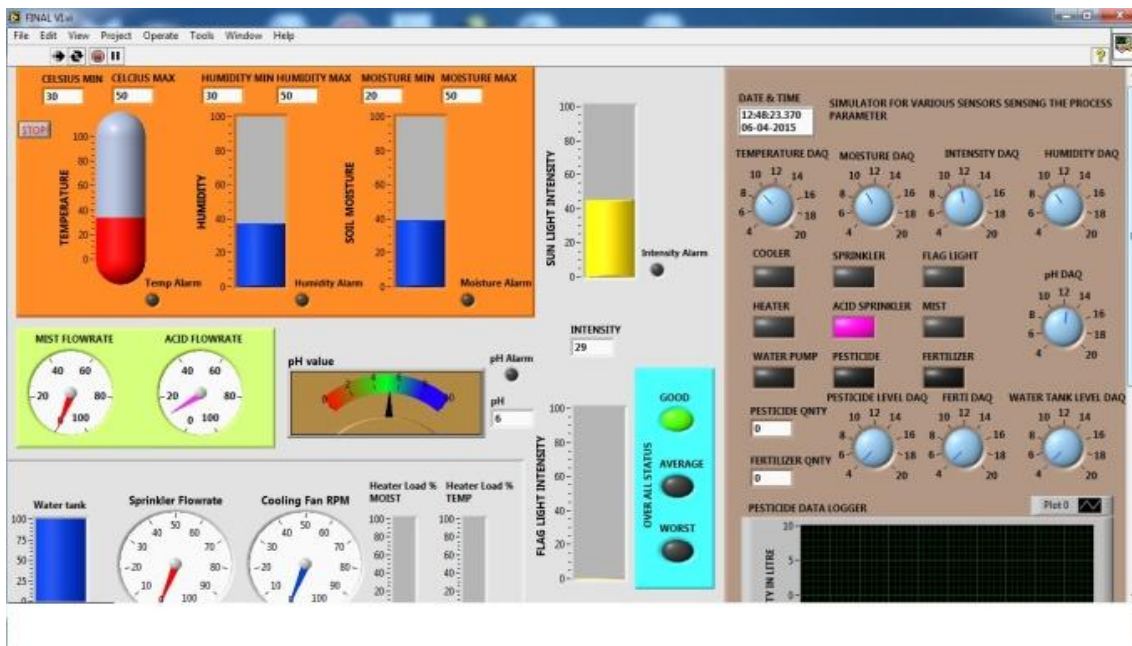


Fig 3: VI of complete system

### 3.4. Creating connection between the labVIEW user interface and the Simulink model

After the Simulation Interface Toolkit enables LabVIEW to run and communicate with the Simulink model once we make the appropriate connections. MATLAB and Simulink must remain open to configure and run the simulation model.

On the front panel menu bar select Tools >> SIT Connection Manger to launch SIT Connection Manager Dialog box. Now the control and indicator list box displays the control and indicators we created on the front panel of the simulation model. Click on the load Model button to display the Select Host dialog box. In the Select Host Dialog box, make sure the Machine Name/ IP are local host. You can run MATLAB Simulink model in different computer and LABVIEW VI in different computer but make sure that both the computers are connected to the server and in such case type the IP address of the host computer in Machine Name/IP. Then click on the OK button. All the parameters and sinks associated [10,11] with the simulation model appear in the model parameter and sinks list box in the SIT Connection Manager Dialog box. Now the parameter and control have an icon in front of them while sinks and indicators have an icon in front of them. To create connection between the indicator in LABVIEW and the NI Sink in the Simulink model, select the indicator in the control and indicators list box and select NI Sink >> NI Sink in the model parameters and sinks list box. Click on add to connection button to add the connection to the current connection table.

Find the SIT Read Loop in the block Diagram. Move the icon of the indicator in the Case structure area. Wire it to the input line of the icon indicator. So we can see the indicator and the wave form chart at the same time. Save this VI with some appropriate name. Click on the Run button to run the VI. The select Host dialog box appears. Verify that the host computer is local host. Click on the OK button. Although the VI starts to run, the Simulink model is not running yet. To run the Simulink model click the run button on the front panel. Adjust the value of set point as per the requirement.

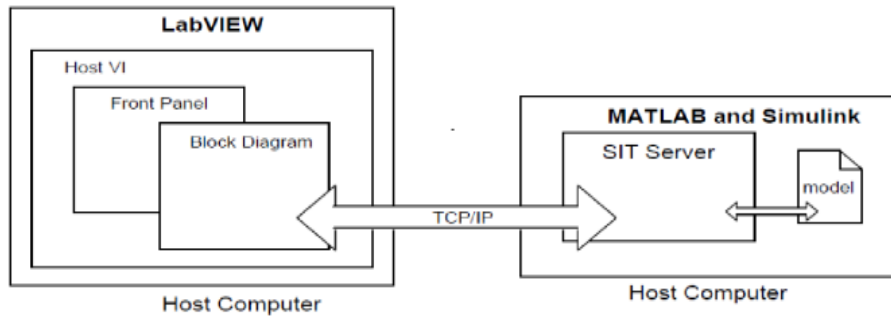


Fig 4. Interfacing labVIEW with Matlab[10]

### 3.5. PID Control-theory and algorithm

The very basic and classical expression of a PID [2,4] control algorithm in time domain is represented as

$$u(t) = K_p e(t) + \frac{K_p}{T_i} \int e(t) dt + K_p T_d \frac{de(t)}{dt}$$

Here

$u(t)$  : Output obtained from the PID controller and to be feed as control input to the process plant

$e(t)$  : Error signal generated after comparing the set point with the feedback signal

$K_p$  : Proportional gain

$T_i$  : Reset Time (Minutes/Repeat)

$T_d$  : Derivative time (Minutes)

**Proportional Band:** It is the band of error which causes a 100% variation in the controller output expressed as a percentage of range of measurement

Control input

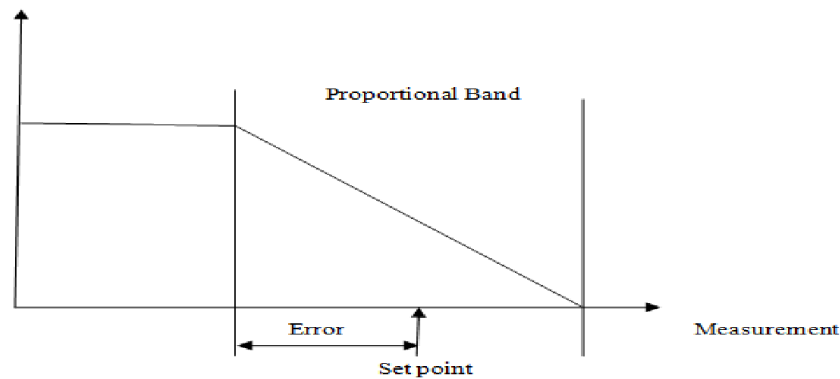


Fig 5 . Proportional Band [4]

Here

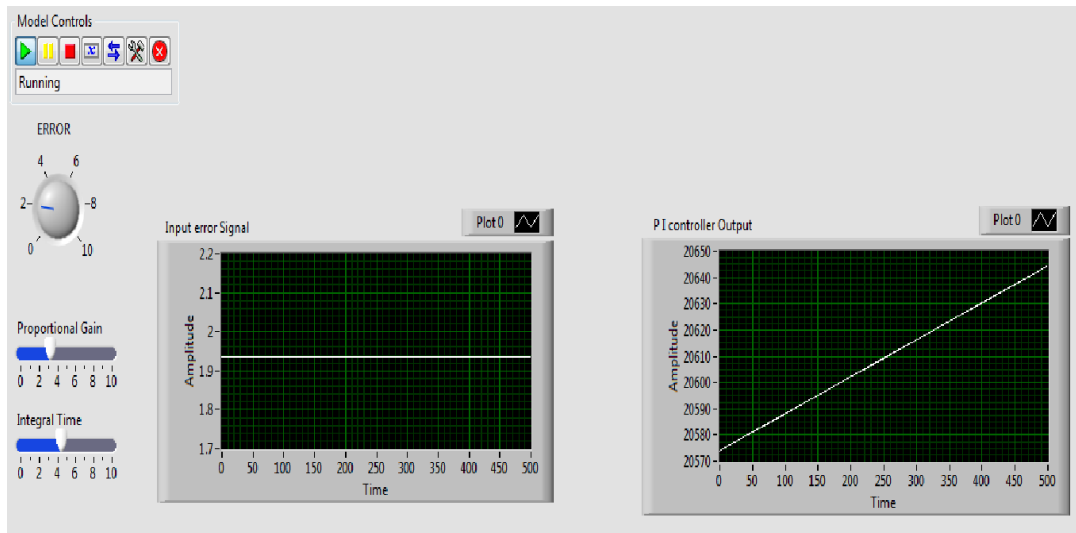
$$K_p = \frac{\Delta u}{\Delta e} \text{ and } PB = \frac{100\%}{K_p}$$

### Integral Gain $K_i$ and Integral Time $T_i$

$T_i$ : Time taken to repeat proportional control action for step error signal is known as integral time

Integral gain is nothing but  $K_i = \frac{K_p}{T_i}$

If you give a step input like this to the above shown controller then the output will vary like the response shown below.



**Set Error** **PI Controller Output**  
**Fig 6.PI Controlled Output Response**

As there is any step change in error signal immediately the  $K_p$  will rise as shown in the figure above and then the integral term will start integrating the error and will go up. After some time the integral part of the input will become equal to the proportional part of the input, so it turns out that exactly after  $T_i$  (Integral time) amount of time the output of the integral control unit will become equal to the output of the proportional control unit.

**Derivative gain  $K_d$  and Derivative time  $T_d$**

**Derivative Time:** Time for the proportional term to be equal to the derivative term for a ramp error signal is called derivative time. Let us assume a Proportional Derivative Controller of following transfer function

$$\longrightarrow \boxed{K_p(1 + sT_D)} \longrightarrow$$

**IV. Results**

In a PID control algorithm in order to have the desire output response of the overall system, tuning of different control parameter is to be done in specific way, which is given by different control analyst and engineers such as Ziegler Nichols, Cohen coon and Pessen. If the tuning of the controller is not done properly depending upon plants or process model (here in our case it is different types of crops which is being cultivated) the quality of the process output will be highly affected. In this work we have taken some reading from our simulation which is the exact replica of a real time process of particular crop cultivation. Here we are trying to tuning our PID controller so that we can get zero steady state error, relatively less settling time and overshoot in the output response of the process.

**Reading obtained from the simulation of the virtual model of temperature control unit**

Sl. No	SET POINT (Celsius)	PROPORTIONAL GAIN $K_p$	INTEGRAL TIME $T_i$ (sec/repeat)	DERIVATIVE TIME $T_d$ (sec)	SETTLING TIME $T_s$ (sec)	STEADY STATE ERROR
1	40	15.47	1.27	1.22	2.5	-2
2	50	17.11	1	1,007	2.5	-1.5
3	60	16.1007	0.5	1	2.3	-1
4	70	12.07	0.753	0.5	2	-2.2
5	80	14	1.5	0.5	2	-4
6	90	10	1	1	2.3	-5
7	30	20	1	1	2	-1
8	20	20	0.5	1	2.2	-0.2
9	10	20	1	0.5	2.5	-0.25
10	5	15	0.5	0.25	2.25	-0.1
11	5	20	0.25	0.25	2.5	-0.01
12	50	150	0.14	0.14	2.5	0

**Table 1: Parameters of Controller**



It is very clear from the above readings that for the mentioned model the proportional gain  $K_p$  of the controller should be set very high to get proper damping oscillation and to have least steady state error therefore the best tuning parameter set in our experiment is reading number 12.

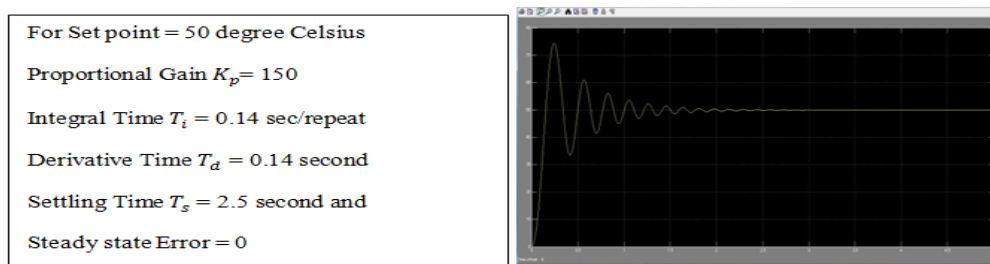


Fig 7: Output response of reading number 12

The virtual user interface for feeding the different values of the control parameter ( $K_p$ ,  $T_i$ , and  $T_d$ ) in the virtual model of our process is shown below.

The above shown figure 2 is the user interface to feed different control parameter such as proportional gain  $K_p$ , integral time  $T_i$ , derivative time  $T_d$  and desire set point for controlling and monitoring the temperature of the soil. Figure 3 shown above is the user interface for controlling and monitoring all parameters which are generally need to be controlled for efficient growth of the crops. It also indicate the overall status of the entire process in three different state i.e. (GOOD, AVERAGE, WORST). It also generates alarm signal when the process parameters are not in the range set by the operator/farmer.

## V. Conclusion

Our interest in agricultural automation lies from the fact that we belong from a country that is heavily dependent on agricultural outcome and revenues. Being a part of such agriculture depended society we have always tried to renovate agricultural systems and processing. Our recent government has also shown keen interest to formulate new legislative rules to help the farmers even at the grass root level. By simulating the real time agricultural parameters into a useful and highly efficient and accurate application based software we have tried to manipulate and control the ever changing weather condition, physical aspects and physio-chemical parameters on which the agricultural society is highly dependent on as far possible, we intend to create its hardware counterpart and apply it on the real time process as per the given model and parameters (user define). We have already evaluated and checked its working aspect using the VI in (figure 1) and have obtained satisfactory results for the same (included in table 2). We should not forget the vitality and need of agriculture and plants for this world.

## Acknowledgements

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