Abstract

The approval of integrated discrete control technology by the automation diligence has exceeded the projections of most manufacturers in the industry. Unfortunately, the crop growing engineering of these systems has not been applied to their greatest advantage. Many of the control sequences are available such as FLC and PID controls were being integrated. Open loop and indirect control loops are employed for Cooling and Heating of the Winter Garden that can have closed-loop control. This paper describes temperature control sequences that practically implemented with Integrated Discrete control with discrete component like pneumatic and electronic control systems.

1 Introduction

The advent of microprocessor has change the field of process control completely. The task which were Performed by complex and costly minicomputer is now easily performed using microcomputer. In the earlier period, it was not possible to connect computer directly to the process but was used for regulation purpose of analog controllers. The specialized controllers were used to interface the analog controllers directly to the process for dedicated functions. The materialization of cost-effective and high-speed microcontroller has made analog controllers out dated, as the same function can be performed by digital computer in more efficient and cost effective way.
The Winter Garden is a cottage-like arrangement with a roof that is translucent to the perceptible piece of the electromagnetic gamut, which is used in the development of agro products. When the interior temperature is maintained in a well-defined manner, the Winter Garden estimated to perform with exceedingly reliable and greater effectiveness. It is necessary to maintain suitable temperature at development stage of several floras. So, with the restricted environment in the Winter Garden it is possible to augment the quality and mass of crop yield per unit land in bare minimum achievable time [1] [2]. Automation can play very important role in flourishing management of the Winter Garden crops. There are several methods available for controlling Winter Garden temperature but are less efficient because they are either based on binary on-off control. Fuzzy control has been widely applied in Integrated Discrete controls. The automatic learning of fuzzy rules is a principle method in fuzzy control. To improve the performance the fuzzy logic controller is combined with PID. In the present design a controller was developed as shown in fig.1 which would take the input of internal and external temperature (and Humidity, light intensity) of Winter Garden, displays it on the LCD, allows consumer to set internal temperature as per the prerequisite and trigger the cooling or heating system accordingly.

![Figure 1.1: IDC System Block Diagram](image1.png)

### 2 Integrated Discrete Controller Structure

The IDC (Integrated Discrete Controller) directly interfaces to the course of action for the purpose of data acquisition and control. That is, it has crucial and essential hardware for interfacing directly and sense the data from process plant. To execute the three mode PID software control algorithmic strategy, it should also have memory and arithmetic capability [6]. At the same time, there must be some mean so that, IDC can control water pump valve. The microprocessor performs the sequential steps as following:

- It senses the different combination of process variables from various input transmitting channels through multiplexer and ADC hardware.
• It decides the inaccuracy and error for each control structure and executes PID control strategy for each structure.
• It sends the adjustment or correction value to the hardware to control valve of the water pump through suitable actuator.

3 IDC Hardware Implementation

Atmel’s 89C52 microcontroller initialize the system, starts reading the sensors, displays the values on LCD screen and take action according to the PID control algorithm [4]. The various sensors were used to read the indoor and outer parameters [temperature, humidity and UV light intensity of the Winter Garden whose analog electrical outputs were connected to 8:1 analog multiplexer which is acts like a switch under the control of microcontroller (refer fig. 3.1). The output of multiplexer is then converted to digital format using 8-bit analog to digital converter IC ADC0804. ADC transforms analog values obtained from sensors into digital signal so that a microcontroller unit can work on them. The output of implemented control logic is interfaced with final control elements i.e. cooling, heating, pneumatic opening windows, through DAC. Additional hardware incorporated for easy operation of analog to digital converter which comprises of Sampler and Sample & Hold Circuit. The sampler is in general type of a switch, which activate usually at predetermined intervals of instance. When the switch closed, it read the sample of the signal at that instant of time. Thus, if the input signal is continuous in nature, the sampler produces a series of pulses. The amplitude strength of each pulse is equivalent to the size of the continuous signal at that sampling instant. The computer output of DAC is a series of pulses and the process will be driven by these pulses. The valve should not operate at certain opening when pulse is present and closing the valve in between the pulses. To resolve this problem Sample hold device is used which latch the signals from DAC. The Zero Order hold (ZOH) is the most popular type Sample and Hold architecture, where each pulse is seize by sample and hold circuit until the next pulse comes along. A LCD of size 20x4 display module was used to flaunt the contemporary values of the temperature as shown in fig. 3. This module has twenty characters arranged in four rows. This module has superior interactivity between the user and the implemented hardware so that messages could be easily displayed on the LCD screen, which could easily be understood by the client. The heating and cooling system arrangements were properly controlled using port 3 pins P3.5 and P3.6 of AT89C52 Atmel’s microcontroller. The solid-state relays [SSR] were connected to these lines through line driver IC 74LS245. The cooling and heating arrangements were tightly connected to these SSR so that output can control the internal environment using electronic as well as pneumatic systems. The required pneumatic or hydraulic action is carried out by interfacing electronic - pneumatic or electronic - hydraulic mechanism.

Figure 3.1: Implemented Hardware for IDC
Analog control related to propose and implement the controllers in continuous domain. The use of Analog controller is bounded by available hardware elements to execute, prescribed algorithms such as P, PI, PD and PID mode. Whereas digital controller works roughly on digital computers and discrete signals. Digital controllers provides usefulness and flexibility so that P, PI, PID and many more complex advanced algorithms can be easily put into practiced by altering the program. Because of computational and networking ability of computers, Integrated Discrete Controller offers many advantages in comparison with past control technologies. Three different benefits of IDC [5] are:

- **Improved Effectiveness**: As the control loop strategy is combined with the software, this logic can be automatically executed according to the algorithmic process. Because of continuous observation of the process, more composite control schemes, energy and optimization can be obtained.
- **Improved operational efficiency**: IDC has ensures the better visualization and data can be stored in various formats, drift analysis of data for error diagnosis and precautionary repairs schedules. They increase the operational efficiency of the plant. Wireless communication network systems allow remote monitoring and, troubleshoot a problem.
- **Increased Energy Efficiency**: Reducing power consumption is always desirable in system. Energy efficiency can be coded easily. Further, monitoring of energy consumption patterns by each unit activate and deactivate at various set points, gives rise to efficient utilization of energy.
- **Economy**: When a process becomes more complex and highly structured, IDC provides economical solution regarding initial development cost, system reliability and expenditure towards performance improvement and modifications.

### 3.2 Integrated Discrete Controller

In the implemented hardware design, a fuzzy logic controller (FLC) [1] [2] was used for stability of Winter Garden temperature at the desired point. The block diagram of integrated discrete controller is shown in figure 3.3.

IDC basically the combination of FLC and a PID controller [6]. The choice of cooling action or heating action is strictly based upon the error value whether it is positive or negative. If error is
positive the heating system will be selected otherwise cooling system was selected and control action would be applicable to selected system.

![Block diagram for IDC](image)

**Figure 3.3: Block diagram for IDC**

The defuzzification stage provides the crisp values of \( e \) and \( ce \), where \( e \) is obtained by subtracting current value of error signal from set point and \( ce \) is equal to error difference of current value of error and corresponding previous value. The crisp values obtained from defuzzification stage were digitally quantized and stored in the of lookup table in predefined memory location so that it will be easily accessed. As figure 2 shows the lookup table value and temperature set point were added and it be acts as new set point for PID block. Error value \( e_i \) for PID controller is obtained by subtracting the present temperature value from the new set point.

The three mode PID controller can be represented by Position algorithm as fallows.

\[
Y_n = K_p e_n + K_D \frac{\Delta e}{\Delta t} + \frac{1}{K_I} \int_0^n e. \Delta t + Y_0
\]

Where
- \( Y_n \) = valve position at time \( n \)
- \( Y_0 \) = medium valve position
- \( K_p \) = proportional constant
- \( K_D \) = derivative constant
- \( K_I \) = integral constant+
- \( e_n \) = error at instant \( t_n = (S - V_n) \)
- \( S \) = set point
- \( V_n \) = value of controlled variable at time instant \( t_n \)

The PID control can be realized with a microprocessor based system by implementing the software. But it is quite difficult to write the software program for above equation. So above equation can be modified such that its software implementation becomes easy. Trapezoidal rule can be used to modify three mode PID control equation for integral and differential terms present in above equation finally modified equation becomes as bellow. This will give better accuracy in obtained result.
\[Y_n = K_p e_n + K_D \frac{e_n - e_{n-1}}{\Delta t} + \frac{1}{k_l} \sum_{i=0}^{n} \frac{e_{i} + e_{i-1}}{2} \Delta t + Y_0 \]  
(2)

The PID controller takes the new control action \(V(n)\) implemented using the velocity equation [8] [9] [10]. The position algorithm has a distinct property that it maintains its own reference in \(Y_0\). It has two drawbacks namely lack of bump less transfer from manual to auto switching, and reset wind up due to integral saturation in test mode [7]. These drawbacks are not present in Velocity algorithm given as follows.

The change in the valve position \(\Delta t\) at \(t_n\) will be
\[\Delta Y_n = Y_n - Y_{n-1}\]  
(3)

Where \(Y_n\) is valve position at \(t_n\), \(Y_{n-1}\) is valve position at previous instant i.e. \(t_{n-1}\)

\[Y_n = \sum_{i=0}^{n} \Delta Y_i + Y_0\]  
(4)

The integral and derivative terms can be changed by adopting trapezoidal rule and Interpolation techniques similar to position algorithm. The above modification to the velocity algorithm [11] will yield the following equation.

\[\Delta Y_n = \frac{\Delta t}{k_l} \left[\frac{e_n - e_{n-1}}{2}\right] + \frac{K_D}{6 \Delta t} [e_n + 2e_{n-1} - 6e_{n-2} + 2e_{n-3} + e_{n-4}] + KD e_n\]  
(5)

The values of KP, KI and KD were taken on hit and trial base and finalized as 2, 1 and 1 respectively. When system reset, all the previous error and control action are set zero. The value given by the above equation is multiplied by predefined scaling factor which is used to calculate the duty cycle percentage for Pulse Width Modulation (PWM) output. The PWM is generated using timer 1 interrupt of AT89C52 microcontroller. Modulation (PWM) output. The PWM is generated using timer 1 interrupt of AT89C52 microcontroller.

4 Conclusion

The proposed Integrated Discrete Control setup for all business farmhouses gained an opportunity to achieve a maximum crop yield than with traditional methods. The implemented system is a combination of FLC and PID which increases efficiency and operating speed of designed hardware.

For achieving the maximum grade of production efficiency all sub components must be integrated and operate in synchronous manner. The agricultural land plays most important role because it is the purpose of the system that being served. The system performance can be improved with other advanced microcomputers for required control applications. A wide diversity of applications can be controlled using the implemented hardware systems which are not restricted to winter gardens.

5 References

