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Optimization and Implementation of Intelligent RF Remote Controlled Heater System

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Abstract

The paper presents an intelligent remote control for heating system, which is capable of maintaining room temperature on a set value, using PID and optimizing algorithm. Heater node receives the set temperature by remote control and maintains a constant temperature by generating error signal from difference between set value and sensor value. Optimized values of KP, KI, KD are calculated by PID controller with optimizing algorithm and has been implemented on real time heater system which comprises dimmer, processing unit, RF modem and remote control consists of switch array, RF modem, LCD display and processing unit. To select optimizing algorithm comparative analysis has been done for GA and PSO. It is observed through experimental set, that as compared to conventional heater the energy saving with PSO-PID is more than PID and GA-PID to maintain a constant room temperature. It is concluded that PSO-PID shows better energy saving, when implemented on heating system.

Keywords: *GA, Heater , Intelligent network, PID, PSO, RF modem, Remote control*

1. Introduction

A Transmission scheme is proposed to enhance the indoor optical wireless communication systems to avoid the limitation of Visible light communications (VLC) of limited bandwidth of LEDs and inter symbol interference due to multipath. In proposed system dimming of the indoor illumination is done by using Expurgated pulse-position modulation (EPPM) with Interleaving [1]. An efficient wireless power transfer system presents with an intermediate coil by compensating the coupling coefficient. A prototype is designed which operates at 100 kHz switching frequency having gap between primary and secondary side of 200mm. with 6.6 kW output a system efficiency of 95.57% is achieved [2]. An integrated wireless sensor network with waspmote and meshlium gateway is designed to save energy by controlling light intensity by pulse width modulation. It will help in developing Smart street lighting system for smart cities [3]. An android smart phone as remote control with to control wireless LED dimming system is proposed. Control signal is generated with smart phone which is decoded by microcontroller to generate PWM signal to LED to control brightness of LED. This system results in improved energy efficiency [4]. A dimming system is developed forT5 fluorescent lamps with the help of EMI filter, an active power factor correction, inverter and dimming system power stage. The experimental prototype is developed for T5 28W and performance is realized [5]. Wireless Intelligent Monitoring and Control of street lights having unique IPv6 and IEEE address is proposed. The system is designed with microcontroller MSP430F6636 and an RF IC CC1180. Control signals are sent via

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gateway with GPRS module by using Ism band. message between the nodes. The communication between nodes takes place in ISM band and that between gateway and control centre through GPRS. This system offers almost 50% power saving and reduces the patrol cost [6]. A solution is provided to the problem of uncertainties in the systems have non minimum phase properties by developing an intelligent network using multiple nodels and neural networks with the help of a set of fixed controllers, a re-initialized neural network adaptive controller and a free running NN adaptive controller [7]. A solution to provide stability to nonlinear system is presented while deals with level control of the system by dynamic response tests on a full scale simulator of a closed feed water heater and set points in the presence of various disturbances [8]. The population of randomly generated individuals and happens in generations. In each generation, the fitness of every individual in the population is evaluated, multiple individuals are stochastically selected from the current population, and modified to form a new population. The new population is then used in the next iteration of the algorithm. Once the genetic representation and the fitness function is defined, GA proceeds to initialize a population of solutions randomly, then improve it through repetitive application of mutation, crossover, inversion and selection operators [9]. Demetreseu and italiano's algorithm- This is for maintaining all pairs shortest paths in general directed graphs with real valued, non-negative edge weights [10].

2. Hardware Development

Experimental set up for the proposed system comprises of two parts one is remote control and other is heater node. The aim is to control the temperature of heater on a constant level using PID and optimizing algorithm. For hardware development simulation has been done with Proteus to check the feasibility of system.

2.1 Block Diagram of Remote Control

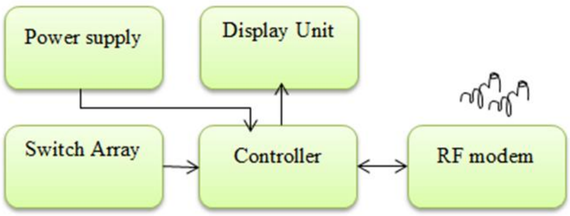
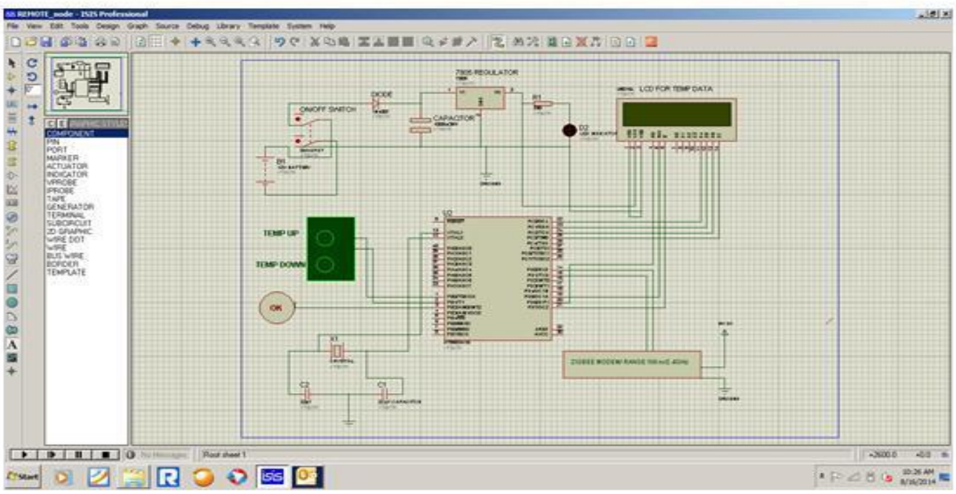


Figure 1. Block Diagram for Remote Control



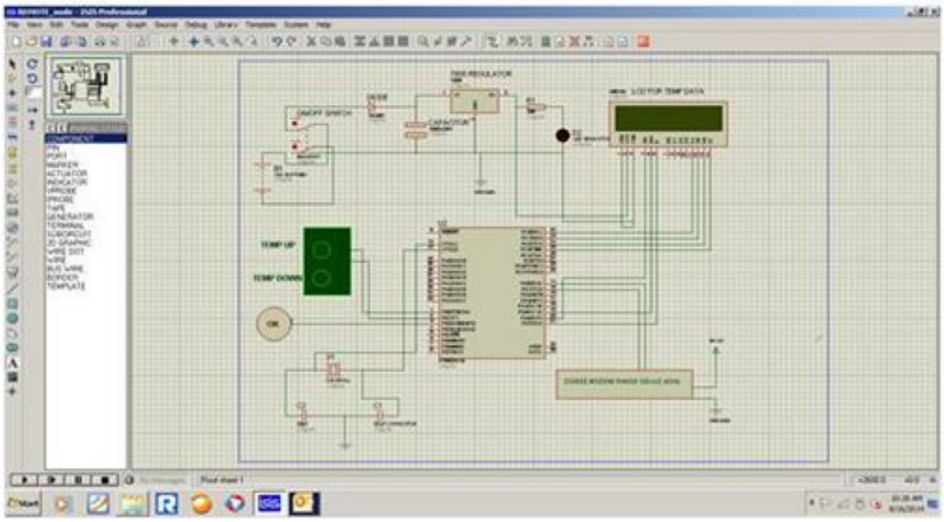


Figure 2. Proteus Simulation of Remote Control

As shown in Figure 1 Remote control comprising of switch array to set the required temperature by user, Display unit is LCD (16x2), controller used is Atmega8, power supply by battery (9V/200mA) and RF module (433MHz) to communicate with heater node. Proteus simulation has been done for remote control as shown in Figure 2.

2.1 Block Diagram of Heater Node

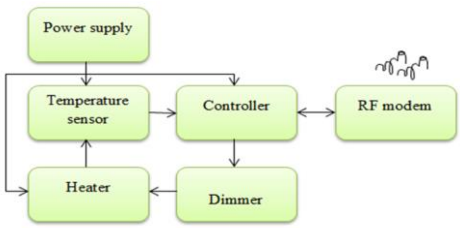


Figure 3. Heater Node

As shown in Figure 3 heater node is comprising of power supply (12V/1A adapter), temperature sensor (LM35), heater, RF module (433MHz) and dimmer (MOC3201).

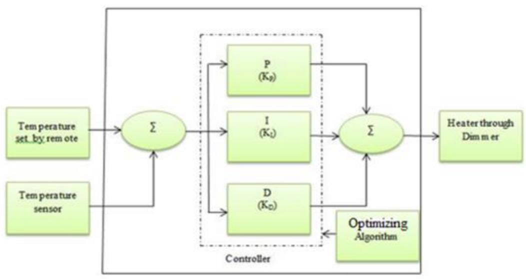


Figure 4. Controller of Heater Node

As shown in Figure 4 controller of heater node comprises the PID controller to set (K_P, K_I, K_D) with use of genetic algorithm. PID controller take error signal from comparison of temperature set by remote and input from temperature sensor, and generates corresponding (K_P, K_I, K_D) with genetic algorithm. The optimized value is then given to heater through dimmer to remain on a constant temperature.

3. Experimental Set up

Hardware has been implemented and controller was programmed with the optimized values Kp, KI and KD using PSO algorithm using Embedded "C" language. The constant set temperature value was observed in the test room of size 10*10*10 cubic feet during experiment.

Figure 5 shows developed remote control to set the required temperature and Figure 6 shows developed heater node having processing unit (Atmega16) which is programmed with optimized values of KP, KI, KD.

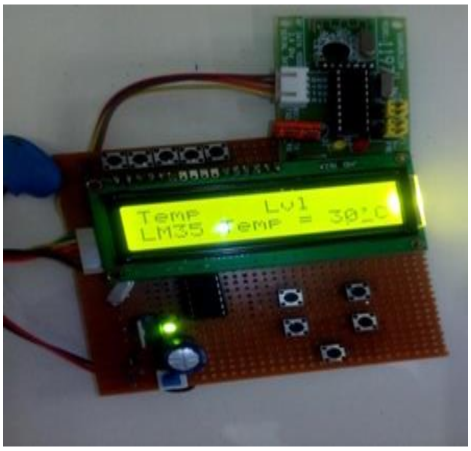


Figure 5. Snapshot of Developed Remote Control

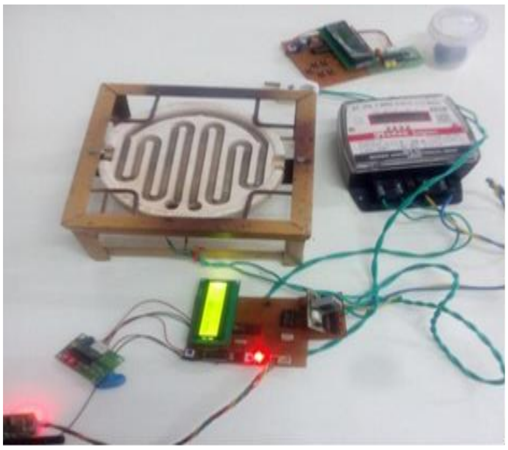


Figure 6. Snapshot of Developed Heater Node

4. Software Development

Room temperature is maintained at constant level by using PID controller with an optimizing algorithm to find out values of parameters KP, KI, KD. Comparative study has been done for GA and PSO algorithms and results shows PSO has better approach for finding appropriate values.

4.1 Implementation of GA-PID

Algorithm for GA-PID

To generate optimized values of three parameters K_P, K_I, K_D of a PID controller Genetic algorithm involves following steps:

- Initialize population of individual
- Evaluate fitness using fitness function
- Select the fitness members of population
- Apply mutation process
- Select the best chromosomes
- If the termination criteria reached the process ends
- If not then search for another best chromosomes.

The simulation for PID and GA has been done with MATLAB Simulink. First PID controller was realized with the MATLAB and M (Overshoot time), T_r (Rising time) and T_s (Settling time), K_P, K_I, K_D were observed.

Then GA was being implemented to measure optimized values K_P, K_I, K_D and set the system by these values and comparative study has been done. Figure 7 shows the MATLAB modal for simulation, Figure 8 MATLAB simulation results of GA-PID and Figure 9 MATLAB simulation results of PSO-PID

4.2 Implementation of PSO-PID

Algorithm for PID controller with PSO

- Input all the desired constraints (M, Ts, Tr),heater transfer function , & PSO constants with no. of particles.
- Initialize the particle positions and velocities.
- Evaluate the fitness value of system with unit step response
- Calculate system constraints for each particle and total error.
- Compare the individual fitness value of each particle to its previous value, if it is better than previous one, replace with new value i.e. local best position otherwise don't change.
- The position of particle having lowest error is global best value.
- Update position and velocity of particles according to (1)
- Go back to step (3) and repeat all steps until system constraints are met

Here
M-Overshoot time
Tr-Rising time
Ts – Settling time
For The optimization of parameters the following equation has been used .

```
n = 40;          % Size of the swarm " no of birds "
bird_setp=40;   % Maximum number of "birds steps"
dimension= 2;         % Dimension of the problem
c2 =1.3;         % PSO parameter C1
c1 = 0.14;        % PSO parameter C2
w =0.9;          % pso momentum or inertia
fitness=0*ones(n, bird_setp);
velocity=w*velocity+c1*(R1.*(L_b_position-c_position)) +c2*(R2.*(g_b_position-c_position)); and
c_position = c_position + veloci
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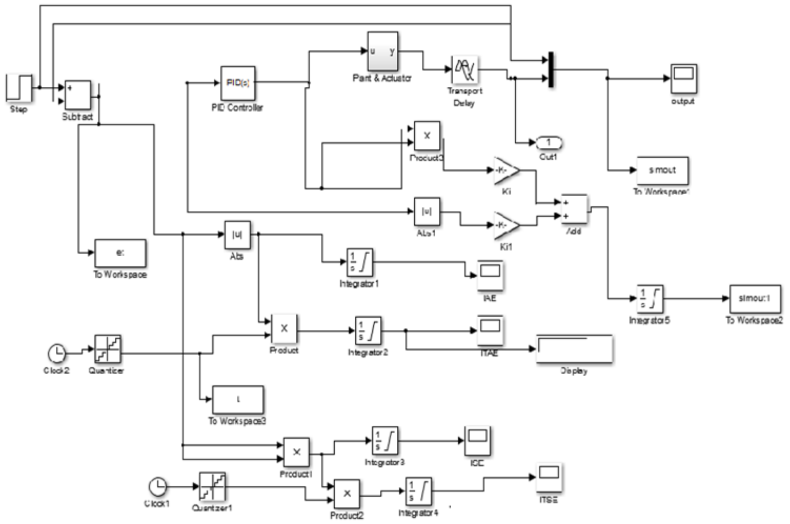

Figure 7. MATLAB Model for Simulation

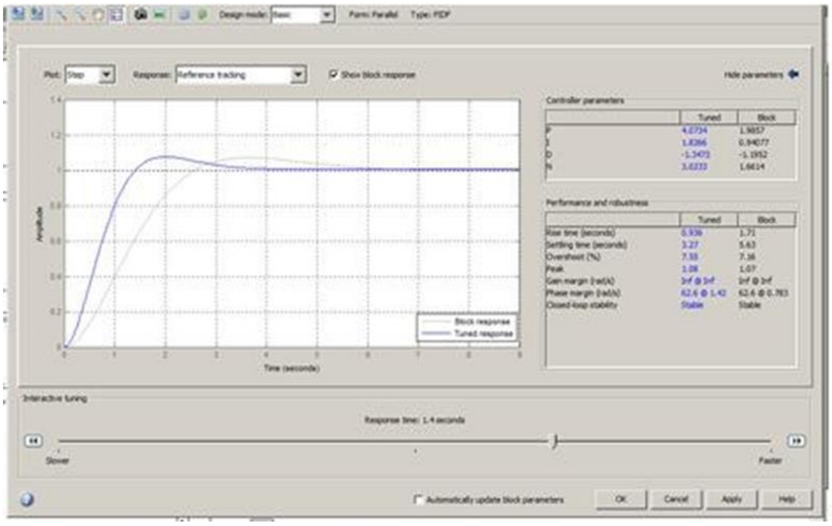

Figure 8. Step Response for Heater System for GA-PID

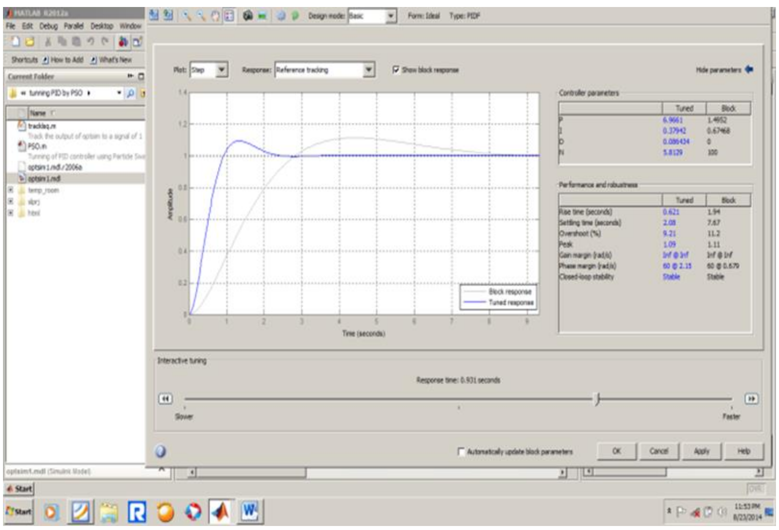

Figure 9. Step Response for Heater System for PSO-PID

Figure 7 MATLAB model for Simulation
Figure 8 MATLAB Simulink for GA-PID
Figure 9 MATLAB Simulink results for PSO-PID

4.3 Comparative Analysis for KP, KI, KD for PID, GA-PID and PSO-PID

Table 1 shows the comparative study for the values of K_P, K_I, K_D of PID and GA-PID and PSO-PID. Figure 10 shows graphical analysis of PID, GA-PID and PSO-PID.

Table 1. Comparative Analysis for PID and GA-PID and PSO-PID

	PID	GA-PID	PSO-PID
K_P	1.318	4.073	6.966
K_I	0.743	1.828	0.379
K_D	-0.820	-1.340	0.086

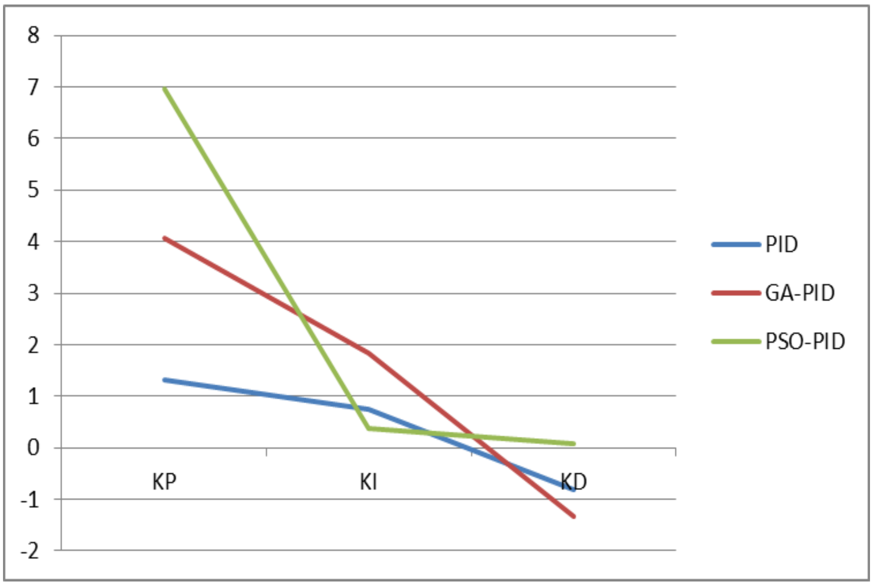

Figure 10. Comparative Analysis for PID and GA-PID and PSO-PID

5. Results and Discussion

The Table 2 shows power consumption for conventional heater, heater with PID, GA-PID and PSO-PID to maintenance constant temperature of the test room.

Table 2. Shows Power Consumption for 1 KW Heater to Maintain Temperature at 26^0C using GA-PID and PSO-PID

S. No	Time Duration	Temperature (to maintain constant at 26^0 C)	Power consumption for conventional heater (KWh)	Power consumption for GA-PID (KWh)	Power consumption for PSO-PID (KWh)
1	8:30 AM to 9:00AM	25^0C to 26^0C	0.5	.500	0.5
2	9:01 AM to 9:15AM	26^0C	0.25	.238	0.232
3	9.16 AM to 9:30AM	26^0C	0.25	.189	0.232
4	9:31 AM to 9:45AM	26^0C	0	.238	0.104

5	9:46 AM to 10:00AM	26^0C	0.25	.174	0.232
6	10:01AM to 10:30AM	26^0C	0.5	.243	0.232
	Total		1.8	1.582	1.532

From above table it is concluded that saving with GA-PID= (1.8kW - 1.582kW)/1.8kW=.1211. power consumption is compared with conventional heater for same temperature, (it is assumed that heater should be switched off for time duration to be set on specific temperature and consumption is of 1800 W) then the power saving is approximately 12.11%.

Energy saving with PSO-PID= (1.8kW-1.532kW)/1.8kW=.1483, energy % saving is of 14.83%.

The preset temperature from the user remote acts as the reference input for generating the error signal in closed loop. The so generated error signal is used to control the temperature of the room.

It is observed that the test room is maintained at preset temperature of 26^0C.

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