CHAPTER-6

RESULTS ANALYSIS

In this Chapter experimental outcomes of the research are explained with the analysis for each appliance. Power consumption is observed for each method- PID, GA-PID and PSO-PID.

The system is developed with two sections- remote control and receiver section. In the receiver section there are three sockets on the board corresponds to appliances-bulb, heater and exhaust fan. The dimmer circuits are designed for controlling the light intensity, humidity and temperature of room. The system is tested in a room size of 10*8*10 cubic feet, with one 100Watt bulb, 1KW room heater and 18 Watt exhaust fan. The system can be operated in two modes autonomous and semiautonomous [58]. In Semiautonomous mode dimming levels of appliances are controlled by setting required level, with remote control as per user's desire. Whereas in autonomous mode the dimming level is controlled by error signal generated from the difference between sensors on remote control and input value of parameter set by user. The sensors are calibrated with standard instruments before implementation on system. For light intensity standard instrument Lux meter, for humidity and temperature Psychrometer is used as discussed in chapter-4. The results are analyzed in terms of percentage saving of power w.r.t conventional appliances.

6.1 Power Consumption Analysis for the Appliances

For the tuning of parameters number of algorithms are found in the previous art including various PID tuning methods. PID with some optimizing algorithm are also discussed, which shows better results for optimized parameters [8][13][32-33][35].

For tuning of parameters overall transfer function of system is generated, which includes transfer function of appliance, objective function of error signal and optimization algorithm. Tuning parameters are calculated with modelling and simulation using MATLAB tool.

The function of the tuning parameters is to trigger the circuit at desired diming level by selecting appropriate firing angle.

6.2 Heater Analysis

For heater the three methods PID, GA-PID and PSO-PID are analyzed with the help of their simulation circuits. The tuning parameters for each method are calculated with the help of MATLAB. Firstly overall transfer function is calculated which includes transfer function of heater, transfer function of controller (PID/GA-PID/PSO-PID) and error signal. Then the Kp, Ki and Kd values are calculated. Step responses for heater by using the different methods are analyzed. The values of rise time, settling time, overshoot, peak time are also observed.

6.2.1 Implementation of PID on Heater

The transfer function for heater is as expressed in equation-5.1, but when heater is placed in the system with PID controller and feedback signal then overall transfer function for system is calculated as equation-6.1 and Table-6.1 shows tuning parameters for PID controller.

Over all transfer function $T(s) = \frac{(0.3295s+0.1858)}{(s^2+0.5795s+0.1858)}$ ……..……………………(6.1)

Table- 6.1 Tuning parameters for heater with PID controller

Kp	Ki	Kd
1.318	0.743	-0.820

Fig.6.1 shows the step response of heater with PID controller and reveals the values of rise time, settling time, overshoot and peak time, which are represented in table 6.2.

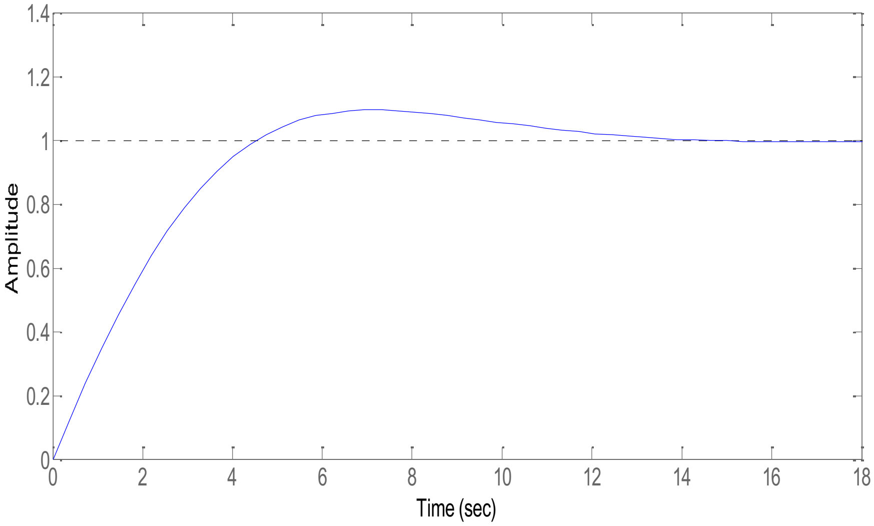

Fig.6.1 Step response of heater with PID control

Table- 6.2 Transient response for heater with PID controller

Rise Time (s)	Settling Time(s)	Overshoot
3.3279	12.1117	9.3814

6.2.2 Implementation of GA-PID on Heater

The simulation for GA- PID is done with MATLAB Simulink. The PID controller is realized with the help of MATLAB with 40 iterations of genetic operation and K_p, K_i, K_d are generated. Fig.6.2 shows the step response of GA-PID. Overall transfer function is given in equation-6.2 and tuning parameters are shown in table-6.3.

Over all transfer function $T(s)=\frac{(1.018s+0.457)}{(s^2+1.268s+0.457)}$ ……………...………… (6.2)

Table- 6.3 Tuning parameters for heater with GA-PID controller

Kp	Ki	Kd
4.073	1.828	-1.340

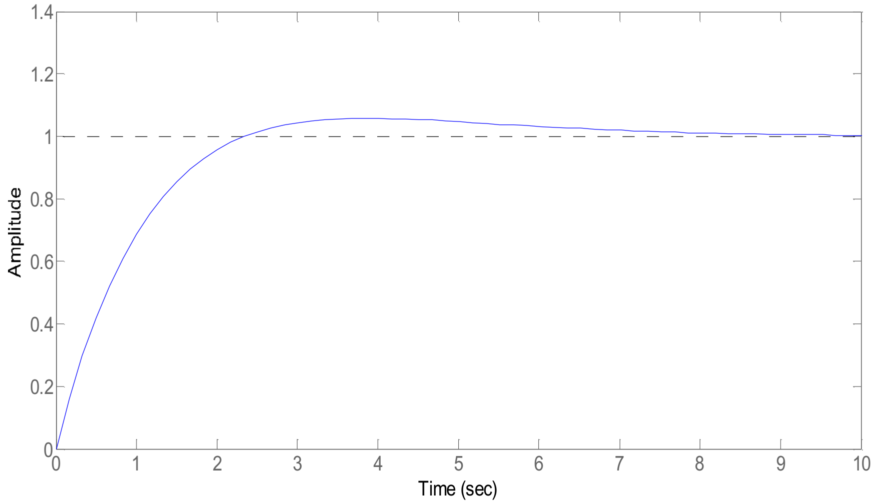

Fig.6.2 Step response of heater with GA-PID

Table- 6.4 Transient response for heater with GA-PID controller

Rise Time (s)	Settling Time(s)	Overshoot
1.5835	7.0130	5.7994

6.2.3 Implementation of PSO-PID on Heater

The simulation for PSO- PID is done for heater with MATLAB Simulink. PSO-PID controller is realized with the MATLAB with 40 iterations of operation and K_p, K_i, K_d are generated. Fig.6.3 shows the step response of the heater with PSO-PID.

Over all transfer function $T(s)=\frac{(1.741s+0.4322)}{(s^2+1.991+0.4322)}$ ………………………… (6.3)

Table- 6.5 Tuning parameters for heater with PSO-PID controller

Kp	Ki	Kd
6.966	1.72879	-1.230

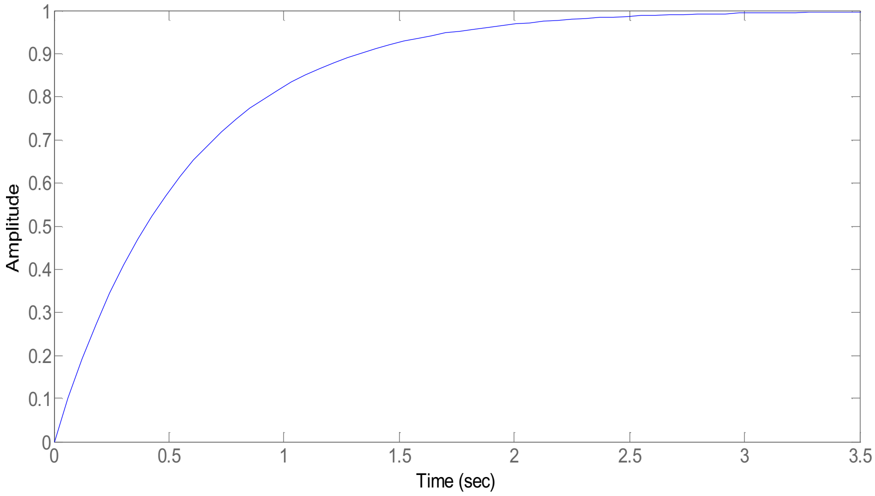

Fig.6.3 Step response of heater with PSO-PID

Table- 6.6 Transient response for heater with PSO-PID controller

Rise Time (s)	Settling Time(s)	Overshoot
1.2656	2.2672	0

6.2.4 Experiment Outcomes for Heater

The tuning parameters are calculated for all three methods with MATLAB tool using PID, GA-PID and PSO-PID. The difference in values of tuning parameters is due to the different steps followed for different algorithms as discussed in chapter-3.

Experiment is conducted in a room size of 10*8*10 and performance of each appliance is analyzed individually. As per the standards 1KW heater is sufficient for this much size of room.

The experiment is performed with 1KW in a room size of 10*8*10 in the month of March 2015, for the duration of two hours [51], with initial temperature observed as 29^0C. The target is to maintain the room temperature at 30^0C.

Table: 6.7 Power consumption for heater to maintain temperature at 30^0C with initial temperature 29^0C using PID, GA-PID and PSO-PID

S.No.	Time Duration	Temperature	Conventional heater	Power Consumption for PID (KW)	Power Consumption for GA-PID (KW)	Power Consumption for PSO-PID (KW)
1	8:30 AM to 9:00 AM	29^0C to 30^0C	0.5	0.5	0.5	0.5
2	9:01 AM to 9:15 AM	30^0C	0.25	0.403	0.305	0.232
3	9:16 AM to 9:30 AM	30^0C	0.25	0.232	0.232	0.232
4	9:31 AM to 9:45 AM	30^0C	0	0.232	0.232	0.104
5	9:46 AM to 10:00AM	30^0C	0.25	0.104	0.104	0.232
6	10:01 AM to 10:30 AM	30^0C	0.5	0.232	0.232	0.232
	Total Power Consumption (KW)		1.8	1.703	1.605	1.532

As shown in the Table 6.7 initially during half an hour, there is increment of 1^0C in the temperature. Power consumption is calculated with the help of energy meter. Also it is observed that it is same for all methods, for the duration in which set value is not achieved. This is because heater is triggered at highest level to achieve the target of input value.

After reaching at target, different methods shows the different values of power consumption. It is due to the selection of diming level by different methods depends on its algorithm, which is not same. Table 6.7 shows power consumption by heater for duration of experiment, during the first half an hour all the methods consumes same power as system, it is to achieve set value of temperature. It is observed that in half an hour (8:30 A.M to 9:00A.M) there is 1^0C of rise in temperature, as the target was to maintain 30^0C with 29^0C initial temperature. So system consumed same power as conventional heater. After reaching at a set value of temperature, temperature starts increasing due to effect of external environment. To nullify this effect the system is triggered at lower level. Now the temperature drops and to maintain a required level, the system is triggered at higher level. This cycle of level triggering repeats itself to maintain the temperature at predefined value.

The power consumption for conventional heater is taken as per standard for that time period. It is assumed that convention heater is switched off for fifteen minutes after one hour, as user could feel much increase in the room temperature, and all other readings in Table-6.7, are based on experimental set up. It is concluded that conventional heater is to control manually as per user requirement and the designed system do it automatically.

The set temperature value by the remote control acts as the reference input and sensor value as feedback signal, for generating the error signal in closed loop at receiver section to control the dimming levels [54].

The error signal is used to control the temperature of the room. It is concluded that the test room is maintained at 30^0C temperature.

Power consumption for experiment duration is calculated with the help of energy meter. It is considered that power consumption by conventional heater is 1.8 KW for two hours (with the assumption that it is switched off for fifteen minutes).

Power consumption by heater with PID controller is 1.703KW, with GA-PID it is 1.605KW and with PSO-PIS it is 1.532 KW. The power saving w.r.t conventional heater is calculated in each case. Fig.6.4 shows power consumption by the heater during experiment for PID, GA-PID and PSO-PID.

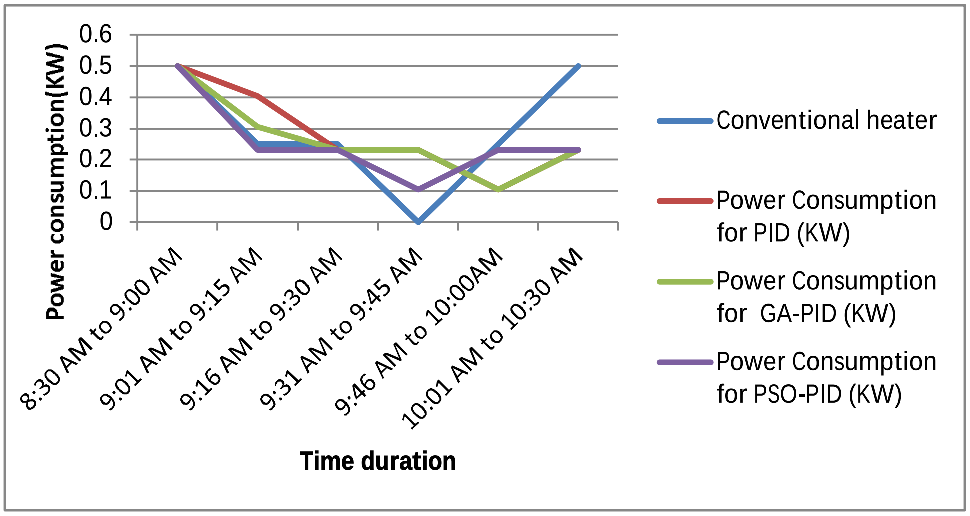

Fig.6.4 Power consumption for heater in (KW) for PID, GA-PID and PSO-PID during experiment

Table-6.8 Percentage Power saving w.r.t conventional heater

Power consumption by conventional heater (KW)	Power consumption by using PID controller (KW)	Power consumption by using GA-PID controller (KW)	Power consumption by using PSO-PID controller (KW)	Power saving by using PID controller (%)	% Power saving by using GA-PID controller (%)	% Power saving by using PSO-PID controller (%)
1.8	1.703	1.605	1.532	5.38	10.83	14.88

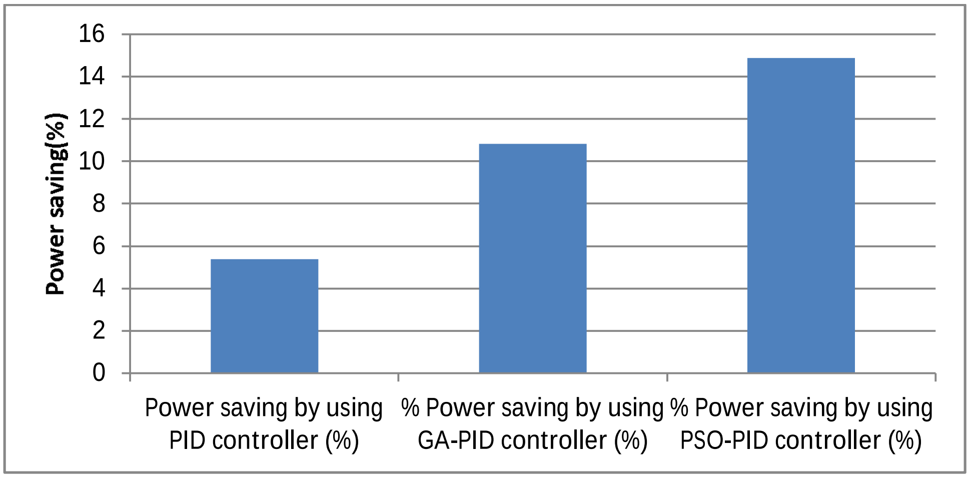

Fig.6.5Power saving (%) w.r.t conventional heater

Fig.6.5shows % power saving for PID is 5.38%, for GA-PID saving is 10.83% [52] and for PSO-PID it is 14.88% Results clearly shows that PSO-PID consumes less power than PID and GA-PID and is best suited for the designed system.

6.3 Bulb Analysis

For bulb the three methods PID, GA-PID and PSO-PID are analyzed with the help of their simulation circuits. The tuning parameters for each method are calculated with the help of MATLAB.

First of all the transfer function is calculated, which includes transfer function of bulb, transfer function of controller (PID, GA-PID and PSO-PID) and error signal, then the Kp, Ki and Kd values are calculated. The step responses for bulb by using the different methods are analyzed. The values of rise time, settling time, overshoot, peak time are also observed.

6.3.1 Implementation of PID on Bulb

The transfer function for bulb is as expressed in equation-5.2, but when bulb is placed in the system with PID controller and feedback signal then overall transfer function for system is calculated as follows.

Over all transfer function $T(s)=\frac{(17970s+7322)}{(s^2+23170s+7322)}$ …………………………(6.4)

Table- 6.9 Tuning parameters for bulb with PID controller

Kp	Ki	Kd
179.7	73.22	-49.32

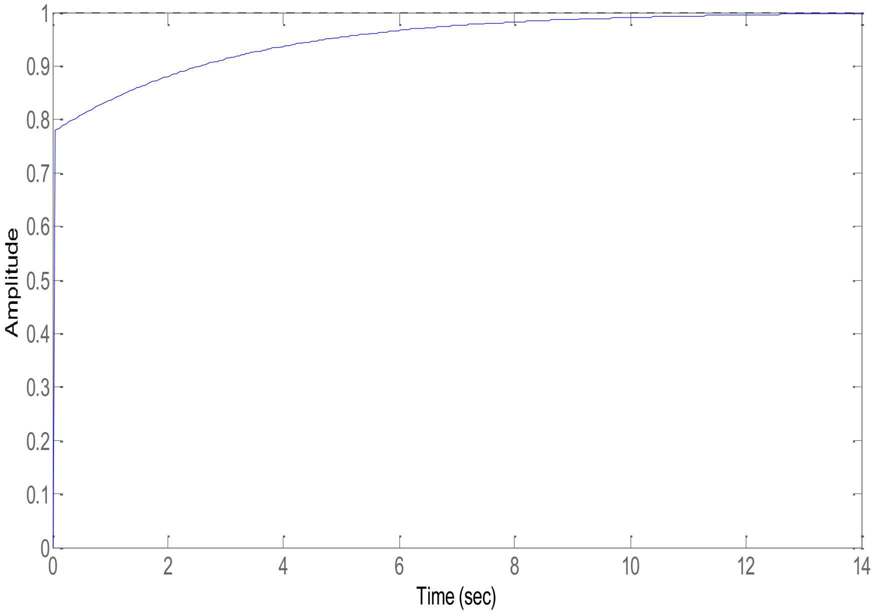

Fig.6.6 Step response of bulb with PID control

Table- 6.10 Transient response for bulb with PID controller

Rise Time (s)	Settling Time(s)	Overshoot
2.5526	7.6509	0

6.3.2 Implementation of GA-PID on Bulb

Overall transfer function for GA-PID is calculated as in equation-6.5

Over all transfer function $T(s) = \frac{(2.003e004\, s+9023)}{(s^2+25230s+9023)}$ .... (6.5)

Table- 6.11 Tuning parameters for bulb with GA-PID controller

Kp	Ki	Kd
200.3	90.23	-59.320

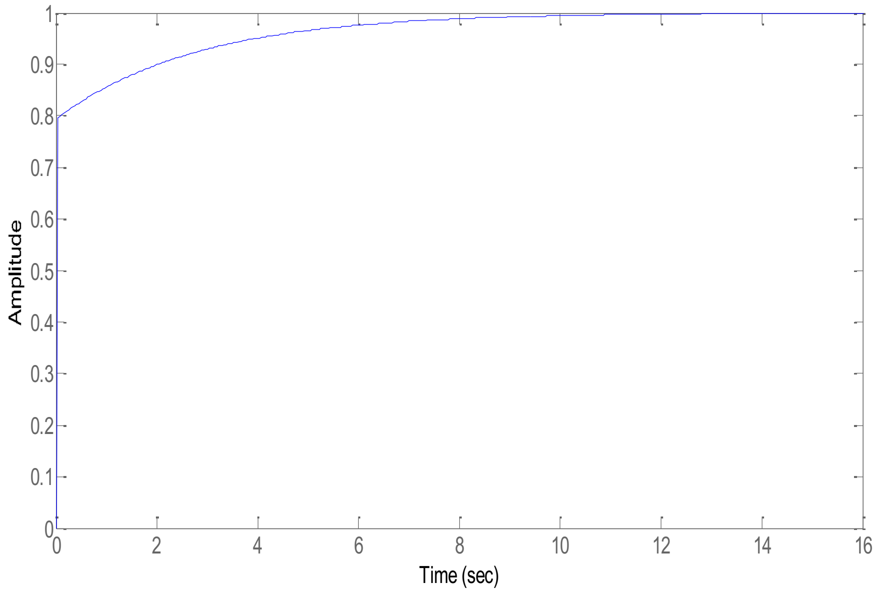

Fig.6.7 Step response of bulb with GA-PID

Table- 6.12 Transient response for bulb with GA-PID controller

Rise Time (s)	Settling Time(s)	Overshoot
2.0175	6.5223	0

6.3.3 Implementation of PSO-PID on Bulb

The simulation for PSO- PID is done for bulb with MATLAB Simulink. PSO-PID controller is realized with the MATLAB with 40 iterations and K_P, K_I, K_D are generated. Fig.6.8 shows step response of the bulb.

Over all transfer function $T(s) = \frac{(3.011e004\ s+1.501e004)}{(s^2+35311s+1.501e004)}$ ……………………….(6.6)

Table- 6.13 Tuning parameters for bulb with PSO-PID controller

Kp	Ki	Kd
300.11	150.12	-66.330

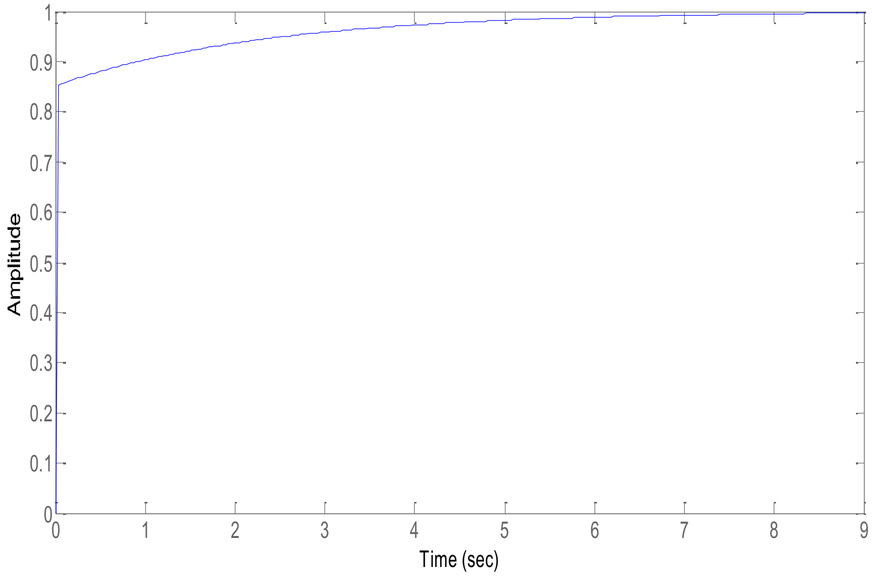

Fig.6.8Step response of bulb with PSO-PID

Table- 6.14 Transient response for bulb with PSO-PID controller

Rise Time (s)	Settling Time(s)	Overshoot
0.9067	4.6960	0

6.3.4 Experiment Outcomes for Bulb

For Bulb Analysis the values of PID parameters Kp, Ki and Kd are tuned with PID, GA-PID and PSO-PID.

Experiment is conducted in a room size of 10*8*10 with 100W, in the month of March 2015 at home. Experiment is performed for the duration of four hours, with background light intensity of 20 lux.

The values from lux meter are in lux and from LDR in %. All the values are mapped by calibrating LDR with lux meter as discussed in Table- 4.3.The target was to maintain the light intensity at 80%.

Table-6.15 Power consumption for 100W Bulb to maintain light Intensity at 200lux or 80% LDR value with initial 20% intensity using PID, GA-PID and PSO-PID

S. No.	Time	Conventional light(W)	% Light Intensity (outdoor)	Light Intensity at 200 lux or 80% LDR (room)	Power consumption for PID(W)	Power consumption for GA-PID(W)	Power consumption for PSO-PID(W)
1	6:30 PM	100	20	80	63.1	57.6	57.6
2	7:30 PM	100	0	80	69.8	63.1	63.1
3	8:30 PM	100	0	80	69.8	63.1	63.1
4	9:30 PM	100	0	80	69.8	63.1	63.1
5	10:30 PM	0	0	10	6.2	6.2	3.12
	Total Power	400			278.7	253.1	250.02

Table 6.15 shows the light intensity observed at different time. As it is evening time the outdoor light intensity is decreasing with passage of time. Power consumption for the bulb is calculated with the energy meter.

Table 6.15 shows power consumption by bulb for duration of experiment. It is observed that at 6:30P.M the outdoor light intensity as 20% and target was to maintain 80% light Intensity. Conventional bulb consumes 100 W as it will glow with full intensity. Power consumption using other methods are not same, it depends on the tuning parameters of the applied method. At 7:30 P.M outdoor intensity was observed as 0%, so power consumption is observed more for this hour. For 8:30 P.M to 9:30 P.M power consumption remains same to maintain intensity at 80%, as outdoor intensity remains zero for this duration.

The readings for conventional bulb is taken as such which is applicable for that time period. It is assumed that conventional bulb is switched off at10:30P.M before going to bed in night. But using other methods light intensity is reduced at 10% during sleep.

Here the input light intensity by the remote control acts as the reference and sensor value as feedback signal, for generating the error signal in closed loop. The so generated error signal is used to control the light intensity of the room. It is observed that the test room is maintained at light intensity of 80% for experiment duration.

On the basis of readings taken with energy meter power consumption is calculated and it is concluded that power consumption by conventional bulb is 400W for four hours (with the assumption it is switched off at 10:30P.M). Power consumption with PID controller is 278.7 W, with GA-PID it is 253.1W and with PSO-PIS it is 250.02W. The power saving w.r.t conventional bulb is observed in each case.

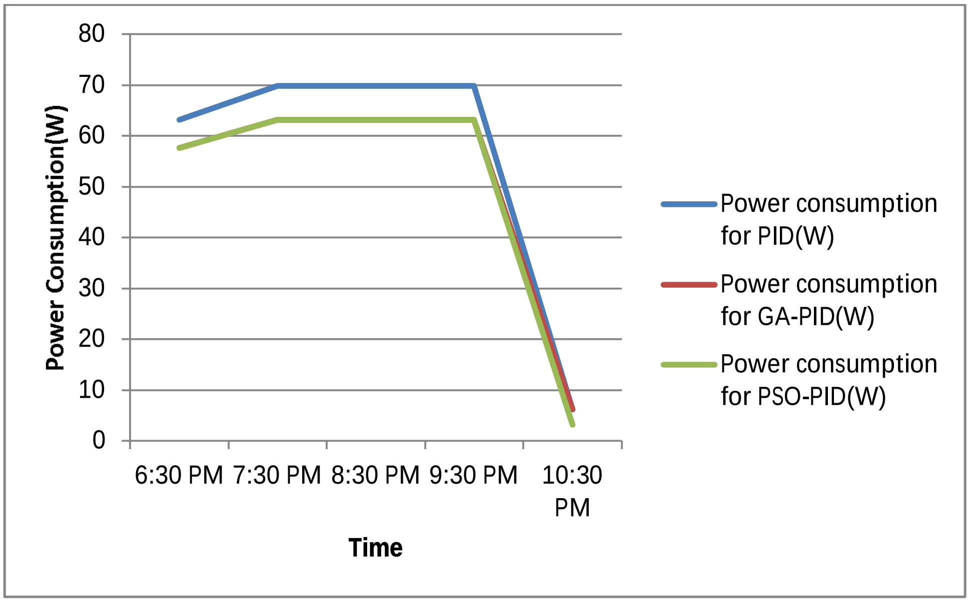

Fig.6.9 Power consumption for bulb in (W) for PID, GA-PID and PSO-PID during experiment

Table-6.16 Percentage Power saving w.r.t conventional bulb (100W) for the four hours of experiment

Power consumption by conventional heater (W)	Power consumption by using PID controller (W)	Power consumption by using GA-PID controller (W)	Power consumption by using PSO-PID controller (W)	Power saving by using PID controller (%)	% Power saving by using GA-PID controller (%)	% Power saving by using PSO-PID controller (%)
400	278.7	253.1	250.02	30	37	37.49

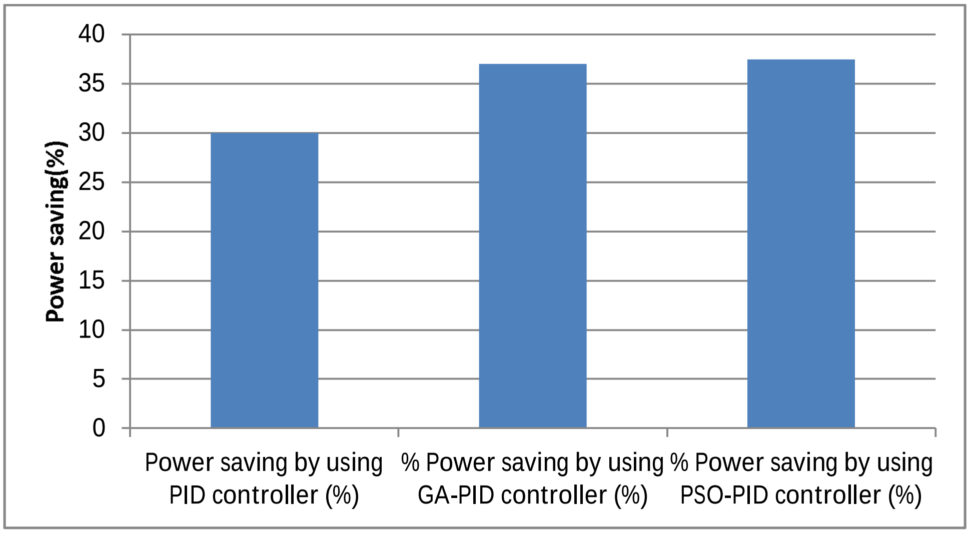

Fig.6.10 Power saving (%) w.r.t conventional Bulb

Fig.6.10 shows % power saving for PID is 30%, for GA-PID saving is 37% and for PSO-PID it is 37.49%. Results shows that PSO-PID method consumes less power than PID and GA-PID and it is best suited for designed system.

6.4 Exhaust Fan Analysis

For exhaust fan the three methods PID, GA-PID and PSO-PID are analyzed with the help of their simulation circuits. The tuning parameters for each method are calculated with the help of MATLAB. Firstly overall transfer function is calculated which includes transfer function of exhaust fan, transfer function of controller (PID, GA-PID and PSO-PID) and error signal, and then the Kp, Ki and Kd values are calculated. The step responses for exhaust fan by using the different methods are analyzed. The values of rise time, settling time, overshoot, peak time are also observed.

6.4.1 Implementation of PID on Exhaust Fan

The transfer function for exhaust fan is as expressed in equation-5.4, but when exhaust is placed in the system with PID controller and feedback signal then overall transfer function for system is calculated as in equation-6.7.

Over all transfer function $T(s) = \frac{(35.35\,s^2 + 4378s + 3120)}{(s^3 + 35.92\,s^2 + 5368s + 3120)}$ ……………………(6.7)

Table- 6.17 Tuning parameters for exhaust fan with PID controller

Kp	Ki	Kd
1.130	0.81	0.032

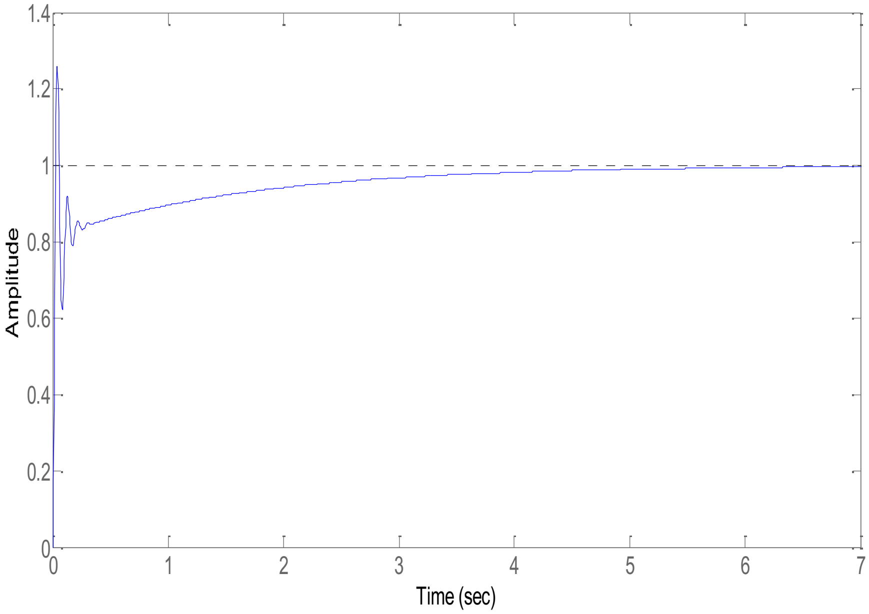

Fig.6.11 Step response of exhaust fan with PID control

Table- 6.18 Transient response for exhaust fan with PID controller

Rise Time (s)	Settling Time(s)	Overshoot	Peak Time (s)
0.0168	3.8210	25.9675	0.0344

6.4.2 Implementation of GA-PID on Exhaust Fan

For GA-PID controller tuning parameters are calculated and as shown in table-6.19 and overall transfer function for GA-PID is given in equation-6.8.

Over all transfer function $T(s) = \frac{(99.56\ s^2 + 1.231e004\ s + 6255)}{(s^3 + 100.1\ s^2 + 1.33e004\ s + 6255)}$ ……………..(6.8)

Table- 6.19 Tuning parameters for exhaust fan with GA-PID controller

Kp	Ki	Kd
3.182	1.624	0.098

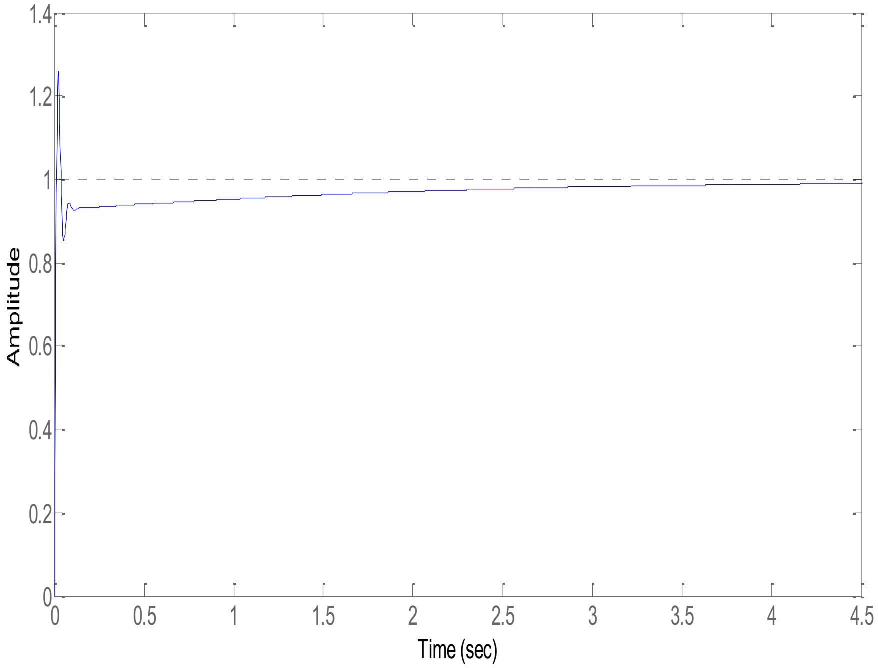

Fig.6.12 Step response of exhaust fan with GA-PID

Table- 6.20 Transient response for exhaust fan with GA-PID controller

Rise Time (s)	Settling Time(s)	Overshoot
0.0090	2.7995	25.8415

6.4.3 Implementation of PSO-PID on Exhaust Fan

The simulation for PSO- PID is done for exhaust with MATLAB Simulink. PSO-PID controller is realized with the MATLAB with 40 iterations and K_P, K_I, K_D are generated. Fig.6.13 shows step response of the exhaust fan with PSO-PID.

Over all transfer function $T(s) = \frac{(150.6\ s^2 + 1.862e004\ s + 1.049e004)}{(s^3 + 151.1\ s^2 + 1.961e004\ s + 1.049e004)}$ ………(6.9)

Table- 6.21 Tuning parameters for exhaust fan with PSO-PID controller

Kp	Ki	Kd
4.812	2.724	0.198

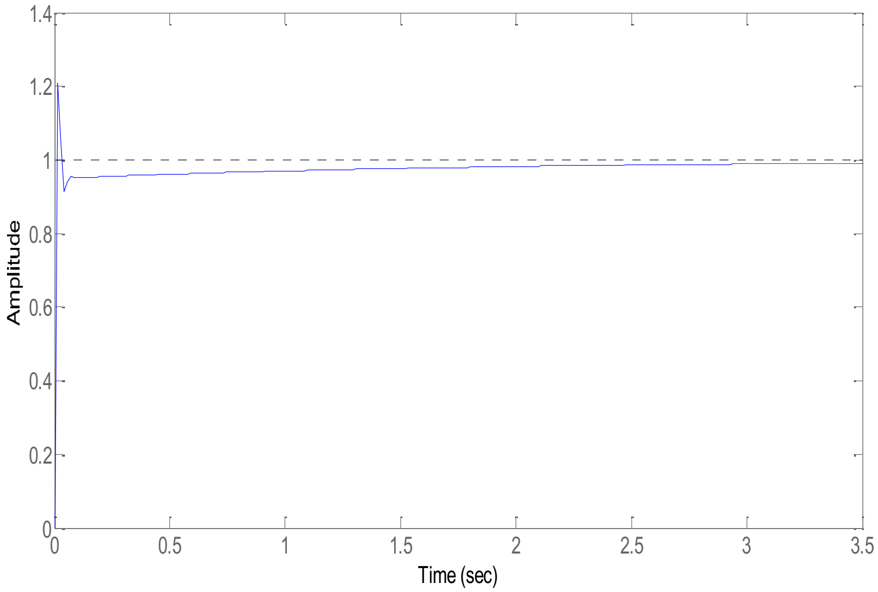

Fig.6.13 Step response of exhaust fan with PSO-PID

Table- 6.22 Transient response for exhaust fan with PSO-PID controller

Rise Time (s)	Settling Time(s)	Overshoot
0.0093	1.7391	20.9404

6.4.4 Experiment Outcomes for Exhaust Fan

For Exhaust fan Analysis the values of PID tuning parameters Kp, Ki and Kd are tuned with PID, GA-PID and PSO-PID. The tuning parameters are calculated for all three methods.

Experiment is conducted in a room size of 10*8*10 with 18W exhaust fan, in the month of March 2015. Experiment data is collected for the duration of four hours, with initial humidity of 44%. The target is to maintain the humidity at 42%.

Table-6.23 Power consumption for 18 W exhaust fan to maintain humidity at 42% using PID, GA-PID and PSO-PID

S.No.	Time duration	Conventional exhaust (W)	% Humidity (Initial)	Instant Humidity	Power consumption in PID(W)	Power consumption in GA-PID(W)	Power consumption in PSO-PID(W)
1	2:00 PM to 3:00 PM	18	44	43	18	18	18
2	3:01 PM to 4:00 PM	18	43	42	18	18	18
3	4:01 PM to 5:00 PM	18	42	42	2.8	1.8	1.8
4	5:01 PM to 6:00 PM	18	42	42	10.1	9.7	7.6
	Total Power (W)	72			48.9	47.5	45.4

Initial value of humidity is observed as 44% at 2:00 P.M. Power consumption for the exhaust fan was calculated with the help energy meter.

Table 6.23 shows power consumption by exhaust fan for duration of experiment, during the first half an hour all the methods consumes same power. It is to achieve set value of humidity. It is observed that in one hour(2:00 P.M to 3:00P.M) there is 1% fall in humidity, as the target was to maintain 42% with 44% initial humidity, so system consumes same power as conventional exhaust fan. Same is for next one hour (3:00P.M to 4:00 P.M). After reaching at set value dimming level is triggered at lower level. But humidity get start increasing due to external environment effect. So for next hour system is triggered at upper level to maintain humidity at constant level. And this cycle repeats itself.

The readings for conventional exhaust is taken as such which is applicable for that time period. All other readings are based on experimental set up.

To generate the error signal, the input value for humidity from the remote control acts as the reference input and the sensor value as feedback, in closed loop. The humidity of the room is controlled with this error signal. It is concluded that the humidity of test room is maintained at 42% for the duration of experiment. On the basis of readings taken with energy meter, power is calculated and it is concluded that power consumption by conventional exhaust fan is 72 W for four hours. Power consumption by exhaust with PID controller is 48.9 W, with GA-PID it is 47.5W and with PSO-PID it is 45.4W.

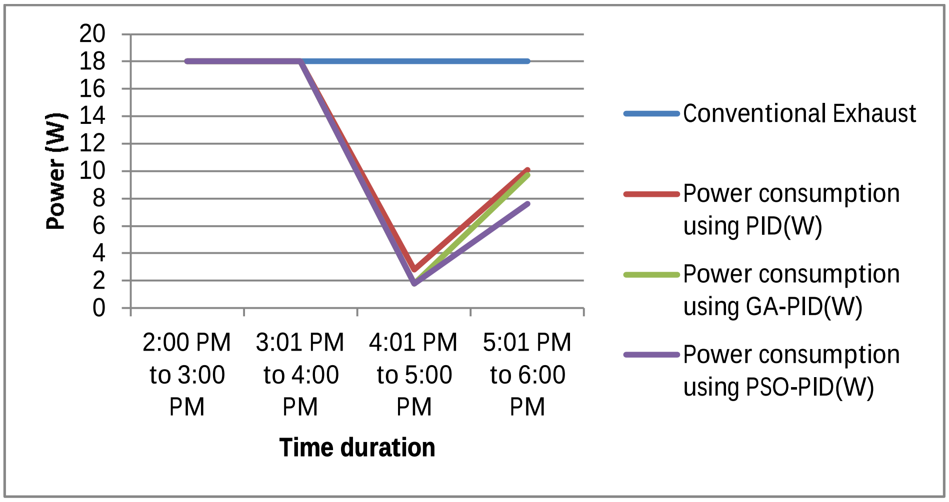

Fig.6.14Power consumption for exhaust fan in (W) for PID, GA-PID and PSO-PID during experiment

The power saving w.r.t conventional exhaust fan is observed in each case.

Table-6.24 Percentage Power saving w.r.t conventional exhaust fan (18 W) for four hours of experiment

Power consumption by conventional heater (W)	Power consumption by using PID controller (W)	Power consumption by using GA-PID controller (W)	Power consumption by using PSO-PID controller (W)	Power saving by using PID controller (%)	% Power saving by using GA-PID controller (%)	% Power saving by using PSO-PID controller (%)
72	48.9	47.5	45.4	32	34	36.9

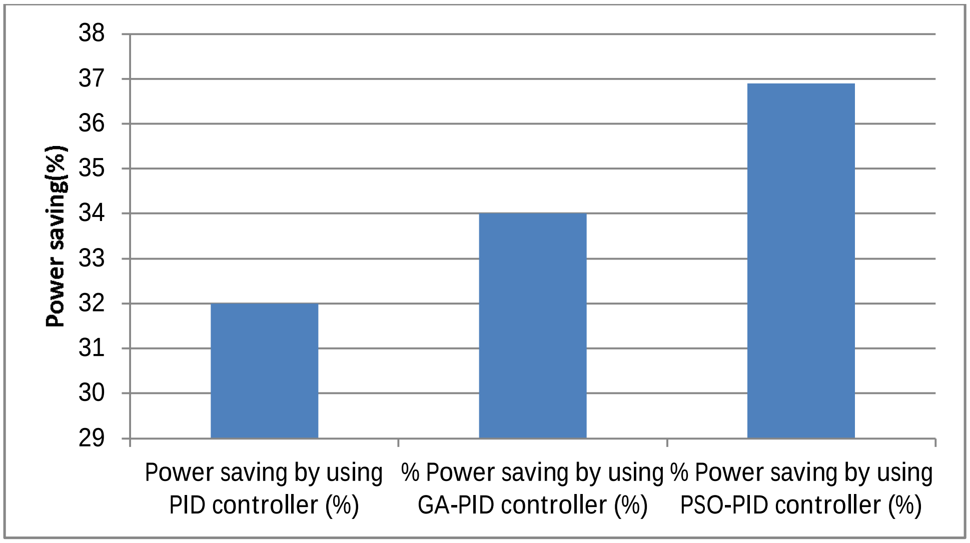

Fig.6.15 Power saving(%) w.r.t conventional exhaust fan

Fig.6.15 shows % power saving for PID is 32%, for GA-PID saving is 34% and for PSO-PID it is 36.9%. Results clearly shows PSO-PID consumes less power than PID and GA-PID and is best suited for designed system.

6.5 Cost Analysis

Cost Analysis is a very important part for actual implementation of any system. The major part for the cost includes the cost for devices and components used to design the system. The software cost and miscellaneous cost is also important. As system is designed in the University lab and basic facilities for hardware development is already available and firmware is developed by myself, so miscellaneous cost and software cost is ignored for the analysis part.

For designing the remote control and receiver section the list of components with their cost is described in table-6.25 and 6.26. The cost is for a complete system with one remote control and one receiver section (For three home appliances- heater, exhaust fan and bulb).

Table-6.25 Cost Analysis for remote control

Components	Cost (Rs.)
Temperature/Humidity Sensor	700
LDR + 10K ohm resistor	5
RF modem	600
LCD (20 x4)	320
Atmega 16	140
Regulator-7805	8
Diode IN4007	0.3
Capacitor 1000 µF	6
DC jack	5
Resistor 300Ω	0.1
LED	1
IC base 40pin	5
Breakaway connector	10
Switches	15
Rechargeable Li-Ion Battery	700
Total	2518.40

As shown in table-6.25 cost for remote control comes out as Rs. 2518.40, which is the cost for a prototype development, further if a bulk amount of remote control is to be fabricated it can be reduced upto Rs. 1500. The major part of cost is due to sensors and communication modem used to develop the remote control and make it intelligent.

The system is developed for three home appliances (heater, bulb and exhaust fan) and tested for a room size of 10*8*10 cubic feet. It is observed that for developing a single receiver node (excluding the cost of home appliances, miscellaneous cost and software cost) cost comes around Rs. 2350.40 as discussed in table-6.26, which is not a high amount and for bulk production it can be reduced upto Rs. 1000. So it can be concluded that the developed system is a cost effective solution as a home automation system.

Table-6.26 Cost Analysis of receiver section

Component	Cost (Rs.)
DC jack	5
Diode IN4007	0.3
Capacitor 1000 μF	6
Regulator-7805	8
Resistor 300Ω	0.1
LED	1
IC base 40pin	5
Atmega 16	140
Breakaway connector	10
LCD (20 x4)	320
Three Dimmer modules	1050
RF modem	600
Copper wire 2mm	50
AC plug	5
Plug board	150
Total	2350.4

For cost analysis of a complete system for a two BHK, with two room size of size 10*10*10 cubic feet and one hall room size of 20*20*10 cubic feet. As the developed system is based on RF communication, a single remote control is sufficient for all four receiver sections (one for each room size of 10*10*10 and two nodes for 20*20*10 room size). Assuming that all four receiver sections are homogeneous nodes, the total cost for installing the system for 2BHK with above mentioned size is Rs. (2518.40+ 4*(2350.40)= 11,920). As referred to table 6.10 and 6.11, it can be reduced to Rs.(1500 + 4*(1000)= 5500), for bulk production. It can be concluded that the system is cost effective, as only few components are required for implementation.

6.6 Current Consumption Analysis

Table 6.27.and 6.28 shows current consumption for both remote control and receiver section in mA. Remote control consumes 99.5 mA of current and receiver section consumes 154mA of current. Even though power was not a design issue for the system, it is evident that designed system requires very less power.

Table-6.27 Current consumption analysis for remote control

Component	Current Consumption (mA)
Atmega 16	17
Temperature/ Humidity sensor	20
LDR	.5
RF modem	58
LCD (20x 4)	4
Total	99.5

The total power consumption by remote control comes out as (99.5mA * 5V = 497.5mW) the three components that dominate power consumption for remote control are the microcontroller, RF modem and temperature/humidity sensor. The battery chosen for the present application is rechargeable Lithium Ion battery with capacity of 12V/1A; hence it can be used (day/night) continuously in the application for around 25 days.

Table-6.28 Current consumption analysis for receiver section

Component	Current Consumption (mA)
Atmega 16	17
Three Dimmers	25 x3 = 75
RF modem	58
LCD (20 x 4)	4
Total	154

The receiver section is to be fitted with switch boards so it takes power from main supply through regulator. Total current consumption by receiver section as shown in table 6.28 comes out 154 mA.

6.7 Code Size

Code size for remote control in AVR studio-4 is observed as follows.

Program size- 3.65 Kilo Byte
Data size – 209 Byte
Total- 3.85 Kilo Byte

Code size for receiver section in in AVR studio-4 is observed as follows.

Program size- 3.39 Kilo Byte
Data size – 152Byte
Total – 3.53 Kilo Byte

Mica2 [http://www.eol.ucar.edu] sensor mote and MicaZ [http://www.memsic.com], which uses the TinyOS over the AVR platform, has been compared in terms of code size with the present work . The code size of the Mica Mote for radio application is 9.5 KB but for the present work it comes out as 3.85 KB for remote control and 3.53KB for receiver section. It is found that code size of the developed system is very less than as compared to Mica Mote. The increase in code size in Mica Mote is due to TinyOS.

ATmega128 and ATmega103 support the TinyOS architecture while Atmega16 do not support it due to memory limitations. The present work is implemented by using Atmega 16, but it is not a limitation it can be implemented by any of the microcontroller. In terms of code size the present system is superior to the existing technology.

6.8 Chapter Summary

The Chapter shows the power consumption by heater, bulb and exhaust fan with PID, GA-PID and PSO-PID and concludes that PSO-PID shows best results in terms of power saving, for the developed system. The results are concluded on the basis of the step response and transient response of appliance with PID, GA-PID and PSO.PID. The cost analysis shows the system is a cost effective solution for the home appliances. Current consumption analysis proves it energy efficient system as compared to already existing systems.