

# PID Controller for Optimum Energy Efficiency in Air-Conditioner

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**Abstract**—Air conditioning is a process of excluding moisture and heat in interior space for better thermal comfort. It is also one of the largest energy consumers in a household. The air-conditioner uses a lot of energy to maintain desired room temperature. The world is getting old and technologies are getting more advanced every day, energy-efficient appliances are needed to preserve the world. This paper presents a design and testing of the PID control for temperature and humidity control using Arduino to get the optimum energy efficiency. The system was developing by implementing the DHT22 sensor. The objectives of this work are; to design experimental model of air conditioning system, and to optimize the system using PID control. The Arduino is used in this work to showcase the temperature and humidity reading. The experimental model has been successfully built for use with PC fan with 12V and 0.26A current rate. The real-life performance is quite satisfactory.

**Keywords**—Air-Conditioner, Energy Efficiency, PID Controller.

## I. INTRODUCTION

Technologies have advanced greatly in many ways and lots of changes have occurred throughout the decade. For example, air-condition, a common and largely used home appliance which was used to control humidity more than temperature back in the early 1900s. Nowadays, modern air-condition can be used to cool, dehumidify or even heat up room temperature thanks to their control system such as PID. All of this continuous improvement was due to the generation of scholars and engineers that strive for a better living environment of the community. Air conditioning is a process of excluding moisture and heat in interior space for better thermal comfort. It is also one of the largest energy consumers in a household. Energy is a term used to describe the capacity to move an object by application of force. Energy exists in a variety of form such as electrical, mechanical, thermal, chemical or nuclear and it can be transformed from one form to another.

The introduction of electrical energy to man has greatly affected the livelihood of people. This was due to the people dependence on the electrical household appliance in their daily life. As air-conditioning is one of the main consumers in a household, it was necessary for it to be energy efficient as to reduce operating cost and subsequently release fewer greenhouse gasses thus saving the Earth atmosphere. To achieve optimum energy efficiency, a PID control system was introduced as an alternative. Among alternate controllers, PID ensured an ideal consolidated execution, near the semi-perfect one accomplished by utilizing the fuzzy logic [6]. The correlation demonstrated that fuzzy logic, legitimately arranged, beat both PID and on/off controllers diminishing the vitality utilization of 30– 70% and keeping up thermal discontent between solaces limits for all the observing time frame. The power heaps of HVAC frameworks are the controllable power requests, which are conceivable to be changed by power request controls [5]. Different researches have exhibit some energy productive structures diminish the customary energy utilization by methods or lessening volume stream with various ventilation underneath the benchmarks, and hence a decrease on IACQ [19].

For this work, the PID algorithm is used to get the optimum energy efficiency when using air-conditioning. PID controller is a feedback controller which delivered output at the desired level. It has 3 branches of basic control behavior, P-controller, I-controller and D-controller respectively. By combining all 3 controllers, the desired result can be achieved. In the air conditioner, switches on/off and PID control are widely used because of their simplicity [18]. P-controller gives an output proportional to the current error. It got a stable operation but cannot get rid of the steady state error. Next, I-controller works by integrating error over time until error becomes zero. After that, D-controller work by anticipating the future behavior of error and correct it. The traditional PID controller is a generally utilized modern controller which utilizes a blend of proportional, integral and derivative activity on the

control blunder to shape the yield of the controller. Expanding the relative gain diminishes the steadiness edge of the framework, builds the recurrence of wavering, and diminishes reaction time. Setting the corresponding addition too high can result in an unsteady framework activity [16].

The typical control strategy based on ON-OFF or direct PID, PI, and P controllers can't acceptably manage the issue of energy proficient adjustment of the essential associating microclimate parameters. The control framework execution isn't sufficient because of the multivariable character of the plant, its nonlinearity, latency, show vulnerability, and various assorted unsettling influences. Calibration of proportional coefficients can reduce the system energy consumption by up to 29% and can improve meeting temperature set points by up to 45% [13]. The incorporation of the proposed control framework with the adjusted cooling framework prompts increment the energy saving and enhance the coefficient of execution over a wide scope of surrounding temperatures (35– 57) degree Celsius [1]. The proposed control procedure can adequately accomplish an ideal cooling conveyance, which guarantees a comparative cooling-down speed of indoor temperature among various zones amid morning begin period, and thus a potentially shortest precooling time [5]. PID can also be based for another algorithm that may achieve better energy efficiency such as decoupled PID-Fuzzy controller. Moreover, this controller ensures the powerful execution by ideal following of wanted set ways; within the sight of model/parametric vulnerabilities of AHU [2]. In the research from [5], [6], PID parameters were hypothetically gotten by utilizing fuzzy sets. Improvement with Fuzzy Modelling Approach of PID Parameters has been performed to augment the execution of the framework [3].

Other than that, there are other studies that used another model approach beside PID like ANN. One of the unmistakable highlights of ANN was its astounding execution in demonstrating complex nonlinear frameworks, for example, cooling frameworks utilizing info and yield information, paying little mind to the physical procedures or the numerical articulations of the objective framework [9]. In specific, not the same as scientific models, for example, relapse display for corresponding basic subsidiary (PID) controllers, ANN models have flexibility through a self-tuning process, so can choose precisely without outside specialist intercession when irregular irritations, unsettling influences, as well as changes in building foundation [17].

This work intends to design a PID control system that will optimize energy efficiency for the air conditioner. This work also studies the tuning of PID to achieve better energy efficiency. This work used the DHT22 sensor to measure temperature and humidity of the interior space. The measured data will then be processed through the PID system which will move the fan of the air-conditioner to achieve the desired temperature.

The objectives of this work are; To design experimental model of air conditioning system, and to optimize the system using PID control. The scope of this work is the operation of the air conditioner with designed PID in a room. For the next step, the designed PID will undergo a tuning process to get the optimum result. The

work used a DHT22 sensor to measure the temperature of interior space converting it into error input for the PID control system. The same is true for the humidity sensor. The controller would then work to achieve the desired output temperature. Finally, the power used by the air conditioner will then be calculated.

## II. METHODOLOGY

The methodology of work is carried out based on the flowchart in Figure 1. The experimental procedures will be discuss step by step with clear explanation. To make it comparative, the experiment is carried out to get the result.

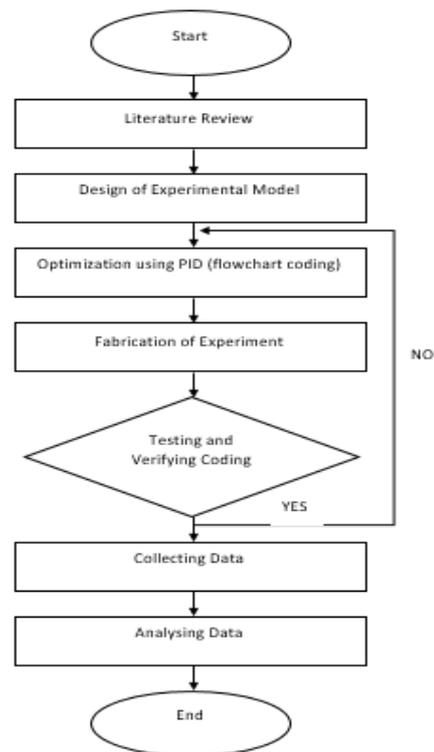


Fig.1. Flowchart of methodology

### A. Design of Model

The build-up for the DHT22 temperature controlled PID using Arduino model can be a bit complex as a whole but easier to do when broken into smaller part.

#### Block Diagram

Figure 2 shows the block diagram of this work, the signal from the DHT22 sensor is send to the Arduino Uno R3, then the CPU fan will spin according to the temperature sensed.



Fig.2. Block diagram

### Experimental Model

Figure 3 shows the proposed experimental model of the work. The model are made from clear acrylic sheet. It has two box, the top box act as the control box which house the Arduino Uno and the other box as space which house the CPU fan and the DHT22 sensor.

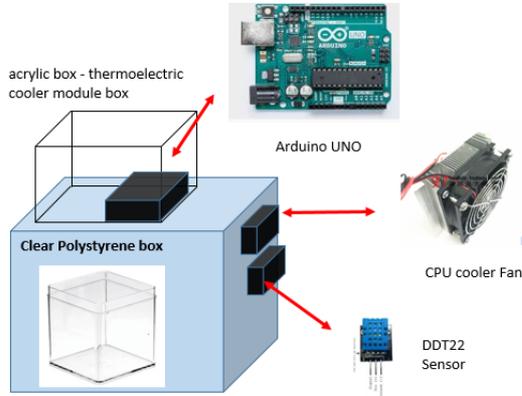


Fig.3. Experimental Model

### Electrical Schematic

Figure 4 shows the schematic diagram of proposed circuit. This circuit include Arduino Uno, DHT22 Sensor, CPU Fan and 12V DC power supply.

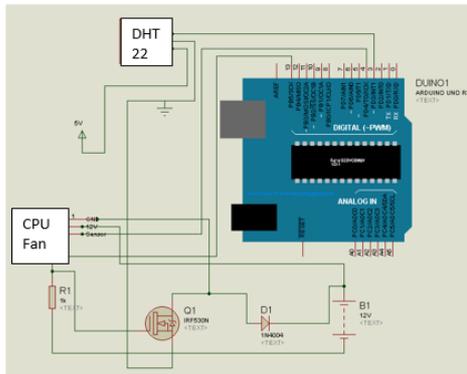


Fig.4. Electrical Schematic

### B. Coding of PID

Figure 3.5 shows the technical flowchart of the coding. The code consist of temperature control including PID

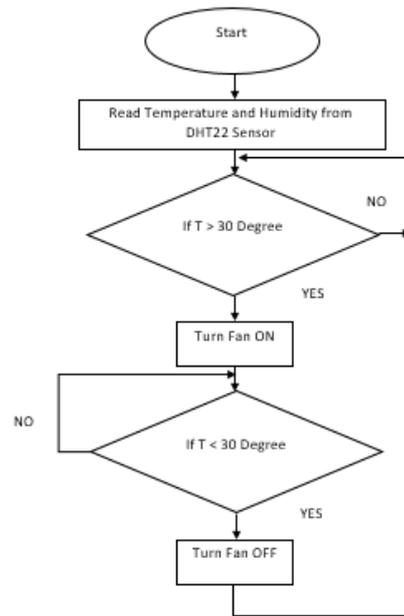


Fig.5. Coding Flowchart

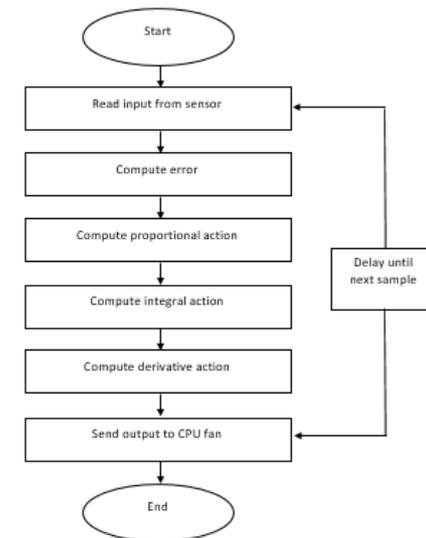


Fig.6. PID Flowchart

Figure 6 shows the full experimental model complete with circuit. The electronic is put in control box located on top of a much bigger box. The box is build using clear acrylic sheet. The circuit is built step by step and had been tested before connected to other electronic component.

### C. Testing and Verification

The coding use is verify and tested. The coding error has been fixed. The entire component used met the specification needed to complete the experiment.

#### D. Collecting and Analysing the Data

The data for this experiment are collected and analyzed. More detail has been discussed in the next chapter.



Fig.7. Full Experimental Model

### III. RESULT AND DISCUSSION

To show the performance of the system, the close-loop control system is built, as illustrated in figure 8. The set-point for the temperature is set to 30 degree Celsius and humidity to 65%. The input data from the DHT22 sensor will go through the PID which act as the controller for the fan. The loop is close so there will be feedback generated to correct the error.

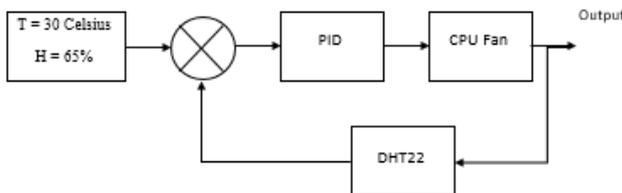


Fig.8. The close-loop system

#### A. PID Simulation

Figure 9 shows the PID controller during simulation. The simulation is done using open source excel simulator. The controller is good because it take short time to reach the desired temperature. If the output lower than the set point, the system is bad.

#### B. Experimentation

Figure 10 show the comparison between the two system, without and with PID control, based on experimengt results as shown in Table 1 and Table 2. The graph shows that the one with PID consume less energy compare to the one without. This is because the PID regulate the fan speed according to the temperature while the one without use

constant speed. The energy consumption where the humidity is constant is lower than when the temperature is constant.

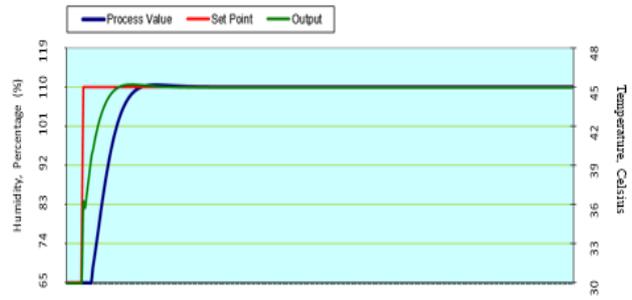


Fig.9. PID simulation graph

Table I. Humidity constant without PID

Temperature, Celsius	Humidity (%)	Fan speed RPM	Power, KW(day)	Time, (s)
set= 30	65	900		
36			0.0000032	282
38			0.0000036	312
40			0.0000052	450
42			0.0000058	498
44			0.0000068	588

Table II. Humidity constant with PID

Temperature, Celsius	Humidity (%)	Fan speed RPM	Power, KW(day)	Time, (s)
set= 30	65	900		
36			0.0000031	270
38			0.0000034	294
40			0.000005	432
42			0.0000055	480
44			0.0000066	576

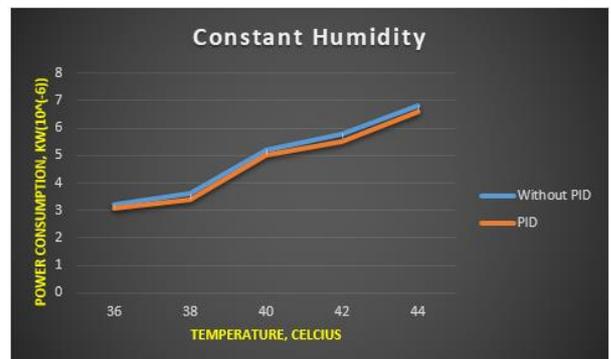


Fig.10. Power Consumption Graph Constant Humidity

Figure 11 show the comparison between the two system, without and with PID control based on experiment results as shown in Table 3 and Table 4. The graph shows that the one with PID consume less energy compare to the one without. This is because the PID regulate the fan speed according to

the temperature while the one without use constant speed. The energy consumption where the temperature is constant is higher than when the humidity is constant.

Table III. Temperature constant without PID

Temperature, Celsius	Humidity (%)	Fan speed RPM	Power, KW(day)	Time, (s)
30	set=65	900		
	70		0.0000035	306
	80		0.0000044	384
	90		0.0000054	468
	100		0.0000065	558
	110		0.0000074	636

Table IV. Temperature constant PID

Temperature, Celsius	Humidity (%)	Fan speed RPM	Power, KW(day)	Time, (s)
30	set=65	900		
	70		0.0000034	306
	80		0.0000043	384
	90		0.0000052	468
	100		0.0000063	558
	110		0.0000072	636

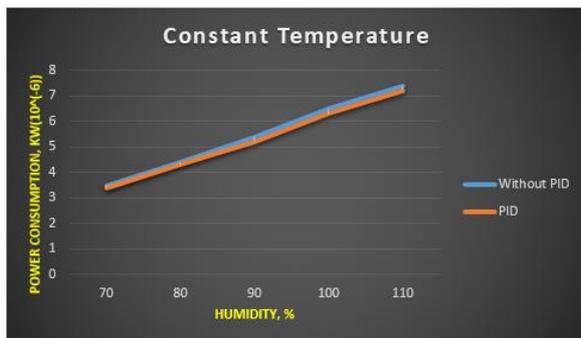


Fig. 11. Power Consumption Graph Constant Temperature

#### IV. CONCLUSION

In conclusion, all of the objectives of the work “Optimization of Air Conditioner Using PID controller” are achieved. Firstly the work is to produce a system using PID to reduce power consumption. To achieve this, an experimental model has been successfully built to simulate the experiment. The temperature control program is successfully generated by using Arduino software. The second objective is to use PID in Arduino coding. The control system has been successfully built by using PID library in Arduino.

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