Proc. of the Fifth International Conference on Advances in Computing, Electronics and Communication - ACEC 2017.

ISBN: 978-1-63248-121-4 doi: 10.15224/ 978-1-63248-121-4-43

Efficiency Enhancement of Air Conditioner through Adaptive Speed Control

Energy Efficiency

Moez ul Hasan, Syed Hasham Hatim, Sharyar Naseem
And M Mustafa Jamal

***Abstract*—The system is designed to improve the efficiency of a typical household air conditioner by managing the speed. As there are many causes that produce high electricity bill consumption, one of the main causes is due to the inrush current and high torque. This paper defines the use of an induction motor of a compressor and the use of VFD (Variable Frequency Drive) which will control the incoming frequency and convert it to produce user's desired frequency; this will be achieved through a temperature controller. The temperature controller uses a PID (Proportional Integral Deferential) which has been implemented on an Arduino. The PID helps the data to be received with minimum errors and reaches its desired temperature gradually; this makes it more efficient and effective. It helps the user to set its own desired temperature which achieves the set temperature by taking care of the overshoots. The product is designed to be cost efficient, easy handling and will work as an Add-On to make it consumer**

***Keywords*— PID controlling; Automation, Efficiency**

I. Introduction

Main Objective of initialization of the project is to make cost effective as well as energy saving .For this purpose we focus on Air Conditioner which is usually a part of household commodity and corporate offices. Project itself is the alternative of DC inverter Air conditioners which are much costly than the normal Air conditioners .In order to make it acceptable in market structure; we are providing Add-On to conventional Air conditioners, which is just a replacement of DC inverter Air conditioners. Instead Of Changing whole existing system, just attach Add-On to conventional Air conditioners. Our project provides a convenient way to both cost saving element as well as energy efficient. [1]. The project is focused for the betterment of the technological progress of the country. The project has the ability to implement three basic initiatives which are:

Moez ul Hassan
SZABIST
Pakistan

Syed Hasham Hatim
SZABIST
Pakistan

Sharyar Naseem
SZABIST
Pakistan

M Mustafa Jamal
SZABIST
Pakistan

1) Energy Efficient: The project specifically works for the efficiency of the entire system and provide an environmental friendly output.
2) Cost Efficient: The project works on the behavior of the compressor motor which is achieved through the implication of a controller in result providing less inrush current hence providing the consumer with lower electricity bill consumption.
3) Easy Handling: The device is submerged in to a small package which works as an Add-On and the user is able to control the output of the air conditioner simply by connecting it to the existing system.

The objectives of this Project are to drive the motor by a variable frequency drive. A Variable Frequency Drive (VDF) is a system for controlling the AC motor by controlling the frequency of the electrical power supplied to the motor. This project is aimed to develop a variable frequency drive for the compressor of an air -conditioner whose voltage and frequency will be a function of the room temperature. The intended range of operation is from 20Hz to 50Hz. The VFD should be able to handle the inrush current of the motor. The existing topologies for VFD will be studied and analyzed. The best suited topology will be selected and implemented on hardware using discrete components. When it is found working, the solution will be transferred on a P.I.D Based microcontroller and realized on hardware format. However it should be noted that we are replacing the usual ON/OFF controller with a PID controller based on Arduino which will act as a P.I.D based temperature controller with indication of room temperature and manipulation of set value through IR remote buttons. [2]. The flowchart of the system is shown in Fig. 1

II. Problem Formulation

It is known that technological progress of a country depends upon their energy potential, i.e. generation, distribution and utilization of their energy resources should be optimum. This is a fact now that the energy is diminishing day by day, energy resources like light, gas are reaching to point where it will not exist anymore. In order to save these resources we must work out a solution to save it in any way possible. Tremendous savings can be made if we work on saving the electricity, gas and other resources. [10].

The research papers related to the efficiency of an air conditioner and as well as parallel we did research on different types of algorithms that would help us in making our temperature controller. As we looked at other algorithms that may have the ability to achieve the same outcome; they were as follows:

1) Neural Network Analysis
2) Genetic Algorithm

Proc. of the Fifth International Conference on Advances in Computing, Electronics and Communication - ACEC 2017.

ISBN: 978-1-63248-121-4 doi: 10.15224/ 978-1-63248-121-4-43

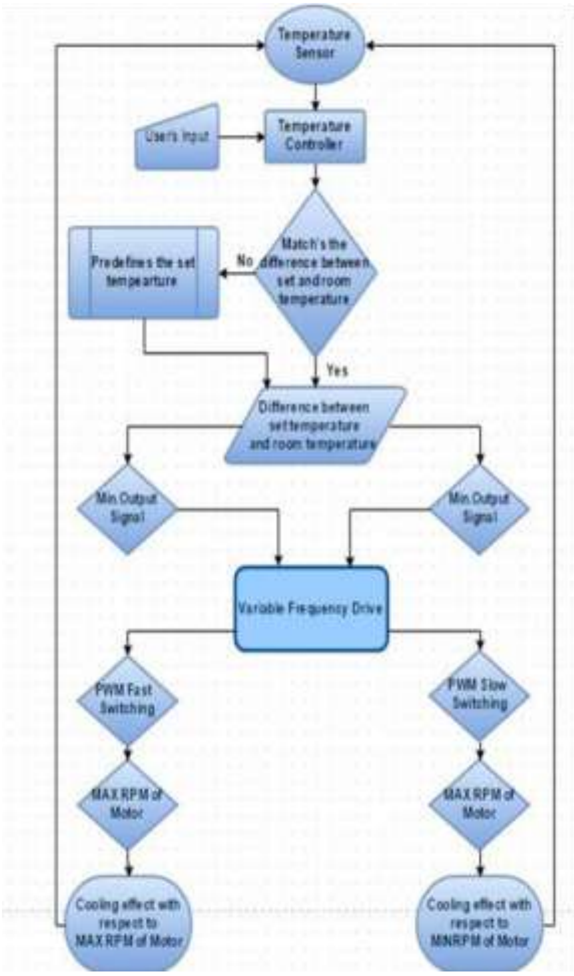

Figure 1 Flowchart

3) Fuzzy Logic
4) Adjustable Reset Relay

They were all complicated to manage and would be needless, paper found PID (Proportional Integral Differential) to achieve the desired outcome and would help it to be cost friendly well. It would achieve the steady state with less over shoot and errors. This shows that it would switch from on and off method. The paper gave us different efficiency enhancement methods at would reduce the consumption of electricity. [4] It was proposed by many research papers that it can be done through FD (Variable Frequency Drive) which would work by changing e outcome through our desired frequency. [5]. Efficiency has been significantly improved by VFDs. The following table demonstrates the difference between a normal air conditioner and a VFD one

III. Experimental Setup

Fig 2 explains the project's objective with all the parts concerning to achieve it. Two main parts of it are the temperature controller and VFD (Variable Frequency Drive) which drives the output of the motor with the user's desire.

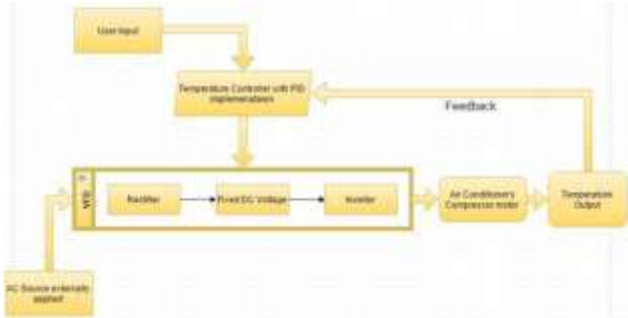

Figure 2 Basic Block Diagram

TABLE I ENERGY CONSUMPTION

Airflow Volume (Maximum Percentage)	*Daily Operating Time (Hours)*	*Energy Consume d with Damper (kWh/year)*	*Energy Consume d Using a VFD (kWh/year)*	*Difference in Energy Consumption (kWh/year)*
50%	2	18500	4800	13700
60%	3	29300	9800	19500
70%	6	61700	26800	34900
80%	6	63300	35900	27400
90%	4	44200	32600	11600
100%	3	34200	35200	-1000
Total	24	251200	145100	106100

Table 1 explains the temperature controller's algorithm step by step which achieves, which is set to show how the programmer has merged the PID (Proportional Integral Differential) algorithm to achieve the desired temperature output with minimum errors.

1) Step 1: Controller decides whether the user has provided with the Set Value or not.
2) Step 2: If Set Value (S.V) is defined by the user then S.V = User Defined Set Value, or in case user decided to just turn ON the System and doesn't want to assign any value, then Controller will make S.V = Pre Defined Set Value.
3) Step 3: Controller now compares the S.V with The Room Temperature (R.T).
4) Step 4: If Room Temperature > Set Value, then the Controller will generate (Maximum) PWM which ultimately pulses to motor, and then Motor rotates on its maximum RPM Value. If Room Temperature = Set Value, then Controller will generate ↓↓↓ (Minimum) PWM which ultimately pulses to motor, and then Motor rotates on its minimum RPM Value in order to maintain SV and R.T.If Room Temperature ≈ Set Value, then Controller will generate as per required. PWM which ultimately pulses to motor, and then Motor rotates on its required level of RPM and will constantly and steadily change its output in order to achieve S.V. However, it should be noted as room temperature approaches set value then PWM will decrease.

IV. Results and Discussion

The final testing with the 1 ton compressor motor and the Variable frequency drive through the temperature controller that we designed. The results shown in TableII

Proc. of the Fifth International Conference on Advances in Computing, Electronics and Communication - ACEC 2017.

ISBN: 978-1-63248-121-4 doi: 10.15224/ 978-1-63248-121-4-43

TABLE II COMPRESSOR MOTOR TESTING

Frequency (Hz)	Voltage(V)	Current (A) with VFD	Current (A) Without VFD
50	240	1.613 – 1.774	2.8 – 3.2
45	221	1.54 – 1.60	N/A
40	201	1.28 – 1.298	N/A
35	181	1.085 – 1.09	N/A
30	161	0.918 – 0.92	N/A
25	138	0.802 – 0.809	N/A
20	114	0.642 – 0.646	N/A
15	90	0.497 – 0.501	N/A
10	61	0.388 – 0.395	N/A
5	25	0.266 – 0.312	N/A
0	0	0	0

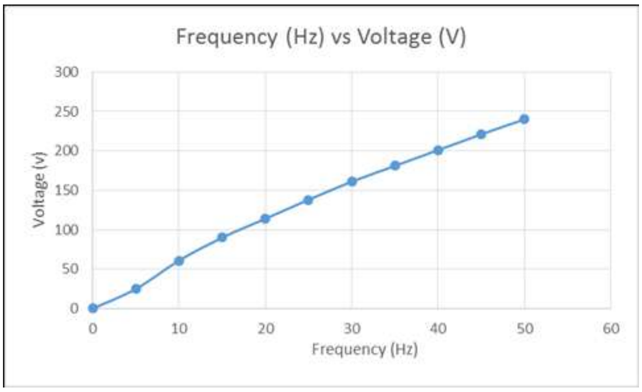

Figure 3 Frequency versus Voltage

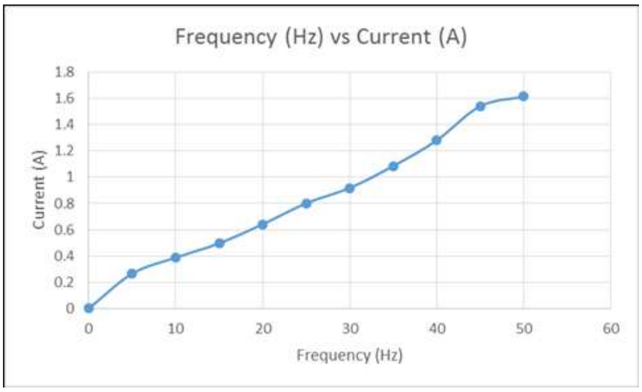

Figure 4 Frequency versus Current

The results in Fig.3 and Fig 4 demonstrates that increasing the frequency will lead to higher currents and voltages where at maximum Frequency the voltage reaches its maximum that is 220 V.

The graphs shows us the linear trend which it follows with respect to its frequency. It should also be noted when the frequency is at its minimum that is at 0 Hz it demonstrates a very low voltage that is in mV or around 2/3 V which is negligible and hence considered as 0 V.

The result demonstrates when the system is used there is a reduction of Current consumption for about approximately 50%.

TABLE III AIR CONDITIONER CONSUMPTION

Air Conditioner's Temperature (degree C)	Consumption (kWh)	Duration (Mins)	Outside Temperature (degree C)
20	0.6	30	32
22	0.6	30	32
24	0.4	30	32

Table III shows the consumption by the air conditioner without the VFD (Variable Frequency Drive) connection, the time is set for 30 minutes as standard; as it can clearly be seen that with the reduction in the temperature there will be a reduction in electricity consumption as well by the K-electric meter. This is mainly because of the effect it has on the compressor motor. The compressor motor shuts and turns itself on accordingly. This creates a radical effect while calculating the consumption. The outside temperature was thoroughly maintained to 32 °C.

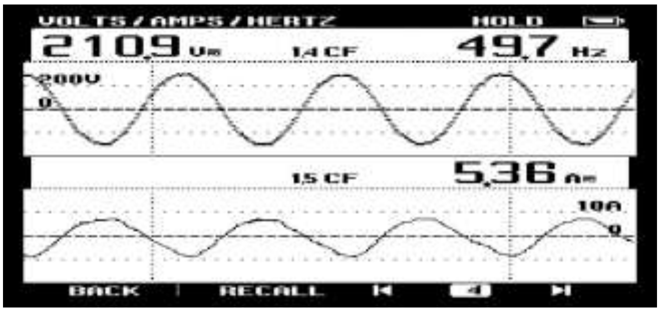

Figure 5 Air Conditioner's Volts and Amps Wave

Fig. 5 shows the waveform of the current and voltage through the main supply to the Air Conditioner without the connection with Variable Frequency Drive. The current during the steady operation of the air conditioner is around 5.36A and the current over here is lagging the voltage as it is experiencing inductive load. The voltage is around 220 V.

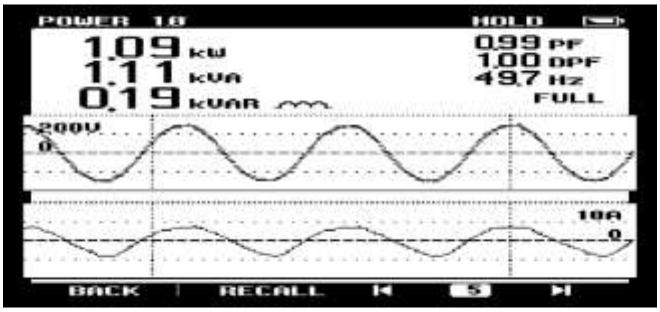

Figure 6: Air Conditioner's Power

Fig 6 shows the power analysis of the air conditioner without the variable frequency drive. The real power is 1.09 kW, the apparent power is 1.11 kVA and the power factor it makes up is almost near to unity that is 0.99 PF. The DPF (Displacement Power Factor) is of unity which means it doesn't affect the Total Power factor; rather the Total Harmonic distortion would affect the TPF. The Distortion factor in the testing was experienced to be very negligible

Proc. of the Fifth International Conference on Advances in Computing, Electronics and Communication - ACEC 2017.

ISBN: 978-1-63248-121-4 doi: 10.15224/ 978-1-63248-121-4-43

hence there little or no effect on the total power factor. The reactive power which is about 0.19 kVAR, this known to be sent back through the lines

TABLE IV RESULTS WITH LOAD

Frequency (Hz)	Input Current (A)	Loaded Current (A)	Voltage (V)	Air Conditioner's Temperature (degree C)
50	7.65	6.96	220	17
48	7.54	6.65	210	17
46	6.95	6.29	207	17
44	6.8	6.18	201	17
42	6.56	6.13	195	17
40	6.01	5.75	183	17
38	5.75	5.5	176	17
36	5.53	5.32	170	17

Results in Table IV shows the linearity between the current and frequency and as well as the linearity between frequency and voltage. It can be clearly deduced that the current can be decreased with the help of the frequency which will lower the current and voltage and resulting in a lower power consumption.

References

[1] Anette Michel, Eric Bush, Jürg Nipkow, Conrad U. Brunner, Hu Bo; Energy efficient room air conditioners – best available technology (BAT) , Topten International Services.

[2] Takanori Yamazaki, Yuji Yamakawa, Kazuyuki Kamimura and Shigeru Kurosu Oyama, Air-Conditioning PID Control System with Adjustable Reset to Offset Thermal Loads Upsets; National College of Technology, Univ. of Tokyo, National Institute for Environmental Studies, Research Inst. "Crotech", Japan

[3] Jianbin Nie; Yuting Zhou; Chen Chen; Ning Han; Deying Li, A PID parameter tuning method for air conditioning system based on annealing genetic algorithm, Acadmia,

[4] K. Pal and R. K. Mudi, Self-Tuning Fuzzy PI Controller and its Application to HVAC Systems.

[5] Liu Luoren, Luo Jinling., Research of PID Control Algorithm Based on Neural Network, Department of Electrical Engineering,. Department of Electronics and Information Engineering Loudi Vocational College, Loudi 41700, Hunan, China

[6] Li Y., Ang K.H and Chong G.C.Y, PID Control system analysis and design, IEEE Control System Magzine, 2006, pp.32-41.

[7] Astr¨om, K.J., Hang, C.C., Persson, P., Ho, W.K., Towards intelligent PID control, Automatica, vol. 28, 1992, 1-9.

[8] Lancet Mit "Introductuon to D.C. Motors" User conference, Austin texas Vol 11 2004

[9] B.C. Kuo "Automatic Control Sytems" (sixth edition), Prentice Hall, 1991.

[10] Moez-Ul-Hassan. (2006). Efficiency enhancment of air conditioner by adpativespeedcontrol[Online]