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Development of PIC18F4431 microcontroller controlled air conditioning system

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Abstract. The aspiration for high performance industrial applications increases owing to advance in the field of power electronics. This contributed to swift developments in digital motor control technology. High energy consumption and poor efficiency are major challenges of motor driven appliances. These appliances need cost-effective solutions controlled drive that improves process precision, cuts operating costs and facilitates less energy. The goal of this research is to develop feasible motor control air conditioning system. The developed system describes the optimization and designing of a microcontroller controlled drive with speed sensing. It is PIC18F4431 based microcontroller primarily for motor control applications. This study focuses on speed control of induction motor using PIC microcontroller through PWM technique. The result of the research indicates that at the 5% air flow rate, the air conditioner without the drive consumed about 87% energy whereas the microcontroller based drive only consumed 20% energy at the same flow rate. This indicated the energy saving of about 67% by the air conditioner with the adoption of PIC18F4431 microcontroller controlled drive.
Key Words: digital motor, motor driven appliances, air conditioning system, drive, PIC18F4431 microcontroller, Pulse Width Modulation (PWM).

1. Introduction

Air conditioning system is the mode of varying and modifying the temperature and humidity of air to more flattering and comfy setting, basically with the requisition of distributing the accustomed air to an engaged room, towards the improvement of thermal comfort and indoor air worth of a room, building, house or vehicle. An air conditioner is a recurrent use appliance that lessens the air temperature. A refrigeration cycle resulted to cooling, but evaporation or free cooling is intermittently applied [12].

The traditional air conditioners are drive by AC induction motors at an invariable speed. These types of operation diverge their ability by switching on and off at diverse intervals. The machine output of this air conditioner is controlled by mechanical methods using throttling devices, valves, dampers and others. Running a motor (in compressor and fan) of air conditioner at full speed continuously regardless of the varying demands of production means that a great deal of electric power is expended and squandered. In the light of this, a drastic reduction in the

power consumption of motors and effective energy increase of machinery is only achieved by a microcontroller based drive [9].

The performance and effectiveness of microcontroller evolution especially in automated applications is of considerably interest of researchers [1], [11]. Different fields of applications such as control systems, automation systems, medical applications and wireless communications are the products of advancement in microcontroller. The control systems are developed by microcomputers such as PIC, dsPIC microcontroller, and Arduino controller as demonstrated in this study [7].

The variable frequency pulse width modulation (PWM) signal provided by the microcontroller controls on the gate drive the applied voltage. The requisite PWM frequency is provided at the output of the power inverter with fewer harmonics [5]. The microcontroller embraced for the study is PIC18F4431. The decisive benefits offered by the adopted microcontroller among others are a high-speed 10-bit A/D converter, great endurance improved Flash program memory and high computational performance at an economical price. The external hardware requirements and levels of motor control capability are simplified and highly enabled respectively by a set of unique peripherals core than the PIC18F452 or PIC16F7X7. Besides, a rational option for motor control applications, many high performances and power control as exhibited in the design enhancements of research proved the versatility of PIC18F4431 microcontroller [6].

The reliability, robustness, ruggedness and simplicity of control enhance the widely used in control systems and home appliances of induction motors [11]. It operates only at the rated speed when connected to mains directly at set specifications. With this, the system depends on the motor design and even simple speed variation is impossible. The speed variation is provided by the Variable Voltage Variable Frequency (V/f) method without transient condition being altered. It is useful only for. This technique is best appropriate for steady state condition and applications that do not required high accuracy speed and position control [4], [3].

The quality of output signal is significantly improved and distinct improvements in the characteristics of drive for power converter are noticeable by the PWM technique with advent in power semiconductor devices [8], [10].

2. Measuring Materials

The measuring instruments applied in this research are energy meter, thermometer, digital multi meter and air flow meter. The digital multi-meter implemented is used to validate the electrical performances of assembled components in the design. The energy meter embraced is the standard meter used by the Nigeria Power Distribution Company to quantify the consumed power by every household in Nigeria. A thermometer used measures temperature or a temperature gradient in the conditioned room.

3. Methodology

The Variable Voltage Variable Frequency (VVVF) control method and solid state electronic conversion technology was adopted to develop the microcontroller controlled drive in this research (Figure 1). A microcontroller (PIC18F4431) based PWM inverter is employed to develop the drive through C language programming. There are speeds variation from 1440RPM to 4200RPM of induction motor at a frequency range of 24Hz to 70Hz. The frequencies, speeds

and load reading of a 3 phase, 415 Volts, 1.5 H.P. were observed and Induction Motor were tested on developed drive.

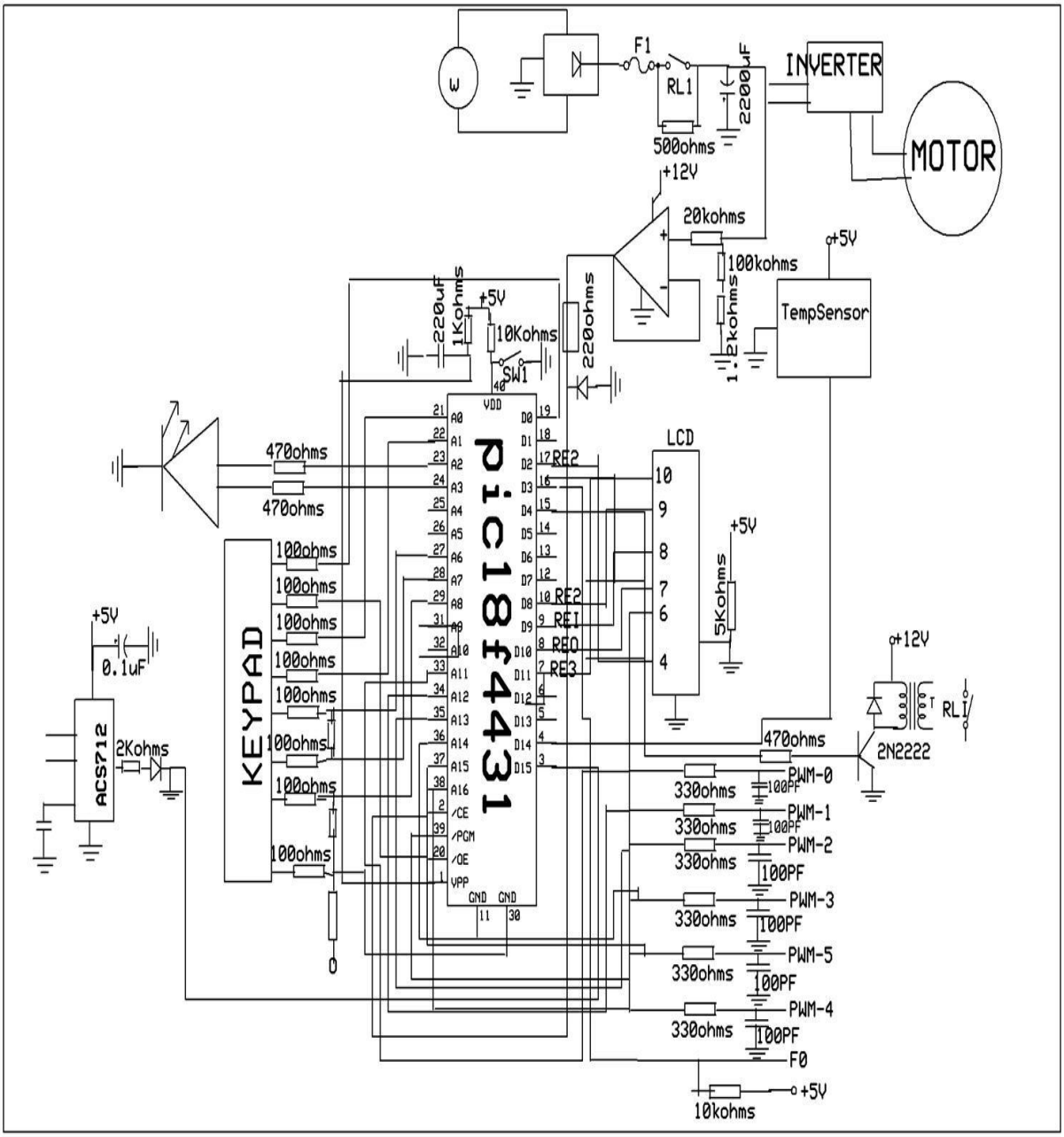

Figure 1: Developed PIC18F4431 Microcontroller Based Drive Model Circuit Diagram [9]

4. Results

The corresponding room temperature, air flow rate and consumption power are observed experimentally for developed drive and conventional air conditioner. The table 1 and figure 2 below displayed the results respectively.

Table 1: Experimental Results of Conventional and PIC18F4431 Microcontroller Controlled Air Conditioner

Time (hr)	Room Temp. (^{0}C) of Dev A/C	Energy (kWh) of Dev A/C	Air Flow Rate (m^3/h)	Temp. (^{0}C) of Conv A/C	Energy (kWh) of Conv A/C
8:05am	25	1.0	50	25	1.5
9:00am	24	1.1	100	24	2.5
10:10am	23	1.2	150	24	4.0
11:07am	22	1.3	200	24	5.5
12:05pm	24	1.4	250	24	7.0
1:01pm	28	1.5	300	28	8.5
2:05pm	30	1.7	350	30	10.0
3:07pm	30	1.9	400	30	11.5
4:03pm	27	2.2	450	27	13.0
5:06pm	26	2.5	500	26	14.5
6:00pm	26	2.8	550	26	16.0
7:50pm	25	3.1	600	25	17.5

In Table 1 and Figure 1, it is clearly observed that at the 5% air flow rate, the air conditioner without the drive consumed about 87% energy whereas the one using the microcontroller based drive only consumed 20% energy at the same flow rate. This indicated the energy saving of about 67% by the air conditioner if the constructed drive is adopted.

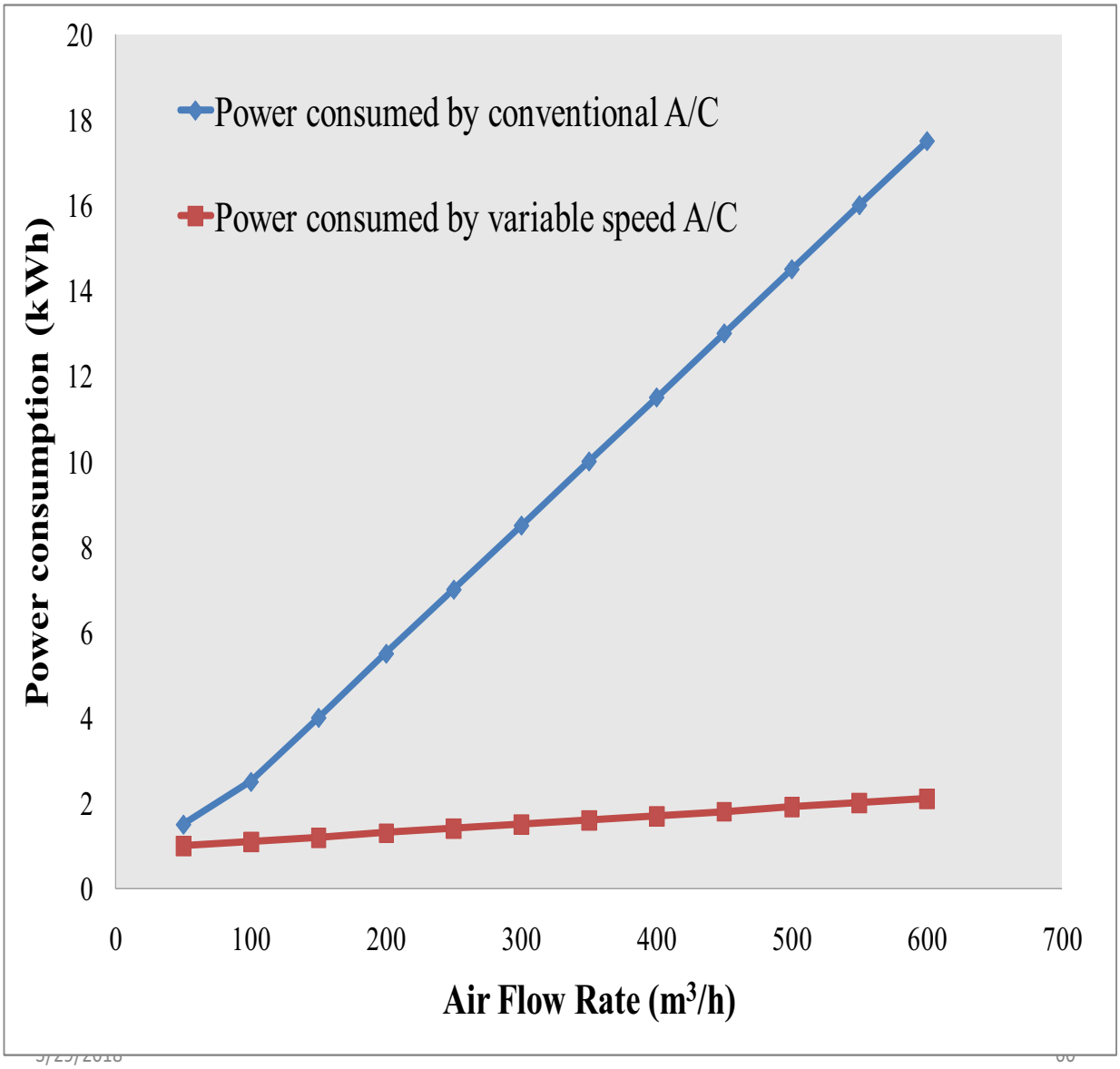

Figure 2: Power Consumption by Conventional and PIC18F4431Microcontroller Based Air Conditioner

5. Conclusion

The higher rate of consumption by the air conditioner without PIC18F4431 control drive is as a result of switch On/Off control of the system. This generates much mechanical stress and pressure peaks due to both the extra starts and stops and the current peaks into the electrical supply when the motor is started. It is evidently showed that the power consumed by air

conditioner with drive saved about 67.7% of energy compares to its consumption without the drive. It shows that the traditional air conditioner runs incessantly at complete speed due mechanically controlled of the system without regulation.

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