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TEMPERATURE AND MOISTURE SENSITIVE INVERTER MODULE FOR ENERGY EFFICIENT REFRIGERATOR

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ABSRACT

The paper describes the method to increase the energy efficiency of domestic refrigerator by a temperature and moisture controlled circuit. The energy used to power refrigerators is mainly supplied through burning of fossil fuels with an ever-increasing economic and environmental cost. Therefore, any reduction in energy consumption will result in reduced CO_2 emissions as well as reduced power bills for the end user of the refrigerator. The proposed method consists of temperature and moisture controlled circuit with an ATmega microcontroller chip that controls the speed of the three-phase motor inverter. This system is a potential low-cost solution to increase the power efficiency of domestic refrigerators.

Keywords: Temperature sensing, moisture sensing, three phase motor inverter, energy efficiency

1. INTRODUCTION

Refrigeration is technology which makes a major contribution to humanity in many ways including food preservation, control of indoor air quality, gas liquefaction, and industrial process control, production of food and drink and computer cooling. Without refrigeration, modern life would be impossible. About 15% of the world's electricity is used to drive refrigerating and air-conditioning systems [3]. Inefficient use of energy is a waste of valuable resource and contributes to global warming. Most of the global warming effect of refrigerating systems comes from generating energy to drive them. Only a small proportion comes from the release of certain refrigerants[1].A refrigeration system extracts heat from the substance being refrigerated (cold reservoir) and rejects it to the ambient at a higher temperature (hot reservoir)[2]. This is analogous to the pumping of water to an elevated storage

tank. The energy consumption of a refrigerator is roughly proportional to rate of heat extraction (amount of water pumped) and to the temperature lift through which the heat is raised (height water is pumped).The energy efficiency of a refrigeration system is usually expressed as a Coefficient of Performance (COP) which is the ratio of the heat extraction rate to the rate of energy use. Whatever type of refrigerating system is being used, it is fundamental to minimize the required heat extraction and to keep the difference between T_c (condensing temperature) and T_0 (evaporating temperature) as small as possible. Minimizing heat extraction is done by insulating the refrigerated room and low-temperature parts of the refrigeration system, minimizing ambient air infiltration (e.g. door openings and leakage) and reducing energy use in refrigerated applications (e.g. fans and forklifts). The temperature deference (T_c-T_0) can be reduced by maximizing condenser and evaporator heat transfer performance and minimizing refrigerant pressure drops in suction and discharge pipelines[5]. In this work, difference of the temperature inside the refrigerator and the moisture change inside the refrigerator is detected by the sensors and use that difference to control the motor speed has investigated to reduce the power consumption of a refrigerator to save energy as today we are in the peak of the fossil fuel and under the threat of finishing it in near future.

2. EXPERIMENTAL

I have identified that; same as (T_c-T_0) difference there are another way of changing the temperature inside a refrigerator. As an example if we need to get a bottle of water cool quickly we increase the cooling rate using the given adjustable cooler meter, at that time to maintain the required level motor should change its speed. Because the difference between the inside temperature and the adjusted temperature is high then to cool it down motor speed should be low. If temperature change, motor speed change according to that. It causes the energy consumption directly. If we can control this circle we can control the power consumption also. In this study we investigate to capture this temperature difference.

- Let's take inside temperature as T_i and user desire temperature as T_u;
  then temperature difference is (T_i - T_u)
- (T_i - T_u) α 1/Motor Speed
- Motor Speed α Power Consumption
- Motor Speed can be changed due to two reasons. They are ,

  1).Temperature difference (T_i- T_u)

2). Current motor speed of the refrigerator

To overcome this problems I decided to develop a temperature and moisture control circuit (Case 2) and a new inverter with a good motor (Case 1).

Case 1: Motor Control

Normally single phase or two phase motors required more energy at the start up process of a refrigerator. Also it consumes more current during the change of the temperature due to switch mode operation.

Case 2: Temperature and Moisture Control

This is the control circuit of the system. When we change the temperature using the adjustable cooler meter, circuit sense the temperature with the inside temperature and get the difference. Pulse frequency of the three phase motor inverter depends on this temperature difference. Motor rotation is programmed and controlled with the temperature difference. As we consider the temperature difference motor does not require more current when change is required. Since inside moisture could also affects the energy consumption, we have added a moisture sensor too.

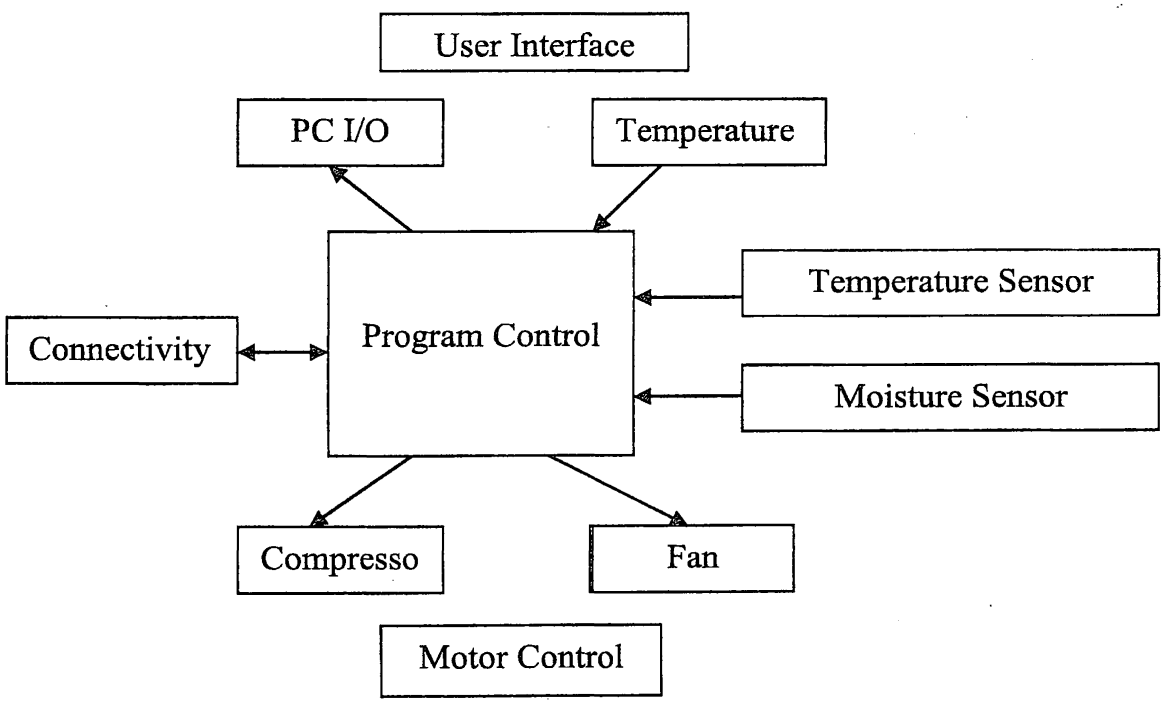

Figure 1: Block diagram of the new commercial product

2.1. Three phase motor inverter

Three phases is where we have 3 related voltage sources supplying the same load. It is a significant improvement over single phase or two-phase because the three voltage or current waves follow each other ⅓ cycle apart, and if we sum the currents together at any instant, we find that they perfectly balance. More importantly, the power is continuous and constant, so three phase motors run more smoothly. Three phase motor instead of single or two phases motor to control the power consumption as it has soft start due to rotational magnetic field has used for the device.[4,5]

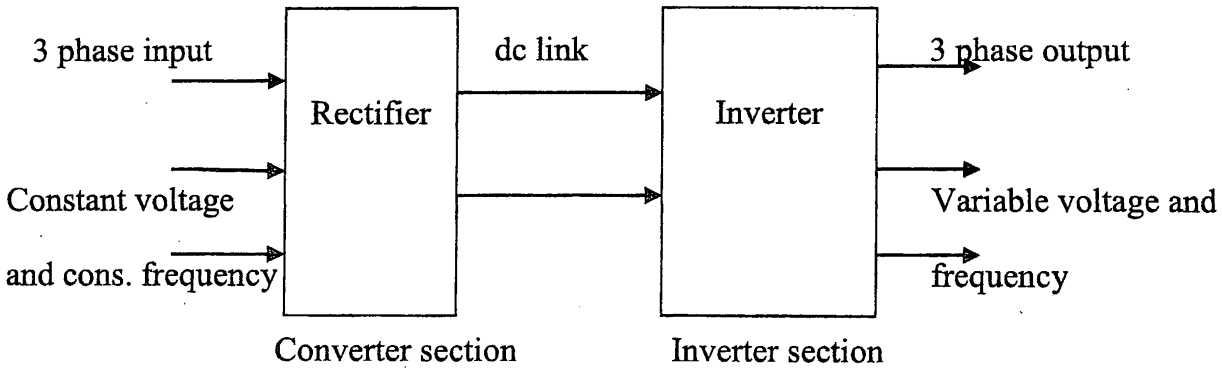

Figure 2: Three phase motor inverter

2.2. Temperature and moisture Control

This is the control circuit of the system. When we change the temperature using the adjustable cooler meter, circuit sense the temperature with the inside temperature and get the difference. Pulse frequency of the three phase motor inverter depends on this temperature difference. So motor rotation is programmed and controlled with the temperature difference. As we consider the temperature difference, motor does not require more current when change is required.

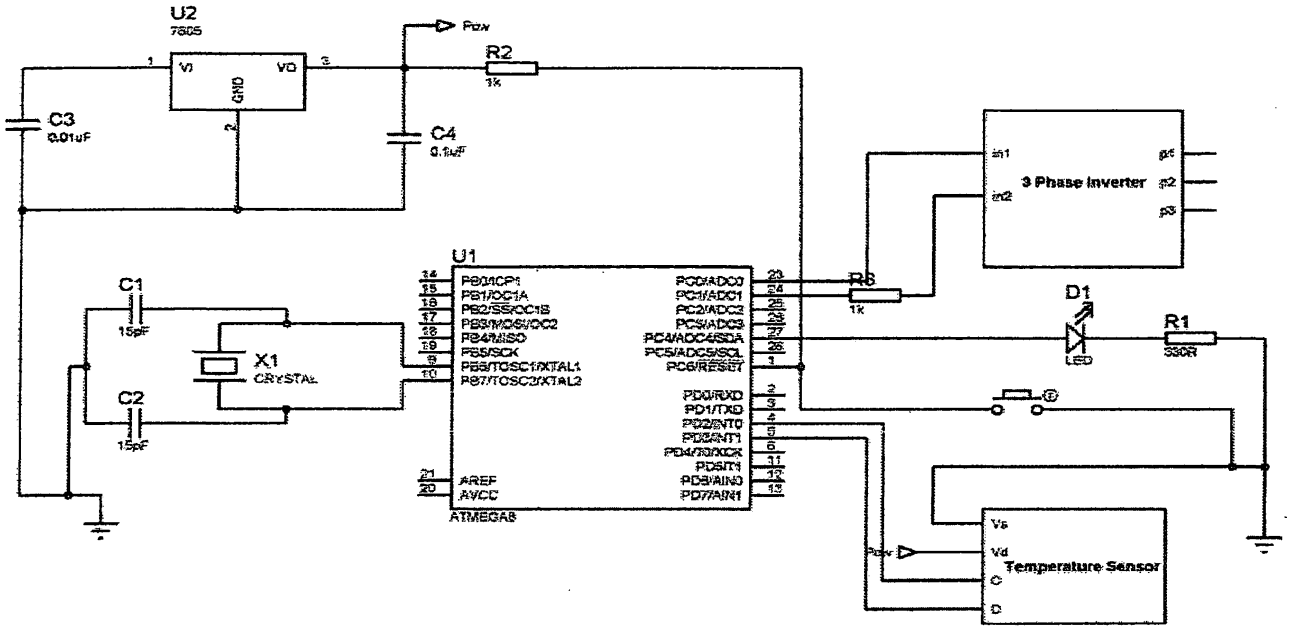

Figure 3: Circuit Diagram of the unit

3. RESULTS AND DISCUSSION

Single phase or two phase motors required more energy at the start up process of a refrigerator due to phase shift mode. Also it consumes more current during the change of the temperature due to switch mode operation. But three phase motor has soft start due to the rotational magnetic field.

Less vibration because it has rotating magnetic field, two phases are always in a motion when changes occur it simply pass the motion to the other phase.

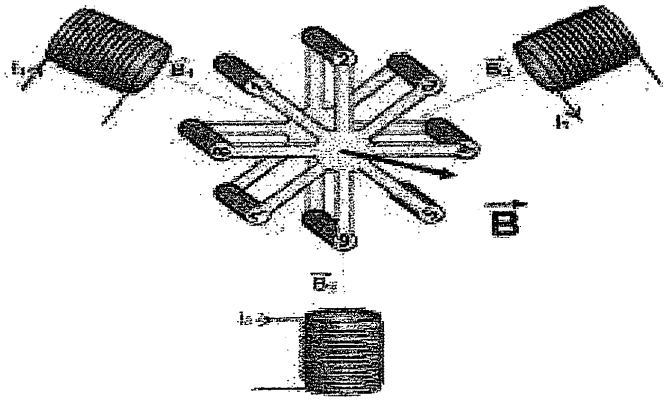

Figure 4: Three-Phase motor rotating field

Motor speed can be changed from one speed to another with minimal loss and Harmonic losses-minimized by an optimum choice of the PWM and the switching operations. Even though the product was developed under the name of ecofriendly, it cannot achieved only by controlling motor speed considering only temperature, moisture and start up current.

3.1. Future developments

Even though the old refrigerators consume more energy customers reluctant to buy a new one as it cost is high. So if this device can fix into an old product it is cost saving as well as save energy.

4. CONCLUSION

We have designed a microcontroller based temperature and moisture control circuit to reduce the power usage of domestic refrigerator. The method described in this paper consists of temperature and moisture controlled circuit with an ATmega microcontroller chip that controls the speed of the three-phase motor inverter. This system is a potential low-cost solution to increase the power efficiency of domestic refrigerators.

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