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Note on RECENT TECHNOLOGIES

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Smart Automated Air Conditioners

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Abstract - This study introduces smart air conditioner which gives a better conditioning without the use of remote or mobile to control it. Smart air conditioner senses the room temperature at different places in a room and automatically provides the control temperature at which the room is to be maintained for better cooling. The explicit feature of the smart air conditioner is that the sensors are not internally connected. The temperature data are transferred in a wireless mode of transmission. The smart air conditioner could provide a comfortable environment and achieve the goals of energy conservation and environmental protection

Keywords: *Temperature sensor, wireless data transfer, automated control, less energy consumption, remote avoidance, avoid overcooling, human control.*

1. INTRODUCTION

For a higher quality and comfortable modern lifestyle, people rely on air conditioners (ACs) much more than before. In both developed and developing countries, air conditioners increase the occupancy ratio of building areas. This also leads to a rapid growth in the energy consumption by ACs. According the static data, HVAC almost consumed half of the energy in buildings and 20% of the overall national energy consumption. Therefore, it is important to decrease the energy consumption of ACs in residential and commercial buildings. The methods of developing new energy-efficient equipment, applying complex control strategies, using solar energy as a new energy source, etc., are all being considered for saving energy in ACs. Among them, applying control strategies may be the more economical and efficient method.

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2. HISTORY OF AIR CONDITIONERS

The developing history of ACs is related to the efficiency, technology, human comfort, and energy consumption. ACs' progress includes window type, split type, fixed frequency, convertible frequency, and the recently presented smart type. Since 2010, mobile phones (also called smart phones), tablet personal computers, and cloud computing and 4th generation (4G) communication in 2014 were widely utilized and have caused an information revolution. These novel technologies were also adopted for the control of air conditioners, and this resulted in further air conditioning technology improvements to become smart air conditioners. By using communication technologies, the adjustment of air conditioners is not only a single feedback of setting information. All these are manually controlled air conditioners.

3. WORKING OF TRADITIONAL AIR CONDITIONERS

The fundamental operating principle of the air conditioner is the vapor cycle introduced by thermodynamics. The vapor cycle includes the following steps: (1) the saturated refrigerant is compressed to a higher pressure vapor, known as superheated vapor; (2) rejecting heat from the system by either the circulating water or air and is condensed into saturated liquid; (3) undergoing an abrupt reduction in pressure through the throttle and expansion process, and becoming a liquid and vapor refrigerant mixture with lower temperature and pressure; (4) absorbing the heat of an enclosed space by a circulating fan in the evaporator and expands into the saturated vapor; (5) vapor is routed back into the compressor to complete cooling cycle by cycle. The vapor cycle includes compression, heat extraction, expansion, and heat absorption. This process is accomplished by the compressor, condenser, expansion valve and evaporator. The detailed operating principles of the vapor cycle include the variation of temperature, pressure, enthalpy and entropy.Air conditioners use chemicals that easily convert from a gas to a liquid and back again. This chemical is used to transfer heat from the air inside of a home to the outside air.The machine has three main parts. They are a compressor, a condenser and an evaporator.

The compressor and condenser are usually located on the outside air portion of the air conditioner. The evaporator is located on the inside the house, sometimes as part of a furnace. That's the part that heats your house. Traditional air conditioner uses a temperature sensor installed on the evaporator of indoor unit for feedback control. It yields a sensor transfer function to enable the difference causing control. Traditional air conditioners use On-Off control method for the working control operation. The indoor temperature is kept stable by turning the compressor on and off, when the motor operates in the fixed rotation speed and the indoor air conditioning load is less. This operating method is also mentioned as On-Off control.

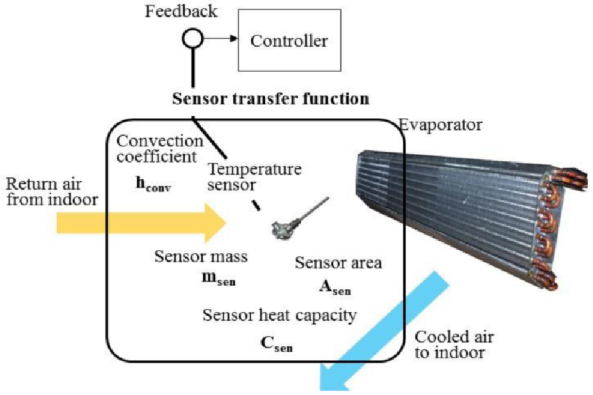


Fig. 1. Control scheme of AC

The control scheme of air conditioner (Fig. 1) with On/Off control adopts a temperature sensor as the feedback to determine the ON/Off status of compressor. Cooled and non-cooled air flow will be delivered to air conditioning space to adjust the differences between feedback temperature and setting point. It's a kind of difference causing control. Under the On-Off control structure, air conditioner turns on the compressor when the return air temperature is higher than the set one, and turns it off on the contrary (Fig. 2). By doing this, the refrigerant would flow through the condenser and evaporator for heat exchanging with the indoor and outdoor air to keep the indoor temperature stable

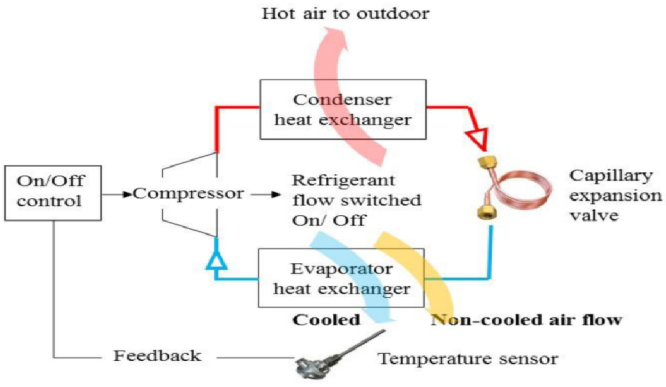


Fig. 2. Control scheme of condenser and evaporator

4. Working of Automated Smart Air Conditioners

In the introduced smart air conditioners, the temperature sensing action and the compressor control is similar to that of the available air conditioners, but the important feature of the smart air conditioner is that the control temperature is generated by the air conditioners itself instead of the getting the control from the human. Elimination of remote usage can be achieved by the air conditioners. For better conditioning of the rooms, room temperature is sensed at two or more places depending upon the size of the room. Room temperatures or sensed at regular intervals of time. Among the sensed temperatures the average of those temperatures are calculated and considered. For the sensed room temperature, the control temperature is automatically generated by the smart air conditioners instead receiving control from the remote. The average of the sensed temperature and the generated control temperature is compared. Until the sensed temperature becomes almost equal to the control temperature generated, the compressor is kept on. Not only the control temperature could be generated, but also the fan speed of the air conditioners can also be adjusted at regular intervals of timefor better automated cooling. When the sensed temperature equals the control temperature the compressor is changed to off mode. During the off mode of the air conditioner the fan is kept on so the cool temperature could be maintained. Similar control methods can be employed for better conditioning. By this way power consumption can be reduced in a great manner.

5. Wireless Data Transfer Techniques:

The smart air conditioners are aimed at large conference halls,theatres, trains and other public places where continuous running of air conditioners causes overcooling and increased power consumption. So for such large places only one air conditioner is not sufficient. The temperature sensors should be placed at various points such that two or three temperature sensors are associated with each air conditioner. Hence the distance between the air conditioners and the sensors are not so long (i.e) the distance ranges from 5 meters to 25meters. For the transfer of data from the temperature sensors to the air conditioner Zigbeecommunication seems to be an efficient way.

MACHINE TO MACHINE:

Machine to machine refers to direct communication between devices using any communications channel, including wired and wireless (Fig. 3). Machine to machine communication can include industrial instrumentation, enabling a sensor or meter to communicate the data it records (such as temperature, inventory level, etc.) to application software that can use it (for example, adjusting an industrial process based on temperature or placing orders to replenish inventory). Such

communication was originally accomplished by having a remote network of machines relay information back to a central hub for analysis, which would then be rerouted into a system like a personal computer. More recent machine to machine communication has changed into a system of networks that transmits data to personal appliances. The expansion of IP networks around the world has made machine to machine communication quicker and easier while using less power. These networks also allow new business opportunities for consumers and suppliers.

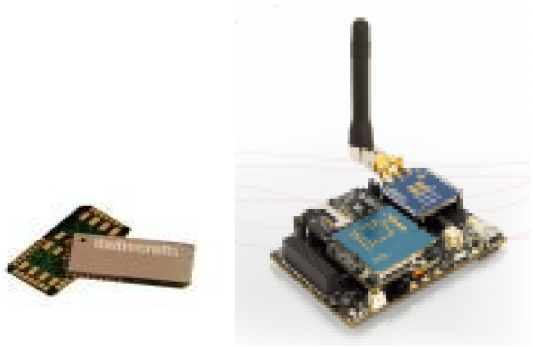
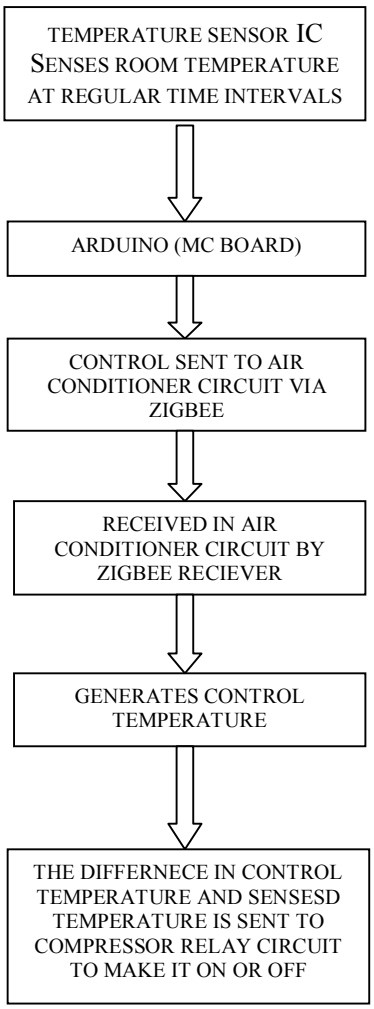


Fig. 3. Smart sensors

6. ZIGBEE

ZigBee suits high-level communication protocols used to create personal area networks with small, low-power digital radios. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other wireless personal area networks (WPANs), such as Bluetooth or Wi-Fi. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that require short-range low-rate wireless data transfer. Its low power consumption limits transmission distances to 10–100 meters line-of-sight, depending on power output and environmental characteristics. ZigBee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. ZigBee is typically used in low data rate applications that require long battery life and secure networking (ZigBee networks are secured by 128 bit symmetric encryption keys.) ZigBee has a defined rate of 250kbit/s, best suited for intermittent data transmissions from a sensor or input device.ZigBee is a low-cost, low-power, wireless mesh network standard targeted at the wide development of long battery life devices in wireless control and monitoring applications. Zigbee devices have low latency, which further reduces average current. ZigBee chips are typically integrated with radios and with microcontrollers that have between 60-256 KB of flash memory. ZigBee operates in the industrial, scientific and medical (ISM) radio bands: 2.4 GHz in most jurisdictions worldwide; 784 MHz in China, 868 MHz in Europe and 915 MHz in the USA and Australia. Data rates vary from 20 kbit/s (868 MHz band) to 250 kbit/s (2.4 GHz band).The fourth in the series, WPAN Low Rate/ZigBee is the newest and provides specifications for devices that have low data rates, consume very low power and are thus characterized by long battery life.

7. FLOWCHART OF SMART AUTOMATED AIR CONDITIONERS



Air conditioner during cooling process, takes the indoor air, cools it by passing it through evaporator coil and throws it back in the room. Air conditioners just work on internal air. The thermostat just checks the temperature of the air inside the room and stops the compressor when the temperature reaches the desired level. This means that the compressor will work longer if the temperature is set to a lower level, i.e it will work more and use more electricity if temperature is set to 18°C (64.5°F) than if it is set to 25°C (77°F). This is because it will take less time for air to reach to 25°C (77°F) than

18°C (64.5°F) as the compressor is working with the same power or wattage. The air conditioner just blows the fan when the compressor stops and thermostat reaches the desired temperature level. At this stage the electricity consumption is only for the fan which is running and not for the compressor. The compressor will start again when the thermostat detects that the temperature has increased again from the levels that are set. Compressor is the most electricity consuming component of an air conditioner. There are 4 factors that influence the electricity load:1) Indoor air temperature.2) Outdoor temperature.3) Thermal insulation of the room.4) Temperature setting of the air conditioner. If the difference between temperature desired and indoor/outdoor temperature is huge, then the air conditioner will need lot more electricity to cool the indoor air to desired temperature as the compressor will run for longer duration (Fig. 4). If the temperature is set at 18°C (64.5°F) and the outdoor temperature is 38°C (100°F) then the electricity required will be lot more than when thermostat temperature is 24°C (75°F) and outdoor temperature is 38°C (100°F).

Smart Automated Air Conditioner:

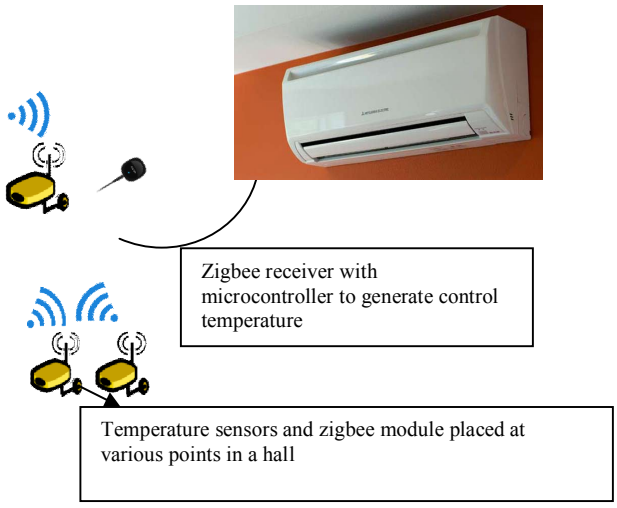


FIG. 4. Smart Automated Air Conditioner setup

ADVANTAGES OF SMART AIR CONDITIONERS:

The automated smart conditioners are mainly proposed for conditioning large closed areas like conference halls, theatres, trains where controlling the air conditioners via a remote is impossible. When air conditioners run for hours together, overcooling may cause human discomfort, yet the public cannot have a control over the airconditioners. In such cases Smart Automated Air Conditioners have great opening.

DISADVANTAGES IN ALREADY PROPOSED SMART AIR CONDITIONERS:

In the air conditioners the temperature sensor is fixed on the upper cover of the rods. As the cooling process is carried on, the temperature sensor instead of indicating the room temperature may indicate a lower temperature available on the cooled rods. This might cause an error and thus reduce the efficiency. Human intention controlled air conditioner proposed in Taiwan is suited only for the split air conditioner which is a main product there. Thus the idea proposed in Taiwan is not suited for other models of air conditioners and hence the automatic control is affected.