Chapter 1 – Basic Cooling and Air Conditioning Systems

EXPERIMENT 1.6 – MATERIALS & CIRCUITS OF THE ELECTRICAL SYSTEM

Name	Class/Period	Date

1. Objectives:

At the end of this experiment session, you will be able to:

- Explain the air-conditioning and refrigeration systems control.
- Explain the basic control types.
- Explain the temperature control.
- Explain the temperature alert system function.
- Explain the freezers and refrigerators control system.
- Explain the temperature control using suction pressure control.
- Explain what protection means for compressors.
- Explain delays in the compressor.
- Explain the overload protection system.
- Explain the domestic refrigerator electric system.
- Explain the operation of the domestic refrigerator with no frost.

2. Equipment Required:

- Main Platform Unit
- Professional Air Conditioning Panel

3. Discussion: **Control systems**

Air-conditioning and refrigeration systems control the cooling area conditions. The devices, which fulfill these conditions, are known as "Operating Controls". Safety or control systems ensure the devices intact operation while maintaining the conditions level required in the cooling area. They also ensure prevention of device damage and human injuries. These control systems are usually divided into three categories:

1. **Conditional area** – the area where the temperature, pressure, and humidity are controlled.

2. **Controlling instrument** – instruments, which respond to changes. They respond using air control, pressure and humidity sensors, sensors, thermostats, and motor control.
3. **System's components** – the mechanism that influences the conditions directly, using the controlling, instrument. For example: valves, fans, compressor etc.

A control system, which constantly works on conditions control, is called "Closed Loop Control System". In the standard operation of a refrigerator, the thermostat is the control device, the compressor is a device controlled by the thermostat, and the cooling area (where the food in stored) is the controlled area. This kind of system is a system that constantly works on controlling the conditions in the cooling compartment, doing it in a closed loop system.

When the thermostat "feels" the temperature rising, it will cause the compressor to start working until the cooling compartment temperature will lower to the desired level in cyclicality.

3.1. Control methods:

The basic control methods are:

- **Two-position control (ON-OFF)** – the most common control. The control activates or deactivates the device's operation. For example, the thermostat operation: when the cooling compartment reaches high temperature (higher than the manufacturer requirement), the control will activate the compressor. When the desired temperature has been reached, the control will stop the compressor operation.

- **Timing control (ON-OFF)** – this type of control is used for rhythmic activation and deactivation of the devices. For example, activating the refrigerator's compressor for 5 hours, deactivating it for 20 minutes and so forth.

- **Variable control** – this type of control gradually changes its state from one state to another. This control in not an "ON-OFF" control, it changes according to the changes it controls.

- **Proportional control** – this type of control is similar to the changing control. It is more sensitive to changes than the changing control. The following terms are customary in proportional control: set point (the control system's starting point), control point (the controlled condition's point), offset (the difference between the set point and the control point).

- **Proportional control with automatic initialization** – this type of control is the most sophisticated. Its operation is similar to the operation of the proportional control, but in addition, it automatically adjusts the required conditions. For example, pressure, temperature etc.

3.2. Principles of temperature control:

There are three types of temperature control (thermostat):

1. **Thermostat** – the thermostat is very common in cooling systems. It operates on the principle of liquid evaporating according the temperature changes in its sensor. Temperature change in the

cooling unit causes the liquid in the sensor bulb to expand or to shrink. The sensor is attached to the cooling unit (the evaporator), and the cooling data is transferred through a capillary tube to the diaphragm located in the thermostat, and the diaphragm pushes electricity contact for connection and disconnection.

2. **Bi-Metal** – this type of thermostat operates on the principle of two metals (each with a different expanding coefficient) glued to each other, usually copper and iron. Because the expansion difference between the two metals, the bi-metal folds when there is a change in temperature, thus causing the circuit to open or close.

3. **Electronic circuit (usually with thermistor)** – This type of thermostat is more advanced, its operation is faster, its reliability is higher, and it has no moving parts. The electronic circuit thermostat operates in low work voltage (usually 5-15V). This voltage is achieved by transformation or by voltage reduction circuits and current rectifier. The part that supposed to feel the temperature is called thermistor, and it is attached to the cooling (evaporator) battery side panel. The thermistor changes its resistance according to the changes in temperature. This data is transferred to the electronic circuit, which disconnects or connects the compressor.

3.3. Temperature alert system:

It is possible to add a device warns when the cooling unit temperature rises above a certain level in the two types of controls (thermostat and bi-metal). In home freezers, the alert is activated when the temperature rises to -12^{o}C. The alert can be a buzzer or an indication red light.

4. Discussion: Air-conditioning and refrigerator controls

Refrigerators and air-conditioners were designed to operate with almost no help from the user. The reason was to provide the desired conditions in the cooled area under various environmental conditions. If the refrigerator works all the time, it will cool more than necessary, thus in different parts of the world, a refrigerator timework will be different. For example, in northern areas, a refrigerator will work less time than in the semi-tropical areas. Usually domestic refrigerators are designed to work for 10-15 minutes and then to be idle for about 10-20 minutes.

Most domestic refrigerators manufacturers designed them to work approximately 40% of the time. They rely on the time average calculation for using the refrigerator. The environment temperature where the refrigerator is located also influences its work duration. Hot environment will cause longer time duration and vice versa.

Defrost refrigerators will need more work time than the old refrigerators.

The temperature in the cooling area in domestic refrigerators is usually between 2^{o}C to 7^{o}C. Work temperatures inside the above range can be tuned by the user. The temperature range in the freezer is between -15^{o}c to -25^{o}C.

5. Discussion: **Temperature control using evaporation pressure motor control**

As described above, the pressure in the evaporator is low in order to allow the cooling effect of refrigerant evaporation. According to this principle, an automatic system exists, based on the evaporator pressures, mainly in professional cooling systems.

How it works: when the evaporator heats up, the liquid in the evaporator expands, the switch closes, and the compressor starts working. When the temperature and the pressure drop to the desired values, the liquid reduces in size, the switch opens, and the compressor stops working.

At the upper part of the device there are screws for tuning the pressure differences, which will activate or deactivate the compressor.

This control is also used as protection form lack of gas.

6. Discussion: **Protection systems for motors/compressors**

There are a number of protection means for compressors. The most common ones are:

1. **Protection against high head pressure** – one common problem in cooling systems is high head pressure, which causes the compressor temperature and the current to rise, which causes obstructions and damages to the cooling system and to the compressor. To avoid this, we need a protection system against high head pressure, which will disconnect the electricity to the compressor.

   There are a number of reasons that cause the condensation pressure to rise:

   - The motor of the condenser's fan is not working.
   - The condenser is blocked with dust and there in no airflow through it, which causes the refrigerant pressure to rise as well at the temperature.
   - Extra gas in the system (if too much gas is filled into the system).
   - The water, which cools the condenser, does not flow correctly (in types of water cooling for the condenser).

2. **Low-pressure protection** – when the gas pressure is too low, the compressor can over heat because not enough gas reaches the compressor head. This can cause the motor to burn. To avoid this, when the pressure drops below the desired level, the protection system disconnects the compressor from the electricity. It indicates lack of gas.

3. **Low oil pressure protection** – large cooling systems have a protection system against low oil pressure or lack of oil, which disconnects the compressor from the electricity when the oil quantity is very low.

7. Discussion: **Relaxation devices**

In order to protect the compressor from damage, the cooling unit must not be activated immediately after shut down (mainly in professional cooling and air-conditions). 5 minutes must be waited before re-activation in order to allow pressure comparison between the condenser and the evaporator.

A number of delay electronic systems exist today. Their function is to delay activating the compressor for 0-8 minutes, even if the cooling unit were shut down and activated immediately. This delay is good mainly when there are voltage drops or momentary electrical blackout.

7.1. Overload protection:

Cooling and air-condition systems must be connected to a separate circuit, apart from the main system. This rule applies to domestic and professional systems alike. The fuse in this system should have enough capacity in order to provide the necessary current for standard working conditions. In case of overload over 25%, the circuit must be disconnected by the fuse. Overload of more than 500% can be created at the beginning of work. This overload will exist for a very short period of time, and the fuse must allow this.

7.2. Starting relays for compressors:

The starting relays for the compressor can be found in hermetic systems outside the hermetic compressor. These relays are usually of the following types:

- Current (magnetic, with thermal over load switch)
- Potential (magnetic)
- Electronic circuit

7.3. Compressors starting methods:

In domestic refrigerators with a relatively low power compressor, the aiding coil of the compressor's motor connects only during start-up, and disconnects during continuous work. The connection between point C and R (the working coil) is constant, and the connection between points C and S exists only while start-up.

The motor's start-up torque is very great in relation to the continuous work torque because at start-up the motor's starter must rotate the standing rotor, while in continuous work the rotor is already rotating, and has the inertia to keep on rotating, thus it easier for the starter to cause the rotor to keep rotating.

During start-up, the starter must be helped to overcome the rotor's static resistance, therefore the aiding coil should be connected to it, thus the rotation torque the starter activates on the rotor rises, and the rotor rotates.

In continuous work, the starter does not need this help, thus the aiding coil can be disconnected.

There are a number of methods for connecting and disconnecting the aiding coil to and from the electrical circuit.

a) Current relay:

One of the more common ways of connecting and disconnecting the aiding coil of the compressor motor is using a current relay.

A current relay is a component, which connects or disconnects an electrical circuit as a function of the current flowing in its commanding coil.

The commanding coil is connected in serial to the electric circuit, thus current that flows to the circuit flows through it. This coil has an iron core. Major change in the current intensity (which flows through the coil) creates a magnetic field in the core. The core becomes a magnet and can connect or disconnect an electric circuit.

The following figure describes a current relay in the refrigerator electrical circuit.

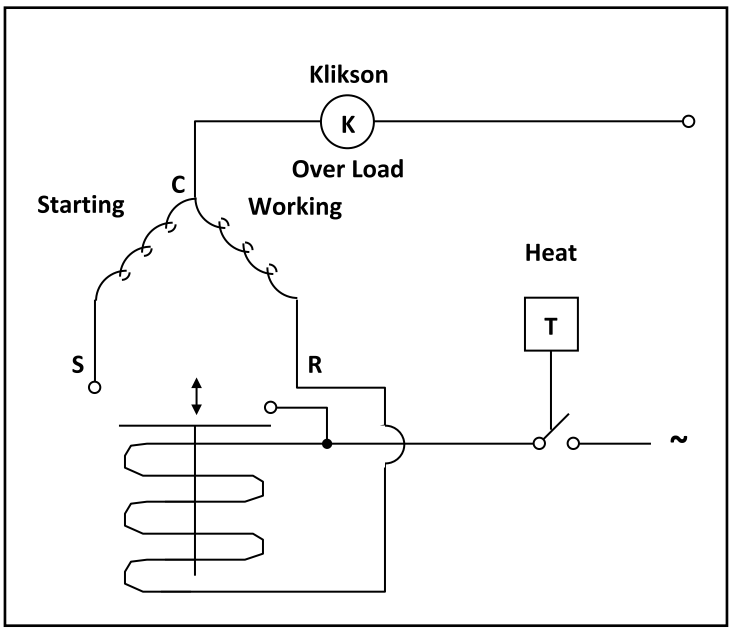

Figure 1-29

As long as the current intensity grows, the magnetic field is created in the coil and in the core magnetic power.

At start-up, network current flows only to the working coil and the compressor motor cannot start. While trying to start-up, the network current rises, and at that moment, a magnetic field is created in the iron core of the current relay. The relay changes its status and connects points R and S. Connecting the aiding coil enables easy start-up of the motor, and the current in the circuit drops. The current stabilization on a fixed value after start-up causes the reduction of the magnetic field and the magnetic power, which activates the core, thus the contact between points R and S is disconnected, and the aiding coil in no longer connected to the circuit.

As the motor is already rotating, there is no longer any need for the aiding coil.

Improvement of the phase difference between the aiding coil and the working coil during start-up is needed in a compressor with high power and start-up torque, thus a start-up capacitor is added in serial to the aiding coil.

A set of a current relay and a start-up capacitor for connection to the compressor can be bought.

Because current relays operate according to the current the motor consumes, various motors sizes need various current relays. The current relay should be chosen according to the motor.

b) Electronic start-up relay (PTC):

This relay is relatively new and does not include any moving parts. It does not have contacts or mechanical devices, which may be damaged, and it is based on one electronic component that performs the switching operation.

The main component in the electronic relay is a special resistor called PTC (Positive Temperature Coefficient).

In temperatures between 20°C to 120°C the PTC's resistance is low (between 4Ω to 15Ω). In temperature over 120oC, its resistance rises considerably and reaches 100,000Ω. This resistance is actually a disconnection for the motor, and the current intensity flowing through it strives for zero.

The PCT is connected in serial to the start-up coil, and it is programmed in a way that its warm up time (above 120°C) is equal to the required start-up time where the start-up coil should be connected. As soon as the motor is started, the conductors' temperature is low; therefore, the electronic relay transfers current and the start-up sprig helps to start the motor. Current rising during the start-up causes the PTC's resistor to warm up, its resistance rises, and that causes the disconnection of the start-up sprig.

The PTC resistor will not return the start-up sprig operation as long as the motor rotates.

The PTC resistor needs 45 seconds to cool down after the motor stops its operation. This cooling down is important in order for the resistor to transfer current to the next start-up. For this reason, it is not recommended to use this method in motors that can start working quickly. In cooling applications, the time between start-ups rises above 45 seconds, thus there is no reason not to use this kind of start-up.

The PTC resistor can be used (with no dependence on the motor size) in the range of 1/12 horsepower up to 1/2 horsepower. This is a significant advantage compared to the current relay.

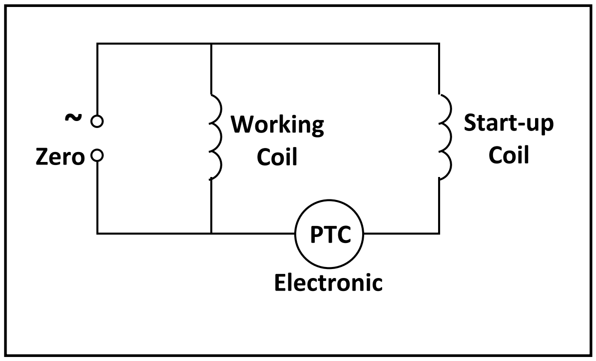

Figure 1-30

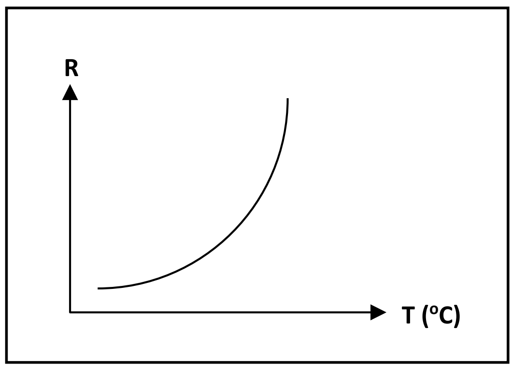

Figure 1-31

8. Discussion: **Protection systems for motors/compressors**

The refrigerator electric system is simple and less complicated than the air-condition electric system. The number of electrical components is smaller and there are less operation options.

8.1. Standard domestic refrigerator:

There is no defrost in old refrigerators, and once in a while it should be disconnected in order to melt the ice created in the freezer.

This refrigerator does not have blowers and motors, and heat transfer from the condenser and evaporator batteries, it is based on natural convection. Heat transfer in natural convection is actually heat transfer from the cooling material to the battery surroundings by natural and free airflow.

The three electrical components in the refrigerator are: compressor, thermostat and a LED, which lights when the refrigerator's door is opened.

The thermostat has two contacts and is used as an ON-OFF switch for the compressor operation when there is no need for cooling; same as in air-conditioners.

The evaporator in these kinds of refrigerators is usually divided into two parts: one for the food compartment and one for the freezer. The sensor is installed on the food compartment's evaporator battery. The food compartment is bigger, opens more frequently, and its temperature and humidity change more frequently than the freezer, thus it is preferable that the heat sensor will connect and disconnect the compressor according to the food compartment's temperature.

The door LED is controlled by a pushbutton. When the pushbutton is pressed (door closed), the LED is disconnected, and when it is not pressed (door opened), the electric circuit is closed and the LED turns ON.

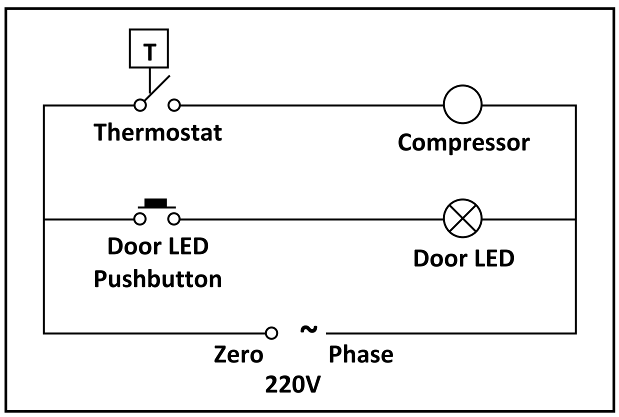

Figure 1-32 Domestic Refrigerator (without a no frost) Electric Diagram

8.2. Domestic refrigerator with non-frost:

The domestic refrigerator with non-frost solves the ice accumulation in the evaporator, and there is no need to disconnect it from the electricity in order to defrost the ice.

Two heating bodies are installed in the refrigerator:

1. Heating body for defrosting the evaporator battery in the freezer (relatively high power).
2. Heating body for heating the freezer's doorpost (low power).

The power of the first heating body is approximately 540W.

The non-frost refrigerator uses an evaporator with cooling flanks and a blower, which transfers the air. This type of heat transfer is based on forced convection.

Forced heat convection means heat transfer form the cooling material to the battery surroundings. It uses airflow through the blower, which "forces" the air to go through the battery.

An evaporator with forced convection, the heat transfer pace to the cooling material is faster than in an evaporator with natural convection, thus the amount of ice accumulating in this kind of evaporator is bigger. The air supply also supplies moisture.

Forced convection increases the need for defrosting by heating bodies. Without the use of evaporators with forced convection, there would be a need to use heating bodies with higher power or to operate them for a longer time. An additional advantage of cooling with forced convection is the air spin in the freezer and in the food compartment.

Heat transfer from stored produce in the refrigerator is faster and more unified in all the compartments, thus a fixed temperature is maintained in the refrigerator. In an evaporator with natural convection, heat transfer from produce stored near the battery is faster than produce that are stored far from it, and a much more significant change will be received in the produce temperature depending on their location in the compartment.

The evaporator in the freezer is latent, and the air is transferred through channels and special passages in the evaporator to the food compartment and to the freezer.

Some no frost refrigerators include only one evaporator with a blower and with forced convection to the freezer. Through an opening between the freezer and the food compartment, cold air is transferred from the freezer to the food compartment.

A shutter is installed in this opening, and it controls the amount of air flowing through it. A heat sensor controls the opening size of the shutter depending on the food compartment temperature. This heat sensor opens and closes the shutter using a mechanical system and it is not connected to the electric system in the refrigerator.

This kind of refrigerator is controlled by two heat sensors:

1. The freezer's heat sensor, which controls the compressor operation.
2. The food compartment's heat sensor, which controls the opening shutter.

The following figure describes a no frost domestic refrigerator with heating bodies and a defrost clock (Timer). The defrost clock is an electrical component, which opens and closes an electrical circuit every defined period of time. The defrost clock activates the heating bodies at pre-defined times. The defrost condition is activated for a fixed period of time, where the ice will be defrosted from the evaporator's battery, and at the end of this process the standard working pace will continue.

Common defrost clocks activate the defrost state once in 6 hours for 20-25 minutes.

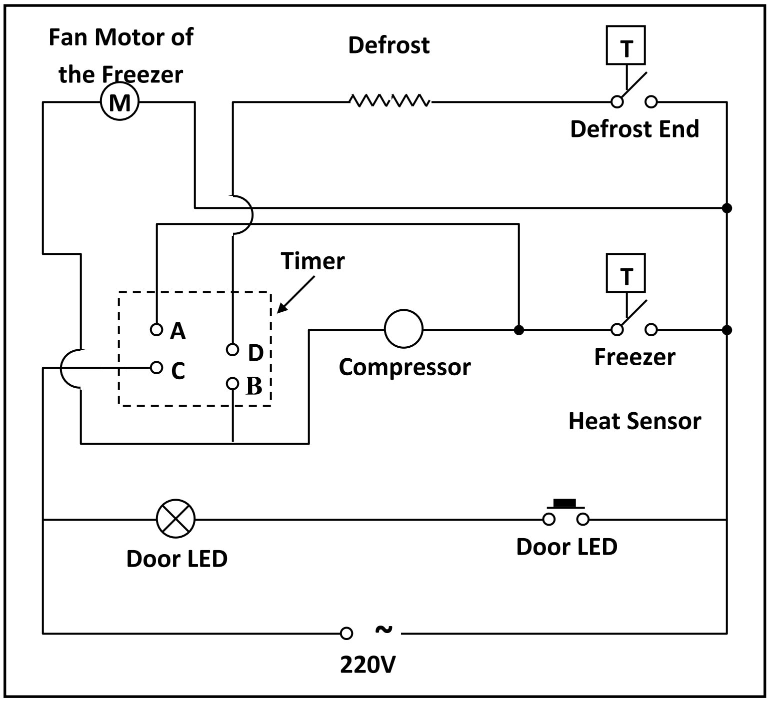

Figure 1-33

The two heat sensors, the door LED pushbutton, and the fan motor constantly receive phase. The timer (in point C) and the door LED constantly receive zero.

The defrost heat sensor transfers phase to the heating body up to point D if there is no need for defrosting, and the freezer heat sensor transfers phase to the compressor and the timer (in point A) if there is no need for cooling.

In standard working conditions, the timer connects point C to point B. The compressor and the fan motor receive zero and starts to work. After awhile, the timer passes to defrost state and connects point C to point D. The compressor and the fan motor stop working and the defrost heating body receives zero and starts heating the evaporator battery.

The freezer heat sensor (thermostat) is installed in the freezer, but its mechanical system (which allows tuning the desired temperature) is installed in the food compartment.

The diagram in figure 1-33 is a typical diagram for no frost refrigerator, but that doesn't mean that this is the exact diagram for every no-frost refrigerator. How the heating body is operated may be different and also the type of timer and how it is connected to the circuit may be different.

In many cases, you can find a capacitor connected in parallel to the main phase and zero in order to improve the refrigerator's efficiency.

8.3. Operation of the heat pump:

The heat pump is a system that can move heat from one direction to another. The refrigeration or air-conditioning systems are a kind of heat pump.

Usually, we call the air-conditioning system a heat pump when it can change its function from cooling to heating and vice versa.

Changing the function from cooling to heating is done by changing the refrigerant flow.

In cooling operation, the refrigerant is compressed into the condenser and sucked from the evaporator.

In heating operation, the refrigerant is compressed into the evaporator and sucked from the condenser. The condenser acts as an evaporator (cooled by the refrigerant) and the evaporator acts as a condenser (heated by the refrigerant).

The direction of the flow is changed using valves. These valves are called reverse valves.

There are two main types of reverse valves. One method uses a single 4-way reverse valve and the second uses 4 valves.

The 4-way valve is a valve with two inlets and two outlets and it also includes an internal piston which is moved by a solenoid.

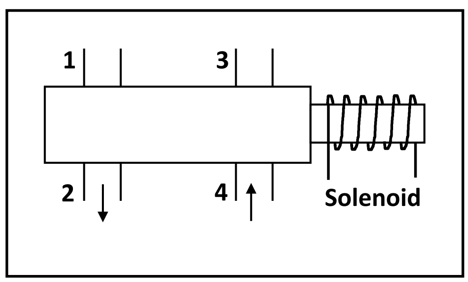

Figure 1-34

At normal position, the refrigerant flows from (1) (the evaporator) to (2) and from (4) (the compressor) to (3) (the condenser).

When the solenoid is ON, the refrigerant flows from (3) (the condenser) to (1) (the compressor) and from (4) (the compressor) to (1) (the evaporator).

This method is a low cost solution for heat pump air-conditioning system. One of the common faults in this valve is that sometimes the piston is stuck in the middle (because of dirt, not enough pressure or a weakened return spring) and the refrigerant flows from the compressor outlet to the compressor inlet or to all the four pipes.

Changing from cooling mode to heating mode (or the reverse) cannot be done under pressure with the 40way valve.

The second solution is more expensive, but much more reliable. Instead of one valve, the system includes four valves as follows:

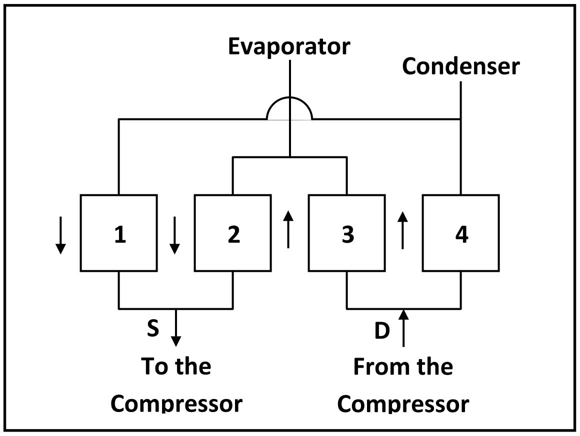

Figure 1-35

In cooling mode, valves 2 and 4 are ON and valves 1 and 3 are OFF. The refrigerant flows from the evaporator to the compressor (S) and from the compressor (D) to the condenser.

In heating mode, valves 1 and 3 are ON and valves 2 and 4 are OFF. The refrigerant flows from the condenser to the compressor (S) and from the compressor (D) to the evaporator.

The valves can be controlled by one control signal. Level '1' of the signal turns ON valves (1) and (3) and level '0' turns ON valves (2) and (4). In this case, the four valves act as one 4-way reverse valve.

Another method is to control each valve separately. In this case, the system can change the refrigerant flow easily. First, all of the valves are changed to ON position, the refrigerant flows freely and the system pressure falls. Then, the required pair is turned OFF and the system moves to the required state (cooling or heating).

This four valve modules system enables demonstrating faults of the 4-way reverse valve as explained above. These faults are demonstrated in experiment 1.7.

This kind of reverse valves are also added to the refrigerators. Although the refrigerators do not need the heating mode, it is used for defrosting the evaporator. This is done by taking care not to heat the cooled chamber thus spoiling the food stored in it.

This way of operation is extended to a system called VRF (Variable Refrigerant Flow) system. In these kinds of systems, the direction and speed of the refrigerant flow are controlled by special valves.

This method enables changing the chamber's temperature without the need of ducts, and each room is not affected by the other rooms' temperature. One room can be cooled and another can be heated.

9. Procedure:

Step 1: Check that the PROFESSIONAL AIR CONDITIONING PANEL panel is properly installed on the refrigeration and air-conditioning general system MAIN PLATFORM UNIT according to the instructions described in the book's preface.

Step 2: Check that the MAIN PLATFORM UNIT MONITOR and PROGRAM switches are at OFF position.

A ground leakage relay, a semi-automatic switch, and a main power switch are installed in a main power box located on the rear panel.

Step 3: Connect the MAIN PLATFORM UNIT power supply cable to the Mains.

Step 4: Check that the high voltage ground leakage relay and the semi-automatic switch are ON.

Step 5: Set the Auto/Manual switch (located on the bottom left of the simulator) to the Manual position.

Step 6: Turn ON the main POWER switch located on the main power box on the rear panel.

Step 7: Turn ON the monitor power switch.

Step 8: The FAULT display should display the number 00. If not, use the keys above the FAULT display to display the number 00 (no fault condition) on the FAULT 7-SEG. display and press the ENTER key beneath this display.

Step 9: The STATE display should display the number 00 (no operation program).

Step 10: On the LCD display you should find the following table:

V1	V2	V3	V4	V5	V6	V7	RV	CM	OF

This experiment measures the temperature difference between the evaporator and the condenser and calculates their heat transfer there in BTU.

It will be checked in the two speeds of the evaporator fan and with and without thermal load.

TEV mode and relaxation device experiment:

Step 11: Change the STATE number to 11 (for °C) or 12 (for °F) and press ENTER

Step 12: Lower the PROGRAM switch and raise it.

Step 13: On the LCD display you should find the following tables:

V1	V2	V3	V4	V5	V6	V7	RV	CM	OF
ON	ON			ON	ON			ON	ON

S1	D1	S2	D2	SP	PD	E1	L1	E2	RT
20°C	5°C					LO			

LP	HP	T1	T2	T3	T4	T5	T6	T7	T8

If "on" (lowercase) appears on the CM and OF columns, it means that the compressor is in a 3 minutes delay state before it starts to work. This delay protects the compressor.

The TEV mode is controlled by temperature and this is why a dash appears in the pressure squares.

Identify the system's default values of S1 and D1.

Observe this sight glass and check that there are no bubbles and the LP value reached the stabilization point.

Step 14: The cooling chamber temperature should continue to go down even after the LP is stable.

Observe that.

Step 15: The chamber temperature T6 goes down as long as the system is cooling (the compressor works).

The compressor should turn OFF when the chamber temperature reaches the S1 (Setup Point) and should turn ON when the chamber temperature goes over S1 + D1.

The default value of S1 is 20°C (68°F), the default value of D1 is 5°C (9°F).

Step 16: Wait until the compressor turns OFF.

Step 17: Wait until the compressor turns ON.

Step 18: Change the STATE no. to 00 and press ENTER.

Lower the PROGRAM switch and raise it, and immediately go to step 20.

All the devices should shut OFF.

Step 19: Let us try to operate the system without waiting.

Step 20: Change the STATE number to 11 (for °C) or 12 (for °F) and press ENTER.

Step 21: Lower the PROGRAM switch and raise it.

Step 22: On the LCD display you should find the following tables (delay check):

V1	V2	V3	V4	V5	V6	V7	RV	CM	OF
ON	ON			ON	ON			ON	ON

S1	D1	S2	D2	SP	PD	E1	L1	E2	RT
20°C	5°C					LO			

LP	HP	T1	T2	T3	T4	T5	T6	T7	T8

If "on" (lowercase) appears on the CM and OF columns, it means that the compressor is in a 3 minutes delay state before it starts to work. This delay protects the compressor.

Step 23: The compressor and the fan should start operating.

Heating system:

Step 24: Change the STATE number to 31 (for °C) or 32 (for °F) and press ENTER

Step 25: Lower the PROGRAM switch and raise it.

Step 26: On the LCD display you should find the following tables:

V1	V2	V3	V4	V5	V6	V7	RV	CM	OF
								ON	ON

S1	D1	S2	D2	SP	PD	E1	L1	E2	RT
20°C	5°C					LO			

LP	HP	T1	T2	T3	T4	T5	T6	T7	T8

If "on" (lowercase) appears on the CM and OF columns, it means that the compressor is in a 3 minutes delay state before it starts to work. This delay protects the compressor.

RV turns ON.

No value is turning ON. The system uses the one-direction values and works at capillar mode.

E1 heats up and OF cools down.

Step 27: Wait until the compressor turns OFF.

Step 28: Wait until the compressor turns ON.

Observe the system reaction.

Step 29: Change the STATE no. to 00 and press ENTER.

Lower the PROGRAM switch and raise it, and immediately go to step 20.

All the devices should shut OFF.

Defrosting:

Step 30: Change the STATE number to 27 (for ^{o}C) or 28 (for ^{o}F) and press ENTER

Step 31: Lower the PROGRAM switch and raise it.

Step 32: On the LCD display you should find the following table:

V1	V2	V3	V4	V5	V6	V7	RV	CM	OF
		ON	ON		ON			ON	ON

If "on" (lowercase) appears on the CM and OF columns, it means that the compressor is in a 3 minutes delay state before it starts to work. This delay protects the compressor.

Step 33: Observe the system behavior.

The system works in cooling capillary mode with defrost function.

After 5 minutes of cooling (refrigeration) the system opens all the four valves of the RV for 30 seconds and after that turns to heating mode for 1 minute and then returns to cooling mode.

The heating mode warms the evaporator in order to defrost the ice.

This method, for heating, is also used in air-conditioning systems. In this kind of operation, the condenser is in cold air and is used as an evaporator.

In cold environment, the condenser is covered with ice and stops functioning. Such defrost operation defrosts the ice very fast.

Step 34: Change the STATE no. to 00 and press ENTER.

Lower the PROGRAM switch and raise it, and immediately go to step 20.

All the devices should shut OFF.