A cooling system including an evaporator to exchange heat with air, a frost detector installed on the evaporator to detect frost, and a control unit to determine whether a current time corresponds to a frost detection point, to control the frost detector to operate when the current time corresponds to the frost detection point, and to control a defrosting operation based on a frost detection signal from the frost detector. It is possible to accurately detect the amount of frost formed on the evaporator by executing the frost detection under constant frost detection environmental conditions.
FIG. 3

(a)

(b)
FIG. 4
FIG. 6

(a) Compressor (com) on off

(b) Valve (VW2) on off
FIG. 7A

1. START
2. EXECUTE COOLING OPERATION
3. MONITOR OPERATION STATE OF COMPRESSOR
4. FROST DETECTION POINT?
   - NO
   - YES
5. COLLECT SAMPLE VoltAGES AND BOARD TEMPERATURE VALUES
6. EXECUTE TEMPERATURE COMPENSATION
7. SET REFERENCE VOLTAGE
8. OPERATION REQUIRED TEMPERATURE ≤ FREEZING COMPARTMENT TEMPERATURE?
   - NO
   - YES

A
FIG. 7B

A

EXECUTE COOLING OPERATION → 208

MONITOR OPERATION STATE OF COMPRESSOR → 209

NO

FROST DETECTION POINT? → 210

YES

COLLECT SAMPLE VOLTAGES AND BOARD TEMPERATURE VALUES → 211

EXECUTE TEMPERATURE COMPENSATION → 212

COMPARE DETECTION VOLTAGE WITH REFERENCE VOLTAGE TO CALCULATE DIFFERENCE BETWEEN THE COMPARED VOLTAGES → 213

NO

REFERENCE VARIATION < DIFFERENCE? → 214

YES

EXECUTE DEFROSTING OPERATION → 215

DETECT EVAPORATOR TEMPERATURE → 216

NO

DEFROSTING COMPLETION TEMPERATURE ≤ EVAPORATOR TEMPERATURE? → 217

YES

COMPLETE DEFROSTING OPERATION → 218

END
FIG. 8

(a) Compressor (con)

(b) Voltage (V)

Number of samples
FIG. 10

- Present Embodiment
- Conventional

Accumulated Electric Power (Wh)

Time (h)

- Defrosting for F compartment
- Defrosting for R compartment
- Defrosting for F+R compartments

FIG. 11

Temperature (°C)
FIG. 12A

START

EXECUTE COOLING OPERATION 301

MONITOR OPERATION STATE OF COMPRESSOR 302

NO

FROST DETECTION POINT? 303

YES

COLLECT SAMPLE VOLTAGES AND BOARD TEMPERATURE VALUES 304

EXECUTE TEMPERATURE COMPENSATION 305

SET REFERENCE VOLTAGE 306

NO

TARGET TEMPERATURE > FREEZING COMPARTMENT TEMPERATURE? 307

YES

COMPLETE COOLING OPERATION 308

NO

OPERATION REQUIRED TEMPERATURE ≤ FREEZING COMPARTMENT TEMPERATURE? 309

YES
FIG. 12B

1. Execute Cooling Operation (310)
2. Monitor Operation State of Compressor (311)
3. Frost Detection Point? (312)
   - Yes: Collect Sample Voltages and Board Temperature Values (313)
   - No: Proceed with Temperature Compensation (314)
   - Compare Detection Voltage with Reference Voltage to Calculate Difference Between the Compared Voltages (315)
   - Reference Variation < Difference? (316)
     - Yes: Execute Defrosting Operation (317)
     - No: Detect Evaporator Temperature (318)
6. Defrosting Completion Temperature ≤ Evaporator Temperature? (319)
   - Yes: Complete Defrosting Operation (320)

End
FIG. 13

(a) Temperature (°C)

(b) Voltage (V)

Number of samples
COOLING SYSTEM AND DEFROSTING CONTROL METHOD THEREOF

BACKGROUND

[0002] 1. Field

[0003] Embodiments relate to a cooling system, which detects frost formed on an evaporator due to heat exchange, and performs defrosting control based on the amount of the detected frost, and a defrosting control method thereof.

[0004] 2. Description of the Related Art

[0005] A cooling system is adapted to cool a confined space by circulating a refrigerant through a refrigeration cycle. As such a cooling system, there are a refrigerator, a Kinetchi refrigerator, an air conditioner, etc.

[0006] Here, the refrigeration cycle includes four stages to change the phase of the refrigerant, namely, compression, condensation, expansion, and vaporization stages. To this end, the cooling system should include a compressor, a condenser, an expansion valve, and an evaporator.

[0007] When a gaseous refrigerant is supplied to the condenser after being compressed in accordance with an operation of a compressor, the refrigerant, which is in a condensed state, is cooled as it exchanges heat with air around the condenser. As a result, the refrigerant is condensed into a liquid phase. The liquid refrigerant is then injected into the evaporator while being adjusted in flow rate by the expansion valve. As a result, the refrigerant is abruptly expanded, so that it is vaporized. As the refrigerant is vaporized, it absorbs heat from air around the evaporator, thereby generating cold air. The cold air is supplied to a confined space such as a storage chamber or a room, thereby cooling the confined space. The refrigerant, which has been changed into the gaseous phase in the evaporator, is again introduced into the compressor, and is then compressed into the liquid phase. Thus, the above stages of the refrigeration cycle are repeated for the refrigerant.

[0008] The surface temperature of the evaporator, which functions to cool a confined space by absorbing heat from the confined space through the refrigeration cycle, is relatively lower than the temperature of air present in the confined space. As a result, moisture condensed from the air in the confined space, which is in a moisture-rich state, is attached to the surface of the evaporator, so that frost is formed on the surface of the evaporator. The frost formed on the surface of the evaporator is accumulated with passage of time, so that the thickness of the frost is increased. As a result, the heat exchange efficiency of the cold air flowing around the evaporator is degraded, thereby causing degradation in cooling efficiency and excessive power consumption.

[0009] In order to solve such problems, in conventional cases, an operating time of the compressor is accumulated, and a defrosting operation is carried out when the accumulated operating time exceeds a predetermined time. In the defrosting operation, a heater arranged around the evaporator operates to remove the frost formed on the evaporator.

[0010] However, this method is inefficient at removing the frost formed on the evaporator because the defrosting operation is carried out based on the operating time of the compressor, irrespective of the actual amount of frost formed on the evaporator. Furthermore, there may be unnecessary electric power consumption. Also, temperature increase may frequently occur in a space to be cooled, due to the defrosting operation.

[0011] To this end, in conventional cases, a frost detector such as a vibration sensor, a piezoelectric element, a temperature sensor, or a capacitive sensor is installed at the evaporator, in order to directly detect the amount of frost formed on the evaporator, and to efficiently perform a defrosting operation based on the result of the detection.

[0012] Where the capacitive sensor is used as a frost detector, a variation in dielectric constant ε may occur due to a small amount of water formed on the surface of a cooling fin of the evaporator as frost on the cooling fin surface thaws slightly due to an increase in the temperature of the evaporator (from about -30°C. to about -18°C.) when the compressor of the cooling system stops a compression operation. As a result, an increase in capacitance C may occur in the capacitive sensor, so that the output voltage from the capacitive sensor may be lowered.

[0013] Furthermore, the capacitive sensor may exhibit a great decrease in output voltage when frost formed between the capacitive sensor and the cooling fin changes into water during a defrosting operation of the cooling system. When the compressor again operates, the output voltage of the capacitive sensor is increased by the capacitance corresponding to the amount of frost left on the surface of the cooling fin. Since the state of the frost formed on the evaporator varies in accordance with the operation state of the cooling system, as mentioned above, it may not be possible to accurately detect the amount of frost formed on the evaporator.

[0014] Also, although a driver board is used to drive the capacitive sensor, there may be a problem in accurately detecting the amount of frost formed on the evaporator, due to the driver board. That is, the capacitive sensor outputs a sensing signal varying in accordance with the oscillation frequency and amplitude of a sensor drive signal output from the driver board. However, the oscillation frequency of the sensor drive signal may influence the output voltage of the capacitive sensor in accordance with the temperature of the driver board. For this reason, it may be impossible to accurately detect the amount of frost formed on the evaporator.

SUMMARY

[0015] Additional aspects and/or advantages will be set forth in part in the description which follows, and in part, will be apparent from the description, or may be learned by practice of the invention.

[0016] It is an aspect of one or more embodiments to provide a cooling system, which detects frost formed on the cooling system under constant frost detection environmental conditions, and a defrosting control method thereof.

[0017] Another aspect of one or more embodiments is to provide a cooling system capable of performing temperature compensation in accordance with the temperature of a driver board to control operation of a frost detector, and a defrosting control method thereof.
Another aspect of one or more embodiments is to provide a cooling system including a driver board to perform signal processing upon sampling data acquired from a frost detector at regular intervals, so as to control operation of the frost detector, wherein the driver board is provided with a non-connection terminal, and a defrosting control method thereof.

Another aspect of one or more embodiments is to provide a cooling system including a driver board to control operation of a frost detector, wherein the driver board is provided with a non-connection terminal, and a defrosting control method.

In accordance with one aspect of one or more embodiments, a cooling system includes at least one evaporator to exchange heat with air, a frost detector installed on the evaporator to detect frost, and a control unit to determine whether a current time corresponds to a frost detection point, to control the frost detector to operate when the current time corresponds to the frost detection point, and to control a defrosting operation based on a frost detection signal from the frost detector.

The frost detection point may be a point of time when a constant state of the frost is exhibited whenever the frost detector operates.

The frost detector may detect a capacitance established between the frost detector and a cooling fin provided at the evaporator, and may output a voltage signal corresponding to the detected capacitance.

The cooling system may further include a storage chamber to be cooled in accordance with the heat exchange of the evaporator, and a chamber temperature detector to detect a temperature of the storage chamber. The frost detection point may be a point of time when the temperature of the storage chamber reaches a predetermined temperature.

The cooling system may further include a storage chamber to be cooled in accordance with the heat exchange of the evaporator, and a chamber temperature detector to detect a temperature of the storage chamber. The frost detection point may be a point of time when the temperature of the storage chamber reaches a predetermined maximum temperature.

The cooling system may further include a storage chamber to be cooled in accordance with the heat exchange of the evaporator, and a chamber temperature detector to detect a temperature of the storage chamber. The frost detection point may be a point of time when the temperature of the storage chamber reaches a predetermined minimum temperature.

The cooling system may further include a compressor to supply compressed refrigerant to the evaporator. The frost detection point may be a point of time when an operation state of the compressor is changed.

The cooling system may further include a valve to adjust flow of refrigerant to the evaporator. The frost detection point may be a point of time when an operation state of the valve is changed.

The cooling system may further include a fan to circulate the air exchanging heat with the evaporator. The frost detection point may be a point of time when an operation state of the fan is changed.

The cooling system may further include a ground terminal. The frost detection point may be a point of time when a potential of the ground terminal reaches a predetermined potential.

The control unit may collect a plurality of sample voltages at regular intervals for a predetermined time from the frost detection point during the operation of the frost detector.

The control unit may calculate an average value of the sample voltages, and stores the calculated average value as a detection voltage.

The control unit may compare the detection voltage with a reference voltage to calculate a difference between the detection voltage and the reference voltage, may compare the difference with a predetermined reference variation value, and may control the defrosting operation when the difference exceeds the predetermined reference variation value.

The reference voltage may be a detection voltage stored during an initial refrigeration cycle executed after power is initially supplied.

The reference voltage may be a detection voltage stored during a next refrigeration cycle executed after the defrosting operation is completed.

The cooling system may further include an evaporator temperature detector to detect a temperature of the evaporator. The control unit may control completion of the defrosting operation based on the temperature of the evaporator detected during the defrosting operation.

The cooling system may further include a driving unit including a driver to output a drive signal to the frost detector in accordance with instructions from the control unit and to receive the detection signal from the frost detector, and a board temperature detector to detect a temperature of the driving unit. The control unit may execute temperature compensation for the detection signal from the frost detector based on the temperature of the driving unit.

The driving unit may receive the detection signal from the frost detector through a connection terminal, to which the frost detector is connected, while receiving a noise signal through a non-connection terminal, to which the frost detector is not connected. The control unit may deduct the noise signal from the detection signal.

The driving unit may further include a filter to filter the detection signal from the frost detector such that low frequency components of the detection signal pass through the filter.

The control unit may further have a function to convert the detection signal from the frost detector into a digital signal.

The at least one evaporator may include at least one of a refrigerating compartment evaporator, a freezing compartment evaporator, and an ice making compartmen evaporator.

In accordance with another aspect of one or more embodiments, a control method of a cooling system including a frost detector to detect frost formed on an evaporator includes determining whether a current time corresponds to a predetermined frost detection point, operating the frost detector when the current time corresponds to the predetermined frost detection point, thereby detecting the frost, and controlling a defrosting operation based on a detection signal generated through the frost detector.

The frost detection point may be a point of time when a temperature of a storage chamber cooled by air exchanging heat with the evaporator reaches one of a predetermined temperature, a predetermined maximum temperature and a predetermined minimum temperature.
The frost detection point may be a point of time when an operation state of one of a compressor to supply compressed refrigerant to the evaporator, a valve to adjust flow of the refrigerant supplied to the evaporator and a fan to circulate the air exchanging heat with the evaporator is changed.

The frost detection point may be a point of time when a potential of a ground terminal provided at the cooling system reaches a predetermined potential.

The control method may further include collecting a plurality of sample voltages from the detection signal generated during the operation of the frost detector.

The control method may further include calculating an average value of the sample voltages, and storing the calculated average value as a detection voltage.

The storing the calculated average value as the detection voltage may include setting the detection voltage to a reference voltage if the detection voltage is a detection voltage stored during a refrigeration cycle initially executed after power is initially supplied.

The storing the calculated average value as the detection voltage may include again setting the detection voltage to the reference voltage if the detection voltage is a detection voltage stored during a refrigeration cycle initially executed after completion of the defrosting operation.

The controlling the defrosting operation based on the detection signal may include calculating a difference between the detection voltage and a predetermined reference voltage, comparing the difference with a reference variation value, executing the defrosting operation when the difference exceeds the reference variation value, and executing a next refrigeration cycle when the difference does not exceed the reference variation value.

The controlling the defrosting operation may include detecting a temperature of the evaporator during the defrosting operation, and completing the defrosting operation when the temperature of the evaporator is equal to or higher than a predetermined defrosting completion temperature.

The control method may further include detecting a temperature of a driving unit to operate the frost detector, and executing temperature compensation for the detection signal based on the temperature of the driving unit.

The operating the frost detector may include outputting a drive signal through a connection terminal to which the frost detector is connected, receiving the detection signal from the frost detector through the connection terminal, outputting a drive signal through a non-connection terminal to which the frost detector is not connected, receiving a noise signal from the non-connection terminal, and removing a component corresponding to the noise signal from the detection signal.

The detecting the frost may include detecting a capacitance established between the frost detector and a cooling fin provided at the evaporator and arranged adjacent to the frost detector, and outputting a voltage signal corresponding to the detected capacitance.

In accordance with one aspect of one or more embodiments, it may be possible to accurately detect the amount of frost formed on the evaporator by executing the frost detection under constant frost detection environmental conditions.

In accordance with another aspect of one or more embodiments, it may be possible to prevent an output voltage of the frost detector from varying due to variation in the temperature of a driver board to control operation of the frost detector by executing temperature compensation for the driver board.

In accordance with another aspect of one or more embodiments, it may be possible to prevent the output voltage of the frost detector from varying due to noise from an external appliance by performing signal processing upon sampling data acquired at regular intervals from the frost detector.

Thus, it may be possible to more accurately detect the amount of frost formed on the evaporator by detecting the amount of frost under constant frost detection environmental conditions while removing external influence on the frost detector and driver board during the detection of the frost amount.

It may also be possible to execute the defrosting operation at an appropriate point of time by virtue of the more accurate detection of the amount of frost formed on the evaporator, and thus to prevent the cooling efficiency of the evaporator from being lowered due to degradation in air flow occurring during heat exchange.

Since the amount of frost remaining on the evaporator during the defrosting operation may be accurately determined, it may be possible to determine when the defrosting operation should be completed. Accordingly, it may be possible to reduce energy consumption caused by the defrosting operation and to minimize temperature variation occurring in the cooling system due to the defrosting operation. Thus, an enhancement in the performance of the cooling system may be achieved. Since the heater is operated only when the defrosting operation is required, it may be possible to reduce the operation time of the heater and the frequency with which the heater is operated.

Where the cooling system is a refrigerator, it may be possible to efficiently operate the heater for the defrosting operation. Accordingly, it may be possible to minimize temperature variation occurring in the interior of the refrigerator, and to store food in the refrigerator in a fresh state for a prolonged period of time.

In accordance with another aspect of one or more embodiments, it may be possible to easily and accurately determine noise included in a signal output from the frost detector by determining, as noise, a signal output from the non-connection terminal of the driver board to which the frost detector is not connected, and deducting the noise from a signal output from a connection terminal of the driver board to which the frost detector is connected.

**BRIEF DESCRIPTION OF THE DRAWINGS**

These and/or other aspects of embodiments will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

**FIG. 1** is a view illustrating a refrigerator according to an exemplary;

**FIG. 2** is a view illustrating a detailed configuration of an evaporator provided at the refrigerator in accordance with an exemplary embodiment;

**FIG. 3** is a sectional view illustrating a frost detector according to an exemplary embodiment;

**FIG. 4** is a block diagram illustrating a control configuration of the refrigerator according an exemplary embodiment.
FIG. 5 is a block diagram illustrating a connection configuration of a frost detector provided at the refrigerator according to an exemplary embodiment;

FIG. 6 is a waveform diagram illustrating a frost detection point of the frost detector provided at the refrigerator according to an exemplary embodiment;

FIGS. 7A and 7B are flowcharts illustrating a defrosting control operation of the refrigerator according to an exemplary embodiment;

FIG. 8 illustrates a driving pattern of a compressor provided at the refrigerator according to an exemplary embodiment and sample voltages of the frost detector, through a waveform diagram and a graph;

FIG. 9 is a graph depicting an average value of sample voltages detected through the frost detector provided at the refrigerator according to an exemplary embodiment, the average value varying in accordance with the number of sample voltages;

FIG. 10 is a graph depicting power consumption of a conventional refrigerator and the refrigerator according to an exemplary embodiment according to time;

FIG. 11 is a graph depicting a frost detection point of the frost detector provided at the refrigerator according to an exemplary embodiment;

FIGS. 12A and 12B are flowcharts illustrating a defrosting control operation of the refrigerator according to another embodiment; and

FIG. 13 is a graph depicting a temperature pattern of a freezing compartment provided at the refrigerator according to an exemplary embodiment and sample voltages of a frost detector provided at the refrigerator.

**DETAILED DESCRIPTION**

Hereinafter, exemplary embodiments will be described by referring to the figures.

Each exemplary embodiment is adapted to enhance the defrosting efficiency of a cooling system, and thus to reduce power consumption by accurately detecting whether or not frost has been formed on an evaporator of the cooling system and the amount of the formed frost, by use of a frost detector using a capacitive sensor and controlling driving of a heater based on the results of the detection, thereby controlling a defrosting operation. The exemplary embodiments are described in conjunction with an example in which the cooling system is applied to a refrigerator.

The exemplary embodiment will be described in conjunction with the case in which the cooling system is applied to a refrigerator adapted to store food in a fresh state for a prolonged period of time by maintaining a storage chamber in a low-temperature state through repetition of a refrigeration cycle to sequentially compress, condense, expand, and vaporize a refrigerant.

FIG. 11 is a view illustrating a refrigerator according to an exemplary embodiment. FIG. 2 is a view illustrating a detailed configuration of an evaporator provided at the refrigerator in accordance with an exemplary embodiment. FIG. 3 is a sectional view illustrating a frost detector according to an exemplary embodiment.

As shown in FIG. 1, the refrigerant 100, which is a cooling system, includes a body 110, a storage chamber 120, and doors 131 and 132.

The body 110 forms an outer appearance of the refrigerant 100. A duct (not shown), through which air flows, is formed in an inner space defined between outer and inner walls of the body 110. A machinery chamber (not shown) is also formed in the inner space of the body 110. Installed in the machinery chamber is a compressor con to compress a refrigerant, and to supply the compressed refrigerant to a condenser (not shown). The condenser, which is also installed in the machinery chamber, condenses the refrigerant, which has been compressed into a high-temperature and high-pressure state by the compressor con, in accordance with a heat discharge operation.

A storage chamber 120 to store food is formed by the inner wall of the body 110. A plurality of holes is formed through the inner wall of the body 110. Air flows between the duct and the storage chamber 120 through the holes.

The storage chamber 120 is laterally partitioned into a refrigerating compartment 121 and a freezing compartment 122 by an intermediate barrier wall. Each of the refrigerating and freezing compartments 121 and 122 is open at a front side thereof.

Compartment temperature detectors T1 and T2 are provided at the storage chamber 120. That is, a first temperature detector T1 is provided at the refrigerating compartment 121, to detect the temperature of the refrigerating compartment 121, and to transmit a value representing the detected temperature to a controller 192. Also, a second temperature detector T2 is provided at the freezing compartment 122, to detect the temperature of the freezing compartment 122, and to transmit a value representing the detected temperature to the controller 192.

The doors 131 and 132 are installed at forwardly-opened portions of the refrigerating and freezing compartments 121 and 122, to shield the refrigerating and freezing compartments 121 and 122 from the outside, respectively.

The refrigerator, which is a cooling system, further includes constituent elements installed at the duct of the body 110, namely, evaporators 141 and 142, fans 151 and 152, heaters 161 and 162, and valves VV1 and VV2.

The evaporators 141 and 142 are installed such that they correspond to the refrigerating and freezing compartments 121 and 122, respectively. The evaporators 141 and 142 cool air present therearound and air present in the storage chamber 120, namely, the refrigerating and freezing compartments 121 and 122, by performing a cooling operation for absorbing ambient latent heat while evaporating a refrigerant supplied from a condenser (not shown). That is, the refrigerating compartment evaporator 141 lowers the temperature of the refrigerating compartment 121, whereas the freezing compartment evaporator 142 lowers the temperature of the freezing compartment 122.

Hereinafter, the structures of such evaporators will be described with reference to FIG. 2. The freezing compartment evaporator 142 includes a refrigerant tube 142a, through which refrigerant flows, and a plurality of cooling fins 142b mounted to the refrigerant tube 142a to enhance heat exchange efficiency. The structure of the refrigerating compartment evaporator 141 is identical to the structure of the freezing compartment evaporator 142.

The valve VV1 is arranged between the condenser and the evaporator 141, whereas the valve VV2 is arranged between the condenser and the evaporator 142. The valves VV1 and VV2 are opened or closed in accordance with instructions from the controller 192 based on respective temperatures of the compartments of the storage chamber 120.
In more detail, the valve VV1 is opened to supply refrigerant to the evaporator 141 when the temperature of the refrigerating compartment 121 exceeds a target temperature, and is closed to cut off supply of refrigerant when the temperature of the refrigerating compartment 121 reaches the target temperature. On the other hand, the valve VV2 is opened to supply refrigerant to the evaporator 142 when the temperature of the freezing compartment 122 is higher than a target temperature, and is closed to cut off supply of refrigerant when the temperature of the freezing compartment 122 reaches the target temperature.

That is, refrigerant is supplied to the evaporators 141 and 142 as the valves VV1 and VV2 are opened, respectively. In this state, low-temperature air flows, which exchange heat with the evaporators 141 and 142, respectively, are supplied to the refrigerating compartment 121 and the freezing compartment 122 of the storage chamber 120. As a result, the temperatures of the compartments 121 and 122 of the storage chamber 120 are lowered.

The fans 151 and 152 are installed to correspond to the refrigerating compartment 121 and the freezing compartment 122, respectively. Each of the fans 151 and 152 sucks air from a corresponding one of the refrigerating compartment 121 and the freezing compartment 122, and sends air passing around a corresponding one of the evaporators 141 and 142 to the corresponding refrigerating compartment 121 or freezing compartment 122. The heaters 161 and 162 are installed to correspond to the evaporators 141 and 142, to remove frost formed on the corresponding evaporators 141 and 142, respectively.

Different from the illustrated embodiment, the refrigerator may include a single evaporator and a single heater, to cool the refrigerating compartment and the freezing compartment using the single evaporator, and to remove frost formed on the single evaporator using the single heater. In this case, a single frost detector is used.

Also, different from the illustrated embodiment, the refrigerator may include a refrigerating compartment evaporator to cool the refrigerating compartment, a freezing compartment evaporator to cool the freezing compartment, an ice making compartment evaporator to cool an ice making compartment (not shown), a heater to remove frost formed on the refrigerating compartment evaporator, a heater to remove frost formed on the freezing compartment evaporator, and a heater to remove frost formed on the ice making compartment evaporator. In this case, at least three frost detectors may be provided.

As shown in FIG. 2, the refrigerator, which is a cooling system, further includes a frost detector 170 installed at a cooling fin of each evaporator to detect the amount of frost formed on the evaporator.

In detail, a plurality of frost detectors 170 are provided. At least one of the plural frost detectors 170 is installed on at least one of the plural cooling fins of the evaporator 141 corresponding to the refrigerating compartment 121. Also, at least one of the plural frost detectors 170 is installed on at least one of the plural cooling fins 142 of the evaporator 142 corresponding to the freezing compartment 122.

Each frost detector 170, which is installed on the cooling fin of a corresponding one of the evaporators 141 and 142, detects the amount of frost formed between the cooling fin, on which the frost detector 170 is installed, and the cooling fin arranged adjacent to the cooling fin on which the frost detector 170 is installed.

The frost amount detection is achieved by detecting capacitance variation in response to variation in the amount of frost formed between the cooling fin, on which the frost detector 170 is installed, and the cooling fin arranged adjacent to the cooling fin on which the frost detector 170 is installed, and acquiring a voltage signal corresponding to the detected capacitance.

That is, the frost detector 170 detects capacitance variation in accordance with the amount of frost formed on the surface of a corresponding one of the evaporators 141 and 142 as moisture condensed from the air in a corresponding one of the compartments 121 and 122 of the storage chamber 120, which is in a high-temperature moisture-rich state, is attached to the surface of the corresponding evaporator, which is lower than the temperature of the compartment air, during heat exchange between the compartment air and ambient air. The frost detector 170 then outputs a voltage signal corresponding to the detected capacitance to the controller 192 via a driving unit 180.

Taking into consideration the fact that a variation in dielectric constant occurs due to state variation of frost, the frost detector 170 detects the amount of frost at the point of time when a predetermined frost detection environmental condition is established (hereinafter, referred to as a “frost detection point”). The predetermined frost detection environmental condition is a condition that a constant state of frost is established, thereby causing the dielectric constant established between the frost detector 170 and the cooling fin facing the frost detector 170 to be constant. Accordingly, it may be possible to enhance frost detection accuracy.

That is, the frost detector 170 operates at the point of time corresponding to the frost detection point in accordance with instructions from the controller 192, to detect an amount of frost for a predetermined time. The frost detection point is set based on whether or not each element provided at the refrigerator operates.

That is, the frost detection point, at which frost formed on the refrigerating compartment evaporator 141 is detected, is one of the point of time when the operation state of the compressor com is changed to an ON state or an OFF state, the point of time when the operation state of the valve VV1 is changed to an open state or a closed state, the point of time when the operation state of the fan 151 is changed to an ON state or an OFF state, and the point of time when a ground potential is changed to a predetermined potential.

On the other hand, the frost detection point, at which frost formed on the freezing compartment evaporator 142 is detected, is one of the point of time when the operation state of the compressor com is changed to an ON state or an OFF state, the point of time when the operation state of the valve VV2 is changed to an open state or a closed state, the point of time when the operation state of the fan 152 is changed to an ON state or an OFF state, and the point of time when the ground potential is changed to a predetermined potential.

Here, the predetermined ground potential is a potential applied to a ground terminal provided at the refrigerator. The ground potential is varied to a certain potential due to operation noise of at least one of the compressor, fan and valve. Accordingly, it may be possible to determine the point of time when the operation state of each of the compressor, fan, and valve is changed by acquiring the potential applied to the ground terminal during operation of the associated compressor, fan, or valve, and monitoring the ground potential, thereby detecting the point of time when the ground potential is changed to the acquired potential.
[0105] In this regard, the reason why the point of time when the ground potential is changed to a predetermined potential is set to the frost detection point is to indirectly determine the point of time when the operation state of each element of the refrigerator is changed.

[0106] Hereinafter, the structure of the above-described frost detector 170 will be described with reference to FIG. 3.

[0107] As shown in FIG. 3(a), the frost detector 170 may include a first electrode 170a to detect frost formed between the first electrode 170a and a cooling fin 171 provided at an evaporator, a first insulator 170b arranged in contact with the first electrode 170a, a second electrode 170c arranged in contact with the first insulator 170b, and a second insulator 170d arranged in contact with the second electrode 170c.

[0108] In this case, the second insulator 170d is installed to be in contact with another cooling fin 172 arranged to face the cooling fin 171. The second insulator 170d insulates the second electrode 170c from the cooling fin 172 while the first insulator 170b insulates the first and second electrodes 170a and 170c from each other.

[0109] Also, as shown in FIG. 3(b), the frost detector 170 may include a first electrode 170a to detect frost formed between the first electrode 170a and a cooling fin 171 provided at an evaporator, a first insulator 170b arranged in contact with the first electrode 170a, a second electrode 170c arranged in contact with the first insulator 170b, and a second insulator 170d arranged in contact with the second electrode 170c.

[0110] In this case, the first insulator 170b has an exposed portion around the first electrode 170a. The second electrode 170c extends around an exposed portion of the first insulator 170b, so as to surround the exposed portion of the first insulator 170b. Thus, the second electrode 170c extends along the surfaces of the first electrode 170a, except for the front surface of the first electrode 170a (frost detection surface), so as to surround the side surfaces of the first electrode 170a. In accordance with this arrangement, the second electrode 170c functions as a shield to cut off an electric field leaking at side surface edges of the first insulator 170b and first electrode 170a.

[0111] An insulation gap g is formed between the second electrode 170c and the first electrode 170a, to insulate the second electrode 170c from the first electrode 170a.

[0112] In the frost detector 170 shown in FIG. 3(a) or 3(b), an electric field is generated between the first electrode 170a and the cooling fin 171. When frost is formed between the first electrode 170a and the cooling fin 171, the electric field is varied due to the formed frost. As a result, the dielectric constant established between the first electrode 170a and the cooling fin 171 is varied, thereby causing variation in capacitance. Accordingly, the frost detector 170 outputs a voltage signal corresponding to the varied capacitance.

[0113] In this case, it may be possible to prevent an electric field from being generated at the side of the cooling fin 172 by connecting the first electrode 170a to a sensor terminal while connecting the second electrode 170c to a shield terminal, and then applying voltages having the same phase and magnitude to the first electrode 170a and second electrode 170c, respectively.

[0114] In particular, the frost detector 170 shown in FIG. 3(b) may prevent the electric field generated at the side of the first electrode 170a from leaking into a frost non-detection region S2 through the side surface edges of the first insulator 170b. Also, the frost detector 170 may prevent the electric field from leaking at the side surface edges of the first insulator 170b even when the dielectric constant of the first insulator 170b is varied due to variation in temperature. Thus, it may be possible to prevent variation of the electric field generated at the side of the first electrode 170a as a frost detection region S1.

[0115] That is, in the frost detector 170 shown in FIG. 3(b), the electric field generated at the side of the first electrode 170a is guided only to the cooling fin 171 by the second electrode 170c of the frost detector 170. Accordingly, it may be possible to allow the electric field of the first electrode 170a to be varied only due to frost formed between the first electrode 170a and the cooling fin 171.

[0116] FIG. 4 is a block diagram illustrating a control configuration of the refrigerator according to an exemplary embodiment. The refrigerator, which is a cooling system, includes first, second, third and fourth temperature detectors T1, T2, T3 and T4, and a control unit 190, in addition to the compressor com, valves VV1 and VV2, fans 151 and 152, heaters 161 and 162, frost detectors 170, and driving unit 180.

[0117] The first temperature detector T1 detects the temperature of the refrigerating compartment 121, and transmits the detected temperature value to a controller 192 included in the control unit 190. The second temperature detector T2 detects the temperature of the freezing compartment 122, and transmits the detected temperature value to the controller 192 of the control unit 190.

[0118] The third and fourth temperature detectors T3 and T4 are evaporator temperature detectors. The third temperature detector T3 is installed on the refrigerating compartment evaporator 141. The third temperature detector T3 detects the temperature of the refrigerating compartment evaporator 141, and transmits the detected temperature value to the controller 192 of the control unit 190. The fourth temperature detector T4 detects the temperature of the freezing compartment evaporator 142, and transmits the detected temperature value to the controller 192 of the control unit 190.

[0119] The compressor com compresses refrigerant in accordance with instructions from the controller 192, and supplies the compressed refrigerant to the condenser (not shown), to establish a refrigeration cycle during a cooling operation, and thus to cool the storage chamber 120.

[0120] The valve VV1 is opened or closed in accordance with instructions from the controller 192, to adjust the amount of refrigerant supplied from the condenser (not shown) to the evaporator 141. The valve VV2 is opened or closed in accordance with instructions from the controller 192, to adjust the amount of refrigerant supplied from the condenser (not shown) to the evaporator 142.

[0121] The fan 151 rotates in accordance with instructions from the controller 192, to suck air from the refrigerating compartment 121 and discharge air flowing around the evaporator 141 during the cooling operation. The fan 152 rotates in accordance with instructions from the controller 192, to suck air from the freezing compartment 122 and to discharge air flowing around the evaporator 142 during the cooling operation.

[0122] The heater 161 operates in accordance with instructions from the controller 192, to generate heat during a defrosting operation, thereby removing frost formed on the evaporator 141. The heater 162 operates in accordance with instructions from the controller 192, to generate heat during the defrosting operation, thereby removing frost formed on the evaporator 142.
At least one frost detector 170 is provided at each of the evaporators 141 and 142. Each frost detector 170 operates at a frost detection point in accordance with instructions from the controller 192, to detect a capacitance corresponding to the amount of frost formed in a region where the frost detector 170 is arranged. The frost detector 170 then outputs a voltage signal corresponding to the detected capacitance to the controller 192 of the control unit 190 via the driving unit 180.

The driving unit 180 is a driver board to drive the frost detector 170 provided at each of the evaporators 141 and 142. The driving unit 180 outputs a drive signal for frost detection to the frost detector 170. The driving unit 180 also receives the voltage signal corresponding to the detected frost amount from the frost detector 170, and outputs the received voltage signal to the control unit 190.

The driving unit 180 includes a driver 181, a filter 182, and a board temperature detector 183. This will be described with reference to FIG. 5.

FIG. 5 is a block diagram illustrating a connection configuration between the frost detector 170 and driving unit 180 provided at the refrigerantor according to an exemplary embodiment.

The driver 181 is constituted by a driver integrated circuit (IC) having a plurality of terminals CH1, CH2, CH3, ..., CH(n), and Out.

A part of the plural terminals provided at the driver 181, namely, the terminals CH1, CH2, CH3, ..., and CH(n-1) (hereinafter, referred to as “connection terminals”) are connected to respective frost detectors 170-1, 170-2, 170-3, ..., and 170-(n-1). The terminal CH(n) is not connected to a frost detector.

The terminal of the driver 181, to which no frost detector is connected, namely, the terminal CH(n), is a non-connection (NC) terminal.

The remaining terminal of the driver 181, namely, the terminal Out, is connected to the filter 182.

The driver 181 sequentially selects the plural connection terminals CH1, CH2, CH3, ..., and CH(n-1) in accordance with instructions from the controller 192, to output a drive signal generated from an oscillator (not shown) through the sequentially-selected connection terminals CH1, CH2, CH3, ..., and CH(n-1). Here, the drive signal is an AC signal having a reference frequency.

Upon sequentially selecting the plural connection terminals CH1, CH2, CH3, ..., and CH(n-1), the driver 181 sequentially receives voltage signals corresponding to amounts of frost detected by the frost detectors 170 through the selected terminals.

The driver 181 also outputs the drive signal generated from the oscillator (not shown) to the non-connection terminal CH(n), and receives a voltage signal applied to the non-connection terminal CH(n).

The driver 181 receives a voltage signal applied to the non-connection terminal CH(n) after outputting the AC signal having the reference frequency to the non-connection terminal CH(n) to acquire a noise signal generated due to oscillation of the oscillator (not shown). That is, the noise signal, which is generated due to oscillation of the oscillator (not shown), not only influences the terminals CH1, CH2, CH3, ..., and CH(n-1), but also influences the non-connection terminal CH(n). In other words, the driver 181 receives, through the non-connection terminal CH(n), a voltage signal corresponding to the noise signal generated due to the oscillation of the oscillator (not shown).

The oscillator (not shown) generates AC signals, each of which has a reference frequency, and supplies AC signals to the first and second electrodes 170a and 170c of each frost detector 170, respectively. In this case, the reference-frequency AC signals respectively supplied to the first and second electrodes 170a and 170c have the same phase and magnitude.

When the driver 181 sequentially receives voltage signals generated in accordance with frost detecting operations of the frost detectors 170-1, 170-2, 170-3, ..., and 170-(n-1) through the connection terminals CH1, CH2, CH3, ..., and CH(n-1), the driver 181 then transmits the sequentially-received voltage signals to the filter 182. The driver 181 also transmits a voltage signal generated at the non-connection terminal CH(n) to the filter 182.

The filter 182 performs a filtering operation to filter each of the voltage signals sequentially input to the filter 182 such that frequency components having a frequency not higher than a predetermined frequency pass through the filter 182. The filter 182 then transmits the resultant signal to an A/D converter 191 included in the control unit 190. Here, the predetermined frequency is lower than the reference frequency of the AC signals generated at the oscillator (not shown).

The filter 182 is a filter to pass frequency components of a voltage signal generated in accordance with a frost detecting operation, which are not higher than the predetermined frequency, through the filter 182, while preventing the remaining frequency components of the voltage signal from passing through the filter 182. That is, the filter 182 is a low pass filter (LPF).

The reason why the voltage signal is filtered to pass frequency components having a frequency not higher than the predetermined frequency, namely, a frequency lower than the reference frequency, is to acquire only a pure frost detection signal. That is, the dielectric constant established between the frost detector and the cooling fin varies in accordance with the amount of frost formed between the frost detector and the cooling fin. Such dielectric constant variation causes a variation in capacitance. As a result, a variation in impedance occurs at the sensor terminal of the frost detector. Due to the impedance variation, the voltage at the sensor terminal is reduced to a level lower than the reference frequency signal in accordance with the voltage divider rule, so that the frost detection signal has a frequency lower than the reference frequency. For this reason, the voltage signal is filtered to pass frequency components having a frequency lower than the reference frequency, so as to acquire only a pure frost detection signal.

Accordingly, it may be possible to acquire only the voltage signal corresponding to the capacitance varied due to the frost formed on the cooling fin of the evaporator by removing the noise signal generated due to the oscillation of the driving unit 180 from the voltage signal of the frost detector 170. Thus, it may be possible to more accurately detect the amount of frost.

The board temperature detector 183 is provided at the driving unit 180, which is constituted by a driver board. The board temperature detector 183 detects the temperature of the driving unit 180, and transmits a signal representing the detected temperature to the A/D converter 191 of the control unit 190.
The reason why the temperature of the driving unit 180 is detected is that it is necessary to perform temperature compensation for the voltage signal of the frost detector in accordance with the temperature of the driving unit 180 because the voltage signal from the frost detector input to the driver 181 constituted by a driver IC is varied due to the influence of the temperature of the driving unit 180.

The variation of the voltage signal of the frost detector caused by the temperature of the driving unit 180 may be about 20 mV under the condition that no frost is formed. When the temperature of the driving unit 180 increases in this state, the level of the voltage signal of the frost detector is lowered. On the other hand, when the temperature of the driving unit 180 decreases, the level of the voltage signal of the frost detector is raised. That is, the voltage signal of the frost detector is inversely proportional to the temperature of the driving unit 180. Data about such variation in the voltage signal of the frost detector caused by variation in the temperature of the driving unit 180 may be experimentally acquired.

The control unit 190 controls operations of the compressor com, valves VV1 and VV2, and fans 151 and 152, based on detection signals from the first and second temperature detectors T1 and T2 representing the temperatures of the refrigerating compartment 121 and freezing compartment 122 respectively. The control unit 190 also controls operation of the driving unit 180, based on the temperatures of the refrigerating compartment 121 and freezing compartment 122 detected by the first and second temperature detectors T1 and T2, respectively, and whether or not each of the compressor com, valves VV1 and VV2, and fans 151 and 152 operates. In accordance with the controlled operation of the driving unit 180, the frost detectors 170 installed on the evaporators 141 and 142 are controlled. The control unit 190 also controls operations of the heaters 161 and 162, based on the amounts of frost detected by the frost detectors 170.

As described above, the control unit 190 includes the A/D converter 191 and controller 192.

The A/D converter 191 converts each of the analog voltage signals sequentially filtered in the filter 182 of the driving unit 180 into a digital signal, and transmits the digital signal to the controller 192. The A/D converter 191 also converts an analog board temperature signal received from the board temperature detector 183 of the driving unit 180 into a digital signal, and transmits the digital signal to the controller 192.

Also, the A/D converter 191 receives, from the first, second, third and fourth temperature detectors T1, T2, T3, and T4, analog compartment temperature signals representing the temperatures of the refrigerating compartment 121 and freezing compartment 122. The A/D converter 191 converts each of the received compartment temperature signals into a digital signal, and transmits the digital signal to the controller 192.

The controller 192 controls operations of the compressor com, fans 151 and 152, and valves VV1 and VV2, based on the temperatures detected by the first and second temperature detectors T1 and T2, to control the refrigeration cycle, and thus to keep each storage compartment at a target temperature.

The controller 192 sequentially transmits drive signals for the plural frost detectors to the driver 181 for a predetermined time when the operation state of one of the compressor com, valves VV1 and VV2, and fans 151 and 152 corresponds to the frost detection point, at which the frost detectors are instructed to be driven.

When the plural frost detectors detect frost, they generate voltage signals, which are in turn converted into digital signals by the A/D converter 191. The controller 192 receives the digital voltage signals from the plural frost detectors via the A/D converter 191.

The frost detection point, at which the frost detectors are instructed to be driven, corresponds to the point of time when a constant state of frost is established. The frost detection point, at which the frost detectors mounted to the refrigerating compartment evaporator 141 are instructed to be driven, is one of the point of time when the operation state of the compressor com is changed to an ON state or an OFF state, the point of time when the operation state of the valve VV1 is changed to an opened state or a closed state, the operation state of the fan 151 is changed to an ON state or an OFF state, and the point of time when a ground potential is changed to a predetermined potential.

On the other hand, the frost detection point, at which the frost detectors mounted to the freezing compartment evaporator 142 are instructed to be driven, is one of the point of time when the operation state of the compressor com is changed to an ON state or an OFF state, the point of time when the operation state of the valve VV2 is changed to an opened state or a closed state, the operation state of the fan 152 is changed to an ON state or an OFF state, and the point of time when the ground potential is changed to a predetermined potential.

When the controller 192 sequentially receives the voltage signals from the frost detectors via the A/D converter 191, starting from the frost detection point, the controller 192 collects sample voltages at regular intervals for a predetermined time. In this case, a plurality of sample voltages are collected for each frost detector. The number of sample voltages may vary in accordance with the position of the temperature sensor in the refrigerator and the temperature condition of the refrigerator.

Hereinafter, operation of instructing the frost detectors to drive for a predetermined time from a frost detection point will be described with reference to FIG. 6.

FIG. 6(a) is a waveform diagram depicting an operation pattern of the compressor com during execution of the refrigeration cycle for the freezing compartment 122. In FIG. 6(a), the period A is a period in which, when the frost detection point corresponds to the point of time when the operation state of the compressor com is changed from an OFF state to an ON state, operation of instructing the frost detectors to be driven for a predetermined time from the point of time when the operation state of the compressor com is changed from an OFF state to an ON state is carried out. On the other hand, in FIG. 6(a), the period B is a period in which, when the frost detection point corresponds to the point of time when the operation state of the compressor com is changed from an ON state to an OFF state, operation of instructing the frost detectors to be driven for a predetermined time from the point of time when the operation state of the compressor com is changed from an ON state to an OFF state is carried out.

FIG. 6(b) is a waveform diagram depicting an operation pattern of the valve VV2 during execution of the refrigeration cycle for the freezing compartment 122. In FIG. 6(b), the period C is a period in which, when the frost detection point corresponds to the point of time when the operation state of the valve VV2 is changed from a closed state to an opened state, operation of instructing the frost detectors to be driven for a predetermined time from the point of time when
the operation state of the valve VV2 is changed from a closed state to an open state is carried out. On the other hand, in FIG. 6(b), the period D is a period in which, when the frost detection point corresponds to the point of time when the operation state of the valve VV2 is changed from an open state to a closed state, operation of instructing the frost detectors to be driven for a predetermined time from the point of time when the operation state of the valve VV2 is changed from an open state to a closed state is carried out.

[0157] The controller 192 may remove offset noise caused by an oscillation signal of the driving unit 180 included in a voltage signal of each frost detector by deducing a voltage of the non-connection terminal CH(n) from a sample voltage of each frost detector.

[0158] The controller 192 may also collect a value representing the temperature of the driving unit 180 whenever the sample voltage of each frost detector is collected, to perform temperature compensation for the sample voltage. In accordance with this temperature compensation, it may be possible to prevent the voltage signal of each frost detector from being varied due to variation in the temperature of the driving unit 180. In this case, the temperature compensation may be achieved using a linear interpolation formula \((r(x1, x2))\).

[0159] The controller 192 calculates an average value of the temperature-compensated sample voltages of each frost detector, and stores the calculated average value as a detection voltage.

[0160] The controller 192 compares the detection voltage of each frost detector with a reference voltage to calculate a difference value between the compared voltages, and compares the difference value with a predetermined reference variation value to determine whether the difference value exceeds the predetermined reference variation value. When the difference value exceeds the predetermined reference variation value, the controller 192 controls the defrosting operation. In this case, the controller 192 controls the defrosting operation for the evaporator, to which the frost detector exhibiting the difference value exceeding the reference variation value is mounted.

[0161] In order to set the reference voltage, the controller 192 determines whether or not the current time corresponds to an initial frost detection point, during execution of a cooling operation for the storage chamber through a refrigeration cycle after supply of electric power to the refrigerator or completion of a defrosting operation. The controller 192 sets, to a reference voltage, a voltage detected by the frost detector at the initial frost detection point. The controller 192 also performs temperature compensation for the voltage detected by the frost detector before setting of the reference voltage. Accordingly, the reference voltage is the temperature-compensated voltage.

[0162] The controller 192 compares the temperatures of the evaporators detected by the third and fourth temperature detectors T3 and T4 with a predetermined defrosting completion temperature. When the temperature of the evaporator, which is currently subjected to a defrosting operation, is equal to or more than the defrosting completion temperature, the controller 192 performs a control operation to complete the defrosting operation.

[0163] FIGS. 7A and 7B are flowcharts illustrating a defrosting control operation of the refrigerator, which is a cooling system, according to an exemplary embodiment. The defrosting control operation will be described in conjunction with a defrosting control operation for the freezing compartment evaporator.

[0164] The defrosting control operation for the freezing compartment evaporator will be described in conjunction with, for example, the case in which one frost detector is mounted to the freezing compartment evaporator, and the frost detection point, at which the frost detector is instructed to be driven, corresponds to the point of time when the operation state of the compressor is changed from an ON state to an OFF state.

[0165] When electric power is supplied or the defrosting operation is completed, the temperature of the freezing compartment becomes higher than a target temperature. In order to lower the temperature of the freezing compartment, the operation state of the compressor com is changed to an ON state. In the ON state, the compressor com compresses refrigerant, and supplies the compressed refrigerant to the freezing compartment evaporator 142 via the condenser.

[0166] In this case, the valve VV2 arranged between the condenser and the freezing compartment evaporator 142 is opened, to allow the refrigerant from the condenser to be supplied to the freezing compartment evaporator 142. Also, the fan 152 arranged in the vicinity of the freezing compartment evaporator 142 rotates to blow air exchanging heat with the evaporator 142 into freezing compartment 122. Thus, a cooling operation to lower the temperature of the freezing compartment 122 is executed (201).

[0167] During the cooling operation for the freezing compartment 122, the temperature of the freezing compartment 122 is detected using the second temperature detector T2. Thereafter, the detected freezing compartment temperature is compared with a target freezing compartment temperature. Based on the results of the comparison, it is determined, while monitoring the operation state of the compressor com (202), whether the current time corresponds to a frost detection point at which the frost detector 170 should be driven (203).

[0168] When the temperature of the freezing compartment 122 reaches the target freezing compartment temperature, the compressor com is stopped. At the same time, the valve VV2 is closed to cut off the supply of refrigerant from the compressor com to the evaporator 142.

[0169] As shown in FIGS. 8(a) and 8(b), when the compressor com is stopped as the temperature of the freezing compartment 122 reaches the target freezing compartment temperature, the controller 192 determines that the current time corresponds to the point of time when the operation state of the compressor com is changed from an ON state to an OFF state, and the determined time point corresponds to a frost detection point. Based on the results of the determination, the controller 192 instructs the frost detector 170 to be driven.

[0170] That is, the controller 192 controls the driver 181 of the driving unit 180 to transmit a drive signal for the frost detector 170, and controls the board temperature detector 183 of the driving unit 180 to detect the temperature of the driving unit 180.

[0171] In this case, the driving unit 180 drives the oscillator (not shown) in accordance with instructions from the controller 192, so as to generate drive power. The drive power generated from the oscillator (not shown) is output to the frost detector 170 through the corresponding connection terminal of the driver 181. The drive power is also output through the non-connection terminal NC of the driver 181.
[0172] Thereafter, a capacitance established between the frost detector 170 and the cooling fin of the freezing compartment evaporator arranged adjacent to the frost detector 170 is detected using the frost detector 170. The frost detector 170 outputs a voltage signal corresponding to the detected capacitance to the corresponding connection terminal of the driver 181.

[0173] The driver 181 receives the voltage signal from the frost detector 170 through the connection terminal. The driver 181 also receives a voltage signal through the non-connection terminal. The voltage signal input to the driver 181 through the non-connection terminal is offset noise caused by the oscillation signal generated during operation of the driving unit 180.

[0174] A filtering operation is then carried out using the filter 182, to filter the voltage signal of the frost detector 170 input through the connection terminal of the driver 181 and the voltage signal input through the non-connection terminal of the driver 181 such that frequency components having a frequency not higher than a predetermined frequency pass through the filter 182. Here, the predetermined frequency is a frequency lower than the frequency of AC signals generated from the oscillator (not shown), namely, the reference frequency.

[0175] The voltage signals filtered in the driving unit 180 are transmitted to the controller 190, to which the temperature signal from the driving unit 180 is also transmitted.

[0176] The filtered voltage signals, which are analog signals, are then converted into digital signals by the A/D converter 191. The board temperature signal from the board temperature detector 183 of the driving unit 180, which is an analog signal, is also converted into a digital signal by the A/D converter 191. The voltage signals and board temperature signal converted in the A/D converter 191 are transmitted to the controller 192.

[0177] Collection of sample voltages is then executed. This operation will be described in detail. When the controller 192 sequentially receives voltage signals of the frost detector 170 from the A/D converter 191, the controller 192 collects sample voltages at regular intervals for a predetermined time from the frost detection point. In this case, the controller 192 also collects board temperature signals of the driving unit 180 corresponding to respective sample voltages (204).

[0178] Thereafter, temperature compensation for the sample voltages is executed using the interpolation formula \((f(x_1, x_2))\) (205). An average value of the temperature-compensated sample voltages is then calculated.

[0179] As shown in FIG. 9(a), the calculation of the average value of the sample voltages may be achieved by calculating an average value of all sample voltages or calculating an average value of 2 or 5 initial ones of the sample voltages, taking into consideration the fact that the voltage signals vary due to state variation of frost occurring during frost detection for a prolonged period of time.

[0180] As shown in FIG. 9(b), the calculation of the average value of the sample voltages may be achieved by calculating an average value of all sample voltages, removing sample voltages different from the calculated average value by about ±20%, and calculating an average value of the remaining sample voltages.

[0181] The average value of the sample voltages is the detection voltage of the frost detector 170. This detection voltage is set to a reference voltage (206). The detection voltage corresponds to the amount of frost formed on the freezing compartment evaporator during one refrigeration cycle executed after supply of electric power to the refrigerator or completion of a defrosting operation.

[0182] Thereafter, the temperature of the freezing compartment 122 is detected by the second temperature detector T2 in a state in which the compressor com and fan 152 are in an OFF state, and the valve VV2 is in a closed state. It is then determined whether the detected temperature of the freezing compartment 122 is equal to or higher than an operation required temperature (207), so as to determine whether or not a cooling operation for the freezing compartment 122 is required.

[0183] When the temperature of the freezing compartment 122 is lower than the operation required temperature, the current state is maintained. On the other hand, when the temperature of the freezing compartment 122 is equal to or higher than the operation required temperature, the compressor com is driven. In accordance with the driving of the compressor com, refrigerant compressed by the compressor com is supplied to the evaporator 142 via the condenser.

[0184] In this case, the valve VV2 arranged between the condenser and the freezing compartment evaporator 142 is opened to allow the refrigerant from the condenser to be supplied to the freezing compartment evaporator 142. The fan 152 also rotates to blow air exchanging heat with the evaporator 142 to the freezing compartment 122. Thus, a cooling operation to lower the temperature of the freezing compartment 122 is executed (208).

[0185] During the cooling operation for the freezing compartment 122, the temperature of the freezing compartment 122 detected by the second-temperature detector T2 is compared with the target freezing compartment temperature. Based on the results of the comparison, it is determined, while monitoring the operation state of the compressor com (209), whether the current time corresponds to a frost detection point at which the frost detector 170 should be driven (210).

[0186] When the temperature of the freezing compartment 122 reaches the target freezing compartment temperature, the compressor com is stopped. At the same time, the valve VV2 is closed to cut off the supply of refrigerant from the compressor com to the evaporator 142.

[0187] When the compressor com is stopped as the temperature of the freezing compartment 122 reaches the target freezing compartment temperature, the controller 192 determines that the current time corresponds to a frost detection point when the operation state of the compressor com is changed from an ON state to an OFF state, and the determined time point corresponds to a frost detection point. Based on the results of the determination, the controller 192 instructs the frost detector 170 to be driven.

[0188] That is, the controller 192 controls the driver 181 of the driving unit 180 to transmit a drive signal for the frost detector 170, and controls the board temperature detector 183 of the driving unit 180 to detect the temperature of the driving unit 180.

[0189] In this case, the driving unit 180 drives the oscillator (not shown) in accordance with instructions from the controller 192, so as to generate drive power. The drive power generated from the oscillator (not shown) is output to the frost detector 170 through the corresponding connection terminal of the driver 181. The drive power is also output through the non-connection terminal NC of the driver 181.

[0190] Thereafter, a capacitance established between the frost detector 170 and the cooling fin of the freezing compartment evaporator arranged adjacent to the frost detector 170 is
detected using the frost detector 170. The frost detector 170 outputs a voltage signal corresponding to the detected capacitance to the corresponding connection terminal of the driver 181.

[0191] The driver 181 receives the voltage signal from the frost detector 170 through the connection terminal. The driver 181 also receives a voltage signal through the non-connection terminal. The voltage signal input to the driver 181 through the non-connection terminal is offset noise caused by an oscillation signal generated during operation of the driving unit 180.

[0192] A filtering operation is then carried out using the filter 182, to filter the voltage signal of the frost detector 170 input through the connection terminal of the driver 181 and the voltage signal input through the non-connection terminal of the driver 181 such that frequency components having a frequency not higher than a predetermined frequency pass through the filter 182. Here, the predetermined frequency is a frequency lower than the frequency of AC signals generated from the oscillator (not shown), namely, the reference frequency.

[0193] The voltage signals filtered in the driving unit 180 are transmitted to the control unit 190, to which the temperature signal from the driving unit 180 is also transmitted.

[0194] The filtered voltage signals, which are analog signals, are then converted into digital signals by the A/D converter 191. The board temperature signal from the board temperature detector 183 of the driving unit 180, which is an analog signal, is also converted into a digital signal by the A/D converter 191. The voltage signals and board temperature signal converted in the A/D converter 191 are transmitted to the controller 192.

[0195] Collection of sample voltages is then executed. When the controller 192 sequentially receives voltage signals of the frost detector 170 from the A/D converter 191, the controller 192 collects sample voltages at regular intervals for a predetermined time from the frost detection point. In this case, the controller 192 also collects board temperature signals of the driving unit 180 corresponding to respective sample voltages (211).

[0196] Thereafter, temperature compensation for the sample voltages is executed using the interpolation formula \( f(x_1, x_2) \) (212). An average value of the temperature-compensated sample voltages is then calculated.

[0197] The average value of the sample voltages is the detection voltage of the frost detector 170. The detection voltage corresponds to the amount of frost formed on the freezing compartment evaporator.

[0198] Since an offset noise signal can be removed, and a signal variation caused by variation in the temperature of the driving unit can be removed, it may be possible to acquire only a voltage signal corresponding to a capacitance established in accordance with the amount of frost formed on the cooling fin of the freezing compartment evaporator.

[0199] In addition, it may be possible to achieve more accurate temperature compensation by increasing the degree of the interpolation formula. It may also be possible to determine variation in the voltage signal of the frost detector depending on the operation required temperature of the refrigerator (−5 to 43°C), and to store the determined voltage signal variation, so as to subsequently use the stored data.

[0200] Thereafter, the detection voltage is compared with the reference voltage to calculate a difference therebetween (213). The difference is then compared with a predetermined reference variation, to determine whether the difference exceeds the reference variation (214). When the difference exceeds the reference variation, the heater 162 is driven for execution of a defrosting operation (215). On the other hand, when the difference does not exceed the reference variation, the refrigeration cycle for the freezing compartment 122 is periodically executed to perform a cooling operation for the freezing compartment 122.

[0201] Thereafter, the temperature of the freezing compartment evaporator 142 is detected by the fourth temperature detector 144 during the defrosting operation (216). The detected temperature of the freezing compartment evaporator 142 is then compared with a predetermined defrosting completion temperature (217). When the temperature of the freezing compartment evaporator 142, which executes the defrosting operation, is equal to or higher than the defrosting completion temperature, the heater 162 is turned off to complete the defrosting operation (218). In this case, the defrosting completion temperature of the freezing compartment evaporator 142 is about 8 to 12°C.

[0202] After a predetermined idle period (about 10 minutes) elapses, the temperature of the freezing compartment 122 is detected by the second temperature detector 122. It is then determined whether the detected temperature of the freezing compartment 122 is equal to or higher than the operation required temperature, to determine whether or not a cooling operation for the freezing compartment 122 is required. When the temperature of the freezing compartment 122 is lower than the operation required temperature, the current state is maintained. On the other hand, when the temperature of the freezing compartment 122 is equal to or higher than the operation required temperature, the compressor 140 is driven. Refrigerant compressed in accordance with the driving of the compressor 140 is supplied to the evaporator 142 via the condenser. In this case, the reference voltage is again set through operations 201 to 206, and a defrosting operation is subsequently executed.

[0203] The above-described defrosting control method for the freezing compartment evaporator is applied to the defrosting control method for the refrigerating compartment evaporator in the same manner.

[0204] Thus, it may be possible to optimize a defrosting operation by accurately detecting the amount of frost formed on each evaporator, and executing and completing the defrosting operation at appropriate points of time determined based on the accurately-detected frost amount. It may also be possible to minimize power consumption. This will be described with reference to FIG. 10.

[0205] FIG. 10 is a graph depicting power consumption of a conventional refrigerator and the refrigerator according to the illustrated embodiment according to time.

[0206] The conventional refrigerator executes a defrosting operation 4 times for the freezing compartment and 7 times for the refrigerating compartment during 136 hours. On the other hand, the refrigerator according to the embodiment executes a defrosting operation once for the freezing compartment (for about 69 hours) and once for the refrigerating compartment (for about 98 hours) during 136 hours. Referring to FIG. 10, it can be seen that the refrigerator according to one or more embodiments exhibits an improvement in power consumption efficiency corresponding to 8.1%.

[0207] Hereinafter, a refrigerator, which is a cooling system according to another embodiment, will be described with reference to FIGS. 1 to 5.
The features of constituent elements included in this refrigerator are the same as those of the refrigerator according to the previous embodiment, except for the frost detectors 170 and the controller 192 of the control unit 190. Accordingly, no description will be given of identical constituent elements.

Also, the descriptions of the frost detectors 170 and the controller 192 of the control unit 190, which are the same as those of the previous embodiment, will be omitted.

Taking into consideration the fact that variation in dielectric constant occurs due to variation in the state of frost, each frost detector 170 detects the amount of frost at the point of time when a predetermined frost detection environmental condition, namely, a condition that a constant state of frost is established, is established (hereinafter, referred to as “frost detection point”). Accordingly, it may be possible to enhance frost detection accuracy.

That is, the frost detector 170 operates at the point of time corresponding to the frost detection point in accordance with instructions from the controller 192, to detect an amount of frost. The frost detection point is set based on the temperature of each storage compartment provided at the refrigerator.

In detail, the frost detection point, at which the frost detector to detect frost formed on the refrigerating compartment evaporator 141 is instructed to be driven, is one of the point of time when the temperature of the refrigerating compartment 121 reaches a predetermined maximum temperature or minimum temperature and the point of time when the temperature of the refrigerating compartment 121 reaches a predetermined temperature.

On the other hand, the frost detection point, at which the frost detector to detect frost formed on the freezing compartment evaporator 142 is instructed to be driven, is one of the point of time when the temperature of the freezing compartment 122 reaches a predetermined maximum temperature or minimum temperature and the point of time when the temperature of the freezing compartment 122 reaches a predetermined temperature. Here, the minimum and maximum temperatures are predetermined temperatures, respectively.

When the temperature of one of the storage compartments corresponds to a frost detection point, the controller 192 of the control unit 190 sequentially transmits, to the driving unit 181, drive signals for a plurality of frost detectors installed for the storage compartment. When voltage signals from the frost detectors are transmitted to the controller 192 after being converted into digital signals via the A/D converter 191, the controller 192 deducts a voltage signal output from the non-connection terminal CH(0) of the driver 181 from the voltage signal of each frost detector. Thus, offset noise caused by an oscillation signal from the driving unit 180 may be removed from the voltage signal of each frost detector.

In this case, the point of time when each frost detector is instructed to be driven is one of the point of time when the temperature of one of the storage compartments 121 and 122 corresponds to a predetermined maximum temperature or minimum temperature and the point of time when the temperature of one of the storage compartments 121 and 122 corresponds to a predetermined temperature. This will be described with reference to FIG. 11.

FIG. 11 is a graph depicting a temperature variation pattern of the freezing compartment 122 exhibited during execution of a refrigeration cycle for the freezing compartment 122. In FIG. 11, the period F is a period in which each frost detector for the freezing compartment 122 is instructed to be driven for a predetermined time from the point of time when the temperature of the freezing compartment 122 corresponds to a predetermined maximum temperature. The period F is a period in which each frost detector for the freezing compartment 122 is instructed to be driven for a predetermined time from the point of time when the temperature of the freezing compartment 122 corresponds to a predetermined minimum temperature. The period G is a period in which each frost detector for the freezing compartment 122 is instructed to be driven for a predetermined time from the point of time when the temperature of the freezing compartment 122 corresponds to a predetermined temperature (for example, -15°C).

FIGS. 12A and 12B are flowcharts illustrating a defrosting control operation of the refrigerator, which is a cooling system, according to another embodiment of the defrosting control operation will be described in conjunction with a defrosting control operation for the freezing compartment evaporator.

The defrosting control operation for the freezing compartment evaporator will be described in conjunction with, for example, the case in which one frost detector 170 is mounted to the freezing compartment evaporator, and the frost detection point, at which the frost detector 170 is instructed to be driven, corresponds to the point of time when the temperature of the freezing compartment reaches a predetermined temperature (for example, -15°C).

When electric power is supplied or defrosting operation is completed, the temperature of the freezing compartment 122 becomes higher than a target temperature. In order to lower the temperature of the freezing compartment 122, a cooling operation is carried out by operating the compressor 101 to discharge refrigerant, opening the valve V2 arranged between the condenser and the freezing compartment evaporator 142 to supply the refrigerant from the condenser to the freezing compartment evaporator 142, and rotating the fan 152 arranged near the freezing compartment evaporator 142 to blow air exchanging heat with the freezing compartment evaporator 142 to the freezing compartment 122 (301).

During the cooling operation for the freezing compartment 122, the temperature of the freezing compartment 122 is detected using the second temperature detector 72.

It is then determined, while monitoring the temperature of the freezing compartment 122 (302), whether the temperature of the freezing compartment 122 reaches a predetermined temperature, so as to determine whether the current time corresponds to a frost detection point at which the frost detector 170 should be driven (303). It is also determined, while monitoring the temperature of the freezing compartment 122 (302), whether the temperature of the freezing compartment 122 reaches a target temperature (about -18°C).

When the temperature of the freezing compartment 122 reaches the predetermined temperature, the controller 192 determines that the current time corresponds to the frost detection point, and instructs the frost detector 170 to be driven.

That is, the controller 192 controls the driver 181 of the driving unit 180 to transmit a drive signal for the frost detector 170, and controls the board temperature detector 183 of the driving unit 180 to detect the temperature of the driving unit 180.
Thereafter, a capacitance established between the frost detector 170 and the cooling fin of the freezing compartment evaporator arranged adjacent to the frost detector 170 is detected using the frost detector 170. The frost detector 170 outputs a voltage signal corresponding to the detected capacitance to the corresponding connection terminal of the driver 181.

The driver 181 receives the voltage signal from the frost detector 170 through the connection terminal. The driver 181 also receives a voltage signal through the non-connection terminal. The voltage signal input to the driver 181 through the non-connection terminal is offset noise caused by an oscillation signal generated during operation of the driving unit 180.

A filtering operation is then carried out using the filter 182, to filter the voltage signal of the frost detector 170 input through the connection terminal of the driver 181 and the voltage signal input through the non-connection terminal of the driver 181 such that frequency components having a frequency not higher than a predetermined frequency pass through the filter 182.

The voltage signals filtered in the driving unit 180 are transmitted to the control unit 190, to which the temperature signal from the driving unit 180 is also transmitted.

The filtered voltage signals, which are analog signals, are then converted into digital signals by the A/D converter 191. The board temperature signal from the board temperature detector 183 of the driving unit 180, which is an analog signal, is also converted into a digital signal by the A/D converter 191. The voltage signals and board temperature signal converted in the A/D converter 191 are transmitted to the controller 192.

Collection of sample voltages is then executed. This operation will be described in detail. When the controller 192 receives voltage signals of the frost detector 170 from the A/D converter 191, the controller 192 collects sample voltages at regular intervals for a predetermined time from the frost detection point. In this case, the controller 192 also collects board temperature signals of the driving unit 180 corresponding to respective sample voltages (304).

Thereafter, temperature compensation for the sample voltages is executed using the interpolation formula \( f(x_1, x_2) \) (305). An average value of the temperature-compensated sample voltages is then calculated.

The average value of the sample voltages is a detection voltage of the frost detector 170. This detection voltage is set to a reference voltage (306). The detection voltage corresponds to the amount of frost formed on the freezing compartment evaporator until the temperature of the freezing compartment initially reaches the predetermined temperature after supply of electric power to the refrigerator or completion of a defrosting operation.

When the temperature of the freezing compartment 122 is lower than the target temperature of the freezing compartment 122 (307), the cooling operation for the freezing compartment 122 is completed by stopping the compressor com, and closing the valve VV2 to cut off the refrigerant supplied from the compressor com to the evaporator 142 (308).

Thereafter, the temperature of the freezing compartment 122 is detected by the second temperature detector 12, to determine whether the detected temperature of the freezing compartment 122 is equal to or higher than an operation required temperature (309), so as to determine whether or not a cooling operation for the freezing compartment 122 is required.

When the temperature of the freezing compartment 122 is lower than the operation required temperature, the current state is maintained. On the other hand, when the temperature of the freezing compartment 122 is equal to or higher than the operation required temperature, the compressor com is driven. In accordance with the driving of the compressor com, refrigerant compressed by the compressor com is supplied to the evaporator 142 via the condenser. Also, the valve VV2 arranged between the condenser and the freezing compartment evaporator 142 is opened to allow the refrigerant from the condenser to be supplied to the freezing compartment evaporator 142. The fan 152 also rotates to blow air exchanging heat with the evaporator 142 to the freezing compartment 122. Thus, a cooling operation to lower the temperature of the freezing compartment 122 is executed (310).

During the cooling operation for the freezing compartment 122, the temperature of the freezing compartment 122 is detected using the second temperature detector T2.

It is then determined, while monitoring the temperature of the freezing compartment 122 (311), whether the temperature of the freezing compartment 122 reaches the predetermined temperature, so as to determine whether the current time corresponds to a frost detection point at which the frost detector 170 should be driven (312). It is also determined whether the temperature of the freezing compartment 122 reaches the target temperature.

When the temperature of the freezing compartment 122 reaches the predetermined temperature, the controller 192 determines that the current time corresponds to the frost detection point, and instructs the frost detector 170 to be driven for a predetermined time, as shown in FIG. 13.

That is, the controller 192 controls the driver 181 of the driving unit 180 to transmit a drive signal for the frost detector 170, and controls the board temperature detector 183 of the driving unit 180 to detect the temperature of the driving unit 180.

Thereafter, a capacitance established between the frost detector 170 and the cooling fin of the freezing compartment evaporator arranged adjacent to the frost detector 170 is detected using the frost detector 170. The frost detector 170 outputs a voltage signal corresponding to the detected capacitance to the corresponding connection terminal of the driver 181.

The driver 181 receives the voltage signal from the frost detector 170 through the connection terminal. The driver 181 also receives a voltage signal through the non-connection terminal. The voltage signal input to the driver 181 through the non-connection terminal is offset noise caused by an oscillation signal generated during operation of the driving unit 180.

A filtering operation is then carried out using the filter 182, to filter the voltage signal of the frost detector 170 input through the connection terminal of the driver 181 and the voltage signal input through the non-connection terminal of the driver 181 such that frequency components having a frequency not higher than a predetermined frequency pass through the filter 182.

The voltage signals filtered in the driving unit 180 are transmitted to the control unit 190, to which the temperature signal from the driving unit 180 is also transmitted.
The filtered voltage signals, which are analog signals, are then converted into digital signals by the A/D converter 191. The board temperature signal from the board temperature detector 183 of the driving unit 180, which is an analog signal, is also converted into a digital signal by the A/D converter 191. The voltage signals and board temperature signal converted in the A/D converter 191 are transmitted to the controller 192.

Collection of sample voltages is then executed. This operation will be described in detail. When the controller 192 receives voltage signals of the frost detector 170 from the A/D converter 191, the controller 192 collects sample voltages at regular intervals for a predetermined time from the frost detection point. In this case, the controller 192 also collects board temperature signals of the driving unit 180 corresponding to respective sample voltages (313).

Thereafter, temperature compensation for the sample voltages is executed using the interpolation formula \( f(x_1, x_2) \) (314). An average value of the temperature-compensated sample voltages is then calculated. The average value of the sample voltages is a detection voltage of the frost detector 170. The detection voltage corresponds to the amount of frost formed on the freezing compartment evaporator.

Thereafter, the detection voltage is compared with the reference voltage to calculate a difference therebetween (315). The difference is then compared with a predetermined reference variation, to determine whether the difference exceeds the reference variation (316). When the difference exceeds the reference variation, a defrosting operation is executed by turning off the compressor and fan 152, closing the valve VV2, and subsequently turning on the heater 162 (317). On the other hand, when the difference does not exceed the reference variation, the refrigeration cycle for the freezing compartment 122 is periodically executed to perform a cooling operation for the freezing compartment 122.

On the other hand, when the temperature of the freezing compartment 122 reaches the target temperature under the condition that the difference does not exceed the reference variation, the compressor and fan are stopped, and the valve VV2 is closed to cut off the supply of refrigerant from the compressor to the evaporator 142. The refrigeration cycle is then executed based on the temperature of the freezing compartment until the difference does not exceed the reference variation.

Thereafter, the temperature of the freezing compartment evaporator 142 is detected by the fourth temperature detector T4 during the defrosting operation (318). The detected temperature of the freezing compartment evaporator 142 is then compared with a predetermined defrosting completion temperature (319). When the temperature of the freezing compartment evaporator 142, which executes the defrosting operation, is equal to or higher than the defrosting completion temperature, the heater 162 is turned on to complete the defrosting operation (320). In this case, the defrosting completion temperature of the freezing compartment evaporator 142 is set at about 8 to 12°C.

After a predetermined idle period (about 10 minutes) elapses, the temperature of the freezing compartment 122 is detected by the second temperature detector T2. It is then determined whether the detected temperature of the freezing compartment 122 is equal to or higher than the operation required temperature. When the temperature of the freezing compartment 122 is lower than the operation required temperature, the current state is maintained. On the other hand, when the temperature of the freezing compartment 122 is equal to or higher than the operation required temperature, the compressor is driven. Refrigerant compressed in accordance with the driving of the compressor is supplied to the evaporator 142 via the condenser. In this case, the reference voltage is again set through operations 301 to 306, and a defrosting operation is subsequently executed.

The above-described defrosting control method for the freezing compartment evaporator is applied to the defrosting control method for the refrigerating compartment evaporator in the same manner.

Thus, it may be possible to optimize a defrosting operation by accurately detecting the amount of frost formed on each evaporator, and executing and completing the defrosting operation at appropriate points of time determined based on the accurately-detected frost amount. It may also be possible to minimize power consumption.

Although a few embodiments have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. A cooling system comprising:
   a. at least one evaporator to exchange heat with air;
   b. a frost detector installed on the evaporator to detect frost;
   and
   c. a control unit to determine whether the current time corresponds to a frost detection point, to control the frost detector to operate when the current time corresponds to the frost detection point, and to control a defrosting operation based on a frost detection signal from the frost detector.

2. The cooling system according to claim 1, wherein the frost detection point is a point of time when a constant state of the frost is exhibited whenever the frost detector operates.

3. The cooling system according to claim 2, wherein:
   a. the frost detector detects a capacitance established between the frost detector and a cooling fin provided on the evaporator, and outputs a voltage signal corresponding to the detected capacitance;
   and
   b. the point of time when the constant state of the frost is exhibited is a point of time when the capacitance is constant.

4. The cooling system according to claim 1, further comprising:
   a. a storage chamber to be cooled in accordance with the heat exchange of the evaporator; and
   b. a chamber temperature detector to detect a temperature of the storage chamber.

5. The cooling system according to claim 1, further comprising:
   a. a storage chamber to be cooled in accordance with the heat exchange of the evaporator; and
   b. a chamber temperature detector to detect a temperature of the storage chamber.
6. The cooling system according to claim 1, further comprising:
   a storage chamber to be cooled in accordance with the heat exchange of the evaporator; and
   a chamber temperature detector to detect a temperature of the storage chamber,
   wherein the frost detection point is a point of time when the temperature of the storage chamber reaches a predetermined minimum temperature.

7. The cooling system according to claim 1, further comprising:
   a compressor to supply compressed refrigerant to the evaporator,
   wherein the frost detection point is a point of time when an operation state of the compressor is changed.

8. The cooling system according to claim 1, further comprising:
   a valve to adjust flow of refrigerant to the evaporator,
   wherein the frost detection point is a point of time when an operation state of the valve is changed.

9. The cooling system according to claim 1, further comprising:
   a fan to circulate the air exchanging heat with the evaporator,
   wherein the frost detection point is a point of time when an operation state of the fan is changed.

10. The cooling system according to claim 1, further comprising:
    a ground terminal,
    wherein the frost detection point is a point of time when a potential of the ground terminal reaches a predetermined potential.

11. The cooling system according to claim 1, wherein the control unit collects a plurality of sample voltages at regular intervals for a predetermined time from the frost detection point during the operation of the frost detector.

12. The cooling system according to claim 11, wherein the control unit calculates an average value of the sample voltages, and stores the calculated average value as a detection voltage.

13. The cooling system according to claim 12, wherein the control unit compares the detection voltage with a reference voltage to calculate a difference between the detection voltage and the reference voltage, compares the difference with a predetermined reference variation value, and controls the defrosting operation when the difference exceeds the predetermined reference variation value.

14. The cooling system according to claim 13, wherein the reference voltage is a detection voltage stored during an initial refrigeration cycle executed after power is initially supplied.

15. The cooling system according to claim 13, wherein the reference voltage is a detection voltage stored during a next refrigeration cycle executed after the defrosting operation is completed.

16. The cooling system according to claim 1, further comprising:
    an evaporator temperature detector to detect a temperature of the evaporator,
    wherein the control unit controls completion of the defrosting operation based on the temperature of the evaporator detected during the defrosting operation.

17. The cooling system according to claim 1, further comprising:
    a driving unit including a driver to output a drive signal to the frost detector in accordance with instructions from the control unit and to receive the detection signal from the frost detector, and a board temperature detector to detect a temperature of the driving unit,
    wherein the control unit executes temperature compensation for the detection signal from the frost detector based on the temperature of the driving unit.

18. The cooling system according to claim 17, wherein:
    the driving unit receives the detection signal from the frost detector through a connection terminal, to which the frost detector is connected, while receiving a noise signal through a non-connection terminal, to which the frost detector is not connected; and
    the control unit deducts the noise signal from the detection signal.

19. The cooling system according to claim 17, wherein the driving unit further includes a filter to filter the detection signal from the frost detector such that low frequency components of the detection signal pass through the filter.

20. The cooling system according to claim 1, wherein the control unit further has a function to convert the detection signal from the frost detector into a digital signal.

21. The cooling system according to claim 1, wherein the at least one evaporator comprises at least one of a refrigerating compartment evaporator, a freezing compartment evaporator, and an ice making compartment evaporator.

22. A control method of a cooling system including a frost detector to detect frost formed on an evaporator, comprising:
    determining whether a current time corresponds to a predetermined frost detection point,
    operating the frost detector when the current time corresponds to the predetermined frost detection point, thereby detecting the frost; and
    controlling a defrosting operation based on a detection signal generated through the frost detector.

23. The control method according to claim 22, wherein the frost detection point is a point of time when a temperature of a storage chamber cooled by air exchanging heat with the evaporator reaches one of a predetermined maximum temperature and a predetermined minimum temperature.

24. The control method according to claim 22, wherein the frost detection point is a point of time when an operation state of one of a compressor to supply compressed refrigerant to the evaporator, a valve to adjust flow of the refrigerant supplied to the evaporator and a fan to circulate the air exchanging heat with the evaporator is changed.

25. The control method according to claim 22, wherein the frost detection point is a point of time when a potential of a ground terminal provided at the cooling system reaches a predetermined potential.

26. The control method according to claim 22, further comprising:
    collecting a plurality of sample voltages from the detection signal generated during the operation of the frost detector.

27. The control method according to claim 26, further comprising:
    calculating an average value of the sample voltages; and
    storing the calculated average value as a detection voltage.
28. The control method according to claim 27, wherein the storing the calculated average value as the detection voltage comprises setting the detection voltage to a reference voltage if the detection voltage is a detection voltage stored during a refrigeration cycle initially executed after power is initially supplied.

29. The control method according to claim 28, wherein the storing the calculated average value as the detection voltage comprises again setting the detection voltage to the reference voltage if the detection voltage is a detection voltage stored during a refrigeration cycle initially executed after completion of the defrosting operation.

30. The control method according to claim 22, wherein the controlling the defrosting operation based on the detection signal comprises:
calculating a difference between the detection voltage and a predetermined reference voltage;
comparing the difference with a reference variation value;
executing the defrosting operation when the difference exceeds the reference variation value; and
executing a next refrigeration cycle when the difference does not exceed the reference variation value.

31. The control method according to claim 22, wherein the controlling the defrosting operation comprises:
detecting a temperature of the evaporator during the defrosting operation; and
completing the defrosting operation when the temperature of the evaporator is equal to or higher than a predetermined defrosting completion temperature.

32. The control method according to claim 22, further comprising:
detecting a temperature of a driving unit to operate the frost detector; and
executing temperature compensation for the detection signal based on the temperature of the driving unit.

33. The control method according to claim 22, wherein the operating the frost detector comprises:
outputting a drive signal through a connection terminal to which the frost detector is connected;
receiving the detection signal from the frost detector through the connection terminal;
outputting a drive signal through a non-connection terminal to which the frost detector is not connected;
receiving a noise signal from the non-connection terminal; and
removing a component corresponding to the noise signal from the detection signal.

34. The control method according to claim 22, wherein the detecting the frost comprises:
detecting a capacitance established between the frost detector and a cooling fin provided at the evaporator and arranged adjacent to the frost detector; and
outputting a voltage signal corresponding to the detected capacitance.

35. The cooling system according to claim 1, wherein the frost detector includes a first electrode to detect frost formed between the first electrode and the cooling fin provided at the evaporator, a first insulator arranged in contact with the first electrode, a second electrode arranged in contact with the first insulator, and a second insulator arranged in contact with the second electrode.

36. The cooling system according to claim 35, wherein the first insulator includes an exposed portion around the first electrode, the second electrode extends around the exposed portion of the first insulator to surround the exposed portion of the first insulator so that an insulation gap is formed between the second electrode and the first electrode to insulate the second electrode from the first electrode.

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