Automotive Training Manual

AUTOMATIC AIR CONDITIONER

STEP 3

mazda

AUTOMATIC AIR CONDITIONER

FORWARD

Because the field of automotive service is an ever-advancing and demanding profession, Mazda Motor Corporation has prepared this Automotive Training Manual (ATM) series to help its technicians, new and experienced, attain a higher degree of technical skills.
Thus, as you progress through the three-step Mazda Technician Certificate of Honor (MATCH) program, use these textbooks and related materials to their fullest for your advancement, Mazda s advancement, and improve customer satisfaction.

The objectives and points of training set out in this ATM are as shown below.

Objective
To teach the basic construction, control, and operation of the auto air conditioner system.

Points of training
After studying this textbook, the trainee should have a full understanding of the following. He should also be able to perform related inspections and repairs based on this understanding when the appropriate workshop manual is used.

Auto air conditioner types
Auto air conditioner major components
Auto air conditioner control systems
Troubleshooting

CONTENTS

OUTLINE

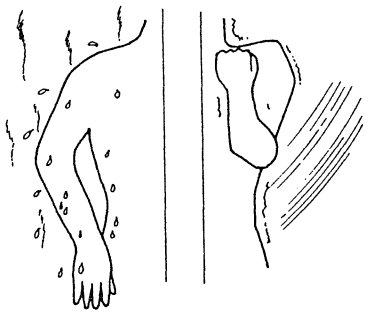
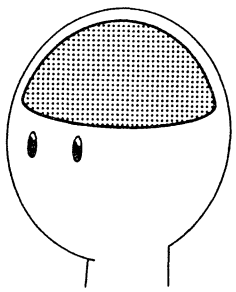
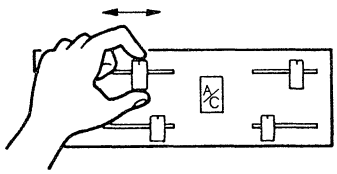
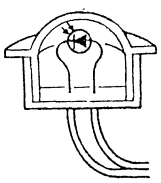
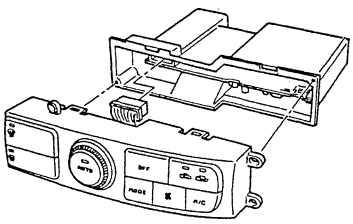
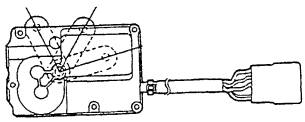
AIR CONDITIONER PRINCIPALS

To create a pleasant climate within the passenger compartment, it is necessary not only to operate the air conditioner and heater, but also to control airflow temperature, airflow volume, airflow mode, air intake mode, and ON/OFF of the A/C compressor, all in accordance with the passenger compartment's environment.

Furthermore, because of variations in the passenger compartment's environment, we must continuously control these systems. This is not an easy task. These controls depend on how the passenger feels. This feeling is not outside air temperature, but the temperature which is felt by the passenger. For example, the passenger does not immediately become aware of high temperature, even if outside air temperature rises. However, when high temperature finally makes the passenger hot, he will turn the air conditioner to its most powerful setting. In short, whenever the passenger feels uncomfortable, he controls air conditioner.

The system just described is for a manually-controlled air conditioner. On the other hand, an auto air conditioner can avoid troublesome control and can make the passenger compartment comfortable.

For an auto air conditioning system : the sensors take the place of our feeling, and detect the air temperature ; the A/C amplifier takes the place of our brain, and controls the system operation; the actually takes the place of our hands, and adjusts the power. By way of these passenger compartment temperature sensors, we can avoid manual control. Other than this, we can also install ambient temperature sensor, solar radiation sensor, and water temperature sensor. These systems can sense a change of temperature, and they adjust the temperature before we even start to feel uncomfortable. Because of this, we can maintain a comfortable temperature in the passenger compartment.

TYPE	INPUT	CONTROL	OUTPUT
MANUAL AIR CONDITIONER	BODY TEMPERATURE 	BRAIN 	HAND 
AUTO AIR CONDITIONER	SENSOR 	A/C AMPLIFIER 	ACTUATOR etc. 

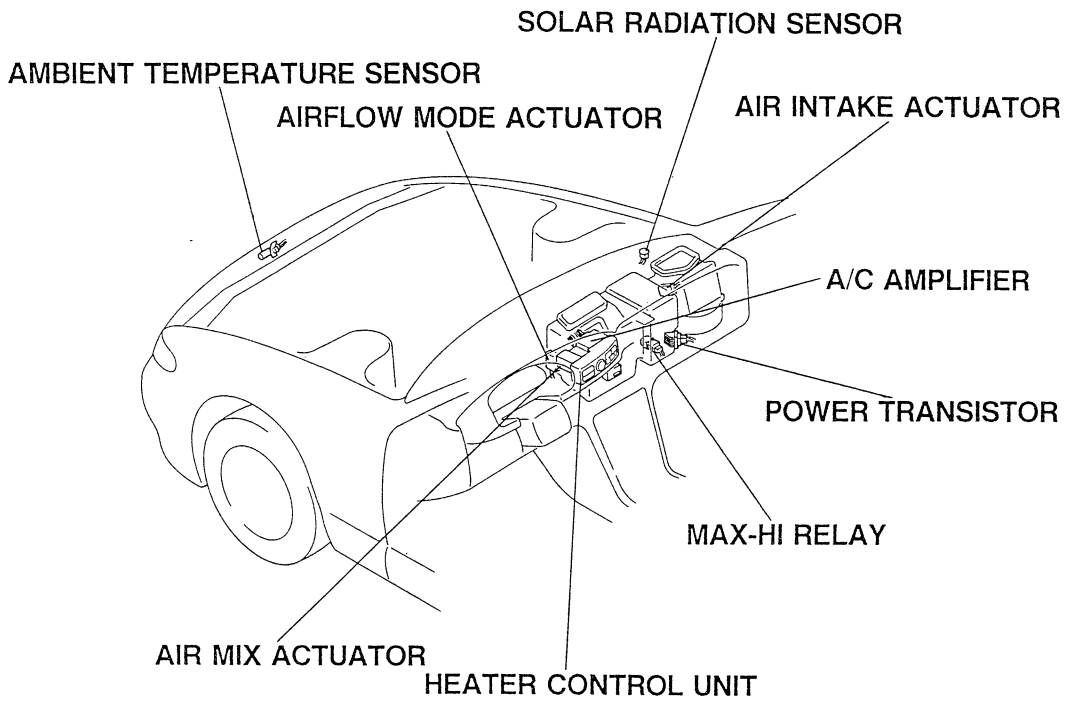
TYPES OF FULL-AUTO AIR CONDITIONER

Auto air conditioners can be classified roughly into semi-auto air conditioner and full-auto air conditioner. Throughout this manual, we will base explanations on the full-auto air conditioner, since the full-auto air conditioner covers all areas.

AUTOMATIC CONTROL	FULL-AUTO AIR CONDITIONER	SEMI-AUTO AIR CONDITIONER
AIRFLOW TEMPERATURE	○	○
AIRFLOW VOLUME	○	○
AIRFLOW MODE	○	×
AIR INTAKE	○	×
A/C COMPRESSOR	○	×

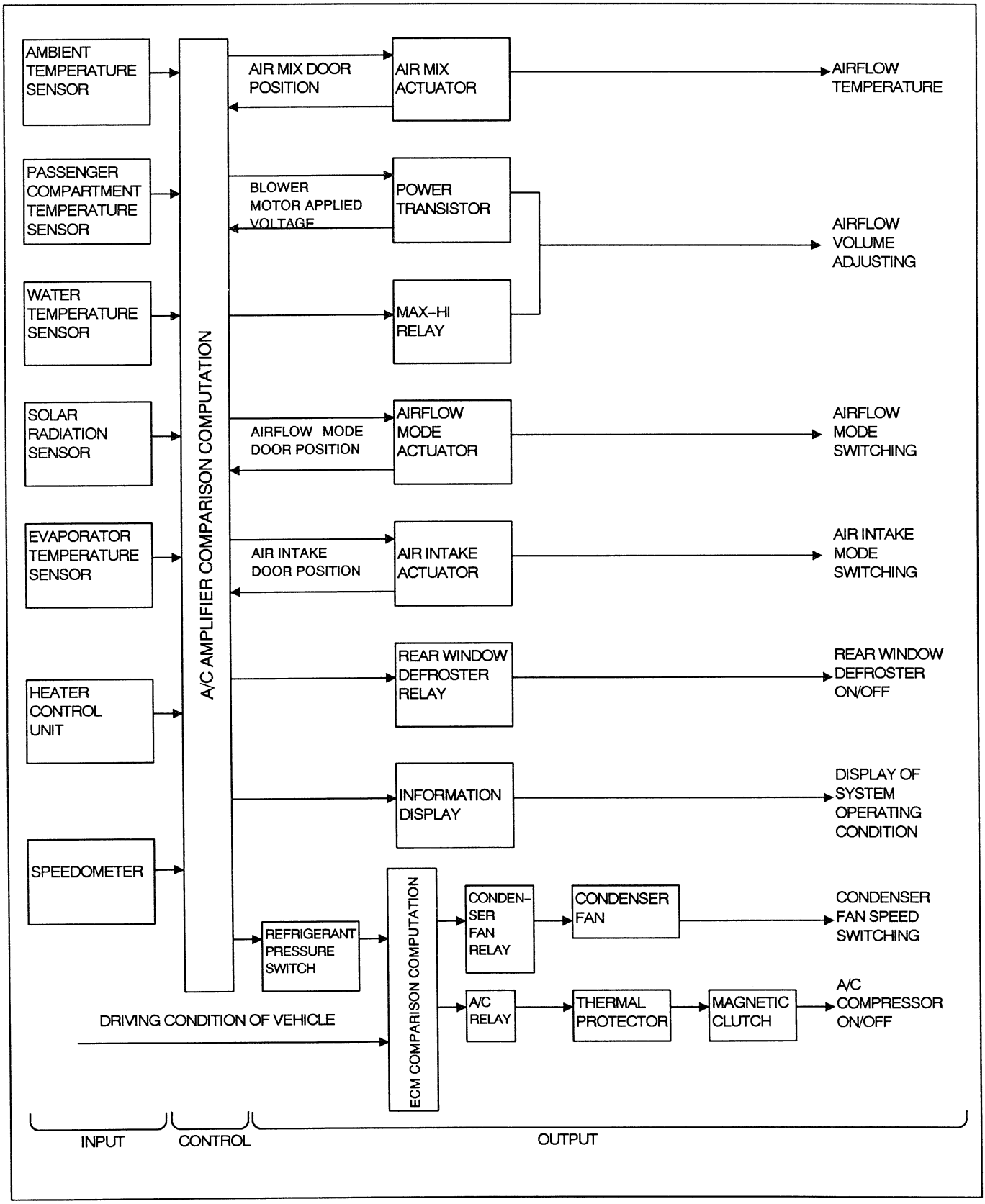
COMPONENTS OF FULL-AUTO AIR CONDITIONER

The components of full-auto air conditioner are as follows.



SEQUENCE FLOW OF AUTO AIR CONDITIONER

The sequence flow chart of the full-auto air conditioner's inputs, controls, and outputs are as follows.



MAJOR COMPONENTS

Let's look at the structure and operation of the main components of the full-auto air conditioner.

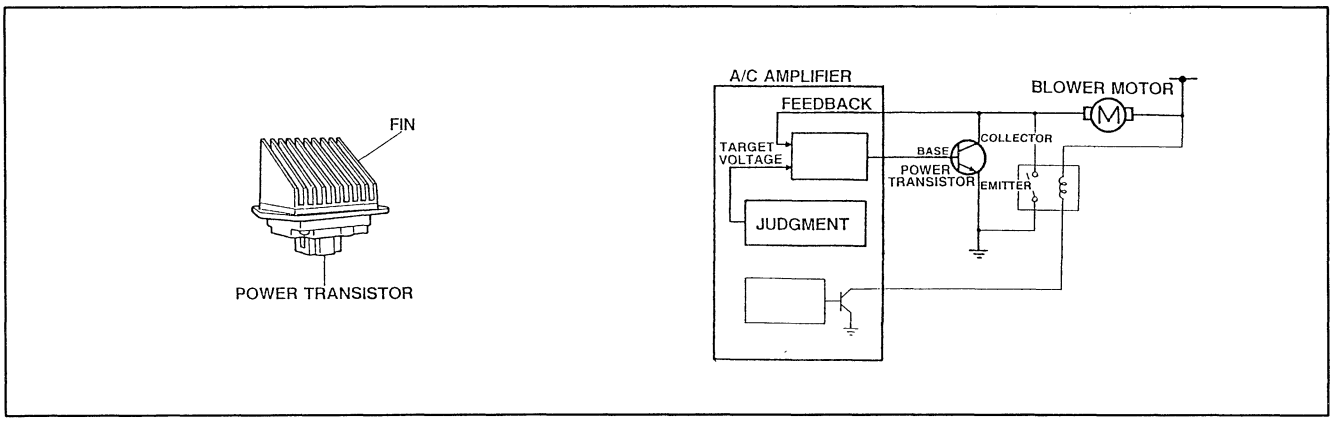
POWER TRANSISTOR

The power transistor can control huge electrical power, and plays a main role in blower motor speed control.

The power transistor is an amplifier which can draw a strong electric current (collector/emitter current) from weak electric current (base current). This is a semi-conductor which changes the electrical current between collector and emitter, based on the size of the base current.

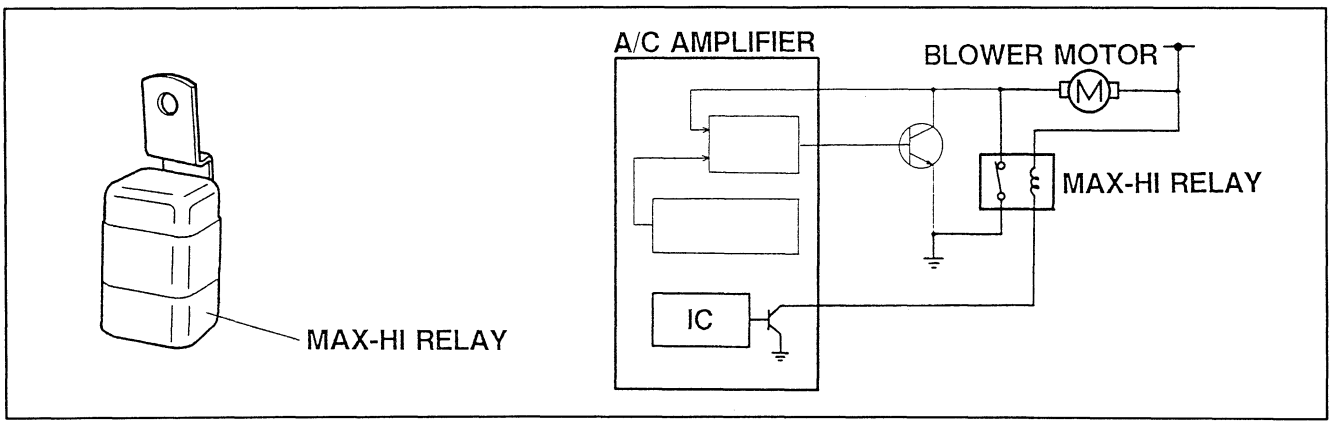
The power transistor is connected to the blower motor circuit as shown in the below illustration. According to the base current, the electric current of the blower motor circuit is adjusted for control of lower motor rotary speed.

When current flows, the power transistor will become hot. To avoid this, radiator fins are installed at the outlet of the blower unit to cool it down.



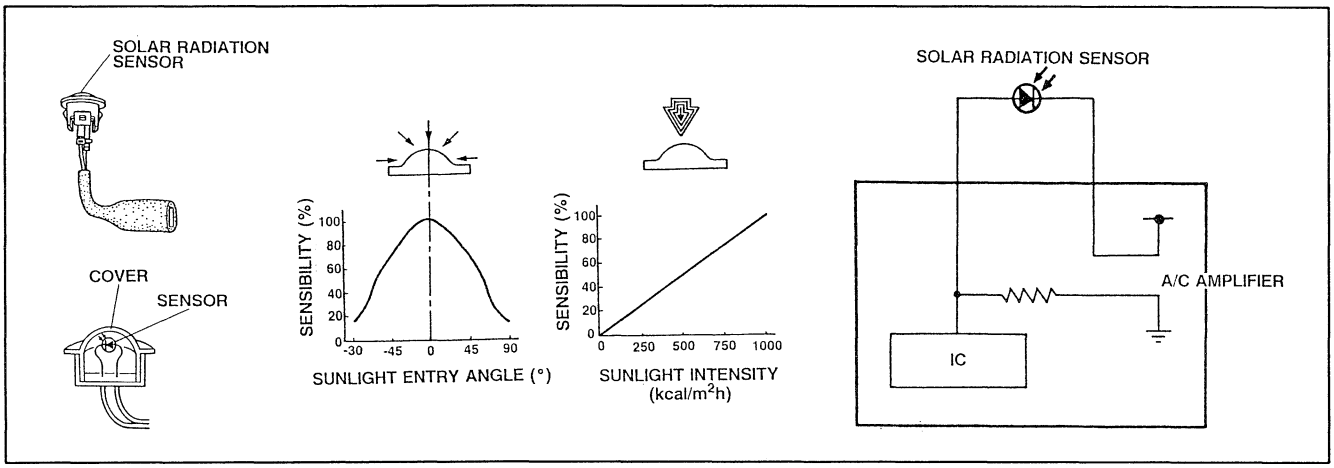
MAX-HI RELAY

The power transistor can not, by itself, obtain maximum blower motor speed. This is because it must naturally succumb to a drop in potential efficiency. Therefore, we need to make a by-pass circuit. This is done by using the Max-hi relay with the power transistor, in order to obtain maximum blower motor speed.



SOLAR RADIATION SENSOR

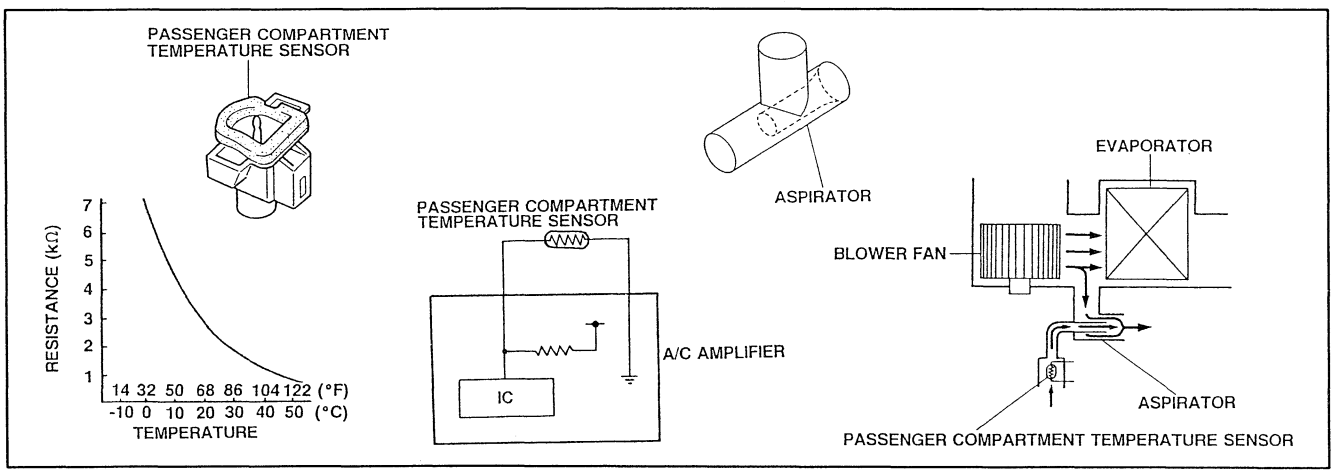
The solar radiation sensor senses sunlight intensity by way of a photo diode. A photo diode is connected to the A/C amplifier. It can change the power of electric current in accordance with the sun's rays. The solar radiation sensor, which simply acts as a variable resister, is connected in line which another resister that is within the A/C amplifier. The A/C amplifier constantly looks at the voltage between the solar radiation sensor and the resister, and observes any changes. Of course, because these voltage changes are very slight, a bias system (constant voltage) is added to amplify that voltage for the purpose of easy detection. The solar radiation sensor is installed on the instrument panel, and is covered by a cover to cut the visible radiation.



PASSENGER COMPARTMENT TEMPERATURE SENSOR

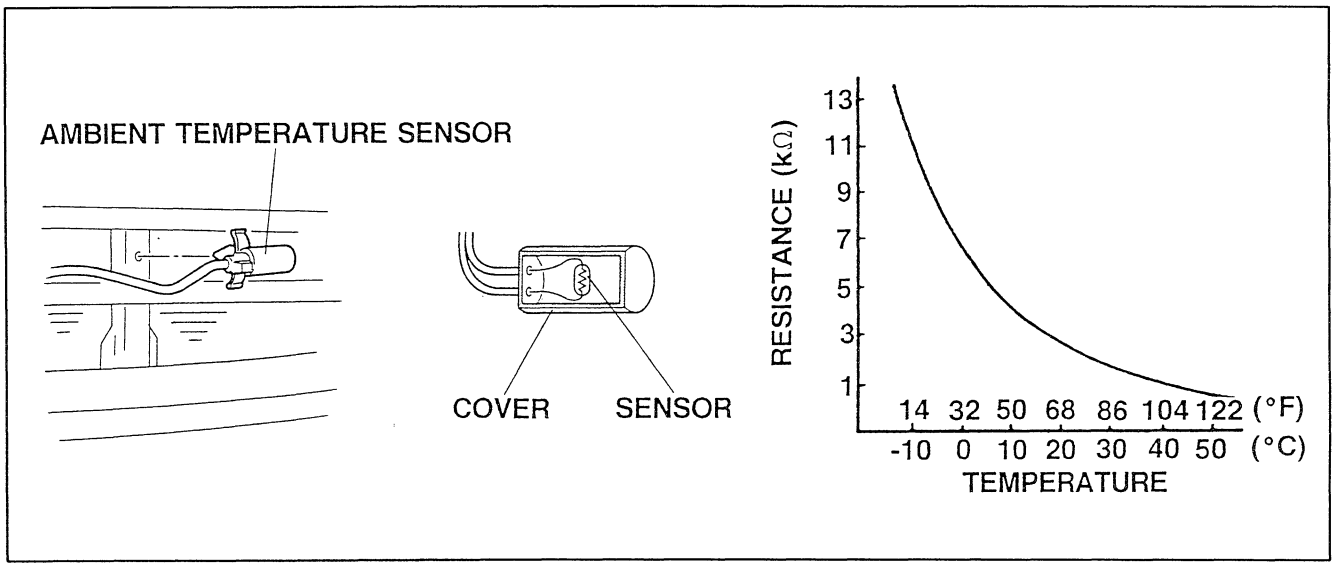
The passenger compartment temperature sensor is a sensor that detects temperature by way of a thermister. Like the solar radiation sensor, it is connected in line with another resistor that is within the A/C amplifier, and must have the voltage magnified by a bias system.

The passenger compartment temperature sensor cannot, by itself, perceive average temperature because the sensor is installed in the lower part of the instrument panel. Therefore, it "breathes" air inside the passenger compartment by using an aspirator, and thus perceives average temperature.



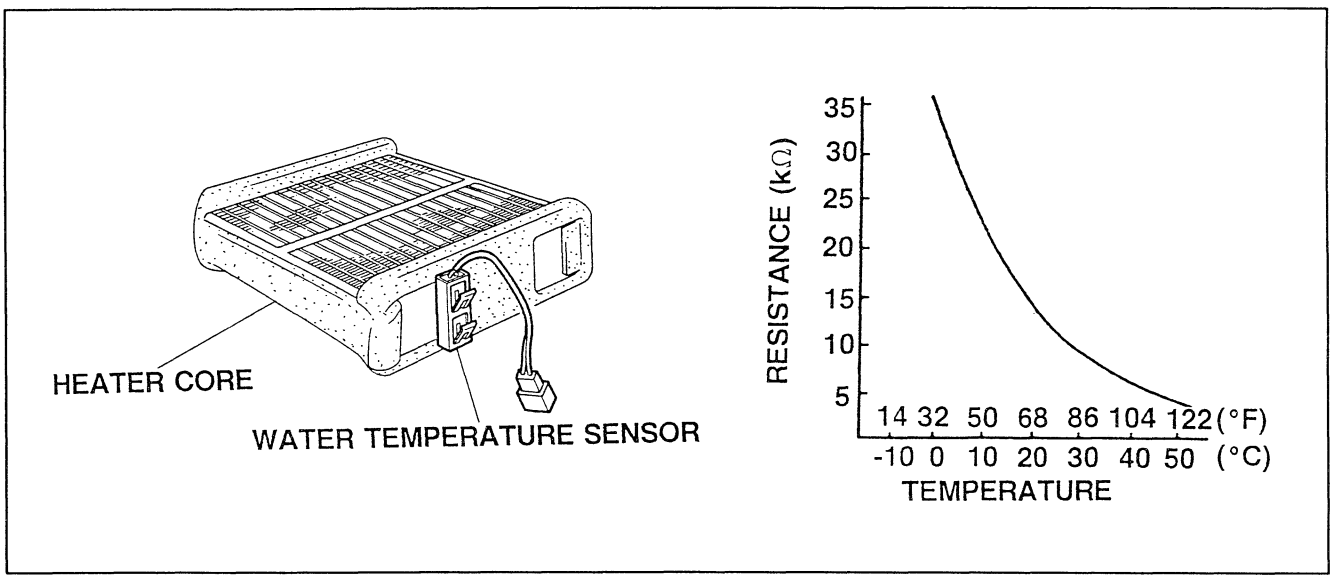
AMBIENT TEMPERATURE SENSOR

The ambient temperature sensor is a thermister that functions in basically the same way as the passenger compartment temperature sensor. It is installed in the front of the vehicle to avoid influence of heat coming from the drive train. However, it can not perceive the correct outside air temperature because of several factors, such as driving condition, wind, and so on, without modification. Therefore, the ambient temperature sensor is equipped with a cover to delay the rate of reaction.



WATER TEMPERATURE SENSOR

The water temperature sensor is a thermister that detects the heater core's temperature.

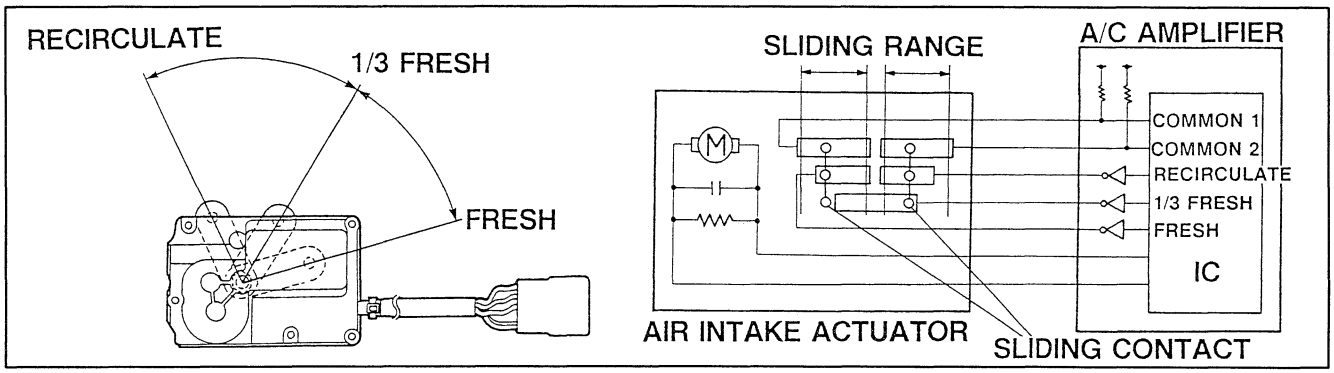


AIR INTAKE ACTUATOR

The air intake actuator opens and closes the air intake door by way of a motor, in accordance with signals from the A/C amplifier.

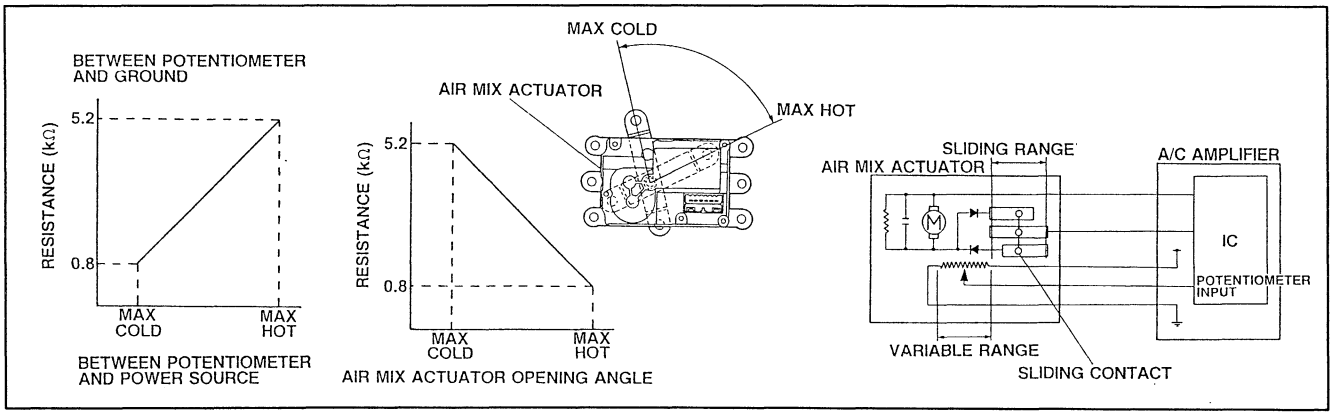
The air intake door is controlled by the actuator movement (operating time and direction), by a sliding contact, to position the door at the RECIRCULATE, 1/3 FRESH, and FRESH position. (Some models have RECIRCULATE and FRESH only.) As shown below, this consists of 3 sliding contacts and sliding bars which slide along the sliding contact. These 3 contacts differ in length.

The A/C amplifier grounds the electrical terminal that corresponds to the selected mode and its target position. A mode and its respective position is released when the A/C amplifier releases the ground point. Therefore, either common 1 or 2 is grounded through the sliding contact, and the common detection voltage will change from 5 V to 0 V. If either detection voltage of common 1 or 2 becomes 0 V, the A/C amplifier will decide the voltage polarity and operate the actuator. The motor turns, and the interlocking sliding contact will turn OFF. Accordingly, the detected voltage of either common 1 or 2 will be 5 V, and A/C amplifier will stop supplying voltage. Then the air intake door will be stopped at the target standing position.



AIR MIX ACTUATOR

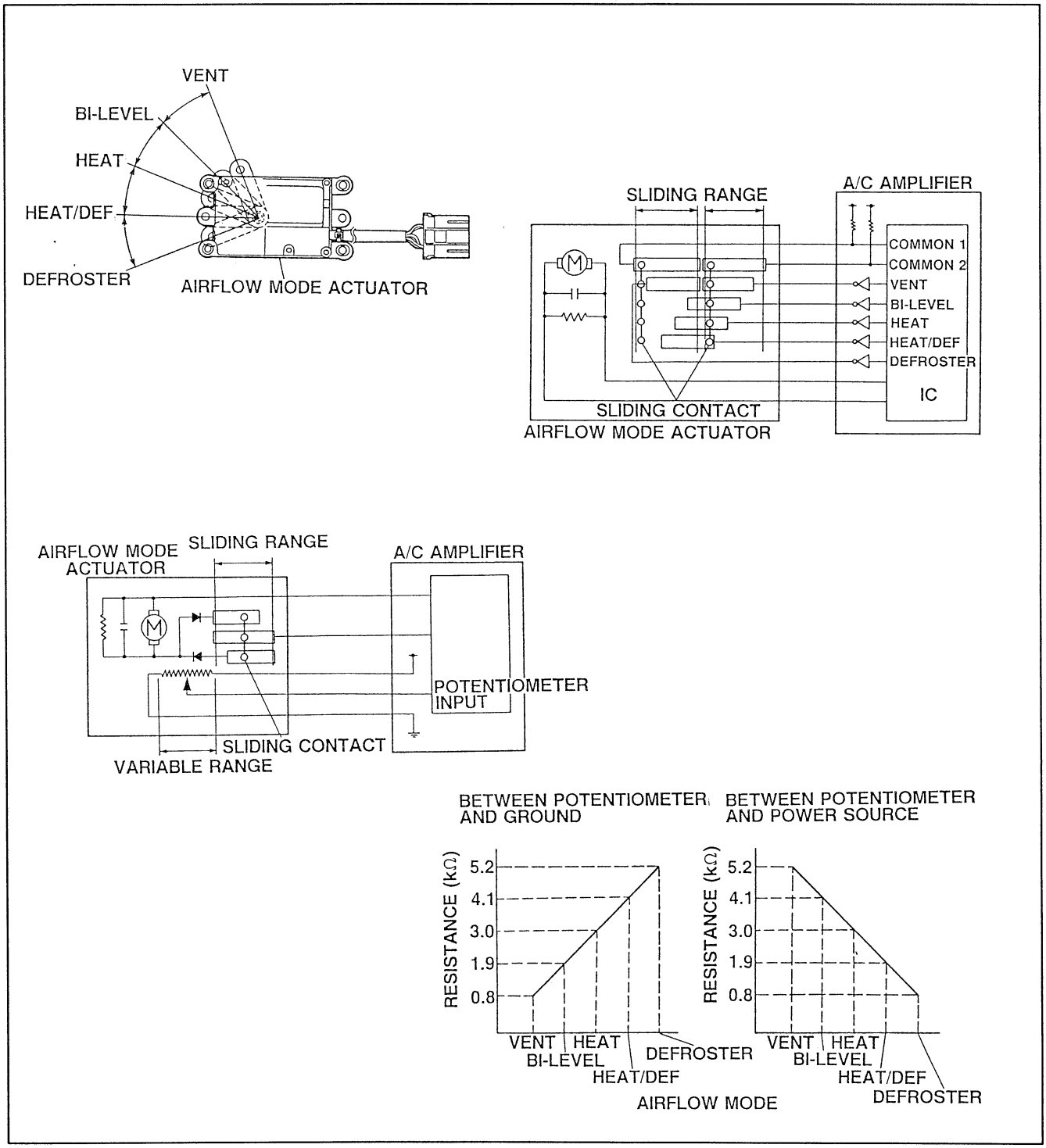
According to the signal from A/C amplifier, the air mix actuator opens and closes the air mix door by way of the motor. The air mix actuator has a built-in potentiometer that moves in tandem with the motor. In this way, the position of the air mix door is electrically detected by the A/C amplifier. When the A/C amplifier operates the air mix actuator, it must also decide the direction in which the motor should turn. The A/C amplifier makes the decision by comparing the present feedback voltage with the target-position voltage, and then by determining whether the target-position voltage is more or less than the present feedback voltage. When the present feedback voltage reaches target-position voltage, voltage supply to the motor will be stopped.



AIRFLOW MODE ACTUATOR

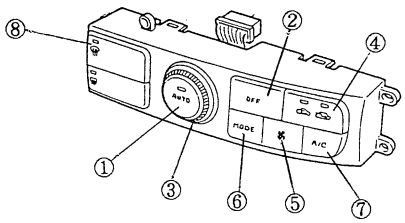
According to the signal from A/C amplifier, the airflow mode actuator opens and close the mode door by way of the motor.

There are two types of airflow mode actuator. They are the "Sliding contact" type (refer to "Air Intake Actuator") and the "Potentiometer" type (refer to "Air Mix Actuator").



HEATER CONTROL UNIT

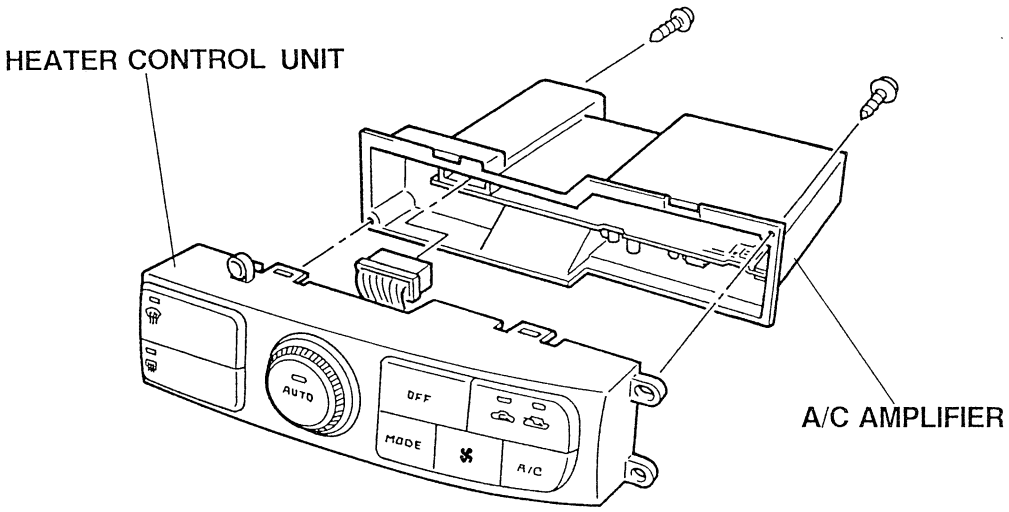
The heater control unit informs the user's request to the A/C amplifier, and then the operating condition of the A/C amplifier will be indicated by the indicator light and/or information display.



①	AUTO SWITCH	All controls, Automatic starting and operation
②	OFF SWITCH	Fan stop
③	TEMPERATURE SETTING SWITCH	Adjustment of the temperature setting
④	REC/FRESH SWITCH	Switches the AIR INTAKE MODE
⑤	FAN SWITCH	Switches the AIR FLOW VOLUME
⑥	MODE SWITCH	Switches the AIR FLOW MODE
⑦	A/C SWITCH	Switches the A/C MODE
⑧	DEFROSTER SWITCH	Selects the DEFROSTER MODE

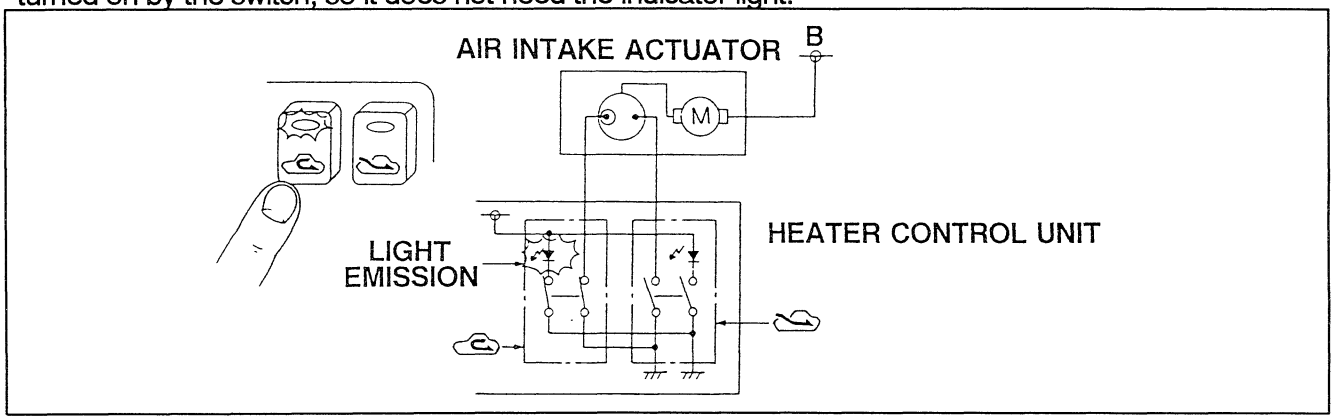
A/C AMPLIFIER

The A/C amplifier controls each actuator in accordance with the output signal that is based on operation signals and several other kinds of sensor signals coming from the heater control unit. It also sends an indication signal, which meets the control condition, to heater control unit. Information interchange between the A/C amplifier and the heater control unit is conducted by serial communication.

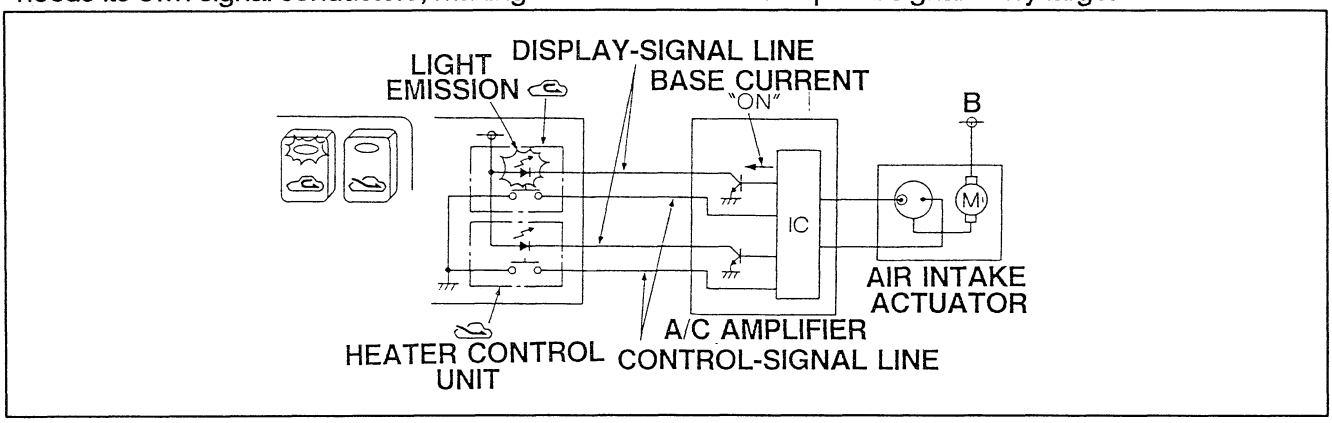


Serial Communication

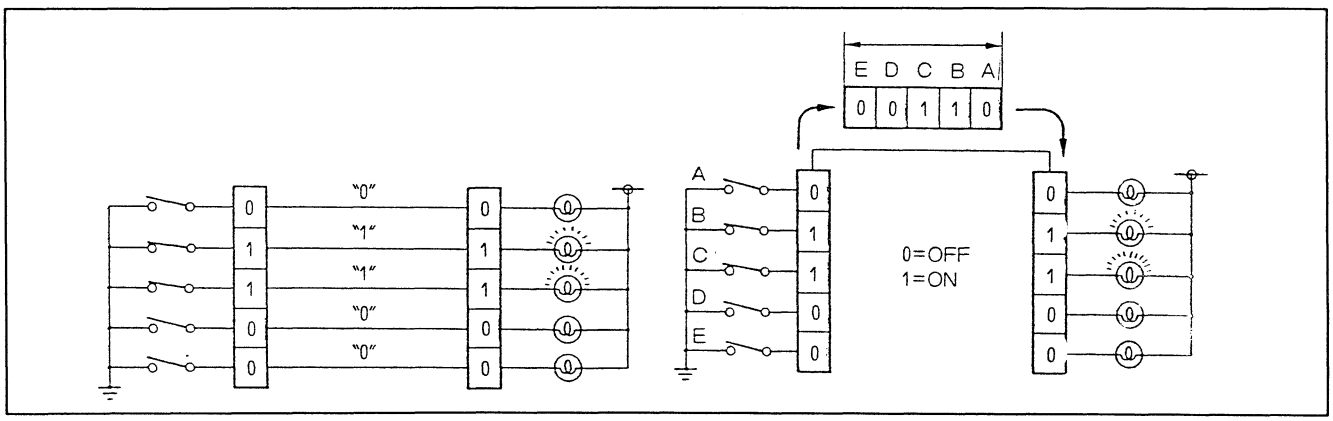
Manual air conditioner operation is maintained at a constant setting. Therefore, the number of switch signals for the heater control is the same as for the A/C amplifier. Furthermore, the indicator light is turned on by the switch, so it does not need the indicator light.



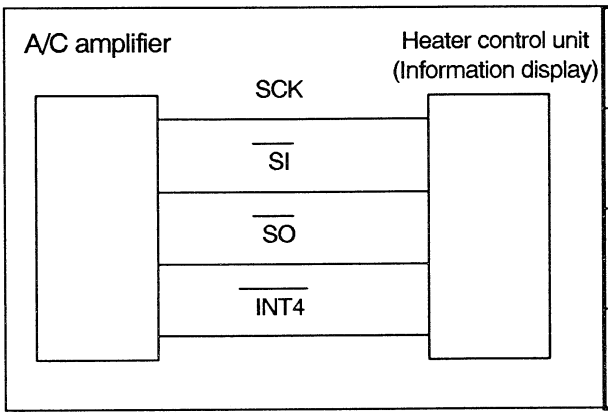
On the other hand, the auto air conditioner does not operate at a constant fixed setting. Therefore, it is necessary to set the same number of switches and indicator lights as there are signal lines between the heater control unit and A/C amplifier. Furthermore, if there is an information display, each segment needs its own signal conductors, making the total number of required signals very large.



As for the Full Auto Air Conditioner, to prevent increasing the number of signal conductors, information interchange is done between the heater control unit and A/C amplifier by serial communication. Normally, to turn on each light, each signal conductor is needed. However, serial communication can be used to send plural signals. Therefore, we can reduce the number of signal conductors.



Serial communication is mainly used between the A/C amplifier and the information display. All display signals can be sent by only 4 signal conductors.



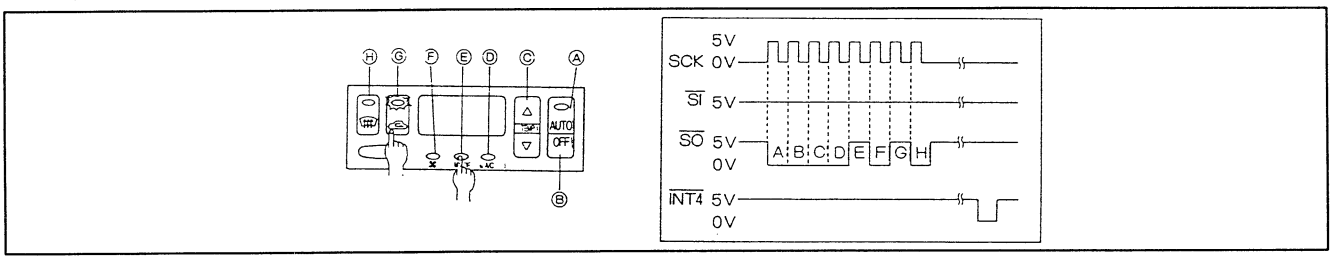
$\overline{\text{INT 4}}$	Indicates the beginning of communication from A/C amplifier to heater control unit.
SCK	Sets a time basis for the clock signal from A/C amplifier to heater control unit in order to send plural messages through only one line.
$\overline{\text{SO}}$	Indicates the switch operating condition of heater control unit to A/C amplifier.
$\overline{\text{SI}}$	Indicates the output control condition of A/C amplifier to heater control unit.

As for the communication, there are the following 2 modes. The A/C amplifier makes a decision as to which mode should be used, and sends its decision to the heater control unit by way of the SI signal.

Switch Signal Transfer Mode
Indicator Signal Transfer Mode

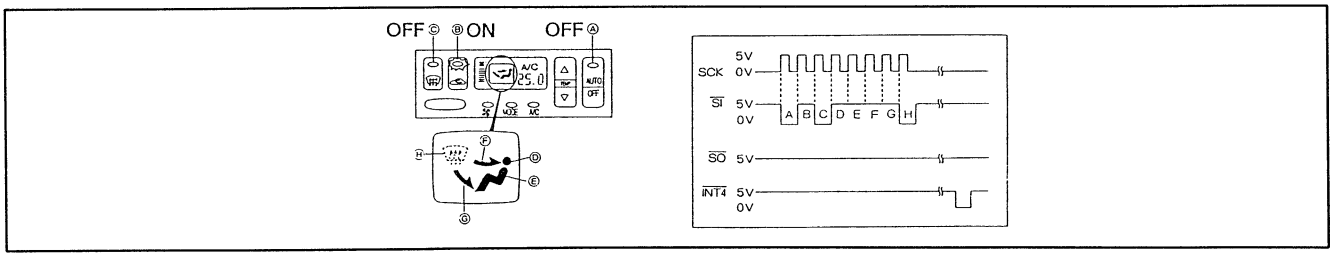
Switch Signal Transmit Mode

During switch operation, clock signals, are SCK signals, or continuously sent from the A/C amplifier to the heater control unit. Each SCK signal lasts for the same period of time. When a switch in the Heater Control Unit is pressed, a corresponding SO signal is selected and is sent to the A/C amplifier in the same cycle with the SCK signal. In this way, the A/C amplifier can understand the meaning of the incoming SO signal by gauging the SO signal's pattern against the SCK signal which is being sent at exactly at the same time. This transmission method has the advantage of being able to relay any signal combination with the use of only two wires.



Indicator Signal Transfer Mode

It is necessary for the display to correspond to the present operating condition of the A/C amplifier. Each indicator of the heater control unit and each segment of the information display are decided by individual SI signals sent in accordance with SCK signals. Therefore, A/C amplifier sends SI signals that are synchronized with SCK signals. Same as above, this transmission method has the advantage of being able to relay any signal combination with the use of only two wires.



CONTROL SYSTEM

OUTLINE

The main function of the auto air conditioner is to maintain a constant temperature inside the passenger compartment. Based on set temperature, the A/C amplifier decides the target temperature in accordance with outside temperature and sunlight intensity. Target temperature will be changed in accordance with several circumstances to meet set temperature.

TYPES OF CONTROLS

Control items of Auto Air Conditioner is as follows.

Basic control	Control description	Correction
Airflow temperature control	Airflow temperature automatic control	● Passenger compartment temperature correction ● Air intake correction ● A/C correction ● MAX HOT & MAX COLD correction ● Air mix actuator opening angle correction ● Fail-safe function
Airflow volume control	Airflow volume automatic control	● Coolant temperature correction (warm-up correction) ● Mild start correction ● MAX HOT & MAX COLD correction ● Window frost prevention correction ● VENT correction ● Start compensation correction ● Defroster correction ● Rush current prevention correction
	Airflow volume manual control	● Defroster correction
Airflow mode control	Airflow mode automatic control	● Coolant temperature correction ● Fail-safe function
	Airflow mode manual control	● Fail-safe function
Air intake control	Air intake automatic control	● MAX COLD correction ● Window frost prevention correction ● Defroster correction
	Air intake manual control	● Defroster correction
A/C compressor control	A/C compressor automatic control	● Defroster correction ● Ambient temperature correction
	A/C compressor manual control	
Idle-up control	A/C compressor idle-up control	—
	Electrical load idle-up control	

Supplementary function
Sensor fail-safe function
Sensor signal delay function
Self diagnosis function

SWITCHES AND THEIR OPERATION

The control and operation of each switch are described as follows.

Control (before switched) / Switch		Airflow temperature control	A/C compressor control	
		Automatic control	Automatic control	Manual control
AUTO switch		AUTO	AUTO	AUTO
OFF switch		AUTO	OFF	OFF
Fan switch		AUTO	OFF Switch ON → Condition before OFF switch ON No other change	OFF Switch ON → Condition before OFF switch ON No other change
A/C switch		AUTO	Fan OFF: OFF → OFF Fan ON: A/C → ECON OFF → A/C	Fan OFF: OFF → OFF Fan ON: A/C → ECON ECON → A/C OFF → A/C
MODE switch		AUTO	*1 Defroster Correction → Condition before defroster correction No other change	*1 Defroster Correction → Condition before defroster correction No other change
DEFROSTER switch		AUTO	*1 AUTO ON → Defroster correction ON Defroster correction ON → Condition before defroster correction ON	*1 Manual → Defroster correction ON Defroster correction ON → Condition before defroster correction ON
REC/FRESH switch		AUTO	No change	No change
Temperature Setting dial	18.0℃ {65°F}	MAX COLD AUTO	AUTO	No change
	18.5℃ {66°F} – 31.5℃ {89°F}	AUTO		
	32.0℃ {90°F}	MAX HOT AUTO		

*1 Defroster Correction : Refer to page 18

Control (before switched) / Switch		Air Intake control	
		Automatic control	Manual control
AUTO switch		AUTO	AUTO
OFF switch		FRESH	No change
Fan switch		AUTO	No change
A/C switch		A/C ON : AUTO A/C OFF: AUTO → FRESH	No change
MODE switch		*1 Defroster correction ON → condition before defroster correction ON No other change	*1 Defroster correction ON → condition before defroster correction ON No other change
DEFROSTER switch		*1 AUTO → Defroster correction ON Defroster correction ON → Condition before defroster correction ON	*1 Manual → Defroster correction ON Defroster correction ON → Condition before defroster correction ON
REC/FRESH switch		FRESH → RECIRCULATE 1/3 FRESH RECIRCULATE → FRESH	FRESH → RECIRCULATE RECIRCULATE → FRESH
Temperature Setting dial	18.0℃ {65°F} 18.5℃ {66°F} – 31.5℃ {89°F} 32.0℃ {90°F}	AUTO	No change

*1 Defroster Correction : Refer to page 18

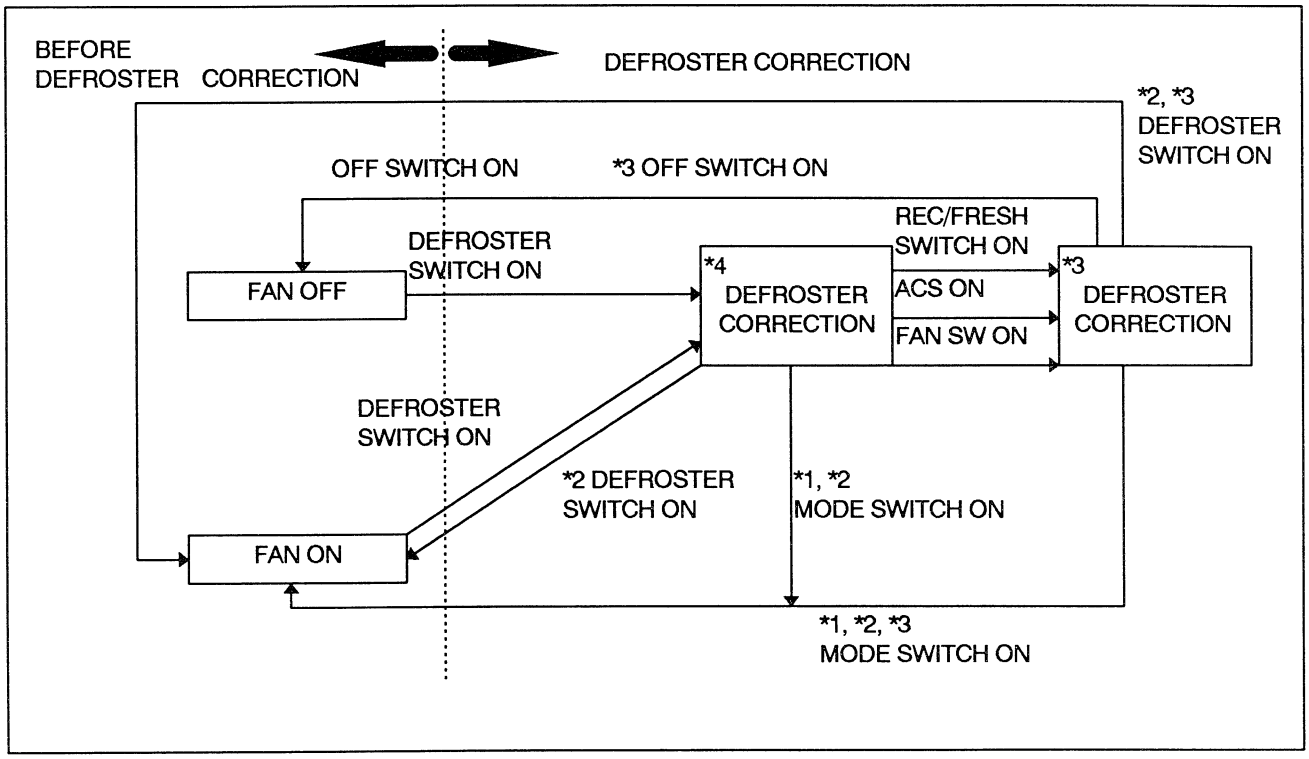
Control(before switched) / Switch		Airflow volume control	
		Automatic control	Manual control
AUTO switch		AUTO	AUTO
OFF switch		OFF	OFF
Fan switch		Speed 1	OFF → Speed 1 Speed 1 → Speed 2 Speed 2 → Speed 3 Speed 3 → Speed 4 Speed 4 → Speed 1
A/C switch		AUTO	No change
MODE switch		*1 Defroster correction ON → condition before defroster correction ON No other change	*1 Defroster correction ON → condition before defroster correction ON No other change
DEFROSTER switch		*1 AUTO → Defroster correction ON Defroster correction ON → Condition before defroster correction ON	*1 Manual → Defroster correction ON Defroster correction ON → Condition before defroster correction ON
REC/FRESH switch		No change	No change
Temperature Setting dial	18.0℃ {65°F}	MAX-HI fixed	No change
	18.5℃ {66°F} – 31.5℃ {89°F}	AUTO	
	32.0℃ {90°F}	AUTO-HI fixed	

*1 Defroster Correction : Refer to page 18

Control(before switched) / Switch	Airflow mode control	
	Automatic control	**Manual control**
AUTO switch	AUTO	AUTO
OFF switch	AUTO	*1 DEFROSTER → Condition before DEFROSTER ON No other change
Fan switch	AUTO	No change
A/C switch	AUTO	No change
MODE switch	VENT → BI-LEVEL BI-LEVEL → HEAT HEAT → HEAT/DEF HEAT/DEF → VENT DEFROSTER → HEAT	VENT → BI-LEVEL BI-LEVEL → HEAT HEAT → HEAT/DEF HEAT/DEF → VENT DEFROSTER → HEAT
DEFROSTER switch	DEFROSTER	*1 Manual → DEFROSTER DEFROSTER → Condition before DEFROSTER ON
REC/FRESH switch	No change	No change
Temperature Setting dial: 18.0℃ {65°F} 18.5℃ {66°F} – 31.5℃ {89°F} 32.0℃ {90°F}	AUTO	No change

*1 Defroster Correction : Refer to page 18

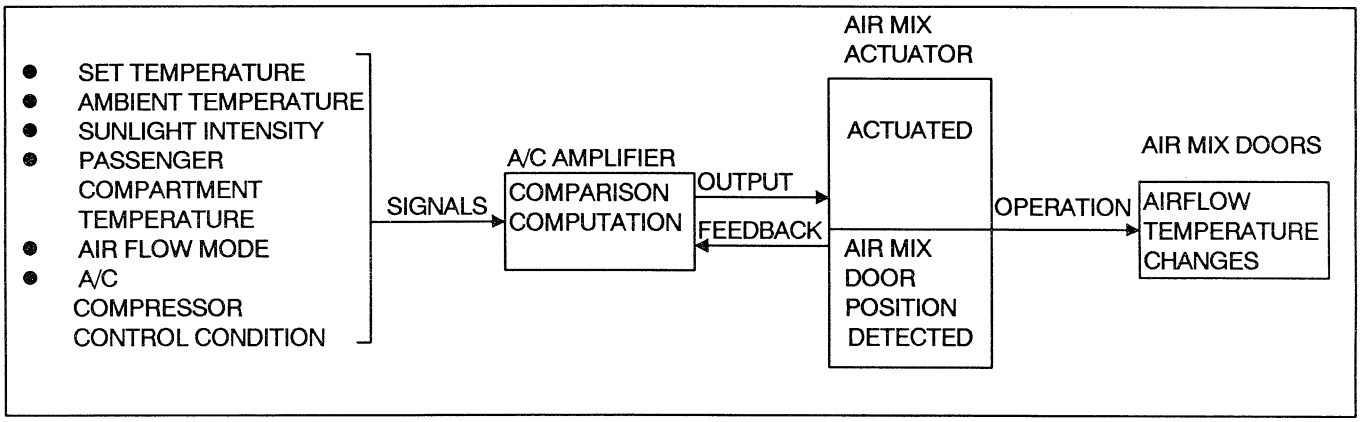
Defroster Correction



*1	MODE	HEAT
*2	FAN	AUTO (FAN OFF BEFORE DEFROSTER CORRECTION)
*3	–	MANUAL OPERATION SET AT MANUAL DURING DEFROSTER CORRECTION
*4	MODE	DEFROSTER
	FAN	AUTO VOLTAGE + 2V
	AIR INTAKE	FRESH
	A/C	A/C MODE

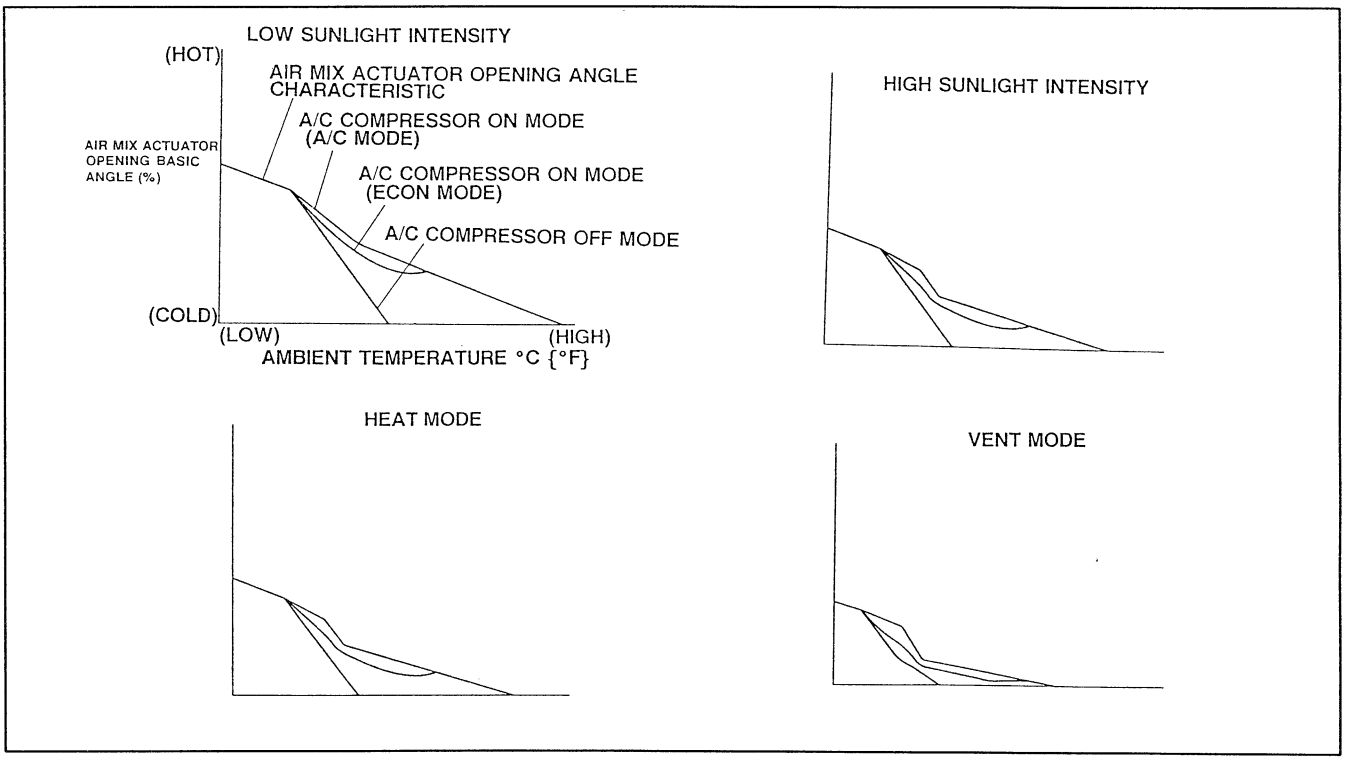
AIRFLOW TEMPERATURE CONTROL

The A/C amplifier constantly controls airflow temperature by way of air mix actuator.



Airflow Temperature Automatic Control

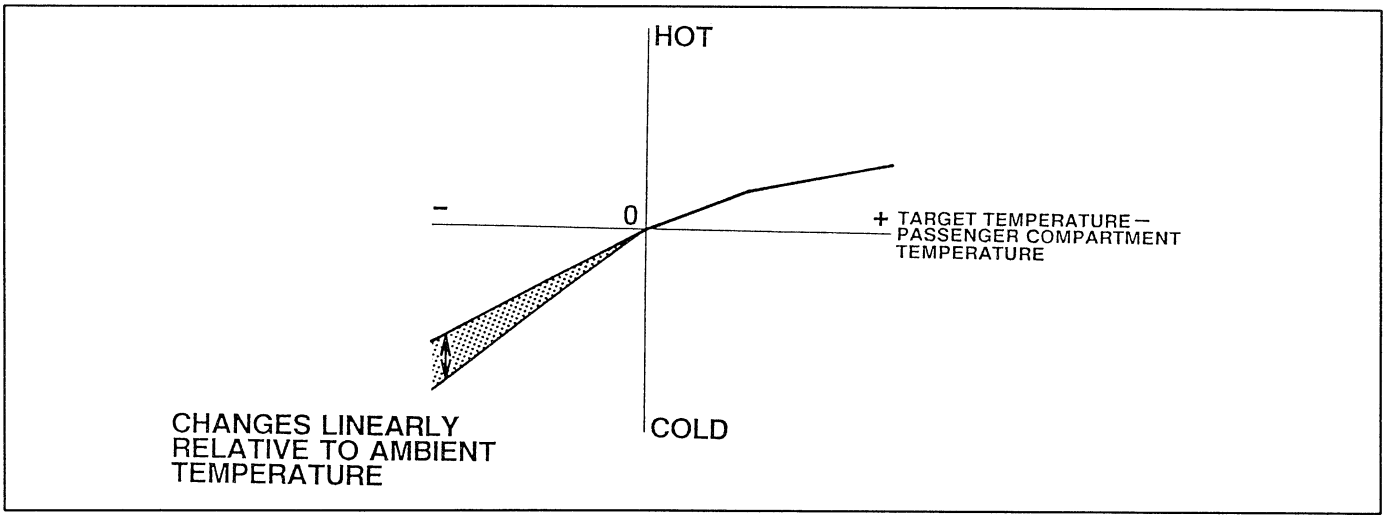
The A/C amplifier selects the air mix actuator's basic opening angle, which is primarily based on ambient temperature, depending on set temperature, sunlight intensity, and airflow mode. The air mix actuator opening angle is decided by comparing the characteristics of the ambient temperature and the outside temperature.



Correction

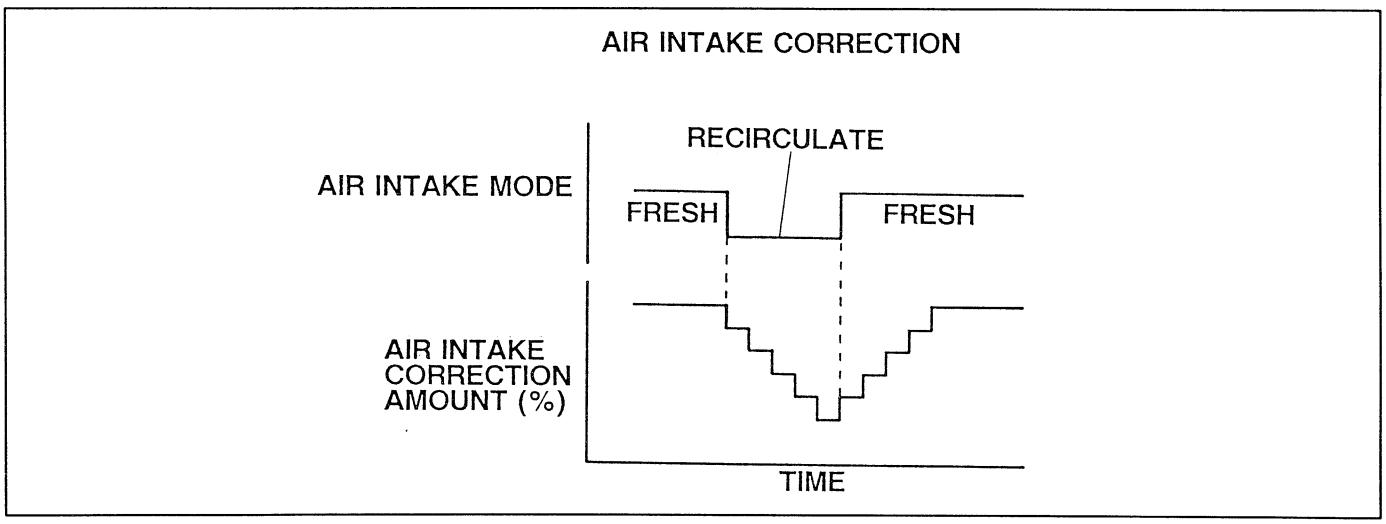
Passenger compartment temperature correction

Sometimes there may be a difference in target temperature and passenger compartment temperature. In this case, it is necessary to return to target temperature as quickly as possible. In order to do this, a correction is made within the A/C amplifier based on the temperature difference, and the air mix actuator opening angle is adjusted accordingly.



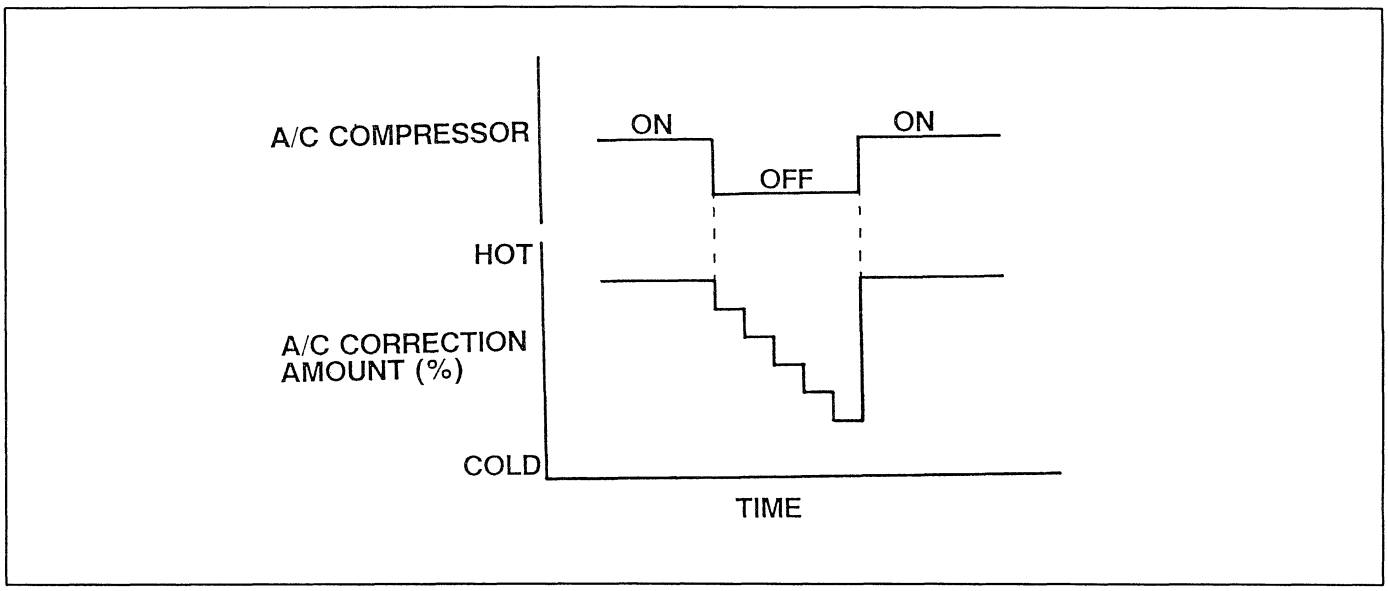
Air intake correction

Sometimes when the A/C compressor is OFF mode , the intake mode is switched from "outside air intake" to "inside air recirculate". In order to prevent the temperature from rising, it is necessary to adjust the air mix actuator opening angle based on the minus correction and also according to the difference between target temperature and passenger compartment temperature. Furthermore, to avoid a sudden decrease in airflow temperature, the correction timing is delayed.



A/C correction

When the A/C compressor switches to each mode (A/C mode, Econ mode, and OFF mode) , it is necessary to adjust the air mix actuator opening angle accordingly to prevent airflow temperature from changing (Please refer to page 18). When the air mix actuator opening angle switches from A/C mode or Econ mode to OFF mode, the temperature may fall. Therefore, it delay correction timing to prevent falling in Airflow temperature.



MAX HOT & MAX COLD correction

If temperature is set to 32℃(90°F), air mix actuator opening angle will be fully open (MAX HOT 100%). On the other hand, if temperature is set to 18℃(65°F), the air mix actuator will be completely closed (MAX COLD 0 %).

Air mix actuator opening angle correction

If airflow mode is operated to VENT or BI-LEVEL manually during heater operation, to prevent hot air from blowing into the passenger's face or body directly, the maximum opening angle of the air mix actuator is decided. However, at the MAX HOT correction, this control is released.

Fail -safe function

If the air mix actuator Potentiometer malfunctions, the air mix actuator opening angle is fixed to MAX HOT. This fail-safe function will be released immediately after the malfunction recovers.

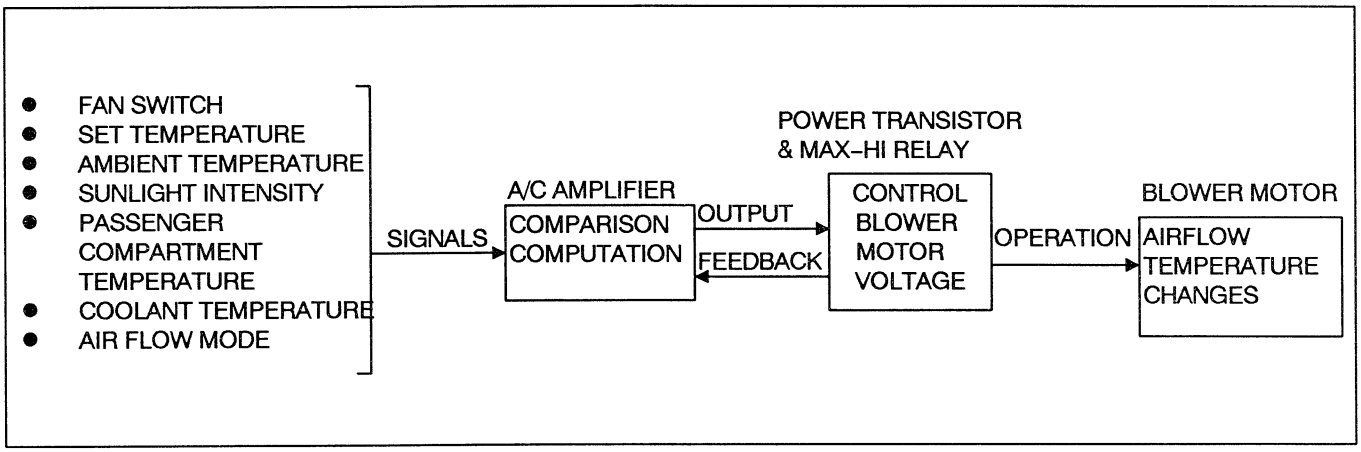
If the air mix door is stopped in mid-travel, it is stopped at that position (transfer from cold to hot), or it is returned to MAX HOT and then stopped (during transfer from hot to cold).

When the ignition switch is turned on, the fail-safe function is released.

The fail-safe function can be released if it is transferring from hot to cold. If is judged that the air mix door is prematurely stopped during transfer from cold to hot.

AIRFLOW VOLUME CONTROL

Airflow volume control consists of airflow volume automatic control and airflow volume manual control. The A/C amplifier controls these functions by power transistor and max hi relay.



Airflow volume automatic control

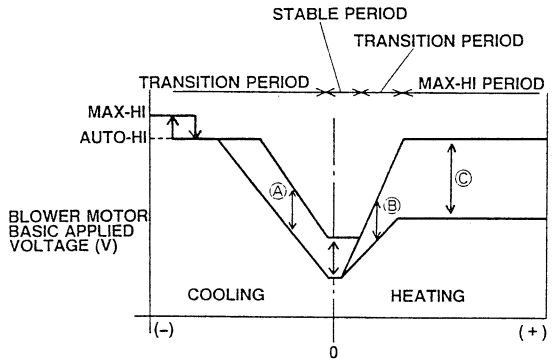
The A/C amplifier calculates the blower motor voltage characteristics for the difference between set temperature and target temperature, based on set temperature, outside temperature and sunlight intensity. Blower motor voltage has different characteristics for both the cooler function and the heater function as follows.

Cooler : When both the ambient temperature and sunlight intensity are high, transition period will be high on the graph. (see A below)

Heater : When the Ambient temperature is low, Transition period and MAX-HI period will be large. (see B and C below)

By comparing the target temperature and passenger compartment temperature for blower motor voltage characteristic, the blower motor basic applied voltage is decided.

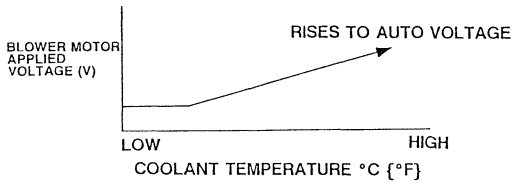
To achieve target temperature as quickly as possible, blower motor basic applied voltage is set to the most suitable speed and mode. This is because it is necessary to maintain stable operation is response to outside factors, such as ambient temperature and sunlight intensity.



Correction

Coolant temperature correction

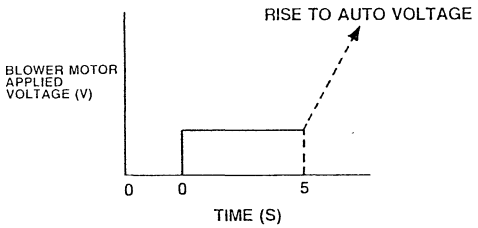
Just after the starting engine, if the heater is turned on, cold air will be blown because of low temperature of the coolant. In order to prevent this, blower motor applied voltage is controlled in accordance with the heater core temperature. However, if the defroster correction is operated, the coolant temperature correction will be released when the passenger compartment temperature is more than 20°C or the airflow mode is switched VENT.



Mild start correction

In the summer, when inside the passenger compartment temperature is very high, if the cooler is turned on in VENT MODE, hot air will be blown. In order to prevent this, the maximum blower motor applied voltage is controlled for 5 seconds. After the correction, if it is necessary to raise the voltage level to the blower motor's basic applied voltage, the voltage increase will change according to the outside temperature and sunlight intensity. This increase will be big, in case of high outside temperature and sunlight intensity.

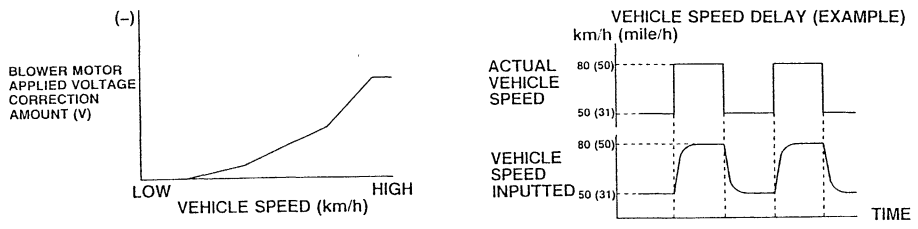
However, this mild start correction is released if the passenger compartment temperature is less than 20°C.



Vehicle speed correction

If the air intake mode is switched to FRESH during high speed driving, the airflow volume will be abnormally increased due to the influence of air that flows into the passenger compartment as a result of the vehicle's movement. In order to prevent this, the blower motor's basic applied voltage is given a minus correction in accordance with the driving speed. Furthermore, the speed signal which is used by this correction is equipped with a delay function in order to soften the effect of sudden speed changes (braking, etc).

- Defroster correction
- Start compensation correction
- Rush current prevention correction
- Max-hi relay ON



MAX HOT & MAX COLD correction

If the set temperature is set to 32℃, blower motor applied voltage is switched to the maximum voltage of the power transistor (Auto Hi). Conversely, if the set temperature is set to 18℃, the Max-hi relay will be fixed at ON.

CONTROL	SET TEMPERATURE	CONTROL DEVICE	BLOWER MOTOR APPLIED VOLTAGE
MAX HOT	22.0	POWER TRANSISTOR	12.0V (AUTO-HI)
MAX COLD	18.0	MAX-HI RELAY	BATTERY POSITIVE VOLTAGE (MAX-HI)

Window frost prevention correction

For improvement of engine startability, during cranking the engine control unit turns off the A/C compressor (A/C cut control) . Because of this, the front window will become misted easily due to inside the passenger compartment not being dehumidified and the subsequent temperature. In order to prevent this, after the IG is turned to ON, the blower motor is stopped for 6 seconds when in heat mode, heat/def mode, or defroster mode.

Vent correction

When the heater is turned on, if the airflow mode is manually switched to vent, maximum voltage of blower motor's applied voltage is controlled 7.5 V, in order to prevent air from blowing into the passenger's face and head directly. However, if the blower motor voltage exceeds 7.5 V, the stable period is given priority.

Start compensation correction

If the blower motor is started at a minimum voltage of 3.2 V, the blower motor applied voltage is set to 4.4 V for 2 seconds to improve the motor's reaction.

Rush current prevention correction

If the blower motor is operated from a stopped condition while the Max-hi relay is ON or the power transistor (Auto Hi) is at maximum voltage, the motor could be burned out. In order to prevent this, the blower motor applied voltage is controlled at 4.4 V for 1 second.

Defroster correction

If the defroster switch is turned ON, the blower motor basic applied voltage is increased 2 V to improve defogging effectiveness.

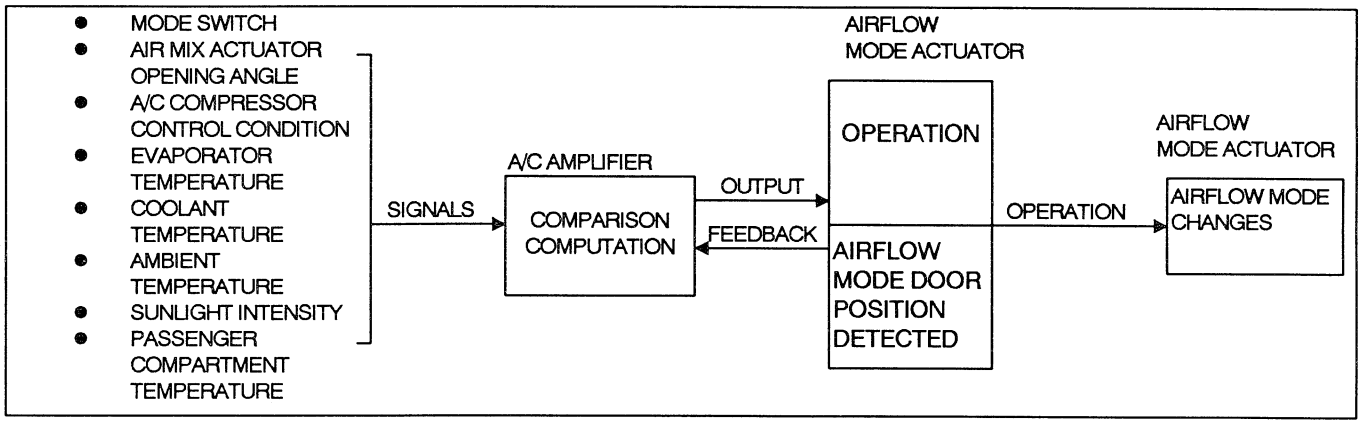
Airflow volume manual control

According to the fan switch operation, the blower motor applied voltage is able to switch between 4 levels.

FAN SPEED	CONTROL DEVICE	BLOWER MOTOR APPLIED VOLTAGE
1st	POWER TRANSISTOR	3.8 V
2nd		7.1 V
3rd		10.1 V
4th	MAX-HI RELAY	BATTERY POSITIVE VOLTAGE

AIRFLOW MODE CONTROL

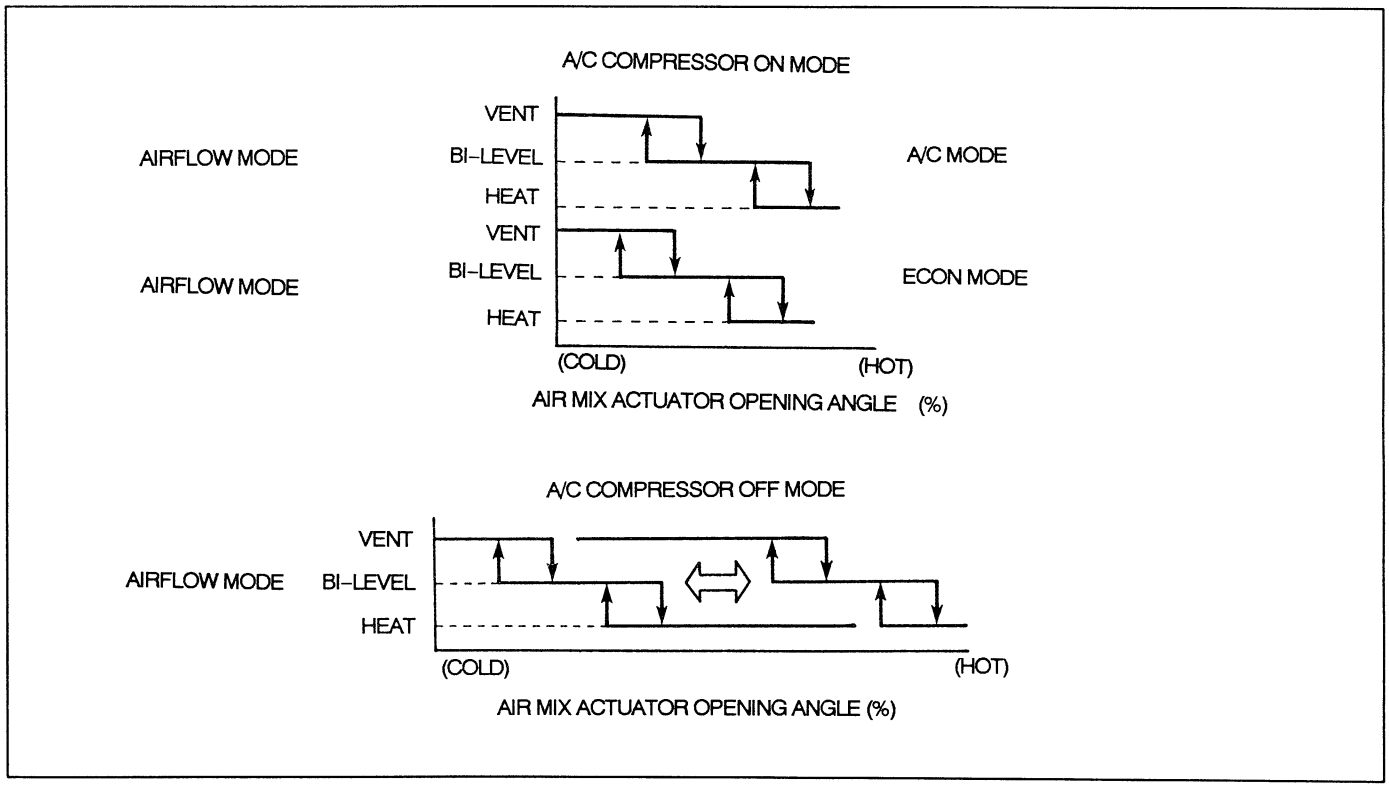
There are 2 kinds of airflow mode controls. They are "auto control" and "manual control". A/C amplifier controls these by way of the airflow mode actuator.



Airflow mode automatic control

A/C amplifier decides airflow mode in accordance with air mix actuator opening angle. The relation between air mix actuator opening angle and airflow mode varies based on the A/C compressor mode (ON, OFF, ECON).

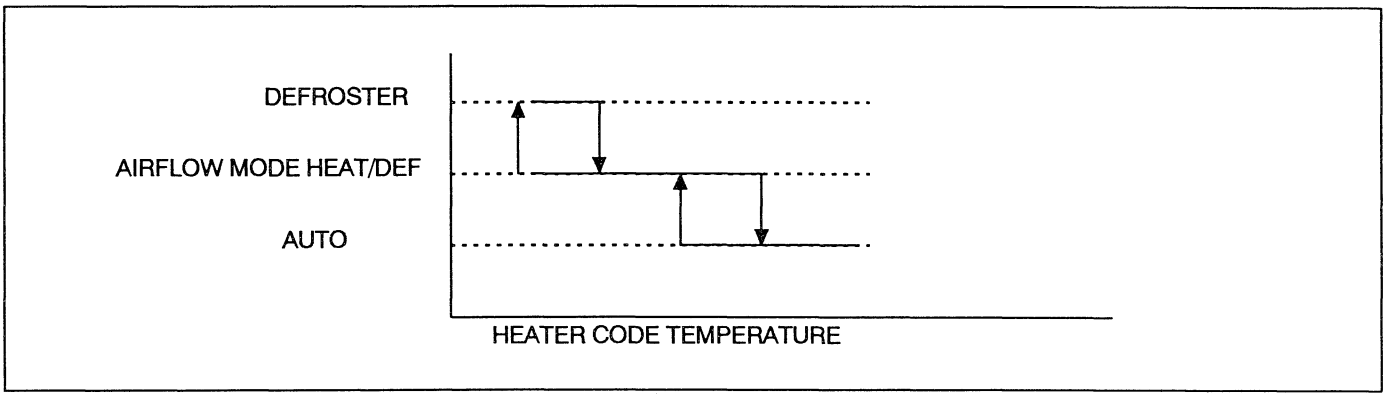
When the A/C compressor is in the OFF mode, the criterion of the airflow mode will be changed in accordance with the evaporator temperature and air mix actuator opening angle. Even if the air mix actuator opening angle is the same, the opening angle will be decided based on the evaporator temperature.



Correction

Coolant Temperature Correction

When the coolant temperature is low during engine starting, airflow mode is switched to defroster or heat/def depending on the heater core temperature.



Fail-safe Function (In case the airflow mode actuator is a potentiometer type)

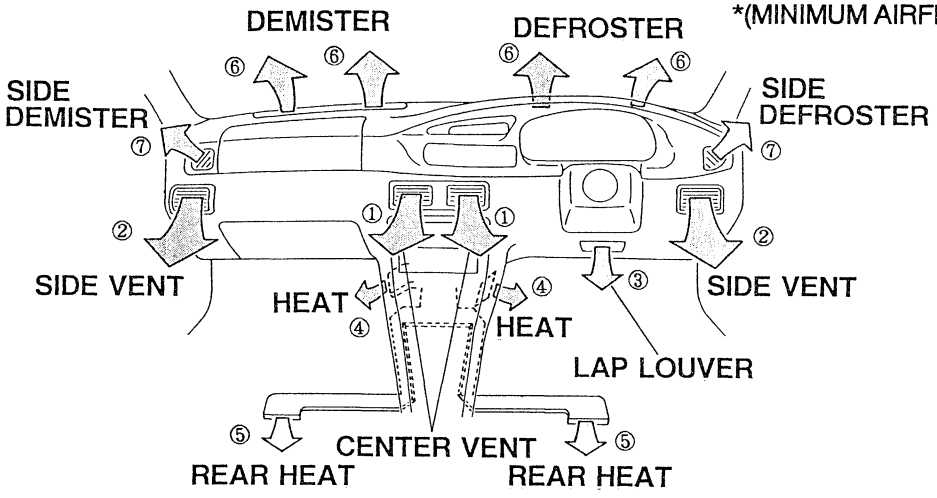
If the potentiometer is judged to be out of order, the airflow mode actuator is fixed at the position where is was immediately before it was broken. The fail-safe function is released when hte malfunction recovers. If the airflow mode is locked, in order to prevent burning, the blower motor applied voltage is cut. The fail-safe function is released when the IG is turned to OFF or when the door goes to its pre-fail position.

Airflow mode manual control

The airflow mode is fixed in accordance with operation of the mode switch and defroster switch.

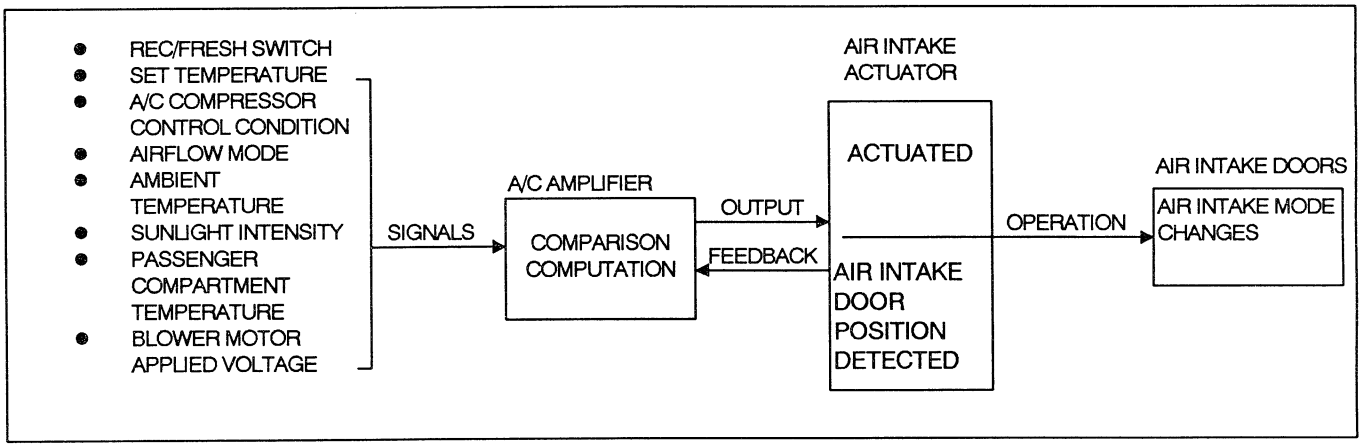
AIRFLOW MODE	OPERATING SWITCH	AIR OUTLET
VENT	MODE SWITCH	①②③
BI-LEVEL		①②③④⑤
HEAT		②③④⑤*(⑥⑦)
HEAT/DEF		②③④⑤⑥⑦
DEFROSTER	DEFROSTER SWITCH	②③⑥⑦

*(MINIMUM AIRFLOW VOLUME)



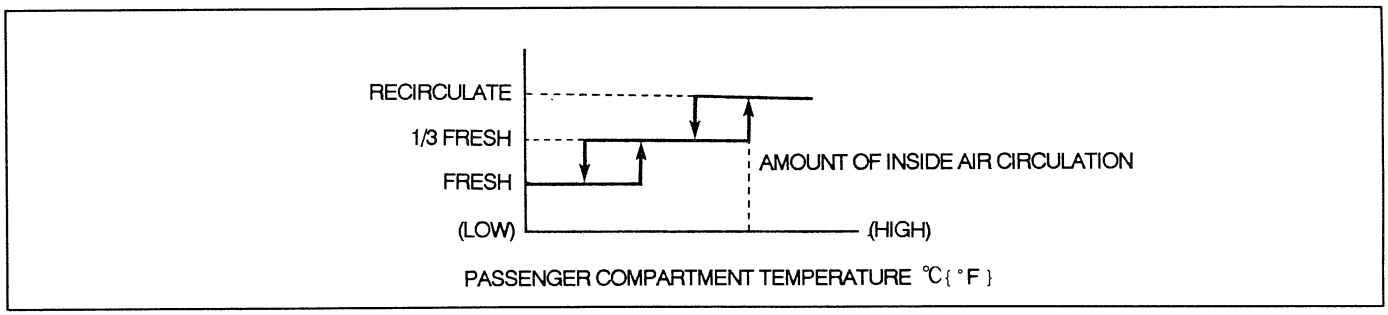
AIR INTAKE CONTROL

There are 2 types of air intake controls. They are "auto" and "manual". A/C amplifier controls these by way of the air intake actuator.



Air intake automatic control

The A/C amplifier calculates the amount of inside air circulation in accordance with set temperature, sunlight intensity, and ambient temperature. By compare this result with the passenger compartment temperature, the air intake mode is decided. The decided value of inside circulation will be small (cold) during high outside temperature and strong sunlight intensity.



Correction

Max cold correction

If the set temperature is 18℃, the inside air circulation is fixed to improve cooler efficiency.
This correction is released when the defroster correction or window frost prevention correction is operated.

Window frost prevention correction

If the A/C compressor is switched to the OFF mode or the IG switch is turned to OFF, the air intake mode is fixed to FRESH to prevent window frost.

Defroster correction

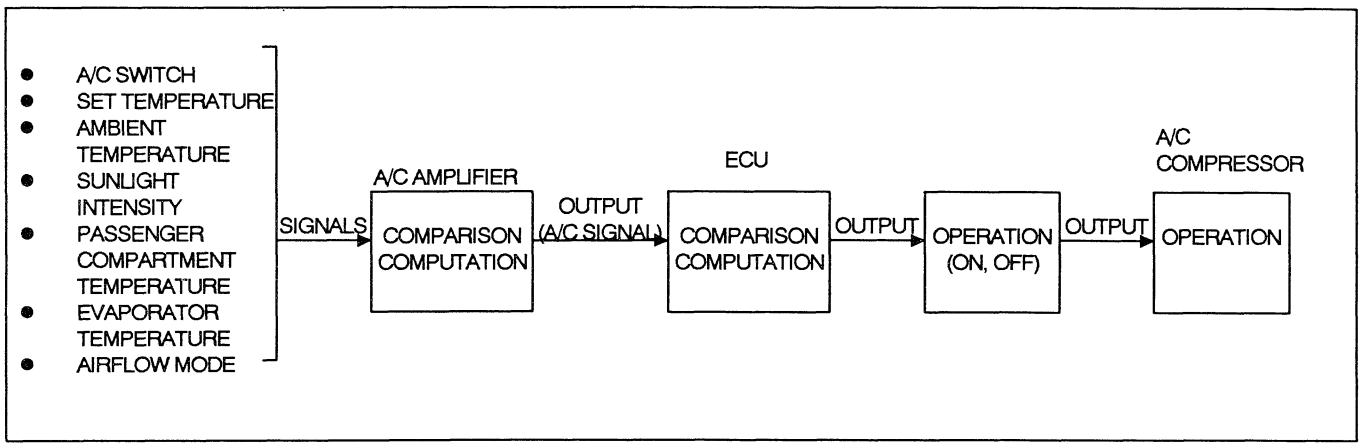
If the defroster switch is turned to ON, the air intake mode is fixed to FRESH to prevent window frost.

Air intake manual correction

A/C compressor operation mode is decided by the A/C amplifier depending on the outside temperature.

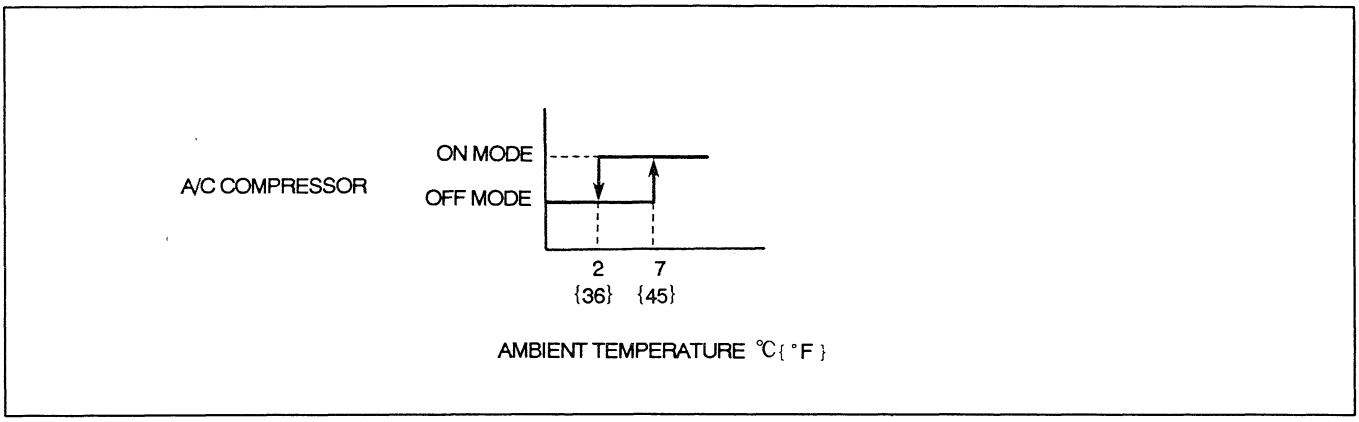
A/C COMPRESSOR CONTROL

There are 2 types of A/C compressor controls. They are "auto" and "manual". The A/C amplifier sends signals to the engine control unit to initiate these controls.



A/C compressor automatic control

The A/C amplifier decides the A/C compressor operation mode depending on the outside temperature.



Correction

Defroster correction

If the defroster switch is turned to ON, the A/C compressor is fixed at the ON mode to improve window frost prevention. However, the defroster correction is released when the ambient temperature correction is operated.

Ambient temperature correction

If the ambient temperature is under –5℃, the A/C compressor is fixed at the OFF mode to protect the A/C compressor.

At this time, the A/C switch can not be operated a manually.

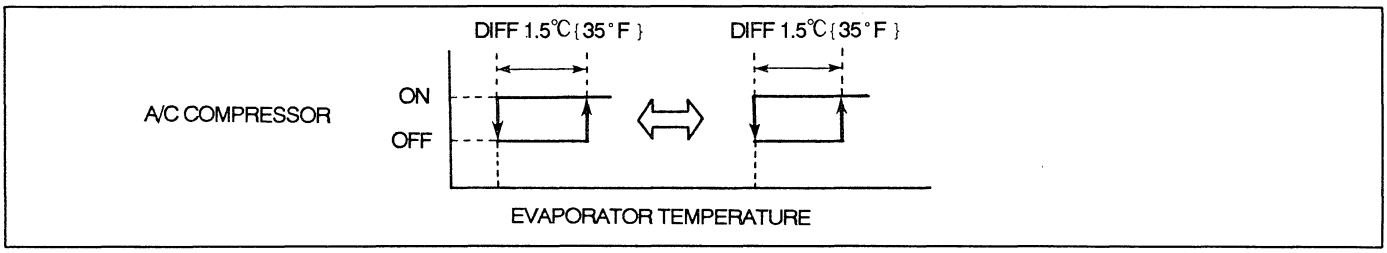
A/C compressor manual control

The A/C compressor is fixed at the ON or OFF mode by way of A/C switch control.

A/C COMPRESSOR MODE		OPERATION CONDITION
A/C COMPRESSOR ON MODE	A/C MODE	A/C COMPRESSOR IS FIXED TO ON MODE.
	ECON MODE	A/C COMPRESSOR IS FIXED TO ON MODE. COMPARED TO A/C MODE, A/C COMPRESSOR ON/OFF MODE CONTROL BY EVAPORATOR TEMPERATURE IS OPERATED AT HIGHER TEMP, MAKING A/C COMPRESSOR OPERATION TIME SHORTER AND MORE ECONOMICAL.
A/C COMPRESSOR OFF MODE		A/C COMPRESSOR IS FIXED TO OFF MODE

Econ mode

The ECON mode varies the A/C compressor OFF temperature (evaporator temperature) based on outside temperature, passenger compartment temperature, and target temperature. Because of this, the engine burden can be reduced (Improved fuel consumption) .



IDLE UP CONTROL

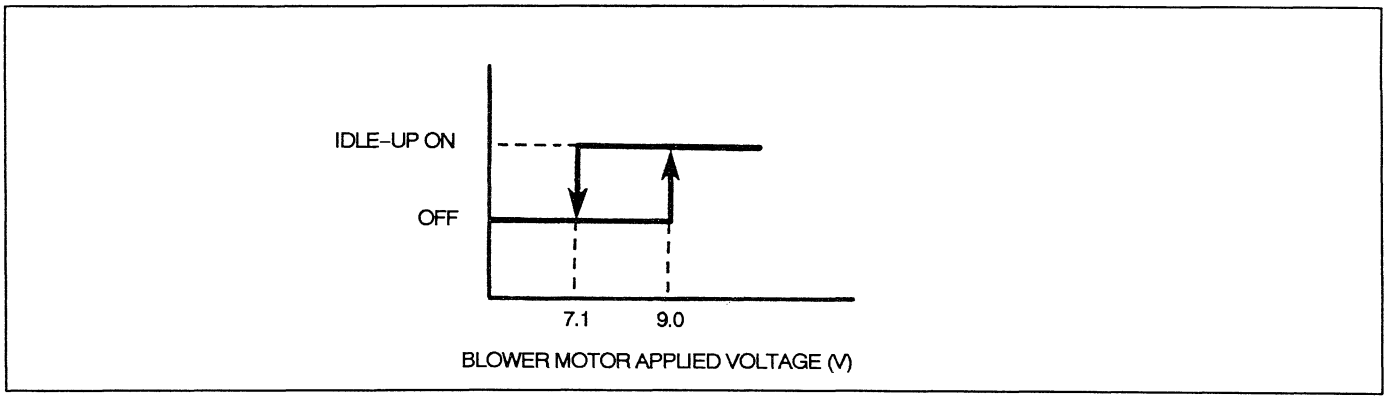
There are 2 types of idle up controls. They are "A/C compressor idle up control "and "electrical load idle up control". They are operated by the A/C amplifier by way of the engine control unit.

A/C compressor idle up control

The purpose of the A/C compressor idle up control is to prevent the engine's idle speedfrom dropping, which would otherwise occurred due to increased resistance from the compressor. This control also improves the cooling ability during A/C compressor operation.

Electrical load idle up control

The purpose of the electrical load idle up control is to prevent the engine's idle speed from dropping, which would otherwise occur due to electrical current consumption. This control also prevents wear and tear of the battery.



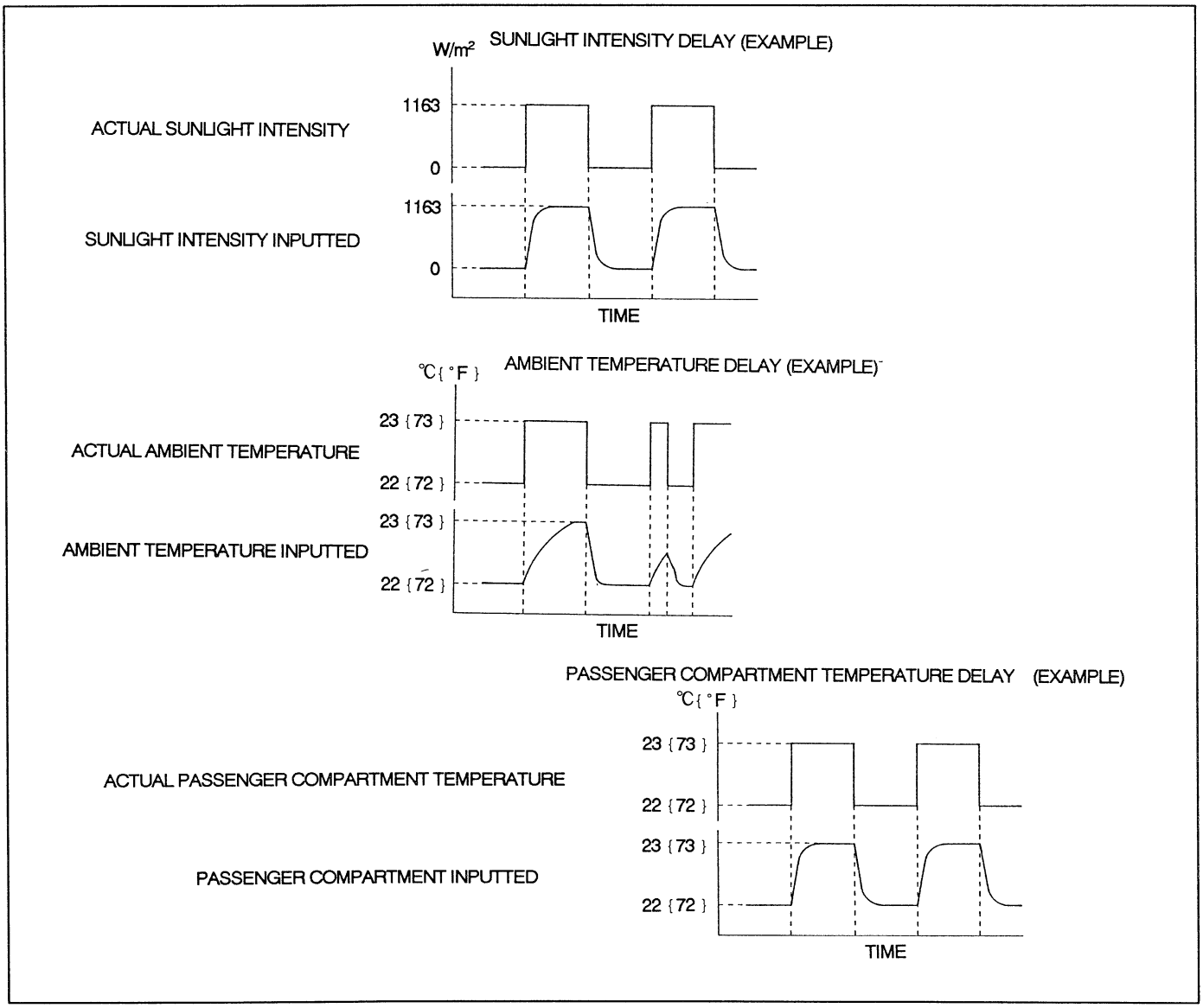
SENSOR FAIL-SAFE FUNCTION

If the A/C amplifier detects that each temperature sensor is failed (open or short circuit), the sensor fail-safe function will be operated with the following fixed temperatures.

SENSOR	TEMPERATURE FIXED AT:
PASSENGER COMPARTMENT TEMPERATURE	25℃{77°F}
AMBIENT TEMPERATURE SENSOR	0℃{32°F}
WATER TEMPERATURE SENSOR	80℃{180°F}
EVAPORATOR TEMPERATURE SENSOR	0℃{32 °F}

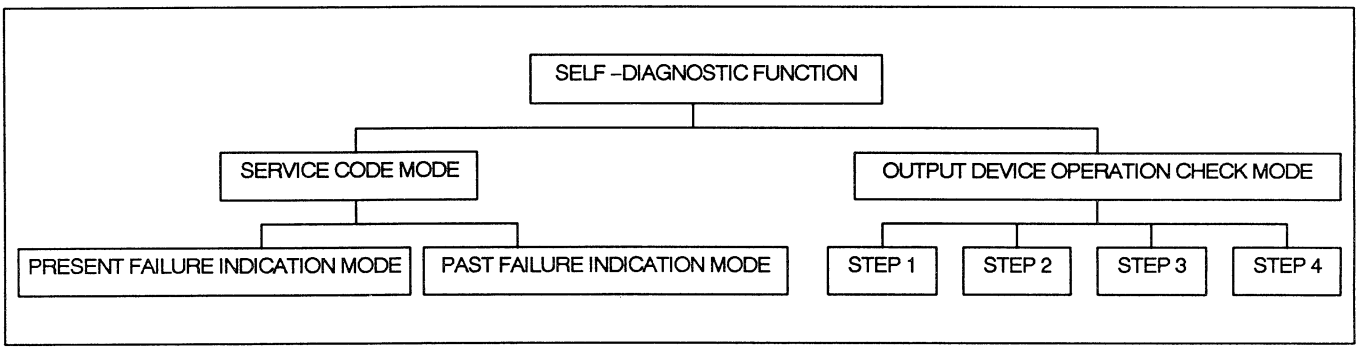
SENSOR SIGNAL DELAY FUNCTION

The auto air conditioner's operation could vary due to sudden changes in outside temperature, passenger compartment temperature, and sunlight intensity, due to travel through temporary shady spots or sunny spots. In order to prevent this, the outside temperature sensor, the passenger compartment sensor, and the sunlight intensity sensor have delay functions, and they control these functions accordingly.

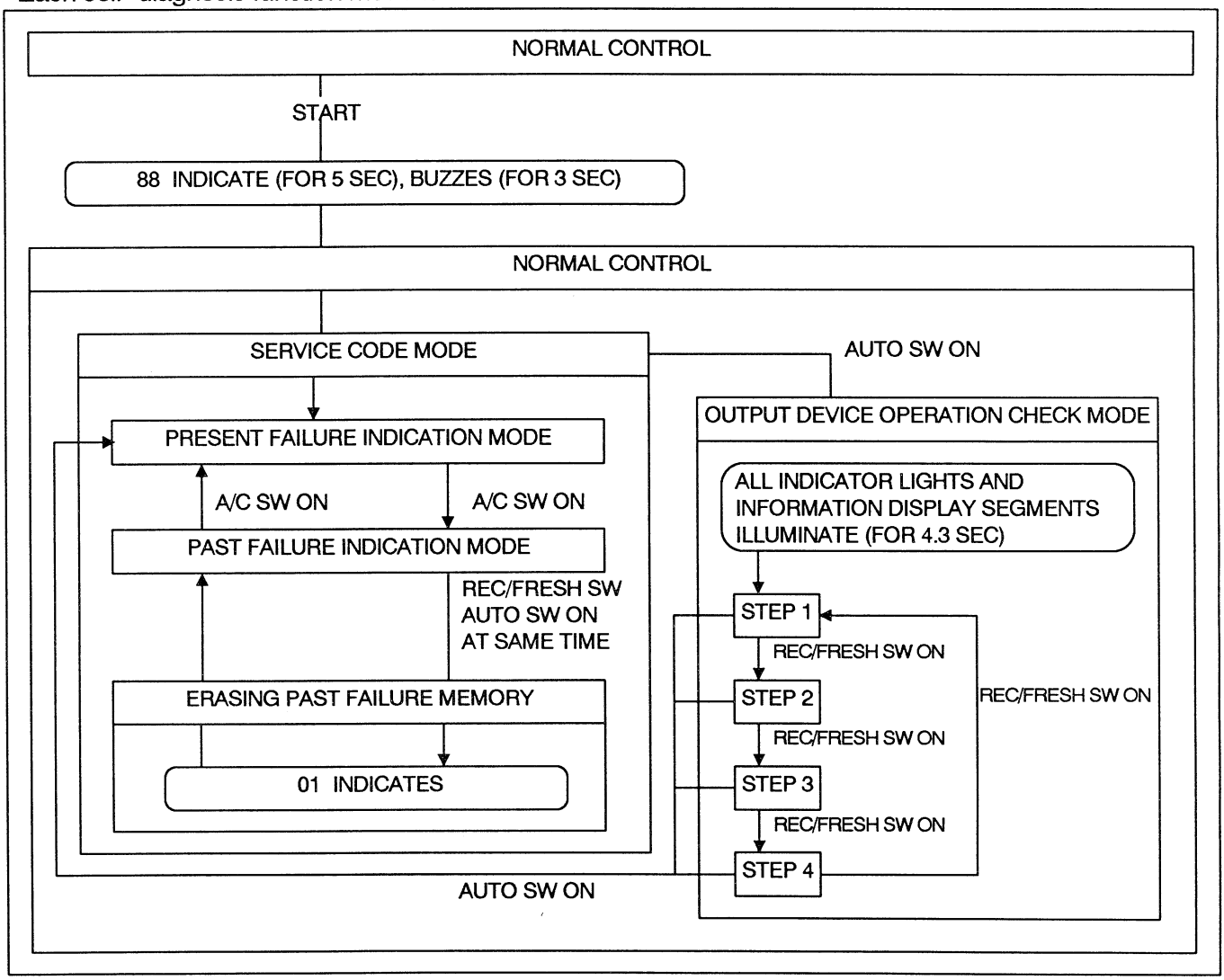


SELF-DIAGNOSTIC FUNCTION

Diagnosis of the auto air conditioner is difficult because the A/C amplifier must do many complicated controls. Therefore, the A/C amplifier is equipped with a self-diagnosis function to improve serviceability. The self-diagnosis function has 2 types of modes. They are "service code mode" and "output device operation check mode". The service code mode consists of the present failure indication mode and the past failure indication mode. The output device operation check mode is divided into 4 steps, based on operating components.



Each self-diagnosis function mode are connected as follows.



Service code mode

The service code mode detects failures of sensors and some input systems (open or short circuit). Malfunctions are then indicated on the SST. There are 2 types of service code modes. They are "present failure indication mode" and "past failure indication mode".

Present failure indication mode

Detects present failures, and indicates them.

Past failure indication mode

Indicates sensors which have malfunctioned (poor contact, etc.) in the past.

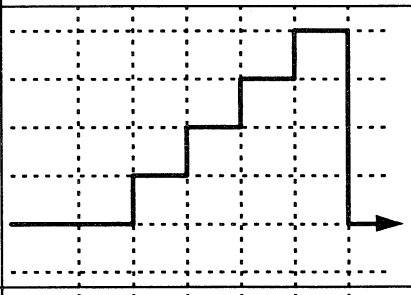
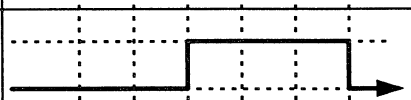
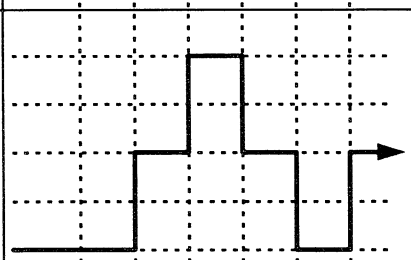
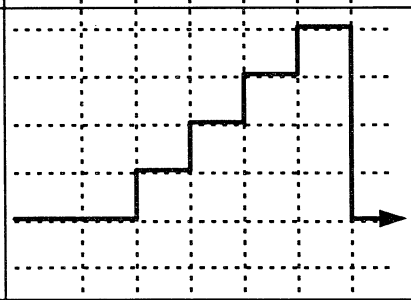
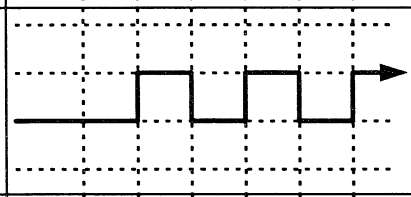
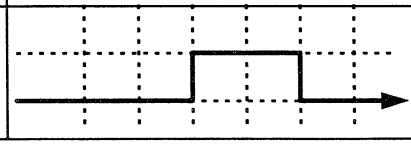
Service code table

SERVICE CODES		FAILURE SYSTEM
PRESENT FAILURE	PAST FAILURE	
00		NO FAILURE
02	-	SOLAR RADIATION SENSOR
06	07	PASSENGER COMPARTMENT TEMPERATURE SENSOR
10	11	EVAPORATOR TEMPERATURE SENSOR
12	14	AMBIENT TEMPERATURE SENSOR
14	15	WATER TEMPERATURE SENSOR
18	19	AIR MIX ACTUATOR (POTENTIOMETER)
21	22	AIR FLOW MODE ACTUATOR (POTENTIOMETER)
46	-	A/C SIGNAL LINE
47	-	ELECTRICAL LOAD IDLE-UP SIGNAL LINE
69	-	SERIAL COMMUNICATION SIGNAL LINE

* Past failure indication mode always keeps service codes in the memory. Therefore, codes should be eliminated after repairing the problem.

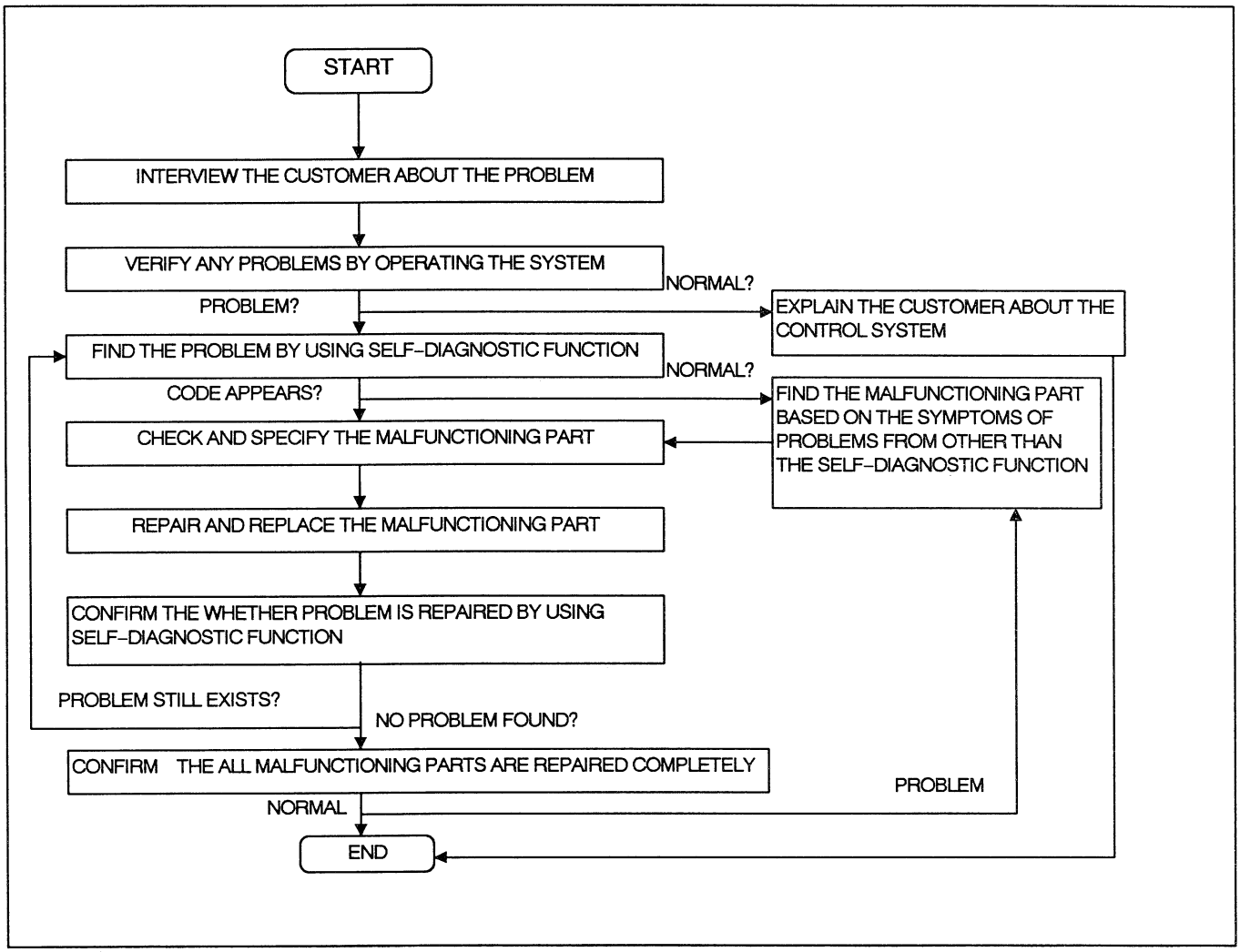
Output device operation check mode

This mode forcibly operates (include the indication and lighting) the output system parts, but is not concerned with input. Each operation is confirmed by sight, by sound, and by feel. Then, if a malfunction exists in a certain part, its malfunction can be easily found.

STEP	OPERATING CONDITION			OTHER DEVICE OPERATION
	DEVICE	ITEM	OPERATION / TIME (SECOND) 0 4 8 12 16 20	
1	BLOWER MOTOR	4TH 3RD 2ND 1ST OFF		● AIR MIX ACTUATOR ----------50% ● AIR INTAKE ACTUATOR -------FRESH ● AIRFLOW MODE ACTUATOR ---VENT ● A/C COMPRESSOR IDLE-UP ---ON ● A/C COMPRESSOR ----------ON ● CONDENSER FAN ----------ON
	ELECTRICAL LOAD IDLE-UP	ON OFF		
2	AIR MIX ACTUATOR	100% (MAX HOT) 50% 0% (MAX COLD)		● AIR INTAKE ACTUATOR -------FRESH ● AIRFLOW MODE ACTUATOR ---VENT ● A/C COMPRESSOR IDLE-UP ---ON ● A/C COMPRESSOR ----------ON ● CONDENSER FAN ----------ON ● BLOWER MOTOR----------2ND ● ELECTRICAL LOAD IDLE-UP----ON
		DEFROSTER HEAT/DEF HEAT BI-LEVEL VENT		● AIR MIX ACTUATOR ----------50% ● AIR INTAKE ACTUATOR -------FRESH ● A/C COMPRESSOR IDLE-UP ---ON ● A/C COMPRESSOR ----------ON ● CONDENSER FAN ----------ON ● BLOWER MOTOR----------2ND ● ELECTRICAL LOAD IDLE-UP----ON
4	AIR INTAKE ACTUATOR	RECIRCURATE FRESH		● AIR MIX ACTUATOR ----------50% ● AIRFLOW MODE ACTUATOR ---VENT ● BLOWER MOTOR----------2ND ● ELECTRICAL LOAD IDLE-UP----ON
	● A/C OMPRESSOR IDLE UP ● A/C COMPRESSOR ● CONDENSER FAN	ON OFF		

TROUBLESHOOTING

As for the auto air conditioner, the self diagnosis function is the fastest way to detect a problem. However, there is the possibility that problems outside the capacity of the self diagnosis function can occur. In order to find the problem properly, please refer to the following basic procedure for troubleshooting.



The most important point in troubleshooting the auto air conditioner is to try to find the cause logically based on customer interview or by the result of the self-diagnosis function, and then to repair the problem. Furthermore, you should confirm whether the problem is repaired completely or not.

N O T E

N O T E

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