2002-07 GENINFO

Climate Control - Overview - MINI

MINI CLIMATE CONTROL

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Air Conditioning in standard on the MINI COOPER and COOPER S. The standard system IHKS is a manually controlled basic air conditioning system. Driver input is required to regulate temperature, air direction and air speed.

Available as an option on both models is the IHKA system. This system is able to function as a totally automatic climate control, affecting outlet temperature, air direction and air speed. The IHKA automatic functions may be overridden giving the driver a more precise manual control than is available with the IHKS system.

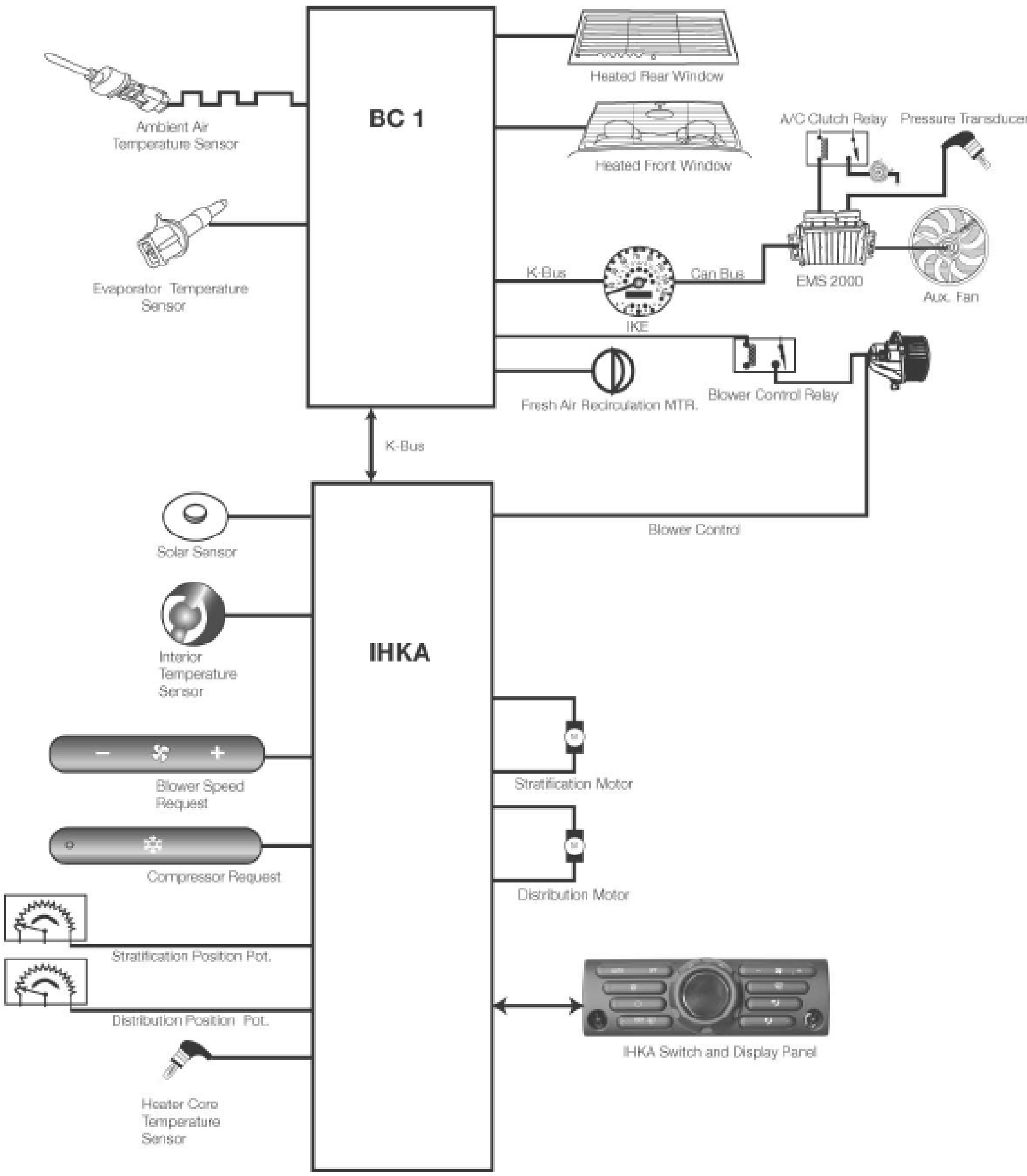


Fig. 1: MINI Climate Control
Courtesy of BMW OF NORTH AMERICA, INC.

Purpose of the System

The purpose of the Climate Control system is to control the temperature and distribution of air supplied to the vehicle interior. The Climate Control system is responsible for the heating or cooling of the air coming into the passenger compartment as well as the heating for the rear window and windshield.

Two systems are available on the MINI:

- IHKS (Standard on MINI COOPER and MINI COOPER S)

- IHKA (Optional on MINI COOPER and MINI COOPER S)

Fig. 2: IHKS Control Unit
Courtesy of BMW OF NORTH AMERICA, INC.

Fig. 3: IHKA Control Unit
Courtesy of BMW OF NORTH AMERICA, INC.

Fig. 4: IHKA Control Unit
Courtesy of BMW OF NORTH AMERICA, INC.

System Components

Both systems (IHKS and IHKA) consist of a refrigerant system, a heater system and a control system. The refrigerant system is the same on both, the heater assembly and control systems are different.

Refrigerant System (IHKS and IHKA)

The Refrigerant System transfers heat from the vehicle interior to the outside atmosphere providing the heater assembly with dehumidified cool air. The system is a sealed, closed loop, filled with a charge weight (350 grams) of R134a refrigerant as the heat transfer medium. Oil is added to the refrigerant to lubricate the internal components of the compressor.

The refrigerant system consists of the following components:

- R134a Refrigerant and Lubricant
- Compressor
- Evaporator
- Condenser
- Receiver/Drier
- Expansion Valve
- Cooling Fan
- Pressure Transducer
- Evaporator Temperature Sensor
- Refrigerant Lines

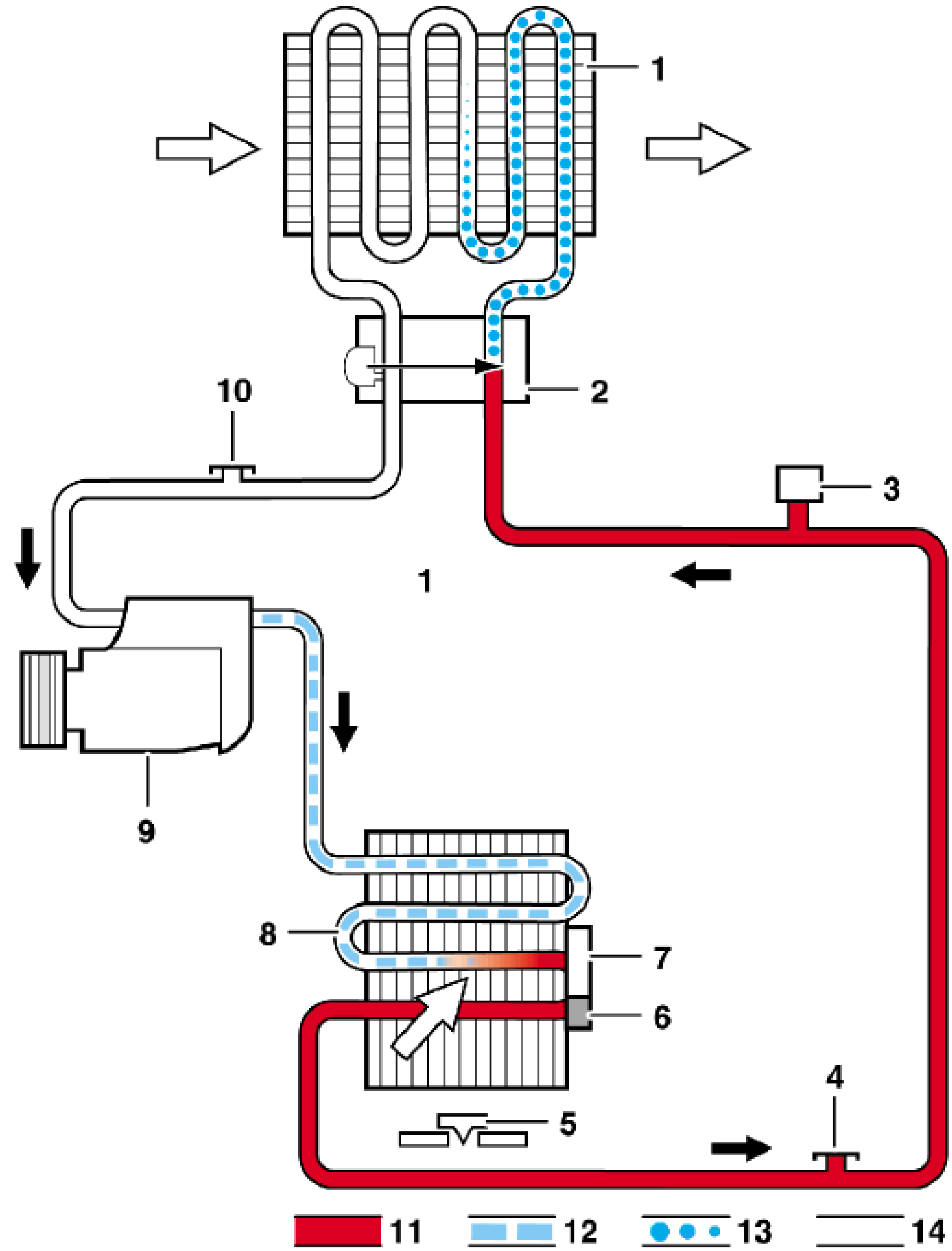
R134a Refrigerant

An air conditioning system uses refrigerant to absorb heat from the air that passes through the evaporator. Refrigerants are special materials that are vapors at room temperature and liquids at much lower temperatures. Automotive refrigerants boil at -16°F to -22°F (-27°C to -30°C). Refrigerants are also able to contain and transport a large amount of heat, efficiently, and can be evaporated and condensed over and over without being damaged.

In the air conditioning system, liquid refrigerant under high pressure flows through a small hole into the evaporator, where the pressure is then greatly reduced. When the pressure drops, the refrigerant boils and changes from a liquid to a vapor. As it changes its state, it absorbs a large amount of heat.

As the air passing through the evaporator gives up some of its heat, it becomes colder; it can then be blown into the passenger compartment, to cool it. Once the refrigerant has absorbed heat from the air, it is returned to the compressor. The A/C system removes the excess heat from the refrigerant as the refrigerant passes through the condenser.

A/C Refrigerant Circuit



1. Evaporator
2. Expansion Valve
3. Pressure Transducer
4. High Pressure Service Port
5. Cooling Fan
6. Filter
7. Desiccant
8. Condenser
9. Compressor
10. Low Pressure Service Port
11. High Pressure Liquid
12. High Pressure Gas
13. Low Pressure Liquid
14. Low Pressure Gas

Fig. 5: A/C Refrigerant Circuit

Courtesy of BMW OF NORTH AMERICA, INC.

Compressor

The compressor in an automotive A/C system serves two important functions:

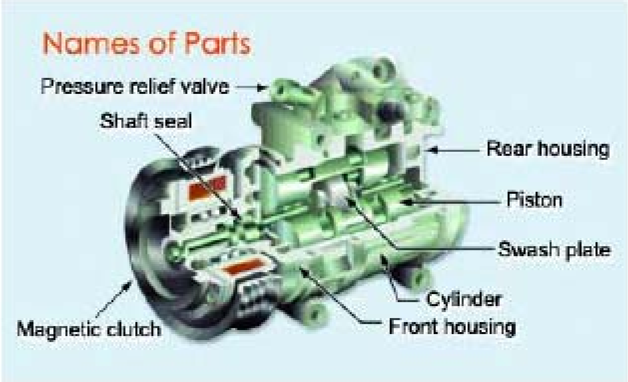
- It creates a low-pressure zone at the compressor inlet, to draw refrigerant vapor from the evaporator.
- It compresses the low-pressure refrigerant vapor into a high-pressure vapor and sends it toward the condenser.

The compressor is a swash plate unit with variable displacement, bolted to an engine bracket, driven by an electromagnetic clutch.

By matching refrigerant flow to the thermal load of the evaporator, the variable compressor maintains a relatively constant evaporator outlet temperature of approximately 3 to 4°C (37 to 39°F).

Compressor Mounted on Engine

Fig. 6: Compressor Mounted On Engine
Courtesy of BMW OF NORTH AMERICA, INC.



Swash Plate Compressor (internal)

Fig. 7: Swash Plate Compressor (Internal)
Courtesy of BMW OF NORTH AMERICA, INC.

Compressor Clutch

The compressor pulley is driven by a belt from the crankshaft; a compressor clutch is used to engage/disengage the pulley and driveshaft. The clutch is electromagnetic. When power is provided to the clutch, the clutch engages and rotates the compressor drive shaft. When the power is cut off, the clutch disengages and the compressor pulley free-wheels. The compressor is cycled on and off, according to evaporator temperature; it is also cycled off at full-throttle, standing start acceleration conditions.

NOTE: The Compressor and clutch can only be replaced as a complete unit.

Evaporator

The evaporator is located in the heater assembly and uses an encapsulated sensor to measure the temperature of the air coming off the evaporator. The evaporator is installed in the heater assembly after the blower and absorbs heat from the exterior or re-circulated inlet air. Low pressure, low temperature refrigerant changes from liquid to vapor in the evaporator, absorbing large quantities of heat as it changes state.

The evaporator (like the condenser) is a "heat exchanger." As air passes over the evaporator fins, the moisture condenses on the fins as the air cools. Water collects in the bottom part of the housing and exits the drain.

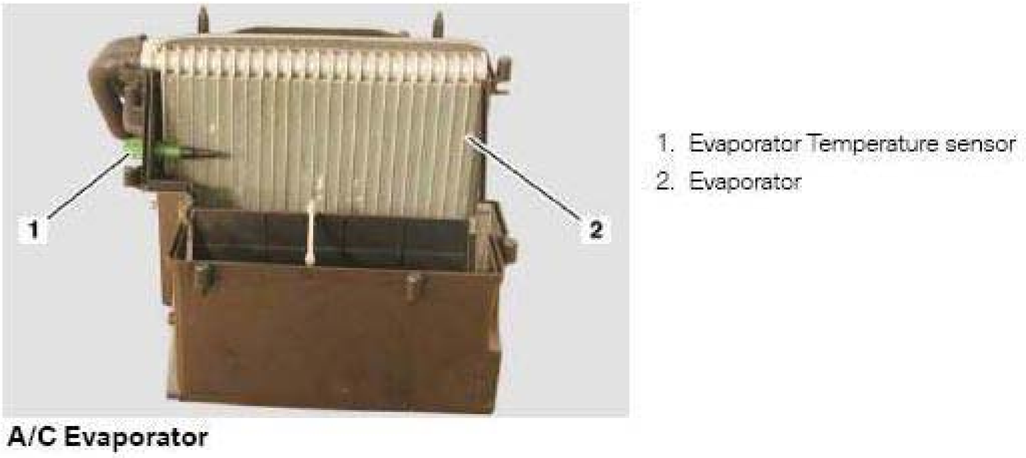


Fig. 8: A/C Evaporator
Courtesy of BMW OF NORTH AMERICA, INC.

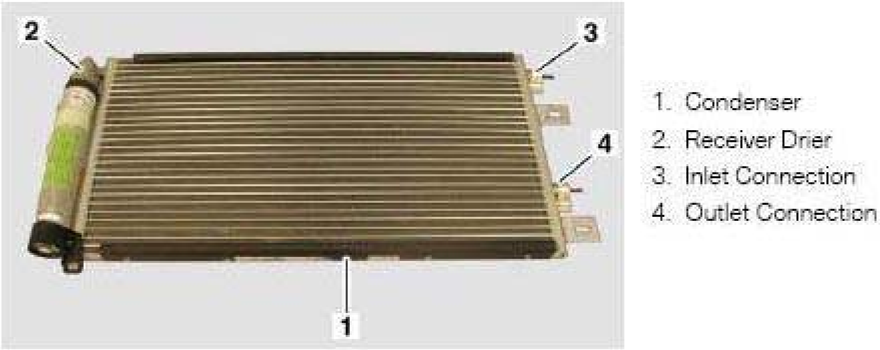
Condenser

The condenser with integrated receiver/drier is installed in front of the radiator. The receiver/drier is a replaceable unit, located in a threaded housing at the lower end and retained by a plastic bracket at the top.

The condenser is a heat exchanger similar to the radiator and evaporator. It transfers heat from the refrigerant to the surrounding air to convert the vapor from the compressor into a liquid.

Receiver/Drier

A receiver/drier integrated in the condenser assembly removes moisture and solid impurities from the refrigerant, and provides a reservoir of liquid refrigerant to accommodate flow changes at the evaporator.



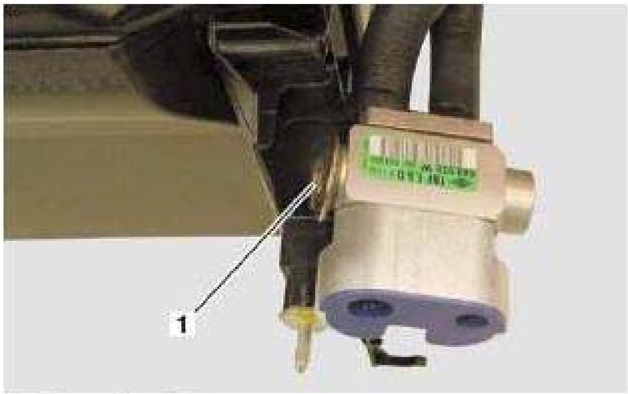
A/C Condenser with Integrated Receiver Drier

Fig. 9: A/C Condenser With Integrated Receiver/Drier
Courtesy of BMW OF NORTH AMERICA, INC.

Expansion Valve

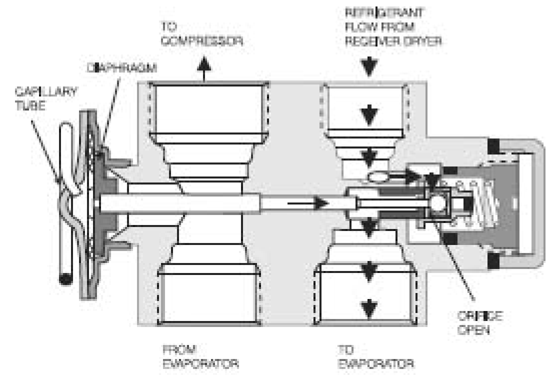
The expansion valve meters the flow of refrigerant into the evaporator to match the refrigerant flow with the heat of the air passing through the evaporator.

The expansion valve is attached to the inlet and outlet ports of the evaporator. The valve consists of an aluminum housing containing inlet and outlet. The expansion valve controls the amount of refrigerant released into the evaporator. It is fitted to the evaporator inlet/outlet pipes. The valve separates the high-pressure side of the system from the low-pressure side. A small passage, or "orifice," allows only a small amount of liquid into the evaporator. The amount of refrigerant that it allows through depends on the evaporator temperature and pressure, and the temperature of the air passing through the evaporator.



1. Expansion Valve

Fig. 10: Expansion Valve
Courtesy of BMW OF NORTH AMERICA, INC.



Expansion Valve Refrigerant Flow

Fig. 11: Expansion Valve Refrigerant Flow
Courtesy of BMW OF NORTH AMERICA, INC.

A block-valve design of expansion valve is used on MINI A/C systems. The refrigerant enters at the upper right inlet. At the left of the valve there is a capillary tube filled with an inert gas, that senses the temperature of the air coming into the housing from the plenum. When the air temperature in the plenum rises, the pressure in the capillary tube increases. This pushes down on a diaphragm and pushrod assembly, which increases the size of the orifice opening, allowing more refrigerant into the evaporator and providing more cooling. When plenum temperature falls, the pressure in the capillary tube falls. The spring pushes up on the pushrod, making the orifice opening smaller; less refrigerant is allowed into the evaporator, allowing less cooling.

Cooling Fan

The condenser on the A/C systems interfaces with the EMS2000 over the bus network for electric fan operation. The electric fan is not directly controlled by the A/C system. The EMS2000 controls the fan via two relays.

This provides additional airflow through the radiator and condenser, when needed. The additional airflow allows more heat to be taken away from the condenser and thus allowing better cooling of the refrigerant.

Pressure Transducer

The Pressure Transducer is fitted into the high-pressure line between the condenser and the expansion valve, on the drivers side rear of the engine compartment, under the battery.

The pressure transducer signals EMS2000 for compressor control and engine electric cooling fan operation.

Because the compressor is lubricated by oil suspended in the refrigerant, the EMS2000 prevents operation of the compressor unless there is a minimum refrigerant pressure, and thus refrigerant and oil, in the system.

When refrigerant pressure increases the EMS2000 increases cooling fan speed to provide more airflow across the condenser.

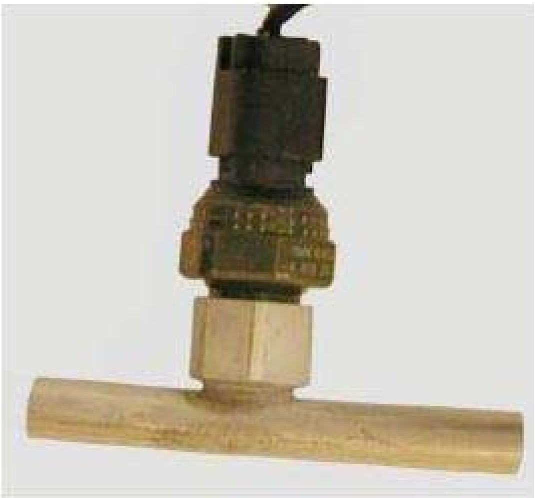


Fig. 12: Pressure Transducer
Courtesy of BMW OF NORTH AMERICA, INC.

Evaporator Temperature Sensor

The Evaporator Temperature Sensor is located on the left side of the heater case and signals directly to the BC1.

The sensor is an encapsulated thermistor that provides the BC1 with an input of the evaporator air outlet temperature.

Fig. 13: Evaporator Temperature Sensor
Courtesy of BMW OF NORTH AMERICA, INC.

Refrigerant Lines

To maintain similar flow velocities around the system, the diameter of the Refrigerant Lines varies to suit the two-pressure/temperature conditions. The larger diameters are installed in the low pressure/temperature zone and the smaller diameters are installed in the high pressure/temperature zone. Low and high pressure service fittings are incorporated into the refrigerant lines for system servicing.

Fig. 14: A/C Service Fittings
Courtesy of BMW OF NORTH AMERICA, INC.

Fig. 15: A/C Service Lines At Condenser
Courtesy of BMW OF NORTH AMERICA, INC.

Principle of Operation

The basic principle at work in a climate control system is heat transfer. An automotive A/C system takes heat from inside the passenger compartment and transfers it outside.

In an A/C system, heat is transferred using a refrigerant. The refrigerant absorbs heat from air entering the passenger compartment, carries the heat outside the compartment, releases the heat, and then re-enters the compartment to begin the cycle again.

An A/C system does not "add cold" to air - it removes some of the heat from it. Some heat is always present, but the less heat the air contains, the cooler it feels.

An air conditioning system's efficiency is based on how well it moves heat. Heat always travels from warm to cold. The reverse is never true. For example, if a hot cup of coffee is left standing, it will cool off, while a cold soda will get warm. The heat from the warm coffee moves to the cooler surrounding air. The heat from the surrounding air moves to the cooler soda, until a balance is reached.

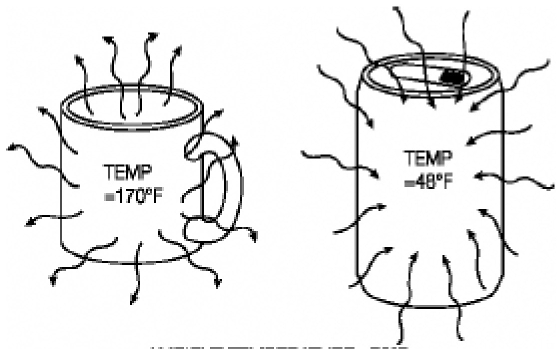


Fig. 16: Ambient Temperature
Courtesy of BMW OF NORTH AMERICA, INC.

Temperature and State Changes

At sea level, water freezes at 32°F (0°C) and boils at 212°F (100°C). These are the temperatures at which water changes state. When a liquid boils (changes to a gas), it absorbs heat. When a gas condenses (changes back to a liquid), it gives off heat.

- As the pressure on a liquid is increased, the boiling point rises.
- As the pressure on a liquid is decreased, the boiling point drops.

Evaporation

Evaporation is one of the basic principles by which a refrigeration system works. In evaporation, liquid changes to a vapor. Adding heat causes a liquid to evaporate.

Condensation

Condensation is the reverse of evaporation. In condensation, a vapor changes to a liquid. Removing heat causes a vapor to condense to a liquid.

The task of an air conditioning system is to absorb a large amount of heat, move it away from the passenger compartment, and exhaust it. When the refrigerant in the A/C system evaporates, it absorbs a large amount of heat from the air entering the passenger compartment.

As the refrigerant vapor is pumped outside the passenger compartment, it transports this heat with it. When the refrigerant condenses back into a liquid, this heat is released.

Compressor

When AC is requested, the clutch is energized and the pulley drives the shaft. The journal and the swash plate turn with the shaft, and the angled swash plate produces reciprocating movement of the pistons. Vapor from the inlet pressure chamber is drawn into the cylinder, compressed, and discharged into the outlet pressure chamber, producing a flow around the refrigerant circuit.

The flow rate through the compressor is determined by the length of the piston stroke, which is controlled by the tilt angle of the swash plate. The tilt angle of the swash plate is controlled by the servo pressure and compressor inlet pressure acting on the pistons during their induction stroke. A relative increase of inlet pressure over servo pressure moves the pistons along their cylinders to increase the tilt angle, the piston stroke and the flow rate. Similarly, a relative decrease of inlet pressure over servo pressure moves the pistons along their cylinders to reduce the tilt angle, the piston stroke and the flow rate.

The control valve regulates the servo pressure in the crankcase as a function of inlet pressure, so that the flow rate of the compressor matches the thermal load at the evaporator, i.e. the more cooling required in the passenger compartment, the higher the thermal load and flow rate. Servo pressure varies between inlet pressure and inlet pressure ±0.07 bar (±1 psi).

As the refrigerant flows through the evaporator and absorbs heat (i.e. as the thermal load increases) the pressure of the vapor entering the compressor increases. In the control valve, the increased inlet pressure causes the diaphragm and push rod to close the ball valve. The resulting reduction in crankcase pressure, together with the increase in inlet pressure, moves the swash plate to a higher tilt angle and increases the piston stroke and the flow through the compressor.

When the thermal load of the evaporator decreases, the subsequent decrease in pressure of vapor entering the compressor causes the control valve to open. This increases swash plate crankcase pressure, which reduces the tilt angle of the swash plate and the flow through the compressor.

Condenser

The condenser, being directly downstream of the compressor, receives the high pressure vapor gas and the condensation process begins.

The unit is classified as an integrated, sub-cooling condenser and consists of a fin and tube heat exchanger installed between two end tanks. Divisions in the end tanks separate the heat exchanger into a three pass upper (condenser) section and a single pass lower (sub-cooler) section, which are interconnected by a receiver drier on the left hand end tank.

Although the receiver/drier is integral with the condenser, It contains a desiccant pack and filter that are replaceable as a unit. It is secured with a metal screw and is retained by a plastic bracket at the top of the condenser.

Ambient air, passing through the condenser due to ram effect and/or the cooling fan, absorbs heat from the refrigerant to change it from a vapor to a liquid. The condenser section cools and liquefies the refrigerant before it enters the receiver/drier.

Drier

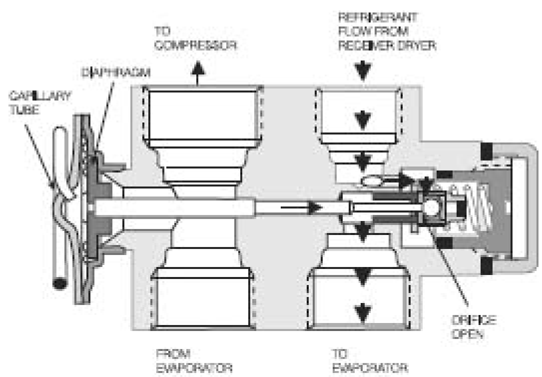
From the condenser, liquid refrigerant under high pressure flows to the receiver/drier. The drier consists of a cylindrical tank to hold the refrigerant and a solid drier. The solid drier is made from zeoliite, molecular sieves and aluminum oxides. The drier is designed to separate the refrigerant vapor from the liquid so that only the liquid is fed to the expansion valve.

After the refrigerant has passed through the condenser the remaining gas in the refrigerant liquefies and passes through the desiccant and filter removing moisture and solid impurities. The refrigerant flows into the sub-cooler section where it is further cooled resulting in the refrigerant at the outlet being almost 100% liquid.

Expansion Valve and Evaporator

The refrigerant, now a high pressure liquid is passed via the refrigerant lines to the expansion valve at the entrance to the evaporator. A ball and spring metering valve is installed in the inlet passage of the expansion valve. The metering valve is controlled by a temperature sensitive tube connected to a diaphragm. The top of the diaphragm senses evaporator outlet pressure and the tube senses evaporator outlet temperature.

Liquid refrigerant flows through the metering valve into the evaporator. The restriction across the metering valve reduces the pressure and temperature of the refrigerant. The restriction also changes the solid stream of refrigerant into a fine spray, to improve the evaporation process.



Expansion Valve

Fig. 17: Expansion Valve
Courtesy of BMW OF NORTH AMERICA, INC.

As the refrigerant passes through the evaporator, it absorbs heat from the air flowing through the evaporator. The increase in temperature causes the refrigerant to vaporize.

The temperature and pressure of the refrigerant leaving the evaporator act on the diaphragm and temperature sensitive tube, which move to regulate the metering valve opening and so control the volume of refrigerant flowing through the evaporator. The more heat available to evaporate refrigerant the greater the volume of refrigerant allowed through the metering valve.

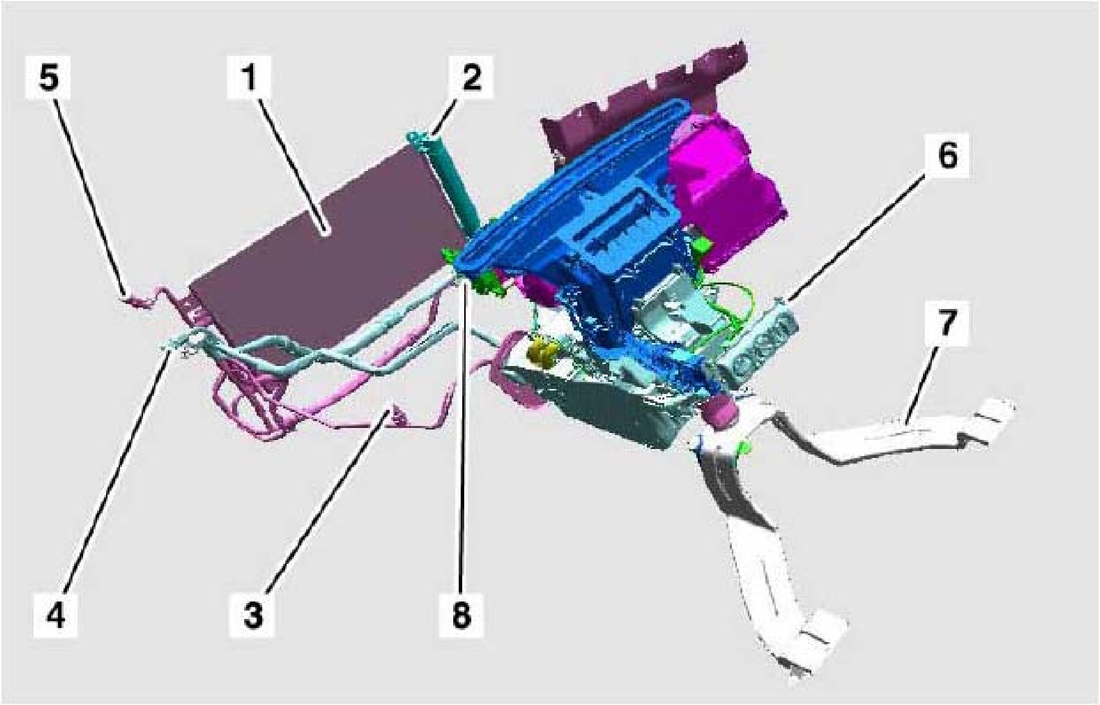
The refrigerant, now a low pressure gas full of latent heat removed from the passenger compartment is drawn back into the compressor. The compressor again increases the pressure of the refrigerant, making it now a high pressure vapor. This pressure increase raises the boiling point of the refrigerant, enabling it to give off heat and be condensed.

HEATING SYSTEM

The heating and ventilation system controls the temperature and distribution of air supplied to the vehicle interior. The system consists of a micro filter housing, a heater assembly, distribution ducts, refrigerant system and a control panel. The MINI heater system uses the air blend principle: fresh air enters through vents beneath the windshield and flows into the heater assembly, a blend flap mixes the warm air passing the heat exchanger with the cool air and distributes it into the vehicle interior. Flow-through vents incorporated in the luggage compartment enable the air to exit the vehicle interior.

Fresh or re-circulated air passes through the filter into the heater assembly where an electrical variable speed blower, and/or ram affect, forces the air through the system. Depending on the settings on the control panel, the air is then heated or cooled and supplied through the distribution ducts to face, defrost and floor level outlets.

Two different Heating Systems are provided depending on Climate Control variation (IHKS or IHKA).



Air Conditioning/Heating Assembly

1. Condenser
2. Receiver/Drier
3. Pressure Transducer
4. Low Pressure Service Port
5. High Pressure Service Port
6. Control Panel
7. Rear Footwell Air Ducts
8. Compressor

Fig. 18: Air Conditioning/Heating Assembly Components
Courtesy of BMW OF NORTH AMERICA, INC.

IHKS HEATING AND AIR DISTRIBUTION

The IHKS System allows manual selection of inlet air source, outlet air temperature, air distribution and blower speed. Components of the IHKS heating and air distribution system include:

- Microfilter
- Heater Assembly (including Air Conditioning System)
- Blower Motor and Resistor Pack

- Heater Core
- Control Flaps
- Distribution Ducts
- Outlet Vents

Microfilter

A pollen or combination pollen/odor filter (IHKA version) is fitted to all vehicles to improve the quality of the air supply to the vehicle interior.

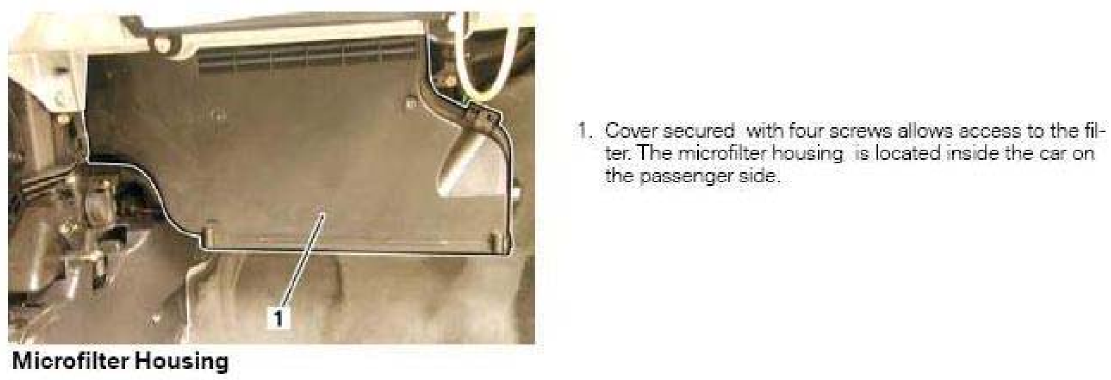


Fig. 19: Microfilter Housing
Courtesy of BMW OF NORTH AMERICA, INC.

Fig. 20: Heater Assembly
Courtesy of BMW OF NORTH AMERICA, INC.

Heater Assembly

The heater assembly heats/cools and distributes fresh or recirculated air as directed by selections made on the control panel. The assembly is installed on the vehicle center line, between the dash and the firewall, and consists of a housing, which contains a blower, a heater core, control flaps, evaporator, expansion valve, and evaporator temperature sensor.

A drain outlet in the bottom of the housing is connected to a tube installed in the right hand side of the tunnel that directs any condensate from the housing interior to beneath the vehicle.

Blower Motor and Resistor Pack

The blower is installed in the driver's side of the heater housing and consists of an open hub, centrifugal fan powered by an electric motor. A rotary switch on the control panel and a final stage unit control the four (4) blower speeds.

The final stage is installed in the blower motor. The blower motor must be removed from the vehicle to replace the blower control unit and the dash assembly must be removed to service the blower motor. Be sure of your diagnosis.


Blower Motor

Fig. 21: Blower Motor
Courtesy of BMW OF NORTH AMERICA, INC.


Blower Control Final Stage

Fig. 22: Blower Control Final Stage
Courtesy of BMW OF NORTH AMERICA, INC.

Heater Core

The heater core provides the heat source for warm the air being supplied to the distribution outlets. The heater core is an aluminum double pass, fin and tube heat exchanger, installed through the left hand side of the housing. Two aluminum tubes attached to the heater core extend through the engine bulkhead to connect the heater assembly to the engine coolant system. When the engine is running, coolant is **constantly** circulated through the heater core by the engine coolant pump.

Fig. 23: Heater Core
Courtesy of BMW OF NORTH AMERICA, INC.

Control Flaps

Control flaps are installed in the heater assembly to control the inlet source, temperature and distribution of air.

Recirculation/Fresh Air Flap

The fresh/recirculation air flap is located in the microfilter housing and is operated by a servomotor. The BC1 controls the servomotor on request from the recirculation switch of the heater control panel.

The servomotor consists of a unidirectional electric motor with an integrated flap lever mechanism. The BC1 activates the servomotor for a maximum of 10 seconds to move the flap to one of the two end positions; no feedback on the actual position of the flap is received at the BC1 (maximum run time = 10 seconds).

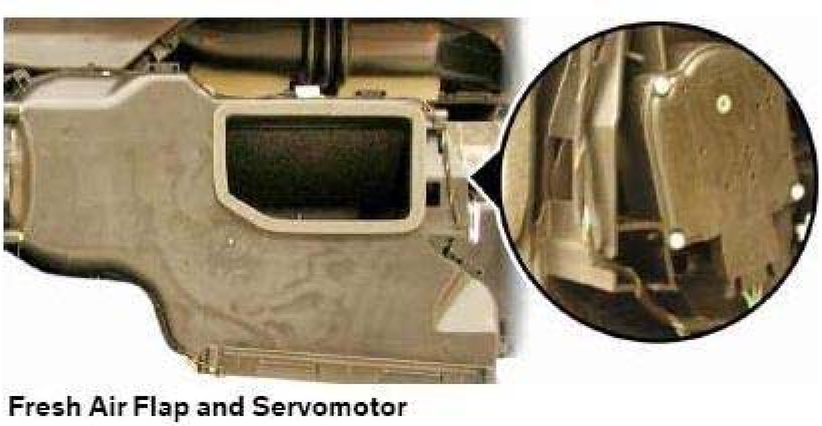


Fig. 24: Fresh Air Flap And Servomotor
Courtesy of BMW OF NORTH AMERICA, INC.

Temperature Flap

A blend flap regulates the temperature of the air leaving the heater unit by mixing heated air from the heater core with fresh or cooled air. A rotary temperature control operates the blend flap via a Bowden cable. The flap control mechanism and cable connection (1) is on the right side of the heater unit.

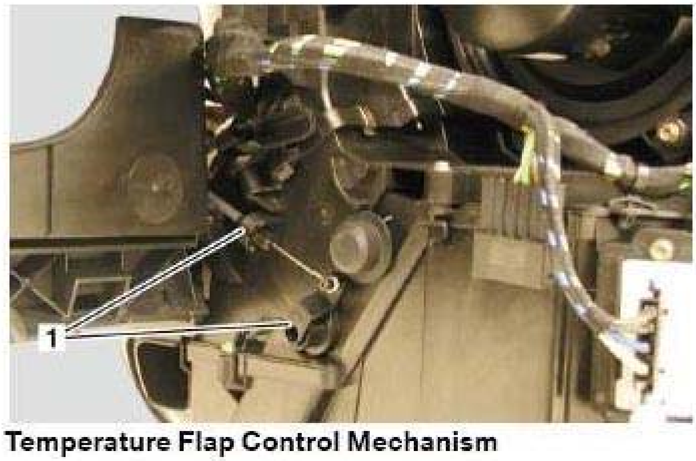


Fig. 25: Temperature Flap Control Mechanism
Courtesy of BMW OF NORTH AMERICA, INC.

Air Distribution Flaps

Three distribution flaps are installed to control the flow of air to the footwell, windshield/side windows and the face level outlets. The flaps are operated via a lever mechanism, linked to the air distribution knob on the control panel by a flexible control cable.

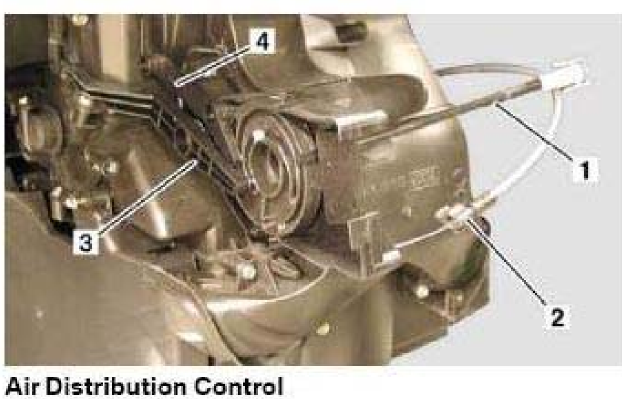


Fig. 26: Air Distribution Control
Courtesy of BMW OF NORTH AMERICA, INC.

Workshop Hint

Prior to attempting to remove the control panel, disconnect the air distribution cable (IHKS) from the rear of the control panel.

Distribution Ducts

Three separate distribution ducts are installed for air distribution.

- The windshield and front side window outlets ducts are integrated into the dash upper.
- The face level outlets and central high-level outlet duct are attached to the dash cross car beam.
- The rear footwell duct is located in the center of the heater assembly floor outlet and extends along the floor below the front seats.

Vent assemblies in the dash allow occupants to control the flow and direction of face level air. Each vent assembly incorporates a control knob to regulate flow and is moveable to control direction.

Rear Flow-Through Vents

The flow-through vents promote the free flow of heating and ventilation air through the cabin. The flow-through vents are located in the rear panel of the luggage compartment and vent cabin air into the sheltered area between the body and the rear bumper. The vents are effectively non-return valves and each consists of a grille covered by soft rubber flaps. The flaps open and close automatically depending on the differential between cabin and outside air pressures.

Rear Flow-Through Vents

Fig. 27: Rear Flow-Through Vents
Courtesy of BMW OF NORTH AMERICA, INC.

Switch Panel (IHKS)

The IHKS system uses three rotary control knobs for temperature, blower speed and air distribution control. The system has a recirculation function and may have the heated front screen as an option with the switch located in the blank above the heated rear window switch. The IHKS system also requests compressor activation from the BC1.

Fig. 28: Rotary Control Knobs For Temperature
Courtesy of BMW OF NORTH AMERICA, INC.

Temperature Dial

Turning the temperature knob on the control panel operates the control cable and in turn the blend flap in the heater assembly. The blend flap varies the proportion of air bypassing and going through the heater core. The proportion varies between FULL COLD with no airflow through the heater core and FULL HOT with 100% of airflow through the heater core. This corresponds with the position of the temperature control knob.

Blower Dial

The blower operates while the ignition is on. Switch positions are OFF or one of four speeds. The blower will function 0.5 seconds after the end of cranking. At switch positions 1, 2 and 3, the blower switch connects the B+ side of the blower to different paths through the resistor pack, to produce corresponding differences of blower operating voltage and speed. At position 4, the blower switch connects a B+ directly to the blower, bypassing the resistor pack, and full battery voltage drives the blower at maximum speed.

Air Distribution Dial

Turning the distribution knob on the control panel operates the control cable to turn the distribution flaps in the heater assembly and direct air to the corresponding outlets in the passenger compartment.

Recirculation Button

When the fresh/recirculated air switch is pressed, the switch connects a ground to the BC1. The BC1 then grounds the indicator LED in the switch and the recirculated air side of the fresh/recirculation air servomotor. The indicator LED illuminates and the fresh/recirculation air servomotor moves the control flap in the filter housing to close the fresh air inlet and open the recirculated air inlet.

Compressor Button (Snowflake)

The Compressor Button operates a ground input to the BC1 to control the on/off selection of the refrigerant system. A green indicator LED in the AC switch illuminates when the air conditioning system is switched on.

Heated Rear Window Button (HRW)

A momentary push switch controls the heated rear window and incorporates an orange LED to indicate status. A single press of the switch will turn the heated rear window on, illuminate the LED, and start a timer. When the timer has expired, the heated rear window and LED will turn off. The HRW is controlled by the BC1.

Heated Front Windshield (HFS)

The heated front screen switch is located on the control panel above the heated rear window switch. The operation and configuration of the heated front screen control is identical to the heated rear window control.

IHKS Control Unit

The IHKS System is a manual climate control. Operator input controls air temperature, air distribution, blower speeds and compressor requests. There are no "Automatic" functions with IHKS.

Temperature Control

The operator controls air outlet temperature by positioning the temperature knob. The knob controls the cable to the blend flap. The flap is linked internally to a secondary air-direction flap that optimizes airflow through the unit by ensuring the airflow does not enter the heater core area thereby preventing any unwanted hot/cold air bleed.

Engine coolant is flowing constantly through the heater core. There is no water valve. Failure of the flap to block off air flow through the heater core would provide constant heated air in the vehicle.

Blower Control

The Blower may only run if the ignition is on. There is a 0.5 second delay after engine cranking to energize the blower. This delay is controlled by the BC1. The BC1 receives the end of cranking (engine started) signal from the EMS2000. After a 0.5 second delay the BC1 energizes the Blower Relay. The Blower Relay supplies power to the 5 position blower switch (Off, 1, 2, 3, 4). Activation of the blower switch creates a power flow through the resistor pack (except in position 4). The varying voltage from the resistor pack is supplied to the blower and the BC1. The blower speed is based on the voltage supply from the resistor pack. Less resistance means higher voltage and higher blower speed. The BC1 looks for the blower speed voltage before requesting the AC compressor. Loss of blower voltage will result in loss of compressor.

IHKS Principle of Operation

Air Distribution

A single cable attached to the Control unit and the heater assembly allow the operator to control the direction of outlet air.

Fresh/Re-Circulation Air

The re-circulation switch on the control panel signals to the Body Control Module (BC1), which in turn controls the fresh/re-circulation flap via a DC servomotor. The servomotor consists of a unidirectional electric motor with a integrated flap lever mechanism and is driven end-to-end, and then switched off on a timer (maximum run time = 10 seconds).

The servomotor also has internal limit switches to disconnect power. There is no feedback to the BC1 or IHKS concerning flap position.

Heated Rear Window (HRW)

The HRW is controlled by the BC1. A momentary push of the switch signals the BC1 of the request for HRW. It is only possible to operate the heated rear window when the engine is running. When the switch is pressed with the engine running below 400 rpm nothing will happen. If the engine stalls while the HRW is on, the heated rear window and LED will switch off until the engine restarts.

The HRW on time is timer controlled.

- The timer duration will depend upon outside ambient temperature. At 10°C (50°F) and above the HRW will operate for 12 minutes. Below 10°C (50°F) the HRW will operate for 20 minutes.
- The timer values are stored in EEPROM in the BC1.

A press of the switch while the LED is illuminated will turn the heated rear window off and extinguish the LED.

Heated Front Windshield (HFS)

The operation and configuration of the heated front screen control is identical to the heated rear window control, with the following exceptions:

- At 10°C (50°F) and above the timer will run for 3 minutes. Below 10°C (50°F) the timer will run for 17 minutes.

The timer values are stored in an EEPROM in the BC1.

Compressor Control

The Compressor is directly controlled by the EMS2000 through a compressor relay. When a request is received at the IHKS for compressor activation, a signal is sent to the BC1. The BC1 looks at blower status (output from the blower resistor pack) and evaporator temperature. If the blower is operational and the evaporator temperature is above 20°C (68°F), the BC1 changes the Compressor "OFF" signal it sends to the EMS2000 to a Compressor "ON" signal.

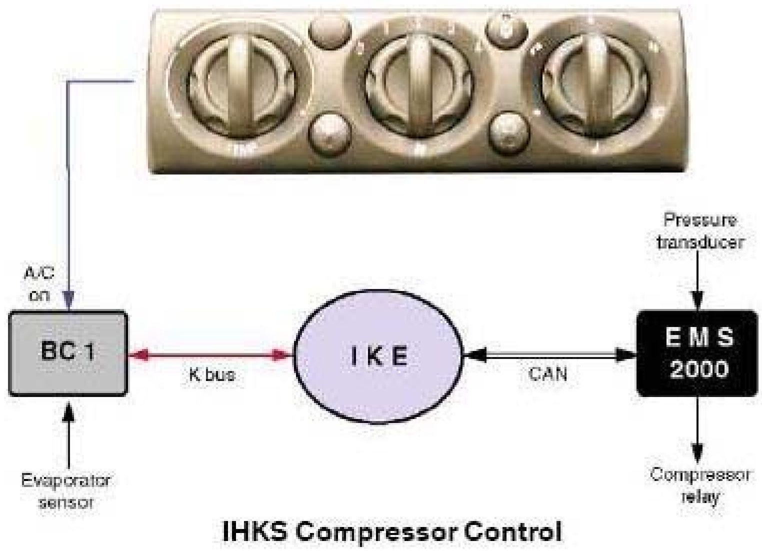


Fig. 29: IHKS Compressor Control
Courtesy of BMW OF NORTH AMERICA, INC.

The Compressor "ON" signal is sent via the K-Bus through the IKE over the CAN Bus to the EMS2000. When this "ON" signal is received by the EMS2000, it checks the status of the pressure transducer, and if the transducer is in operating range (1.6 - 30 Bar / 23 - 435 psi) the compressor clutch relay is energized.

The BC1 is advised of the compressor activation (or no activation) and the illumination in the compressor request button of the IHKS remains illuminated. (No activation causes the LED to flash.)

Hard acceleration can cause the compressor clutch to be disengaged. After three occurrences in a single ignition cycle the EMS2000 disregards further hard acceleration occurrences and leaves the compressor clutch engaged.

The air conditioning will be automatically suspended if:

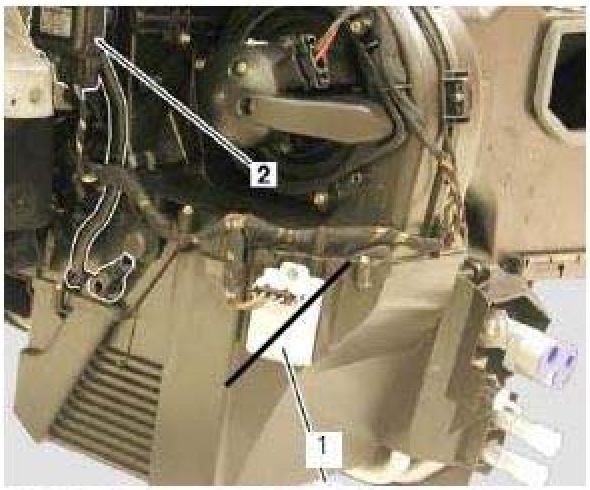
- The engine speed is above 6016 rpm.
- The evaporator temperature falls below 2°C (36°F) - to prevent freezing.
- The coolant temperature goes above 118°C (244°F)- to protect the engine.
- The AC system pressure goes above 30 Bar (435 psi) - to protect the system.
- The AC system pressure goes below 1.6 Bar (23 psi)- to protect the system.
- The accelerator pedal is fully depressed (continuous full pedal demand) for more than 5 seconds.
- The accelerator pedal is depressed rapidly (instantaneous full pedal demand) for more than 2 seconds.
- The engine speed is below 500 rpm (engine stall).

IHKA HEATING AND AIR DISTRIBUTION

The Heating and Air Distribution of IHKA systems differ from the IHKS system in the following ways;

- Two servomotors controlled by the IHKA module operate the temperature blend flap and air distribution mechanism. Flap position is monitored by the IHKA using potentiometers integrated in the servomotors.

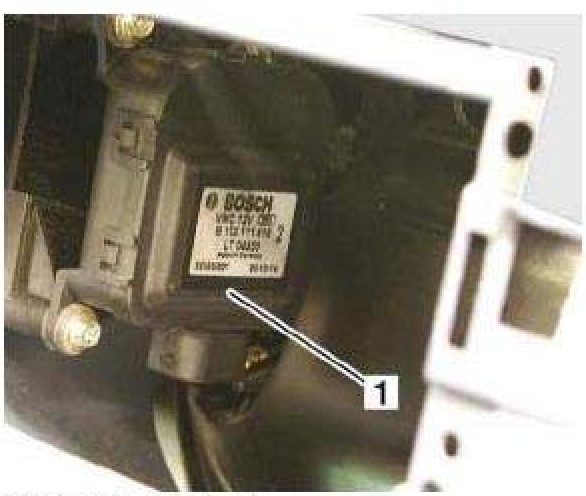
- A heater core sensor measures the temperature of the air coming off the heat exchanger. The sensor is located on the right side of the front of the heater unit.
- A rocker switch and a power transistor (final stage) controls the blower motor at eight speeds. The blower speed is controlled manually via the rocker switch or automatically in the AUTO mode.



IHKA Temperature Control

1. Blower Transistor Pack (Final Stage)
2. Temperature Blend Flap Servo Motor

Fig. 30: IHKA Compressor Control
Courtesy of BMW OF NORTH AMERICA, INC.



IHKA Air Distribution

1. IHKA Air Distribution Servo Motor

Fig. 31: IHKA Air Distribution
Courtesy of BMW OF NORTH AMERICA, INC.

NOTE: **Depending on production the date of the vehicle, the final stage unit (resistor pack) can be located as pictured above or on the blower motor assembly.**

Switch Panel (IHKA)

An integral control panel on the IHKA module contains switches for system control inputs and a display to provide system status information.

The IHKA control system controls the operation of the refrigerant system and the control flaps in the heater assembly to control the temperature and distribution of air in the vehicle interior. It also outputs signals to the BC1 to control the fresh/re-circulation air servomotor and to the blower to control the air volume.

Display

The Display integrated into the IHKA will provide current temperature setting and fan speed information. The display will show LO or HI at the extreme temperature settings and indicate fan speed by the number of streamers illuminated around the fan blade. It is possible to display the temperature in 0C or 0F, changeable at the control unit.

IHKA Control Unit Display Minimum

Temperature Max Blower Speed

Fig. 32: IHKA Control Unit Display Minimum
Courtesy of BMW OF NORTH AMERICA, INC.

Fig. 33: IHKA Control Unit Display 220C
Courtesy of BMW OF NORTH AMERICA, INC.

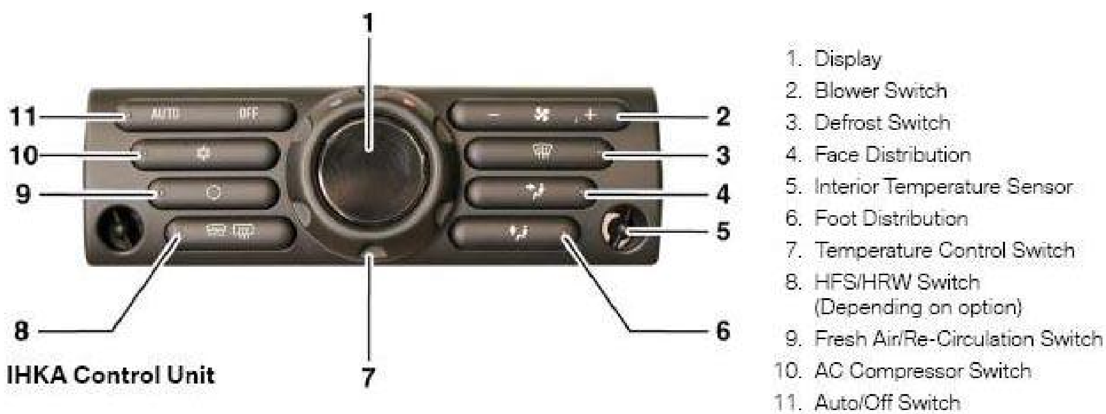


Fig. 34: IHKA Control Unit
Courtesy of BMW OF NORTH AMERICA, INC.

Blower Switch

The blower speed control is adjusted by a horizontal rocker switch, with + and - on the right and left respectively. This switch provides manual control of blower speed.

There are eight blower speeds. Each press of the blower switch will adjust the blower speed by one speed step in the appropriate direction. Pressing and holding the control will cause the fan speed to change every 0.8 seconds, until the control is released or the maximum or minimum speed is reached.

Blower speed will be indicated by a series of "streamer effect" bars arranged around the top edge of the central display panel. Each bar represents one speed step; eight bars are visible at maximum blower speed.

Blower speed will be controlled automatically if AUTO is selected. The blower will function 0.5 seconds after the end of cranking.

Defrost Switch (Programmed Defrost)

The programmed defrost mode is activated by briefly pressing the defrost switch.

The LED in the switch flashing at 0.5 Hz signals this to the driver.

The programmed defrost can be switched off by pressing the switch again or pressing one of the other air distribution switches. Pressing the AUTO or OFF button also deactivates the defrost function.

To distribute air to the windshield without activating the defrost program requires a long press of the defrost switch (> 2 seconds).

Air Distribution Control

Manual control of the air distribution is provided by three switches which control the distribution of air to the face, foot and windshield outlets. Each switch has a green LED to indicate that it has been selected. Pressing one of the switches will illuminate the LED and open the selected air outlet.

Air distribution will be controlled automatically if AUTO is selected.

Interior Temperature Sensor

The Interior Temperature Sensor is an encapsulated thermistor that provides the IHKA module with an input of passenger compartment air temperature. The sensor is installed in the right hand corner of the IHKA module and incorporates a fan to draw air from the vehicle interior over the sensor element.

Temperature Control Switch

The air temperature control is a rotary three-position switch, which is sprung to the center (rest) position. Rotating the control clockwise or anti-clockwise will increase or decrease respectively the desired temperature.

The rotary temperature control functions as follows:

- A momentary rotation increases or decreases the related temperature setting, in steps of 1 °C (2°F), between 16 and 28°C (60 and 84°F).
- Switch held in the increase or decrease positions, step changes occur every 0.4 seconds until LO or HI is reached.
- Switch rotated in the decrease position when a temperature of 16°C (60°F) is set, the display changes to LO (maximum cold).
- Switch rotated in the increase position when a temperature of 28°C (84°F) is set, the display changes to HI (maximum hot).

Pressing the AUTO button for longer than two seconds can change the unit of measurement (°C/°F).

Heated Rear Window (HRW)

A momentary push switch controls the heated rear window and incorporates an orange LED to indicate status.

A single press of the switch will turn the heated rear window on, illuminate the LED, and start a timer. When the timer has expired, the heated rear window and LED will turn off. The HRW is controlled by the BC1.

Heated Windshield (HFS)

For the IHKA system the heated front screen shares the same control switch and LED as the heated rear window. The heated front screen operation is timed dependent on the outside temperature and controlled by the BC1.

When the programmed defrost mode is requested with a short push on the defrost switch, all heated screens are switched on automatically. The LED will switch on only when the engine is running.

Workshop Hint

The Heated Rear Window Relay is attached to the back of the fusebox located near the A pillar.

This relay is integral with the fuse box and cannot be replaced separately.

Workshop Hint

Neither Heated Window (Front or Rear) will operate unless the engine is running. If the engine is turned off while the Heating is active, Heating will be switched off.

Fresh Air/Recirculation Switch

The fresh/recirculation air control is a momentary push switch with a green LED to indicate status. A single press of the switch will close the fresh air intake and illuminate the recirculation LED. Another press of the switch while the LED is illuminated will open the fresh air intake and extinguish the LED.

Air recirculation will be controlled automatically if AUTO is selected. This may be overridden by pressing the air recirculation control. Recirculated air will then remain manually controlled until the air recirculation control is pressed again.

AC Switch

Provides manual on/off control of the refrigerant system compressor. The AC can be switched off to reduce fuel consumption when there is no requirement for cool or dehumidified air. The AC control is a momentary push switch with a green LED to indicate status. A single press of the switch will provide the AC function and illuminate the LED; another press of the switch will switch off the AC function and extinguish the LED. Air conditioning compressor is automatically switched on when the AUTO switch is pressed.

Auto/Off Switch

The automatic mode is activated with a single press of the AUTO switch; the green LED illuminating indicates this to the driver. The air distribution and blower speed is controlled automatically, and the air conditioning is switched on when AUTO is active.

The driver can over-ride the automatic mode of the air distribution or blower by pressing one of the distribution buttons or manually adjusting the blower speed. When the blower is being controlled in AUTO mode the blower speed bars and fan symbol are not displayed in the central display panel. In the automatic mode, if the temperature is set to LO or HI, the blower runs at maximum speed with correction only for vehicle speed.

The IHKA control panel may also be switched off by using the OFF horizontal rocker switch. This will switch off the blower and air conditioning, distribution control functions and temperature control will also be switched off.

Solar Sensor

The solar sensor consists of a light sensitive diode that provides the IHKA module with inputs of sunlight intensity. The input is used as a measure of the solar heating effect on vehicle occupants. The sensor is installed in the center of the upper dash.

Heater Core Temperature Sensor

The heater core temperature sensor is an encapsulated thermistor that provides the IHKA module with air temperature of the heater core. The sensor is installed in the right hand side heater housing.

Notes:

IHKA Control System Principle of Operation

IHKA Controls

On the IHKA system all functions have automatic and some manual modes of operation. The automatic modes provide optimum control of the system and require no manual intervention. The manual modes allow individual functions of automatic operation to be overridden, to accommodate personal preferences.

The IHKA control system controls the operation of the refrigerant system and the control flaps in the heater assembly to control the temperature and distribution of air in the vehicle interior. It also outputs signals to the BC1 to control the fresh/recirculation air servomotor and to the blower to control the air volume.

Temperature Control

The IHKA receives a temperature input from the Temperature Control Switch. Inputs from the Ambient Air Temp Sensor, Evaporator Temp Sensor, Interior Temp Sensor and Heater Core Air Temp Sensor are evaluated and a Target Temperature is set. The Target Temperature is the required temperature of the outlet air to achieve the requested temperature.

The IHKA module then signals the servomotor controlling the blend flap in the heater assembly to move the flap to the appropriate position. Feedback information is received by the IHKA from the blend flap servo motor to indicate flap position and confirm flap movement.

The target temperature is constantly updated and, in the automatic mode, also used in further calculations to determine the blower speed and the air distribution.

Blower Control

IHKA equipped vehicles have a blower final output stage in place of the resistor pack. The output stage is installed in the blower assembly.

NOTE: Resistor pack may be installed on early production vehicles on the A/C housing (driver's side).

In AUTO mode, the blower is automatically regulated. In the manual mode, 8 blower speeds are available. These correspond to approximately 20, 30, 40, 50, 60, 75, 90 and 100% of battery voltage.

The blower relay is energized by the BC1 whenever the ignition switch is in position 1 or 2, and the IHKA module modulates the output stage to regulate the voltage across the blower motor to control blower speed.

In the automatic blower and fresh air mode, the blower speed is corrected for vehicle speed to compensate for the increase in ram effect on the inlet air as the vehicle speed increases.

In the automatic mode, if the temperature is set to LO or HI, the blower runs at maximum speed with correction only for vehicle speed. When the temperature is set to a specific temperature, blower speed corrections are added to compensate for the heater coolant temperature, external air temperature, and the solar load on the vehicle:

- During warm-up, to avoid blowing excessive amounts of cold air into the passenger compartment, the blower speed is limited if the heater core air temperature is below approximately 60°C (140°F). A similar limitation is applied when the exterior temperature falls below -10°C (50°F).
- During cool down, to purge the ducting of hot air, blower speed is limited for a period of approximately 5 seconds after the system is switched on. The blower speed is then progressively increased over a period of approximately 10 seconds.
- As the temperature in the passenger compartment approaches the selected temperature, blower speed is progressively reduced until, once the selected temperature has been established, blower speed stabilizes.
- Solar heating correction is employed and progressively increases the blower speed with increasing values of solar heating.

Air Distribution

In automatic mode, to control air distribution within the passenger compartment, the IHKA module signals the servomotor controlling the distribution flap in the heater assembly to move the flap to the appropriate position. When a specific temperature selection is set, air distribution is determined from the target air outlet temperatures. For higher target air outlet temperatures, air distribution is set to footwell only. For lower target air outlet temperatures, air distribution is set to face level only. For intermediate target air outlet temperatures, air varies the bias between the footwell and the face level outlets, in three stages, to provide a gradual transition of air distribution from footwell only to face level only. Position and movement confirmation is received from a feedback potentiometer in the air distribution servo motor.

Fresh/Re-Circulation Air

The IHKA module outputs the required position of the fresh/re-circulated air flap to the BC1, which then operates the servo accordingly.

Air re-circulation will be controlled automatically if AUTO is selected. This may be overridden by pressing the air re-circulation control. Re-circulated air will then remain manually controlled until the air re-circulation control is pressed again.

Fresh or recirculated air is controlled by a flap, driven by a servomotor controlled by the BC1. The IHKA requests the position of the servomotor and flap by sending a K-Bus message indicating either fresh or recirculated air. The Body Control Module (BC1) responds with a K-Bus message that is used to switch the LED on/off. The fresh/recirculation servomotor is driven end to end, and then switched-off on a timer. No servo position feedback is available.

Programmed Defrost Function

The programmed defrost function is activated by a momentary push of the defrost switch. This function is only available when the engine is running,

0.5 seconds after cranking is completed. The programmed defrost functions as follows:

- AUTO mode off.
- AC stays ON if ON before or OFF if OFF before.
- Fresh/recirculation function is set to fresh air mode.
- Desired temperature will be under manual control.
- Air distribution will be set to DEFROST vents.
- Blower speed 8 selected (depending on battery level).
- Heated rear window and (heated front screen if fitted) is requested on.

The display will show the fan speed at MAX (8 bars), and the desired temperature. The defrost LED will flash at 0.5 Hz to indicate programmed defrost function is active. The programmed defrost function is not automatically recalled after ignition off.

The programmed defrost function is de-activated by the following actions:

- Brief press of the screen distribution switch will cancel the programmed defrost function. The control panel will return to its state prior to selection of programmed defrost.
- Foot or face air distribution mode switches will provide manual air mode operation with all other settings returning to their state prior to selection of programmed defrost and cancel the programmed defrost mode.
- A press of the AUTO switch will restore auto operation of the panel and cancels programmed defrost mode.
- A press of the OFF button will switch the panel off. A subsequent press of the OFF button will switch on the panel and restore the programmed defrost function.
- A long push (>2 second) of the defrost switch will provide manual screen distribution and cancel programmed defrost mode.

Heated Front and Rear Windows (HFS/HRW)

Operation of the Heated Front and Rear Windows is the same in the IHKA system as in the IHKS system.

Compressor Control

The control of the compressor is the same as that of the IHKS with the exception of the IHKA module signals compressor request to the EMS2000 via the K-bus and not the BC1. The evaporator sensor still signals to the BC1 as on the IHKS.

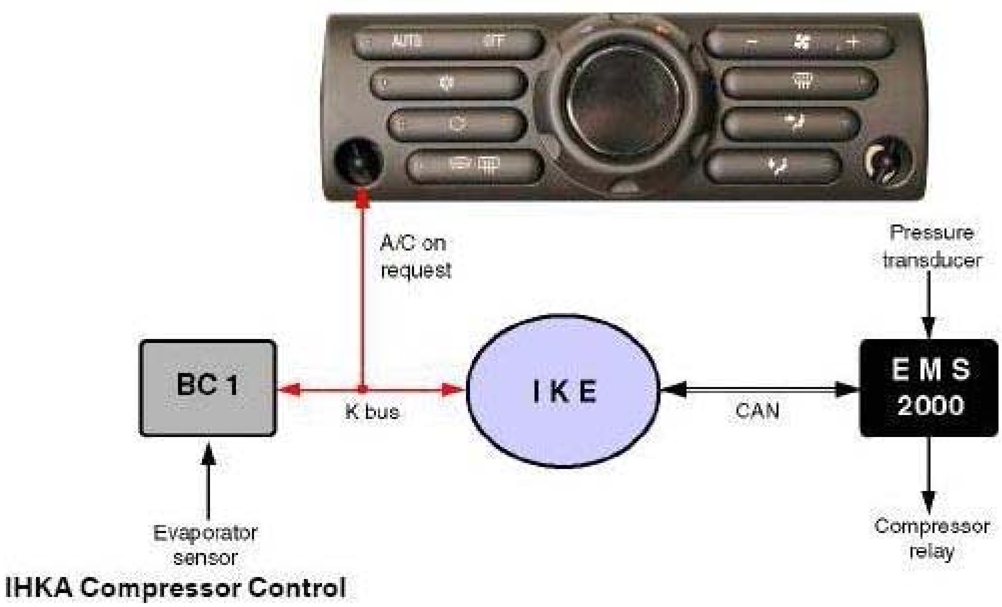


Fig. 35: IHKA Compressor Control
Courtesy of BMW OF NORTH AMERICA, INC.

Compressor Cut-out Criteria

For both versions of air conditioning the following conditions will suspend the operation of the compressor:

- Full-load acceleration
- Engine coolant temperature > 118°C (244°F)
- Engine speed < 6016 rpm
- Engine speed < 500 rpm
- Evaporator temperature < 2°C (36°F)
- Refrigerant pressure < 1.6 bar / < 30 bar (23 - 435 psi)

Notes:

IHKA On Board Diagnosis

The on board diagnostics function is a special feature of the IHKA that provides three test modes:

- Mode 1 - Read fault memory
- Mode 2 - Calibration run
- Mode 3 - Manual check of functions

To access the on board diagnosis function the OFF button and the blower PLUS switch must be pressed simultaneously for approximately two seconds with the ignition in position 2. The central display panel will show a single "streamer bar" to represent mode 1 -Read fault memory. To access mode 1 the AUTO button must be pressed.

To select mode 2 or 3 it is necessary to press the OFF button, the second or third streamer bar illuminating will indicate the relevant mode to the Technician depending on how many times the OFF button is pressed. To access the mode the AUTO button must be pressed.

To exit the on board diagnosis mode the ignition must be switched to the off position.

Mode 1: Read Fault Memory

The IHKA fault memory is read and displayed in the central display panel. If no faults are present 00 is displayed and if a fault is stored FF followed by a code number is displayed. This display flashes at 0.5 Hz.

Mode 2: Calibration Run

The objective of the calibration procedure is to correct the position drift of the servomotors for temperature and air distribution control. During a calibration run:

- Both servomotors are driven to their two end positions and the new values stored in the IHKA EEPROM.
- All LED's activated simultaneously.
- Blower streamer bars individually illuminated.
- CA flashes in the central display panel at 0.5 Hz.

IHKA Fault Codes

Code	Description
01	Solar sensor fault
02	Interior temperature sensor fault
03	Heater core temperature sensor fault
04	Air distribution servomotor feedback fault
05	Blend flap servomotor feedback fault
06	Blower switch minus fault
07	Blower switch plus fault
08	Interior sensor fan fault
09	Air distribution servomotor fault
10	Blend flap servomotor fault

Fig. 36: IHKA Fault Codes Description
Courtesy of BMW OF NORTH AMERICA, INC.

There are three possible operating statuses shown in the central display:

- CA = Calibration Active
- CC = Calibration Complete
- FF = Fault

Mode 3: Manual Mode

In this mode blower, air distribution, recirculation, heated screens, air conditioning ON/OFF and temperature are manually controlled.