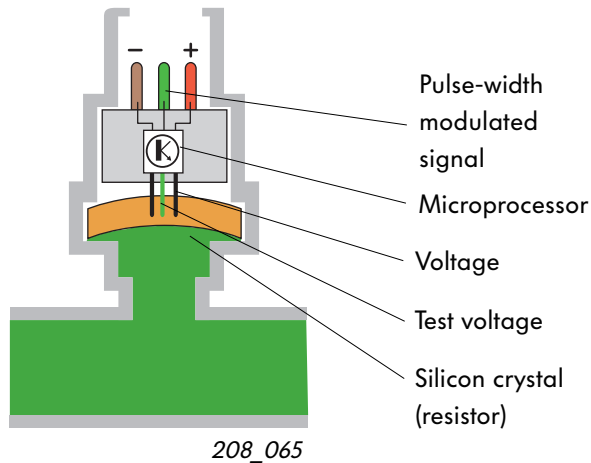


System control

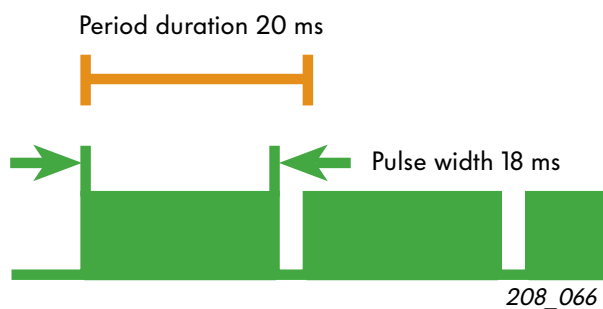
At high (increasing) pressure



At high (increasing) pressure, the crystal is “deformed” more, so the change of resistance is larger. The test voltage decreases proportionately.



Pulse width signal



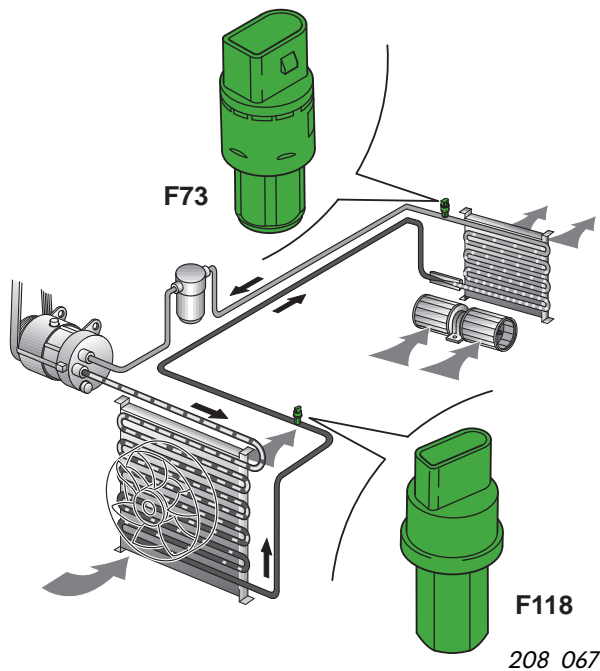
The pulse width increases in proportion to the increasing pressure.

At a high pressure of 3.7 MPa (37 bar), the pulse width is 18 ms. This is equivalent to 90% of the period duration.



Using the digital memory oscilloscope of the new vehicle diagnosis system VAS 5051, it is possible to visualise the pulse width signal.

Disconnected safety switch in the refrigerant circuit with restrictor



In the refrigerant circuit with restrictor, the low pressure and the high pressure are often monitored by two separate safety switches.

Low pressure

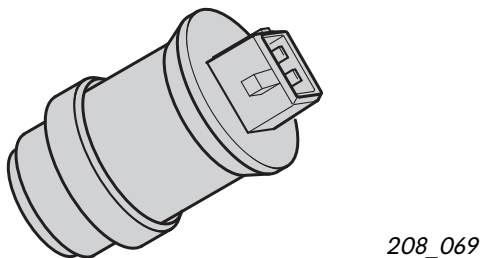
Air conditioner low-pressure switch F73 switches off the compressor when the pressure drops below approx. 0.17 MPa (1.7 bar) in the refrigerant circuit, for example. (This pressure drop can occur if the refrigerant level in the circuit is too low. The compressor is protected.)

High pressure

Magnetic clutch high-pressure switch F118 switches off the compressor when the pressure exceeds approx. 3.0 MPa (30 bar) for example.

The absolute values should always be regarded as being system-specific.

Coolant temperature switch with pilot lamp



The compressor constitutes an additional load for the engine.

To avoid overheating the coolant when the engine is under heavy load, e.g. when travelling uphill, the additional compressor load is switched off.

For this purpose, the coolant temperature is monitored additionally by a coolant temperature switch with a pilot lamp.

(The primary monitoring device is the coolant temperature sender with indicator lamp in the dash panel insert.)

The compressor cuts out at approx. 119 °C and cuts in at approx. 112 °C.



In vehicles with extended electronic sensor evaluation via the control unit combination of the vehicle, this additional check is no longer necessary. The signal generated by the primary monitoring device is utilized.

Various switches with pilot lamp are used depending on vehicle type, e.g.

- F18 - Radiator fan thermo switch
- F163 - Air conditioner cut-off thermo switch.

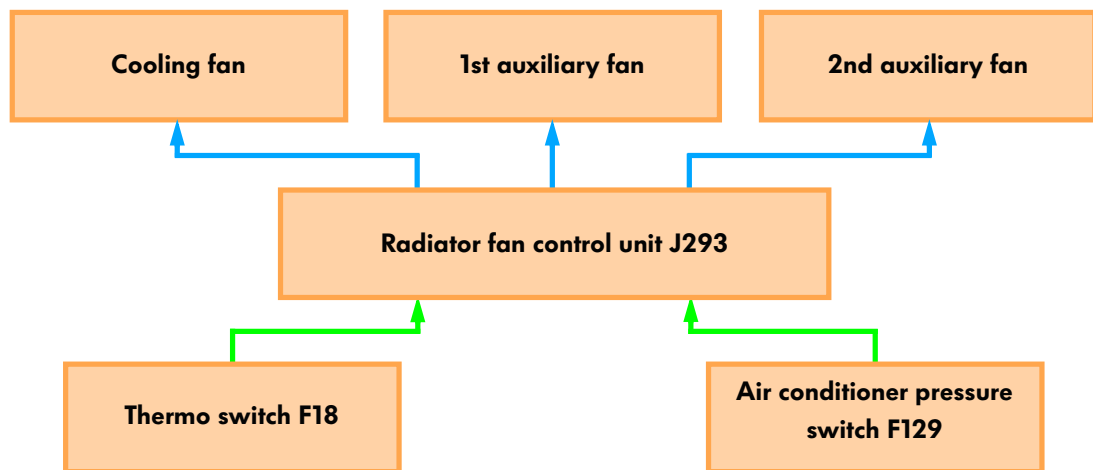


Cooling fan circuit

Circuit connecting fan to engine/ condenser cooling system shown using the VW Golf/Audi A3 as an example

Fan operation is a basic condition for proper functioning of an air conditioner (refrigerant circuit) and the engine (coolant circuit). Condenser performance will be impaired if there is no cooling. Proper functioning of the air conditioner is no longer assured. In air conditioning, a second or third fan is often also used.

These fans provide the necessary fresh air flow through the radiator and condenser. The fan control regulates radiator fan control unit J293 depending on the temperature of the coolant and the pressure in the refrigerant circuit. The absolute values are always vehicle-specific!



Example: Check functions

Coolant temperature

The signal generator is radiator fan thermo switch F18.

The thermo switch is located in the vehicle radiator.

Speed 1	ON	92 .. 97 °C
	OFF	84 .. 91 °C
Speed 2	ON	99 .. 105 °C
	OFF	91 .. 98 °C

Pressure in refrigerant circuit

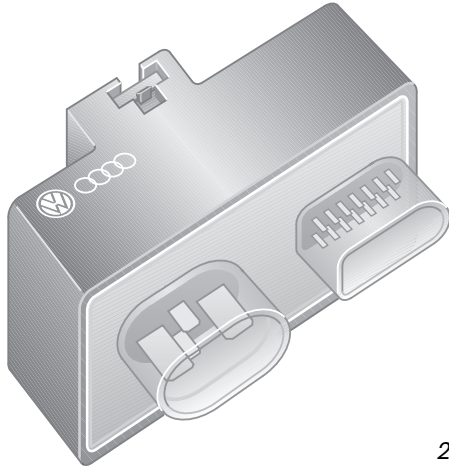
The signal generator is air conditioner pressure switch F129 or the high pressure sender G65.

F129 switches the fan(s) to speed 2 at a pressure of approx. 1.6 MPa (16 bar) (also refer to page 35).

Example: 2-fan combination

- The air conditioner is switched on, therefore the compressor is switched on and the pressure in the refrigerant circuit is greater than 0.2 MPa (2 bar).
= both fans run at speed 1
- High pressure in the refrigerant circuit is greater than 1.6 MPa (16 bar) and/or coolant temperature is above 99 °C
= both fans run at speed 2
- If the pressure in the refrigerant circuit drops below 1.6 MPa (16 bar) and the coolant temperature is below 99 °C
= both fans will again run at speed 1
- When the engine is being operated without the air conditioner, only the cooling fan will be running. The fan will be running at speed 1 or 2 depending on coolant temperature.

Radiator fan control unit J293



208_070

The radiator fan control unit is integrated in the vehicle control system.

Incoming signals in the basic version:

- from thermo switch F18
- from pressure switch F129
- from operating and display unit E87 (with automatic air conditioner)

Tasks

To convert the incoming signals

- To switch the cooling fan on and off
- To switch the compressor magnetic clutch on and off.

Expanded functions of a new generation:

Radiator fan control unit J293 has been developed technically and adapted functionally to the new high pressure sender G65.

It is fitted together with the high pressure sender and, as a distinguishing feature, has modified plug connections.

The control unit evaluates the pulse-width modulated signal from the high pressure sender. The overall pressure range of the refrigerant pressure is monitored continuously in this way.

Functions

- To switch the radiator fan speeds and the magnetic clutch of the air conditioner compressor on and off
- Bidirectional signal interchange with the engine and gearbox control unit
- Monitoring the coolant temperature
- with timer module for activating coolant run-on pump V51 (e.g. 1.8-ltr. 5 V engine 165 kW)

New generation

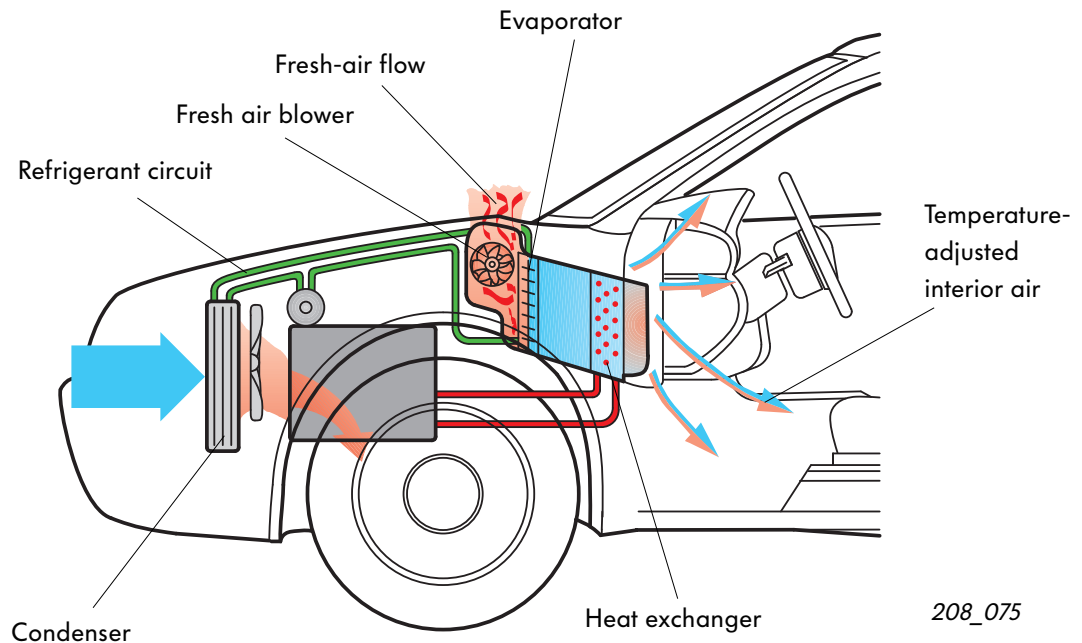


There are also circuit variants where the functions of the control units are assumed by an air conditioner control unit.

Integration in their control system is always vehicle-specific. For details, please refer to the current flow diagram.



Manual control



Why temperature control?

- The fresh-air flow cooled down at the evaporator is pumped into the passenger cabin by means of the fresh air blower.
- This air is usually cooler than necessary (blower capacity is designed for maximum cooling, however the prevailing ambient temperatures are usually moderate).
- To attain a pleasant interior temperature, a portion of the cold fresh air flow is therefore ducted over the heat exchanger the heating system and heated up.
- Temperature fluctuations can also be caused by different ambient temperatures, road speeds, coolant temperatures, fresh air supplies etc.
- In the case of simple manual air conditioners, the driver has to regulate the temperature.

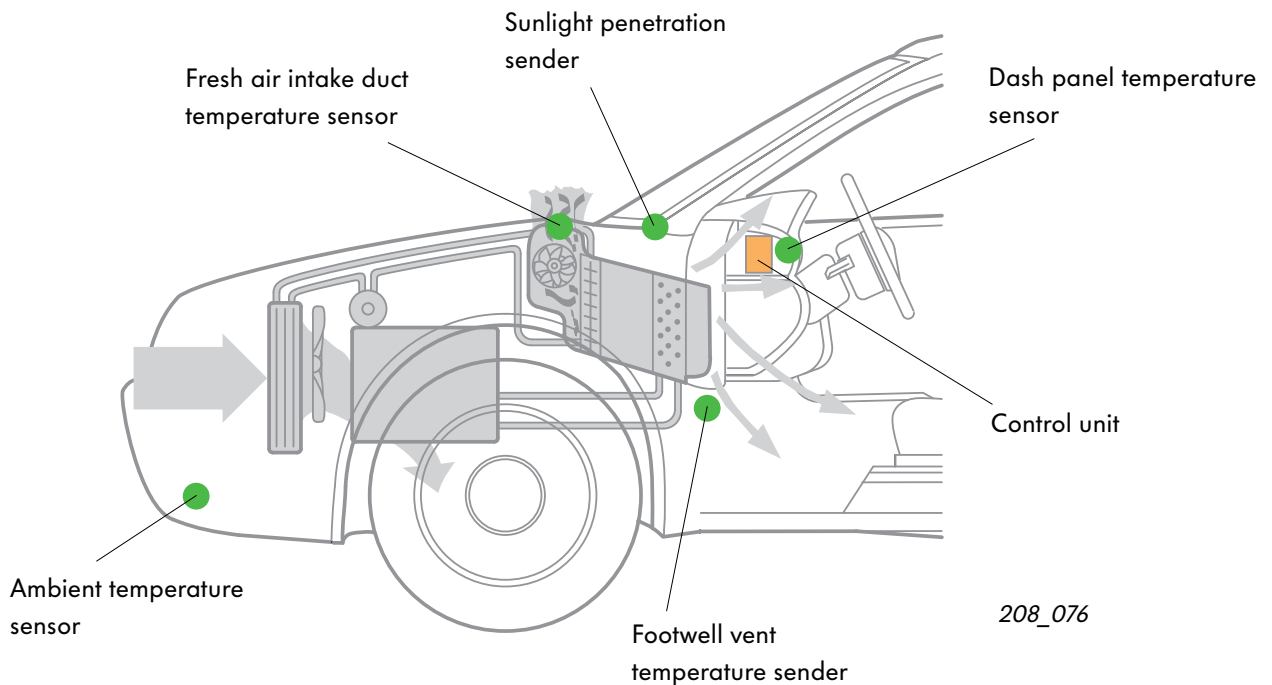
What is regulated?

- Registration of actual values, i.e. temperature sensing.
- Setpoint/actual value comparison, i.e. the driver performs an individual evaluation. The driver defines the comfort temperature, i.e. whether too warm or too cold.
- Based on the evaluation, the driver decides whether
 - the temperature needs to be adjusted
 - in what direction
 - by how muchand makes this adjustment manually.

The driver is, in the figurative sense, both the controller and the actuator.

The driver adjusts the temperature flap.

Automatic control



Automatic air conditioners relieve the driver of this task.

They have the advantage that they can include many more parameters in the control system and calculate the thermal result of your adjustment in advance.

Various names are used to describe electronic air conditioner controls:

- Digital temperature control
- Climatronic
- Air conditioner with automatic control

What they all have in common is:

- a control unit
- ambient temperature sensor (one or two)
- interior temperature sensor
- additional senders (not in every system), e.g. sunlight penetration sender
- Positioning motors on the heater/air conditioner

The diagram shows the positions of the sensors.

The digital control unit is the master station. It processes all input signals from the sensors (information sender), interference-suppresses them and feeds them to the microcomputer in the control unit.

The microcomputer calculates the output signals in accordance with the pre-programmed setpoints.

The output signals are fed to the actuators via output stages.

The actuators are the positioning motors on the heater/air conditioner.

Suitable positioning motors are assigned to the flaps.

Air conditioners of the current generation are linked to other vehicle control units either directly or via the CAN-BUS. Information on road speed, on engine speed and on 'time parked' are also included in the evaluation of the air conditioner control unit in this way.



Temperature control

System overview of an electronically controlled air conditioner

(the temperature is regulated evenly at the left- and right-hand sides of the passenger cabin as shown using the Golf as an example. An identical system is used in the Audi A3)

Sensors

(for system control and temperature control)

Sunlight penetration
photo sensor G107

Temperature sensor
Dash panel
Temperature sensor G56
Blower V42

Ambient temperature
sensor G17

Temperature sensor
Fresh air intake duct temperature
sensor G89

Footwell vent
temperature sender
G192

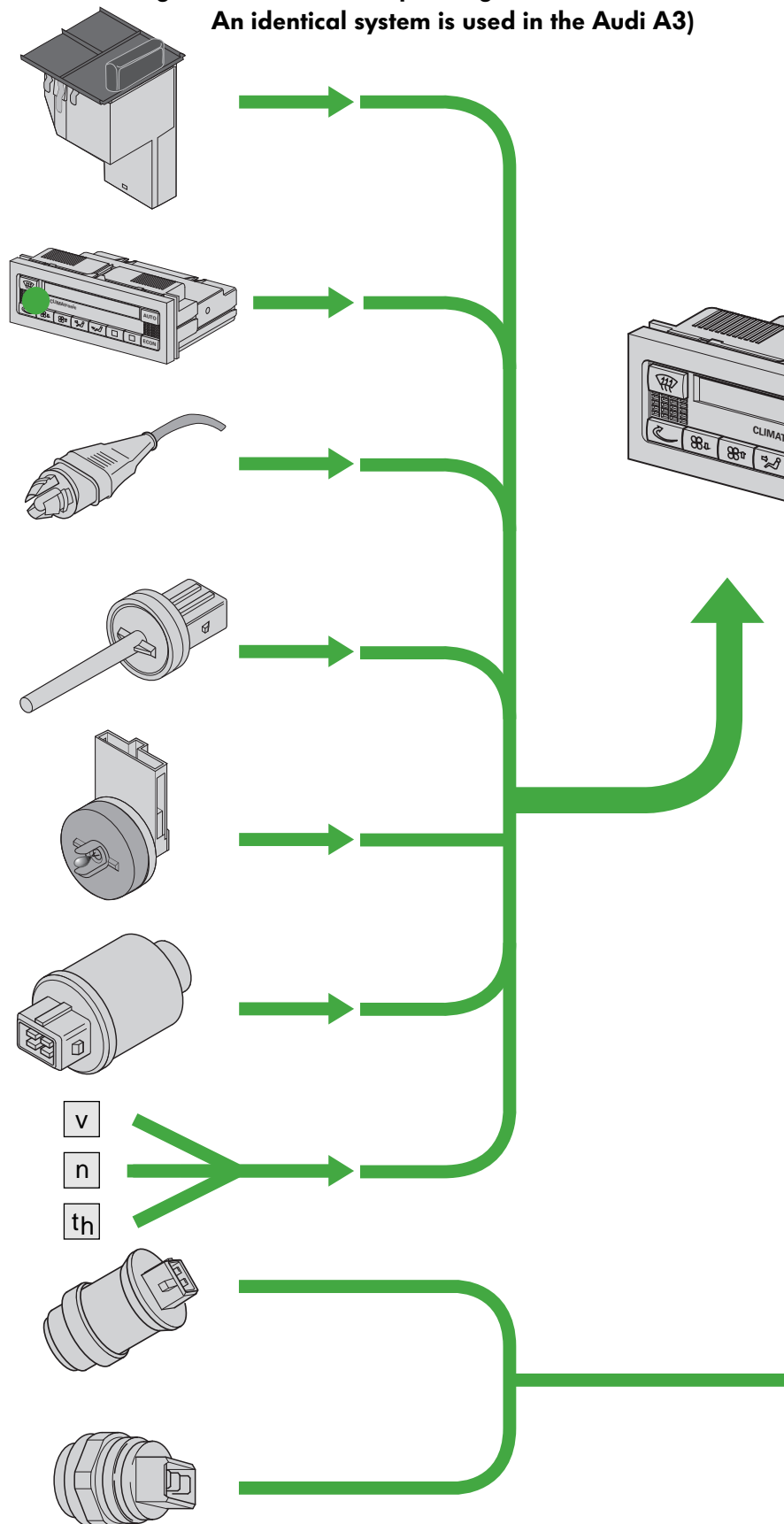
Air conditioner
pressure switch F129

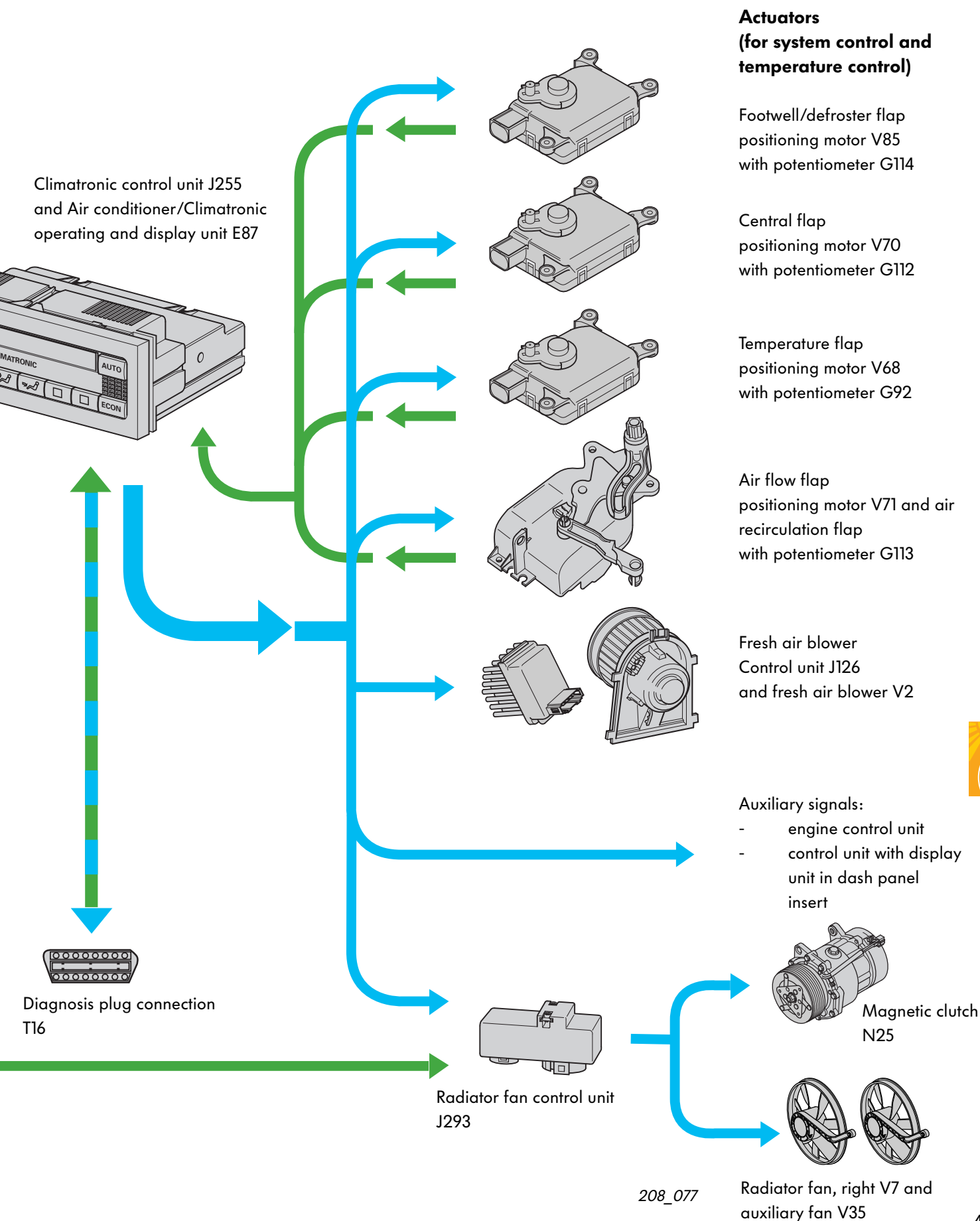
Auxiliary signals:

- road speed signal
- engine speed signal
- 'time parked' signal

Coolant temperature warning switch
(overheating) F14

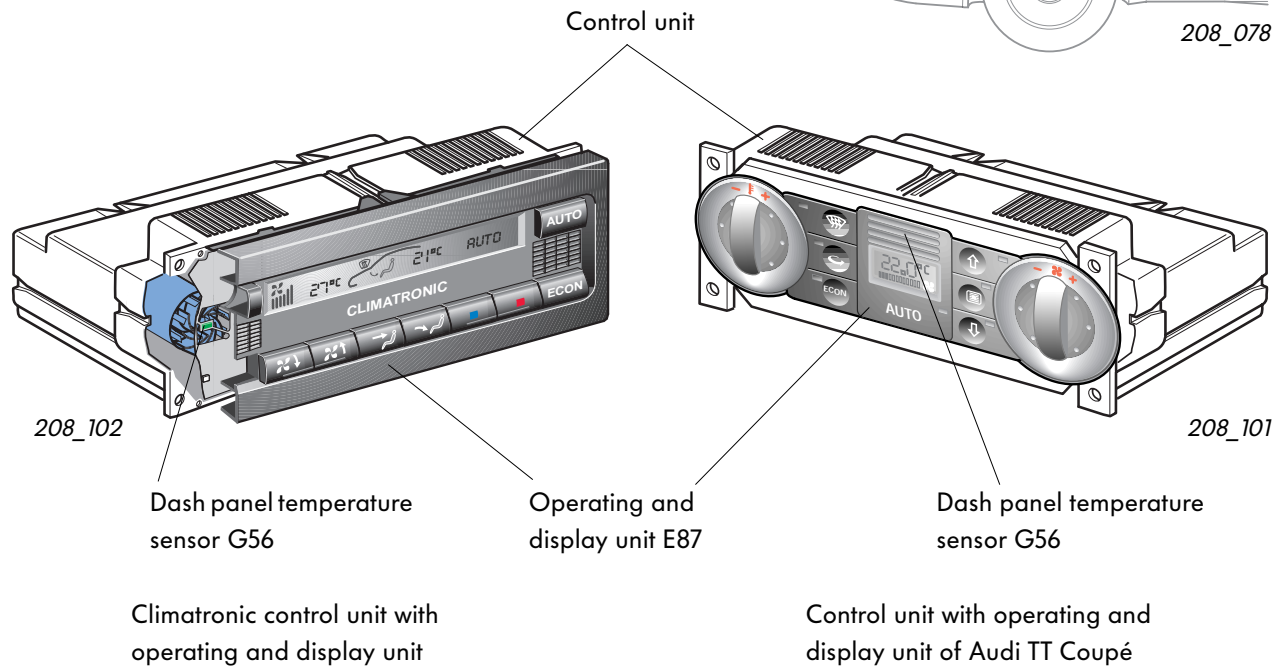
Radiator fan
thermo switch F18





Temperature control

Control unit with operating and display unit



Design

The control unit is combined with the operating and display unit which is adapted to the design of the vehicle in question.

A vehicle interior temperature sensor is also integrated in the control unit.

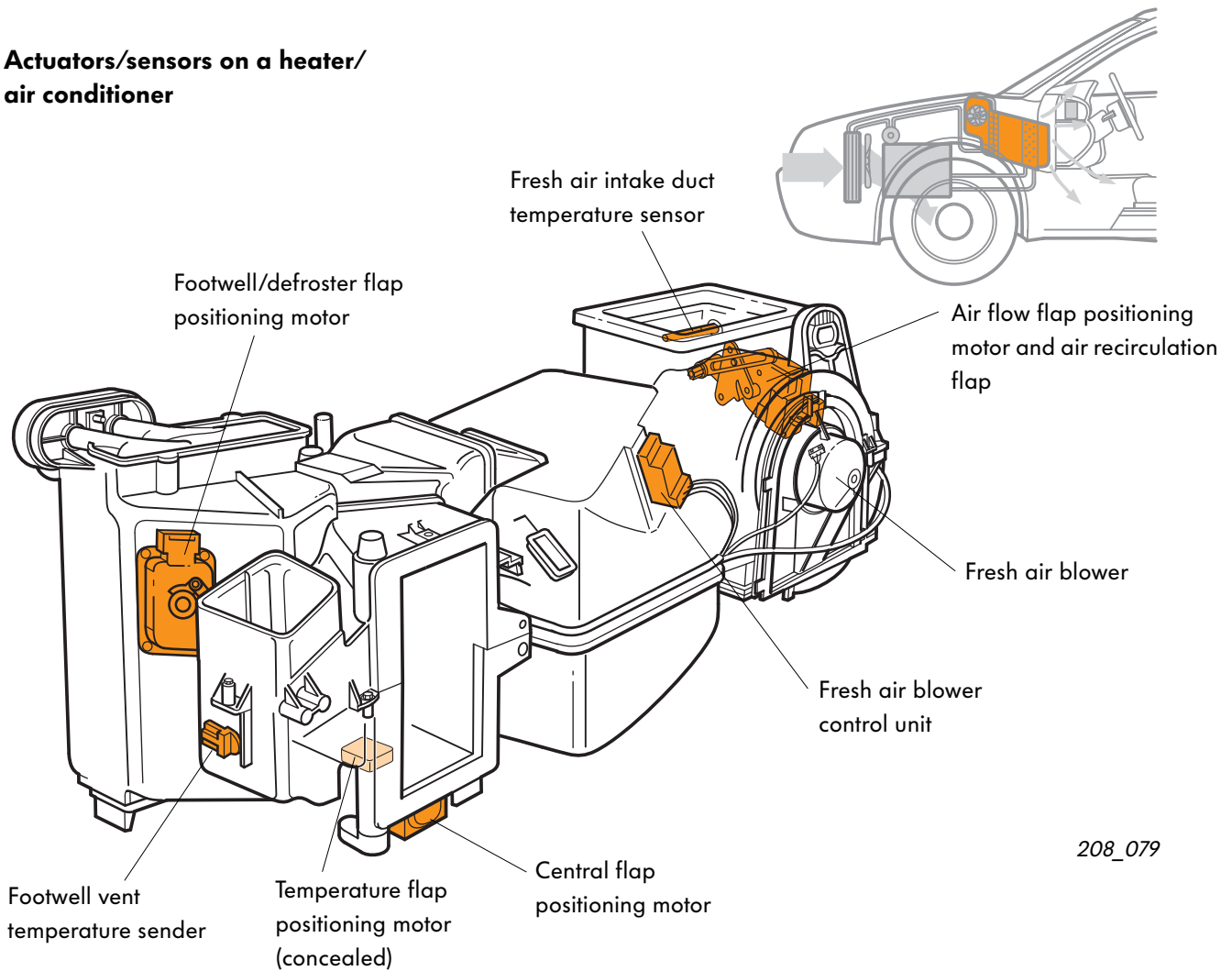
Function

The control unit receives information from the electrical and electronic components (sensors). These signals are processed by the control unit in accordance with the setpoints. The output signals of the control unit then control the electrical actuators.

The control unit is equipped with a fault memory. Failure of a component or an open circuit can be detected quickly via the self-diagnosis.

No matter what fault occurs, the control unit will remain in operation and maintain the temperature settings in emergency mode.

Actuators/sensors on a heater/ air conditioner



A positioning motor is assigned to each flap for air ducting in the heater/air conditioner.

The air flow flap and air recirculation flap are driven by a positioning motor. These flaps are adjusted separately by a driving pulley with two guide rails.

In other systems, the air recirculation flap can also be adjusted by means of vacuum and solenoid valves.

In this case, the fresh air blower and fresh air blower control unit are separate components.

However, they can also be combined to a unit.



Temperature control

The main temperature sensors

Ambient temperature sensor G17

The temperature sensor is positioned in the vehicle front section.
It registers the actual ambient temperature.

Signal utilisation

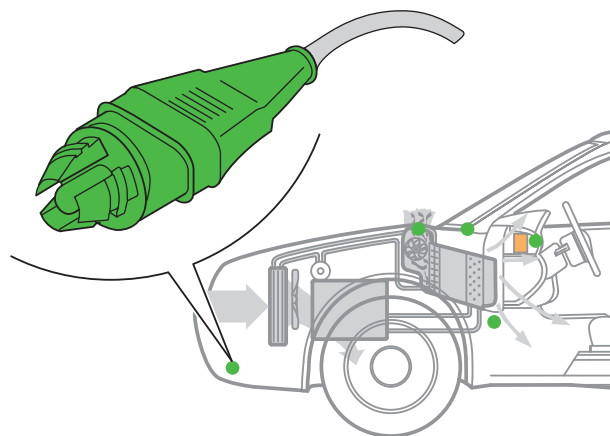
The control unit controls the temperature flap and the fresh air blower in dependence upon the temperature.

Effects of signal failure

If the signal fails, the measured value of the second temperature sensor (temperature sensor in fresh air intake duct) is utilised.

If this signal also fails, the system continues to operate by assuming a substitute value of +10 °C. Air recirculation is not possible.

The temperature sensor has self-diagnostic capability.



208_081

Fresh air intake duct temperature sensor G89

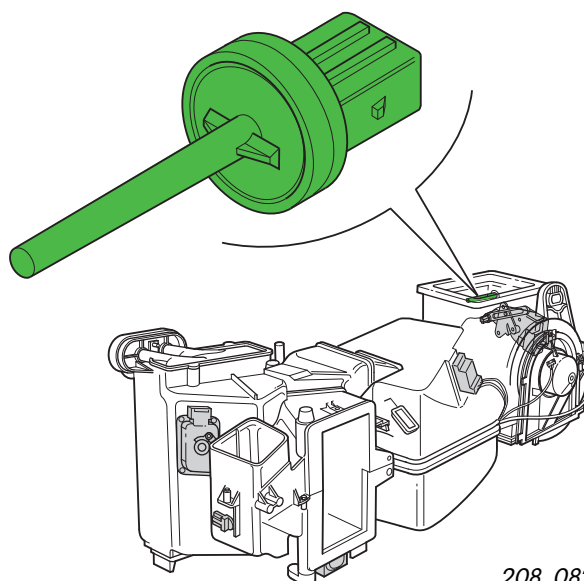
The temperature sensor is located directly inside the fresh air intake duct.
It is the second actual ambient temperature measuring point.

Signal utilisation

The control unit controls the temperature flap and the fresh air blower in dependence upon the temperature.

Effects of signal failure

If the signal fails, the measured value of the first temperature sensor (ambient temperature sensor) located in the vehicle front section is utilised. The temperature sensor has self-diagnostic capability.



208_082



Both temperature sensors always process the lowest value.

Dash panel temperature sensor G56 with temperature sensor blower V42

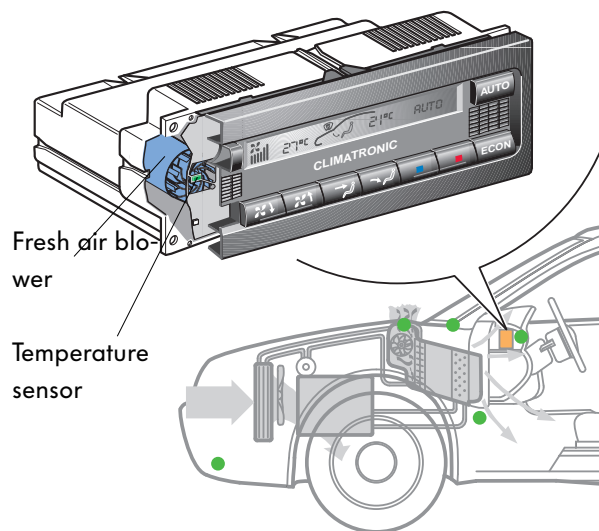
The temperature sensor is usually integrated directly in the control unit and transfers the actual interior temperature to the control unit. It is located in the air stream of a fresh air blower which is used to draw off interior air. The fresh air blower is activated by the operating and display unit. It draws off the interior air in order to avoid measurement errors at the temperature sensor.

Signal utilisation

The measured value is used for comparison with the setpoint. The temperature flap and the fresh air blower are controlled accordingly.

Effects of signal failure

In the event of signal failure, a substitute value of +24 °C is assumed. The system remains in operation. The temperature sensor has self-diagnostic capability.



208_083

Footwell vent temperature sender G192

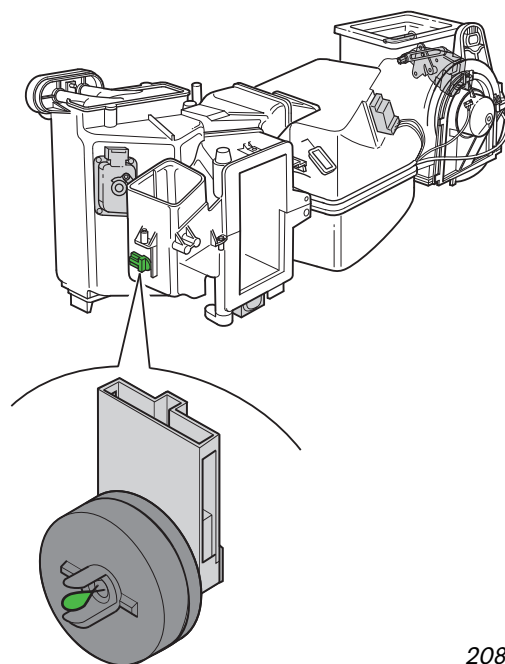
The temperature of the air flowing out of the heater/air conditioner (and into the vehicle interior) is measured. The temperature is registered with a temperature-dependent resistance. The electrical resistance increases as the temperature drops.

Signal utilisation

The signal is evaluated by the control unit. The signal is used to control the defrost/footwell air distribution and the volumetric capacity of the fresh air blower.

Effects of signal failure

In the event of signal failure, the control unit calculates a substitute value of +80 °C. The system remains in operation. The sender has self-diagnostic capability.



208_084



Temperature control

Sunlight penetration photo sensor G107

Air conditioner temperature is controlled by means of photo sensors.

They register the direct sunlight exposure of the vehicle occupants.

Depending on air conditioner type, they can measure sunlight penetration via one or two sensors and separately for the left- and right-hand sides of the vehicle.

Function

The sunlight passes through a filter and an impinges upon an optical element on the photo diode. The filter functions in much the same way as sunglasses and protects the optical element against UV radiation.

Photo diodes are light-sensitive semiconductor elements. When there is no incident light, only a small current can flow through the diode. This current increases when the photo diode is exposed to sunlight. The stronger the incident sunlight, the higher the current.


When the current increases, the air conditioner control unit recognises that the sunlight is stronger and regulates the interior temperature accordingly. The temperature flap and fresh air blower are controlled accordingly.

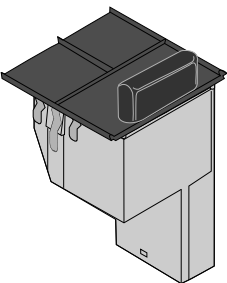
In the version with two sensors, the side of the vehicle exposed to stronger sunlight is cooled more (refer to page 58).

Effects of signal failure

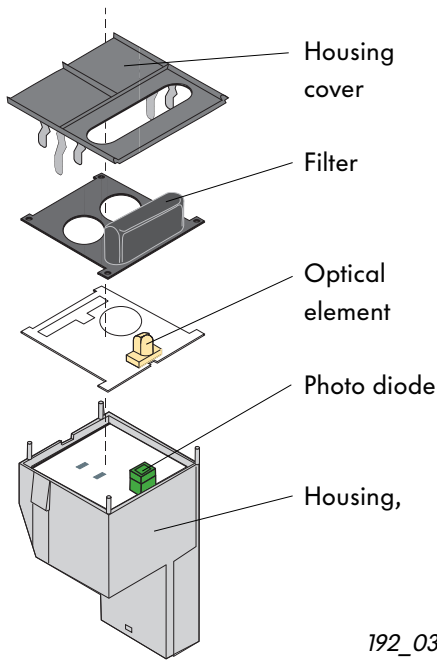
The control unit utilises an assumed fixed value for sunlight penetration.

Electrical circuit

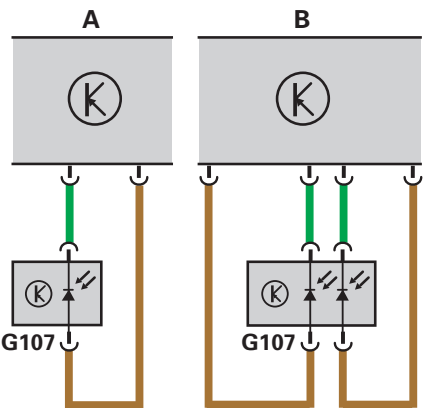
-  Air conditioner control unit
- G107 Photo sensor
- A 1 sensor
- B 2 sensors



192_093

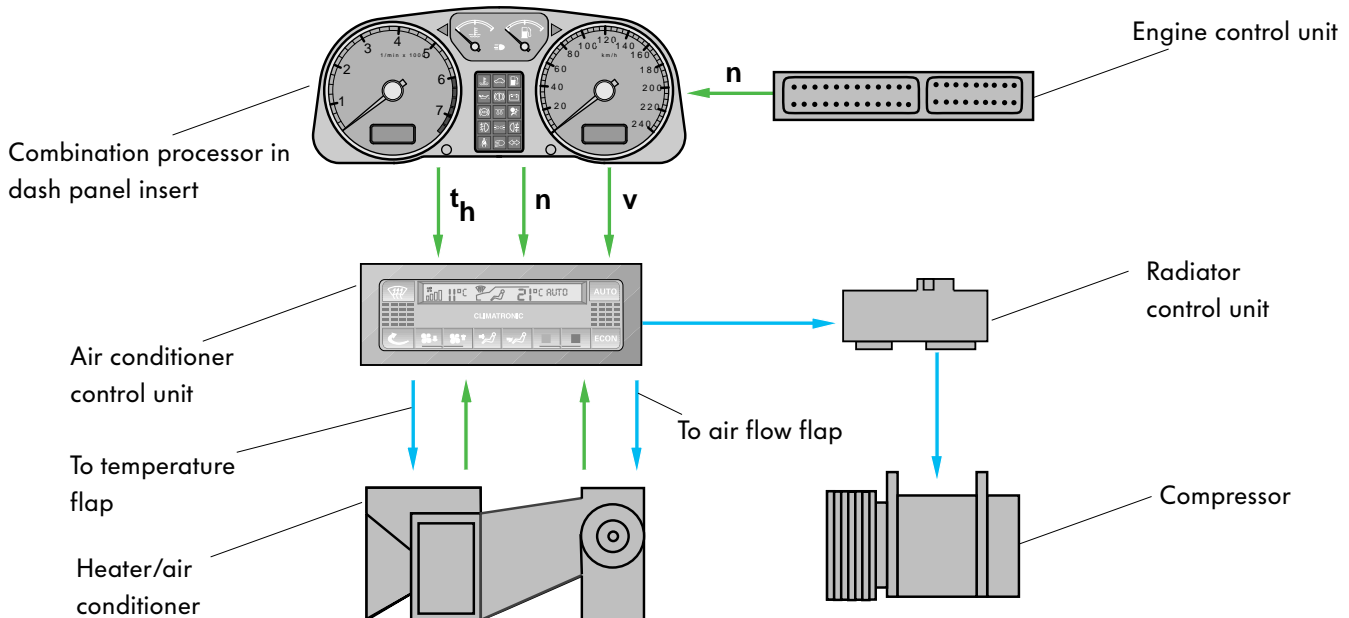


192_034



208_088

Auxiliary signals for temperature control



208_087

With regard to temperature control, additional information enhances comfort and is utilised for system control.

These auxiliary signals are supplied by other vehicle control units and are processed by the air conditioner control unit.

Important signals are:

- 'Time parked' t_h
- Road speed v
- Engine speed n

'Time parked' signal t_h

Time parked=the time between switching off the ignition and restarting the engine

This signal is utilised for adjusting the temperature flap. When the engine is restarted, the control unit processes the ambient temperature values stored before turning off the engine.

Changes in measured data (e.g. due to radiant heat) are disregarded for control purposes. The comfort temperature is set quickly and exposure to subnormal temperatures is avoided.

Road speed signal v

Is required to control the air flow flap.

The signal generated by the speedometer sender is utilised and implemented in the control unit. At higher road speeds, the cross-section of the fresh air inlet is reduced in order to keep the air flow into the passenger cabin as steady as possible.

Engine speed signal n

This signal provides information to the air conditioner control unit on actual engine operation. It is required for system control (to switch off the magnetic clutch), e.g. if there is no engine speed signal, the compressor is switched off.



Temperature control

Positioning motor

In a manual air conditioner, air-ducting flaps such as

- the temperature flap
- the central flap
- the footwell/defrost flap

are adjusted individually by the driver by means of Bowden cables.

In the automatically controlled air conditioner, the flaps are operated by electrically activated positioning motors. The air recirculation flap is also positioning motor operated.

The positioning motors are always positioned level with the flap axis on the heater/air conditioner .

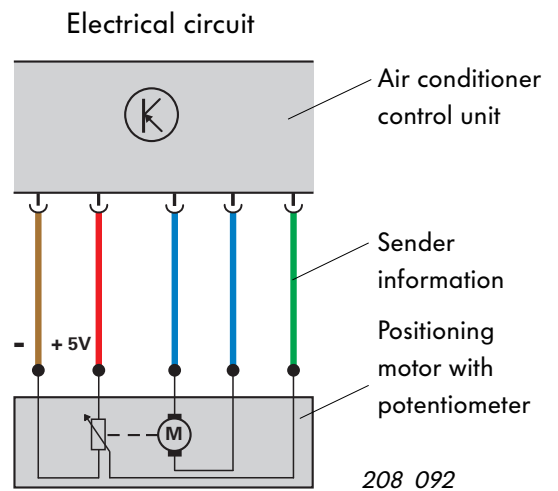
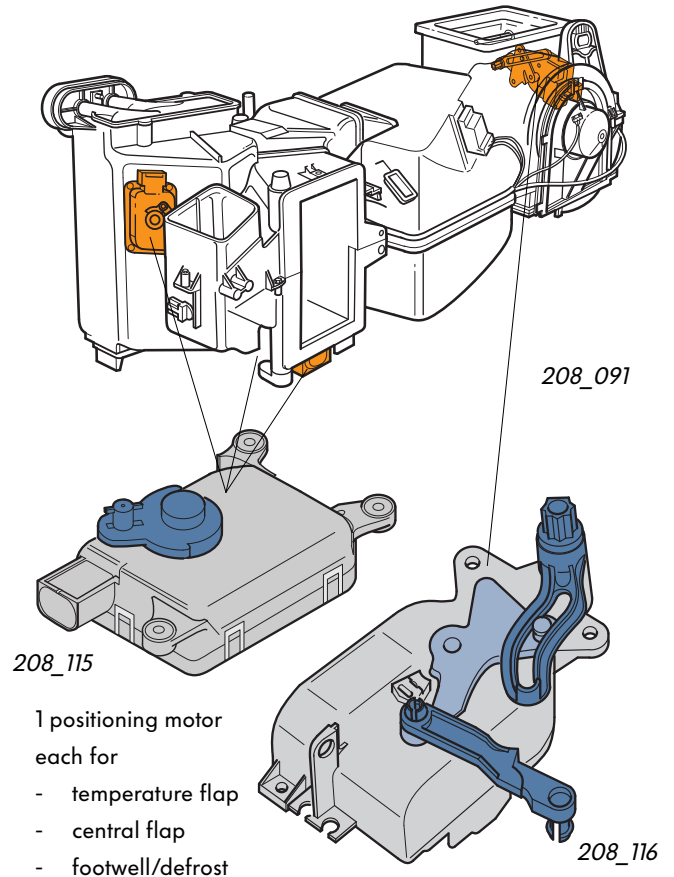
All motors receive the corresponding control signals from the air conditioner control unit.

Each positioning motor has a potentiometer. The potentiometer signals the position of the flap to the control unit in the form of a feedback value.

Thus, the electrical output signals are converted to mechanical quantities by means of positioning motors (actuators).

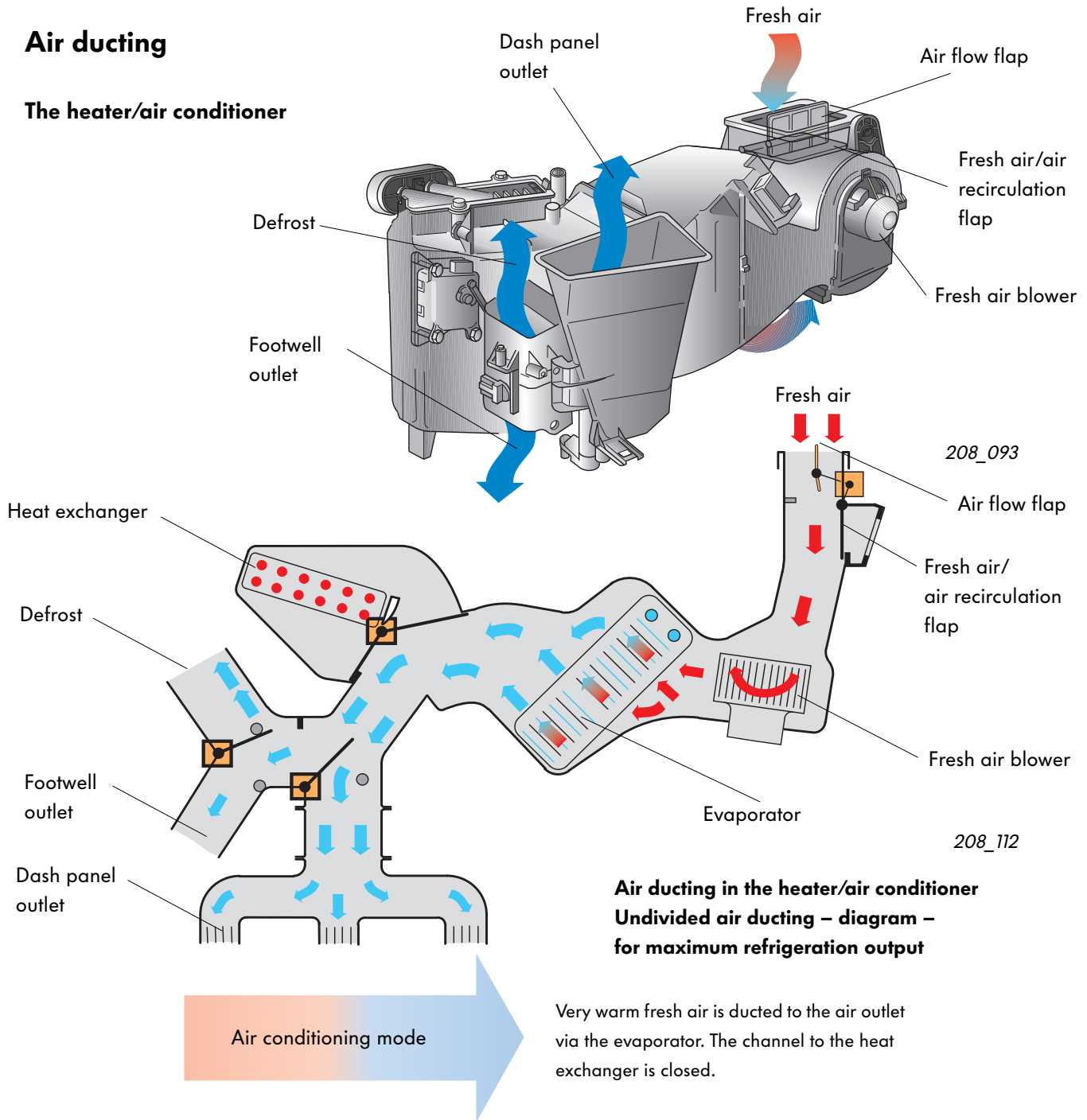


The flaps have different adjustment mechanisms. The arrangement of the cranks and angle of rotation are always referred to a particular flap.



Air ducting

The heater/air conditioner



Air ducting and distribution are always dependent upon the design of the heater/air conditioner and by the required level of driving comfort.

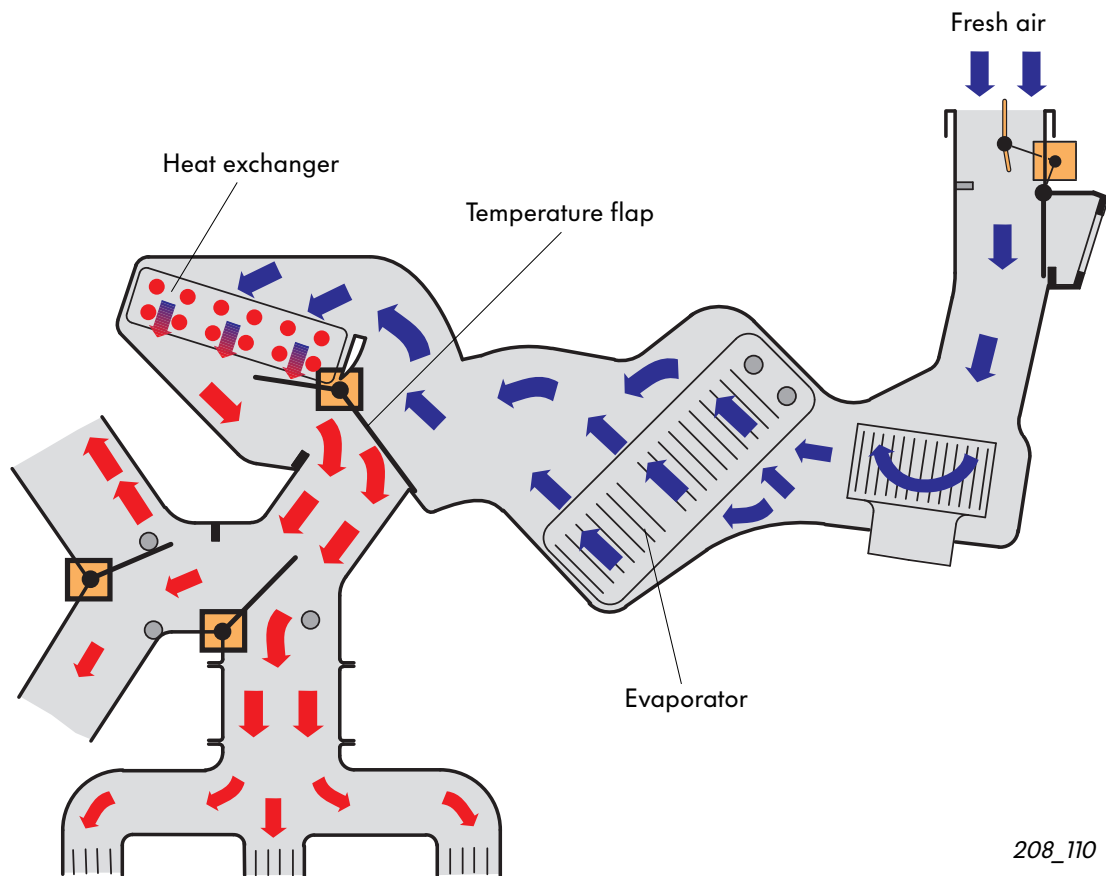
A basic distinction is made between

- undivided air inflow into the passenger cabin
- divided air inflow for the left- and right-hand sides of the passenger cabin.

The latter version, of course, requires more sensors, actuators and air flaps.



Temperature control



208_110

Air ducting in the heater/air conditioner
Undivided air ducting – diagram–
for maximum heat output

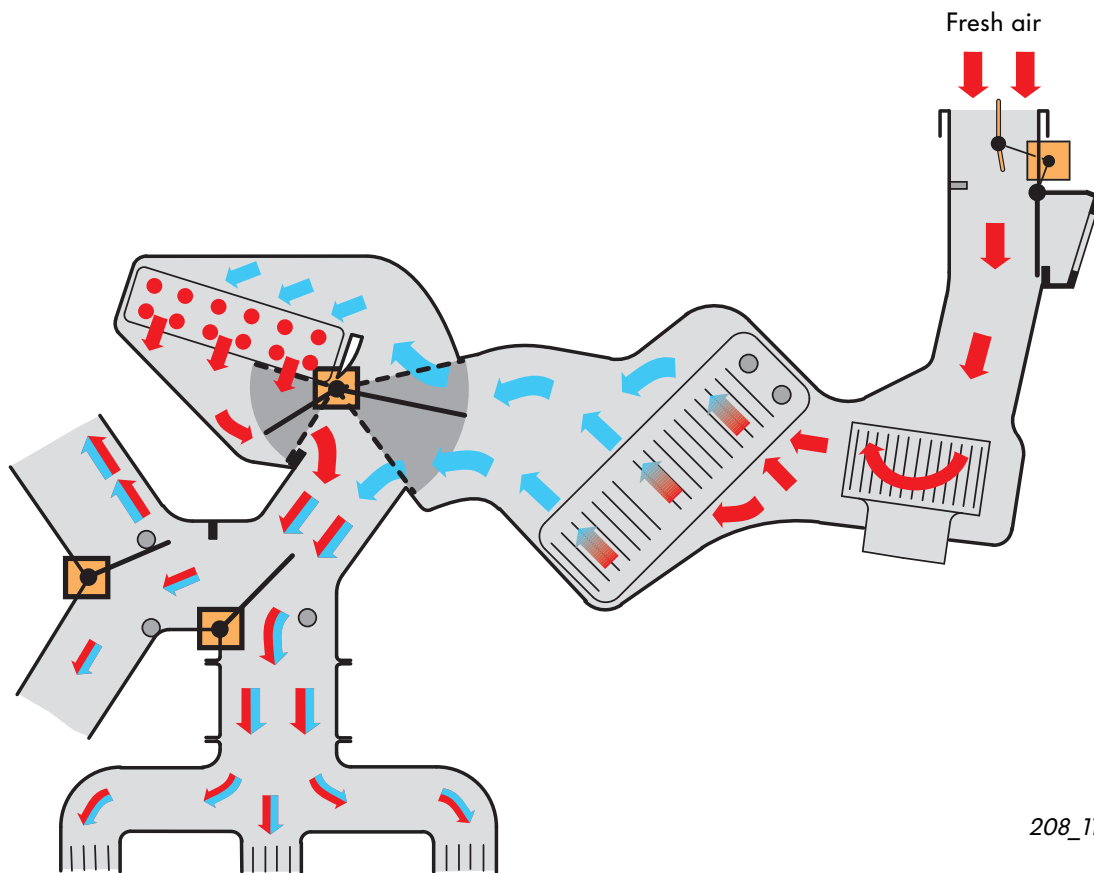


Air conditioner OFF,
 heating ON

Very cool fresh air flows through the evaporator;
 evaporator is not working.
 Fresh air is passed over the heat exchanger and
 heated.

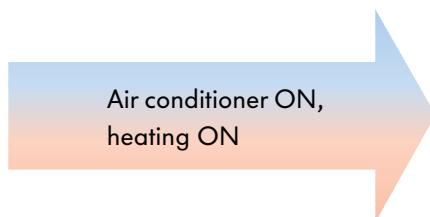
All heaters/air conditioners are basically
 designed as shown in the diagram:

- Air inlet for ambient air
- Air inlet for air recirculation mode (if provided)
- Fresh air blower
- Evaporator (for cooling the air down)
- Heat exchanger (for heating the air up)
- Regulating flaps and ducts for selective air ducting (footwell, defrost, dash panel outlet).

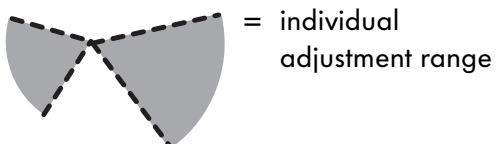


208_111

Air ducting in the heater/air conditioner
Undivided air ducting – diagram–
for mixed operation



Warm fresh air flows through the evaporator in order to cool down. The fresh air is too cool, therefore a partial air flow is ducted over the heat exchanger in order to attain the individually selected vent temperature.



208_114



Air conditioning mode can be selected even if the fresh air is cool and moist. The fresh air passing over the evaporator is dehumidified and the windows are demisted.

Temperature control

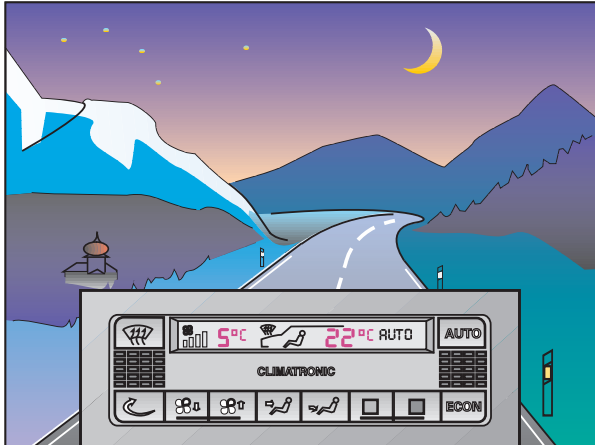
Different ambient temperatures

Constant interior temperature

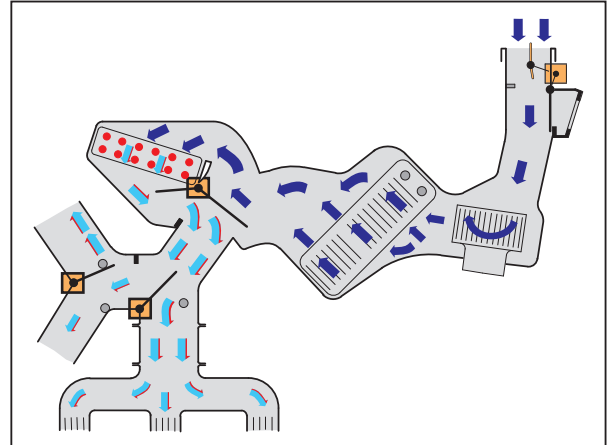
through

Automatic flap control and

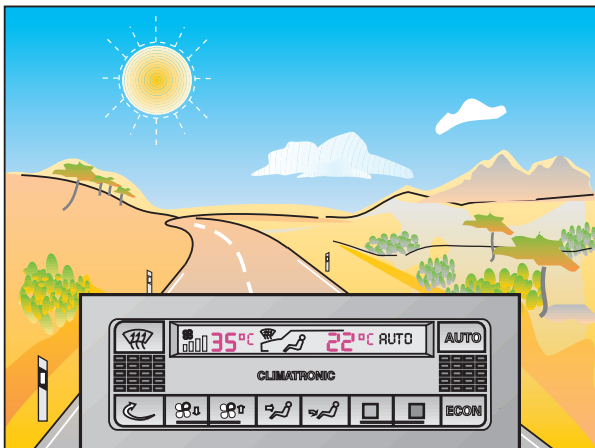
switching the air conditioner on and off



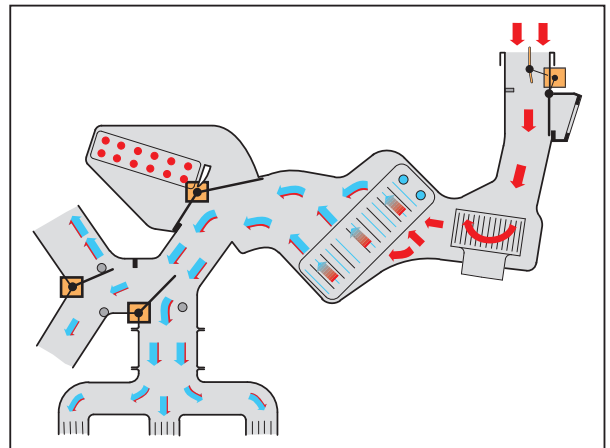
208_094



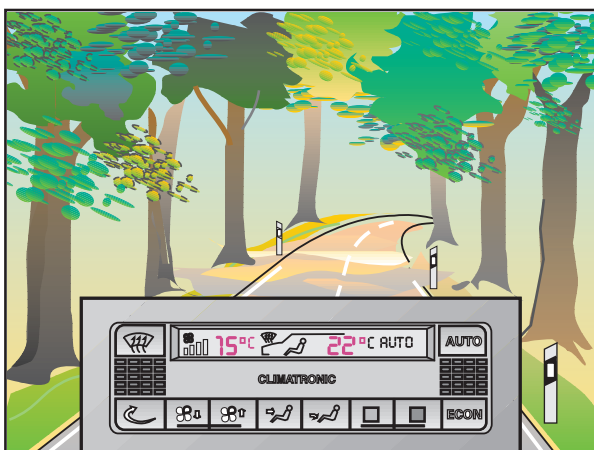
208_095



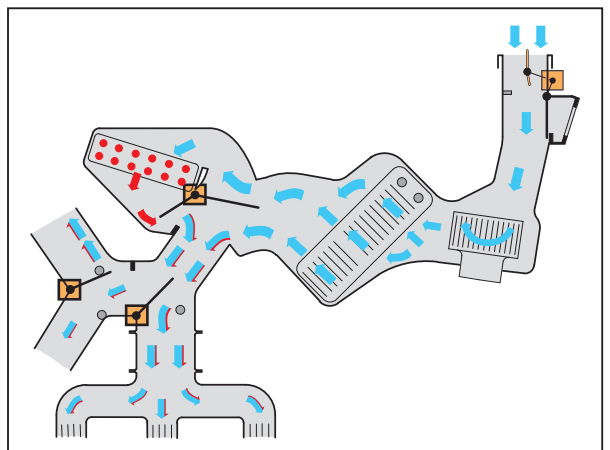
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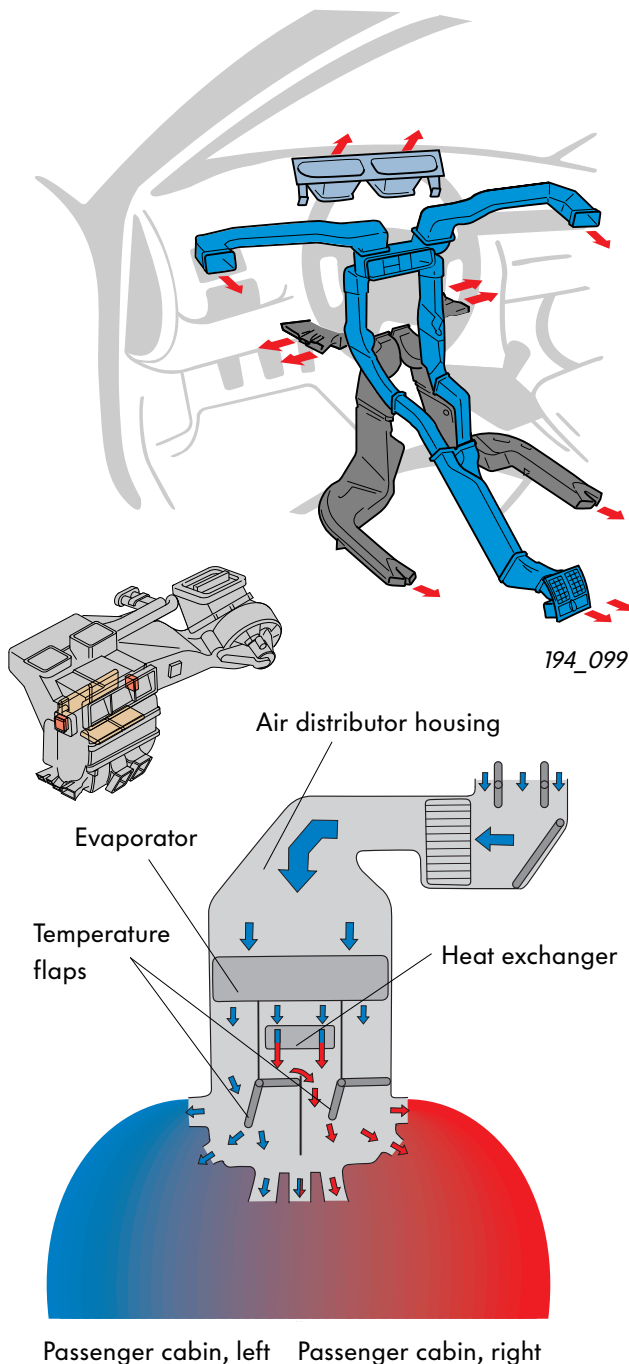
208_098



208_099

Air distribution – split into two separate air flows in the automatic system

(example: Audi A6)



In this case, air distribution inside the vehicle is regulated by air-side flaps in the air conditioner (in the Audi A8, air distribution is regulated on the water side).

Depending on flap control, the air flow is ducted to the individual air outlets.

All flaps are actuated electrically by the positioning motors.

The flaps are adjusted either automatically according to program flow, or manually at the operating and display unit.

The temperature flaps

In this version, the temperature for the left- and right-hand sides of the passenger cabin can be adjusted independently.

In the air distributor housing, the air flow is divided into cold/warm and passenger cabin left/right.

Depending on temperature requirements, the proportion of warm and cold air for the passenger cabin can be adjusted with the temperature flaps.

- The temperature flaps are actuated by
- a positioning motor for the left-hand side of the passenger cabin
 - a positioning motor for the right-hand side of the passenger cabin.



Temperature control

System overview a electronic regulated air conditioner
(with separate air-side temperature control for the left- and right-hand sides of the passenger cabin, as shown using the Audi A6 as an example)

Sensors

Sunlight penetration
photo sensors G107

Dash panel
temperature sensor G56
with temperature sensor
blower V42

Ambient temperature
sensor G17

Temperature sensor
Fresh air intake duct G89

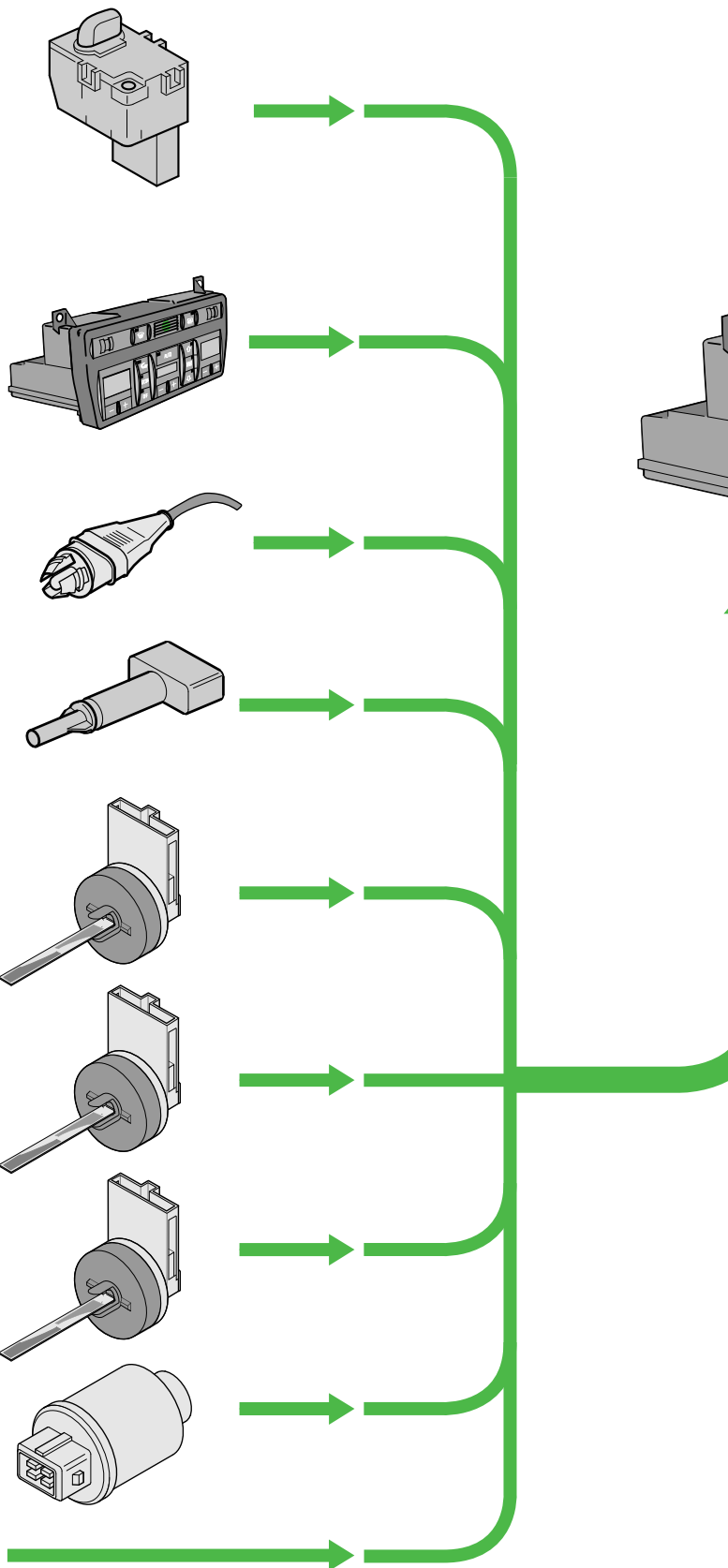
Vent temperature sender, right
G151

Vent temperature sender, left
G150

Footwell vent temperature sender
G192

Air conditioner pressure switch F129

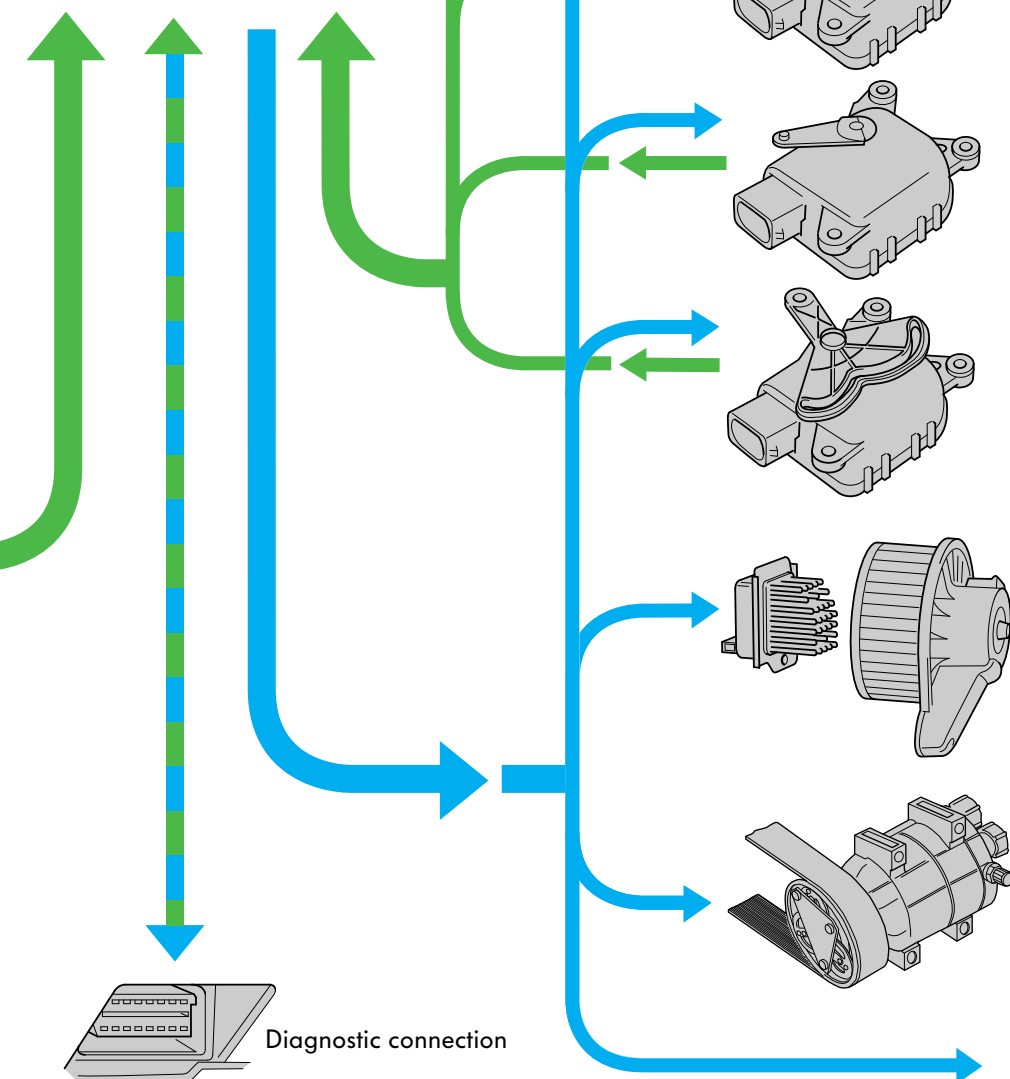
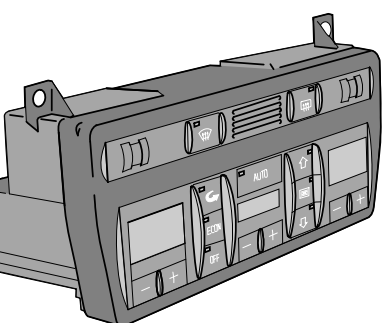
Auxiliary signals



The temperature can be set differently for the left- and right-hand sides to between 18 °C and 29 °C.

The temperature flaps for left/right temperature distribution are located in the air distributor housing

Control unit J255 or
air conditioner operating and
display unit E87



Actuators

Air flow flap positioning motor
and fresh air/air recirculation flap
V71
with potentiometer G113

Defrost flap positioning motor
V107
with potentiometer G135

Left temperature flap
positioning motor V158
with potentiometer G220

Right temperature flap positioning
motor V159
with potentiometer G221

Central flap and footwell flap
positioning motor V70
with potentiometer G112



Fresh air blower V2 and
fresh air blower control unit J126

Magnetic clutch N25

Auxiliary signals

Temperature control

Air recirculation mode

What do we mean by air recirculation mode?

The air conditioner processes two types of air, namely ambient air and cabin air (air recirculation).

In air recirculation mode, the air used for cooling the passenger compartment is not extracted from the outer atmosphere, rather from the vehicle interior.

Therefore, the system only recirculates and controls the temperature of the air which is available inside the vehicle.

Why air recirculation mode?

Air recirculation mode is the quickest way to cool down the vehicle interior. This is done by recycling the cabin air, which is always cooler. When heating the vehicle interior, the converse effect occurs, i.e. the air is heated more rapidly. An advantage of air recirculation is that the evaporator output or compressor drive output required is more than halved in air recirculation mode.

In addition to rapid cooling/heating, air recirculation mode can be used to avoid breathing in polluted ambient air (unpleasant odours, pollen).

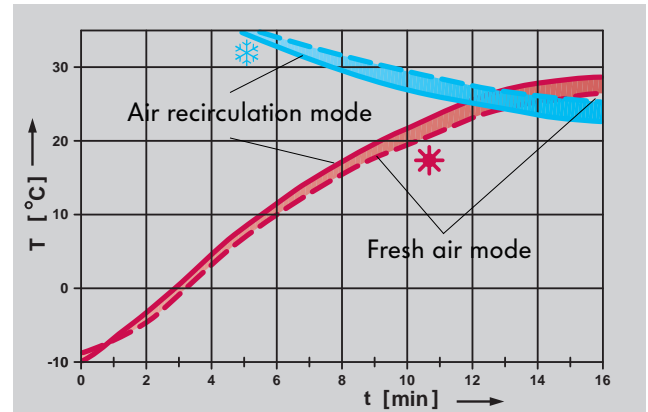
Does air recirculation mode have any drawbacks?

In air recirculation mode, there is no air exchange. The air will be “used up”. Therefore, air recirculation mode should not be used any longer than is necessary, and for no more than 15 minutes.

In air recirculation mode, the atmospheric humidity in the passenger cabin rises due to moisture released with the air respired by the occupants. When the dew point of the interior air exceeds the temperature of the windows, the windows will inevitably mist up.

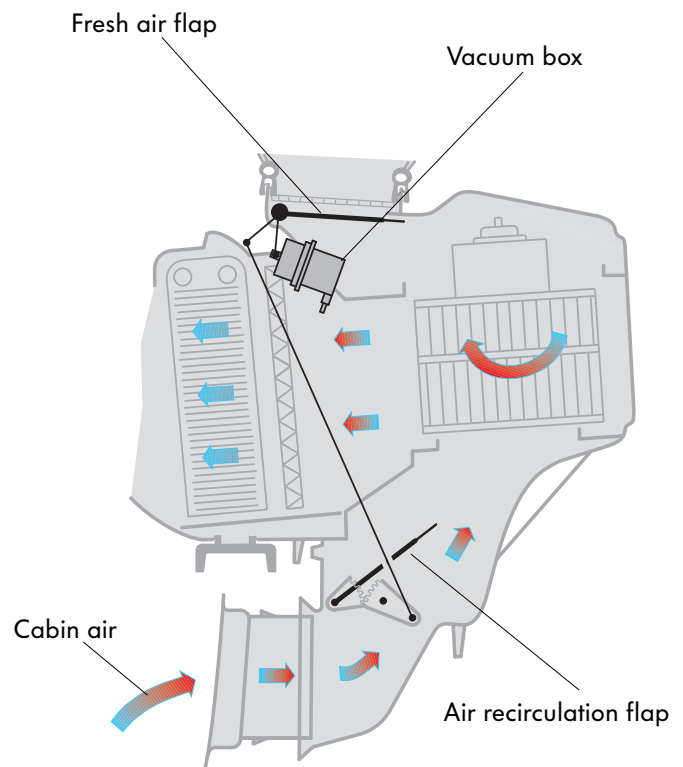


In the Defrost setting, therefore, air recirculation mode is automatically disabled.



208_089

Average values for vehicle temperature reduction/increase in the air recirculation and fresh air modes



208_117

Vehicle air conditioning
in air recirculation mode – pneumatically operated

Manual air recirculation mode

With the manual air conditioner, the driver is responsible for controlling and operating air recirculation mode.

The driver decides on when and for how long.

After pressing the air recirculation button, the flaps are adjusted pneumatically with vacuum.

With automatic air conditioners, too, air recirculation mode is mainly selected manually by the driver.

In this case, the fresh air/air recirculation flap is adjusted electrically by means of a positioning motor.

What both systems have in common is

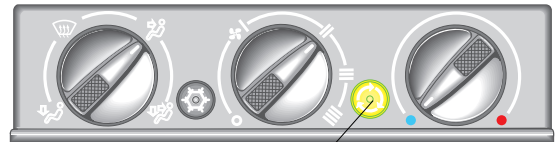
- Fresh air flap closed
= air recirculation flap open
- Fresh air flap open
= air recirculation flap closed

The air recirculation flap positioning motor is also used to adjust the air flow flap.

Several versions of automatic air conditioners already control air recirculation mode automatically.

As soon as pollutants enter the ambient air, the fresh air supply is blocked.

These systems have additional system components.



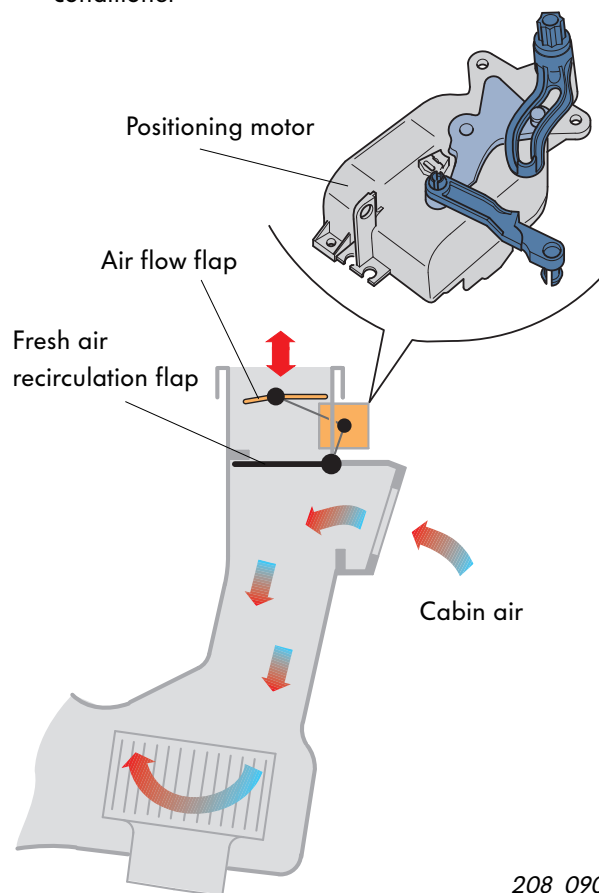
208_118

Air recirculation button – manual air conditioner



207_043

Air recirculation button – automatic air conditioner



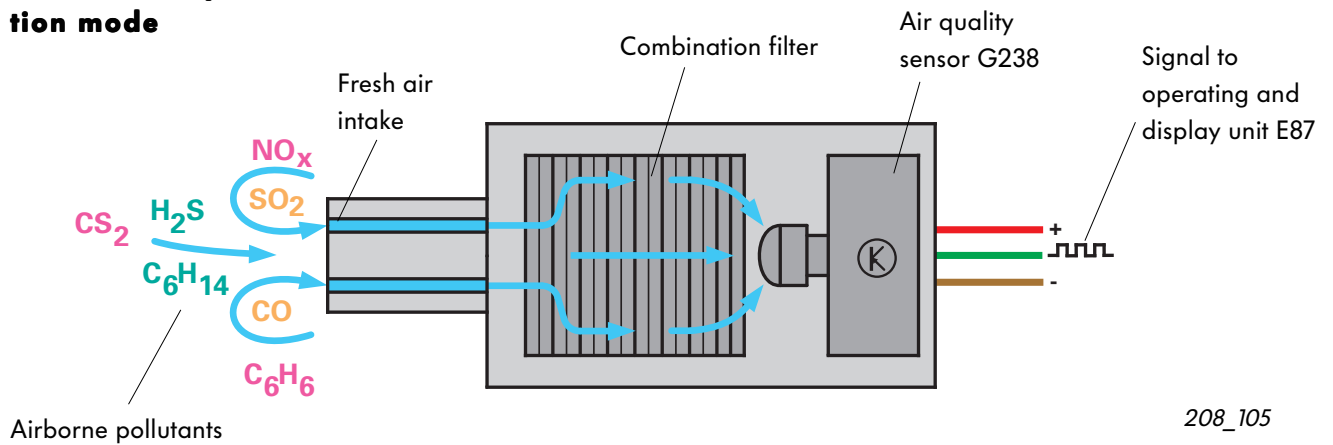
208_090

Vehicle air conditioning
in air recirculation mode – electrically operated

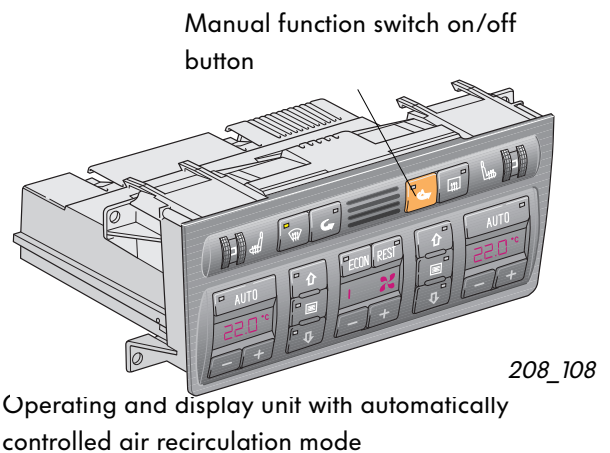


Temperature control

Automatically controlled air recirculation mode



In systems with a manually operated air recirculation mode, the changeover is logically not performed by the driver until an odour nuisance occurs, by which time the air inside the vehicle will have already been fouled. In systems with an automatic air recirculation mode, the vehicle ventilation system will be closed as soon as pollutants in the air have been detected (by a sensor), i.e. before an odour nuisance occurs. The automatic air recirculation function can be switched on and off manually.



The system components

- Air quality sensor G238
An electronic component which is located in the area of the fresh air intake upstream of the combination filter.
- Combination filter
The combination filter replaces the dust and pollen filter. It comprises a particle filter containing activated charcoal.

The operating principle

A gas sensor detects pollutants in the ambient air. When a high pollutant concentration occurs, the air conditioner control unit implements the signal which the gas sensor generates by changing over from fresh air mode to recirculation mode. If the pollutant concentration drops below a given threshold, then fresh air is again supplied to the vehicle interior.

What pollutants are detected?

The primary pollutants contained in the exhaust gases of the petrol engine are:

CO - Carbon monoxide
C₆H₁₄ - Hexane
C₆H₆ - Benzene
C₇H₁₆ - n-heptane

In exhaust gases of diesel engines:

NO_x - Nitrogen oxides
SO₂ - Sulphur dioxide
H₂S - Hydrogen sulphide
CS₂ - Carbon bisulphide

Air quality sensor G238

The sensor operates, in principle, in much the same way as a lambda probe.
The metering element is a mixed oxide sensor which uses semiconductor technology (stannic oxide - SnO₂).
The sensitivity of the air quality sensor is increased by catalytic additives of platinum and palladium.
The operating temperature of the sensor is approx. 350 °C. Its power consumption of 0.5 watts is very low.

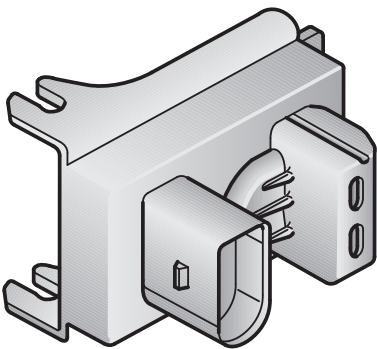
The evaluation electronics in the sensor

The evaluation electronics integrated in the ultrasonic sensor module react to changes in sensor conductivity.
High sensitivities are achieved.
The system is self-learning.
The electronics determine the average pollutant concentration in the ambient air and sends information on the type and quantity of the materials by means of a digital square-wave signal to the air conditioner control unit.

The control unit now closes the air recirculation flap at peak pollution levels depending on the ambient temperature and air pollution level.
This ensures that the ventilation system does not remain stuck in air recirculation mode in heavily polluted areas.
Regardless of the electronic evaluation, several systems switch to air recirculation mode when the wash/wipe system is operated.

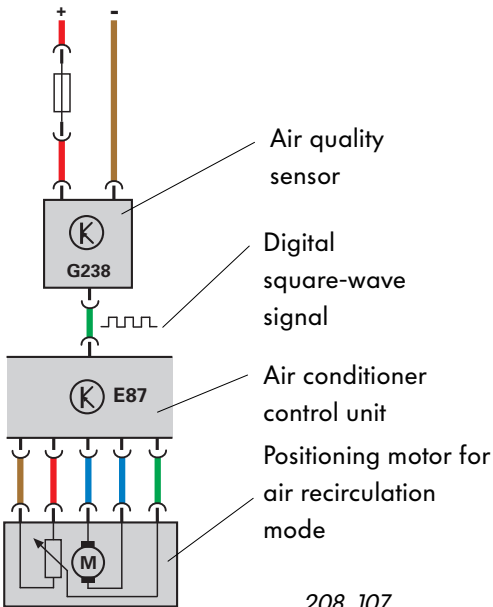
Service

The air quality sensor is wear-free.
The combination filter must be replaced after service intervals.



Air quality sensor G238

208_106



208_107



Ambient temperature	Air pollution level	Air recirculation
> +2 °C	Low rise	yes min. 25 sec.
> +2 °C	Low	no
+2 °C ... -5 °C	Higher rise	yes
< -5 °C	Higher rise	max. 15 sec.
ECON mode compressor off		max. 15 sec.
Defrost mode		no
Warm-up phase of sensor approx. 30 sec.		no

Technical Service

Safety precautions for working on air-conditioned vehicles and handling refrigerant R134a

Set codes of conduct and safety precautions must be observed when working on air-conditioned vehicles and handling refrigerants in order to ensure that no-one is endangered by leaking refrigerant.

Work performed incorrectly can also damage the air conditioner itself and should therefore be avoided at all costs in the interests of proper customer care.



Wear protective gloves



Wear protective goggles



Naked flames, exposure to direct sunlight and smoking are prohibited.

208_085



Important!

General servicing work on the vehicle should be prepared and performed in such a way that the vehicle refrigerant circuit is not opened (e.g. radiator/engine removal).

Direct contact with refrigerant should be avoided at all costs in order to avoid skin damage (frostbite).

Escaping refrigerant has a temperature of – 26 °C.

If it is necessary to open the refrigerant circuit in order to perform repair work on the vehicle, bring the vehicle to a service station for air conditioners. At the service station, the refrigerant circuit will be emptied by expert personnel.

These are the only workshops which have the equipment required to draw off refrigerant properly. The refrigerant will also be processed in an environmentally friendly manner and can be reused.

What is the correct code of conduct when refrigerant discharged accidentally from the refrigerant circuit comes into contact with the skin?

If liquid refrigerant comes into contact with the eyes, rinse eyes thoroughly with water for 15 minutes.

Then apply eye drops and contact a doctor even if no eye irritation has occurred.

Inform the doctor that refrigerant was the cause.

In the event of skin contact, remove wet clothing immediately and rinse the areas of skin affected with copious amounts of water.



Neither welding or brazing or soldering work may be performed on parts of the filled air conditioner.

This also applies to welding and brazing/soldering work on the vehicle if there is a danger of parts of the air conditioner heating up. During spot painting work, the object temperatures in the drying oven or preheating zone may not exceed 80 °C.

Why not?

Heating produces a higher excess pressure in the system which can cause the pressure relief valve to open. During electrical welding work, invisible ultraviolet rays can penetrate the refrigerant hoses and degrade the refrigerant.

What is the correct code of conduct?

Damaged or leaky parts of the air conditioner may not be repaired by welding or brazing/soldering them. Such parts must always be renewed. Draw refrigerant out of the refrigerant circuit with the service station beforehand.

Work may only be performed on the refrigerant circuit in well-ventilated rooms. Refrigerant may not be stored in shafts or at basement windows.

Why not?

Refrigerant is a colourless and odourless substance. It is also heavier than air, and therefore displaces oxygen and can flow down into lower regions. If refrigerant escapes even though all the applicable safety precautions have been observed, there is an unforeseeable risk of suffocation in badly ventilated rooms or assembly pits.



208_119

Although refrigerant is not highly flammable, it is not permitted to smoke or perform welding or soldering or brazing work in a room filled with refrigerant.

Why?

The high temperature of an open flame or a hot object will cause chemical fission of the refrigerant gas. Inhalation of the resulting toxic fission products will lead to dry coughing and nausea.

What is the proper code of conduct?

If a person breathes in refrigerant vapours in a high concentration, bring the victim out into the open air immediately.

Contact a doctor.

If the victim is having difficulty breathing, provide the victim with oxygen.

If the victim has impaired breathing or is no longer breathing, bend the victim's head back and administer artificial respiration.



Why service station for air conditioners and special equipment?

The refrigerant circuit is in a closed system. To ensure that the system functions properly:

- the refrigerant must be clean
- the refrigerant may not contain any moisture
- the piping must be evacuated and dry before being filled
- only refrigerant resistant original spare parts may be used.

To avoid damaging the environment and physical injury,

- the refrigerant circuit may not be filled in the open air
- the refrigerant must be disposed of in an environmentally friendly manner.

The equipment developed specially for air conditioners conforms to these requirements. This equipment is expensive, however, and is therefore not available nationwide rather only at service station for air conditioners.

Working on the refrigerant circuit calls for

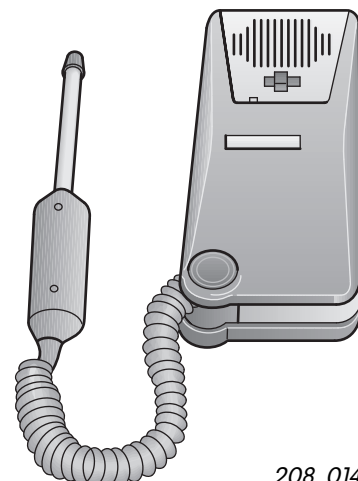
- a special knowledge of proper repairs
- a knowledge of the safety regulations and the Pressure Vessel Code
- verification of appropriate qualifications (country-specific).

This specialist personnel at the service station for air conditioners meet the above requirements.

What equipment does the service station for air conditioners have for carrying out work expertly and in an environmentally friendly manner?

The leak detector for inspection work on the vehicle –

A possible cause of insufficient cooling output is loss of coolant due to leaky lines. Minor leaks (external damage) can only be verified by means of suitable leak detecting equipment, due to the minute quantity of refrigerant which is discharged. Leaks with less than 5 grammes of refrigerant loss per annum can be detected using this equipment.



208_014

An all-in-one system for checking, drawing off, evacuating and filling – the Service Recycling Station

This station meets all the requirements relating to the maintenance, testing and commissioning of vehicle air conditioners in refrigeration terms.

Various makes of station are available.

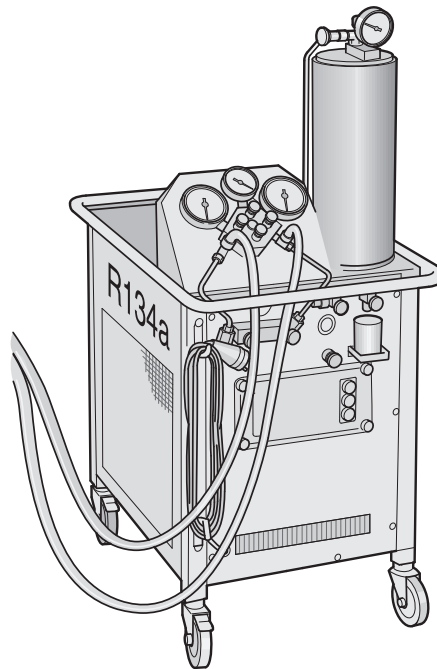
A station comprises various individual units:

Filling cylinder, pressure gauges, vacuum pump, shut-off valve, filling hoses.

Quick-connect adapters for the service connections in the high- and low-pressure areas of the refrigerant circuit.

The stations can be used to empty, evacuate and fill the vehicle air conditioner.

The extracted refrigerant is recycled (dried and cleaned by removing suspended matter) in the station and refilled after being repaired.



208_113

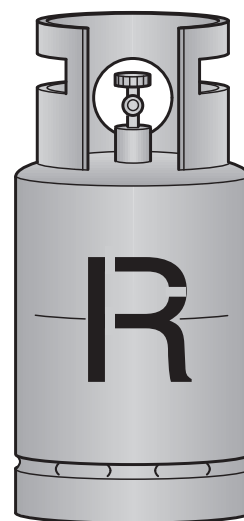


Under the government ordinance prohibiting the use of CFCs and halogens, it is not permitted to perform work on air conditioners without the recycling station. Recycling stations may only be operated by expert personnel.

For refrigerant disposal – the recycleable bottle

Refrigerant which contains excessive amounts of impurities, e.g. due to internal mechanical damage to the compressor, should not be cleaned. This refrigerant is drawn off in a separate extractor station with a recycleable bottle, which is evacuated on delivery and then disposed of.

Recycleable bottles may only be filled up to 75 % of the specified filling weight (expansion of the refrigerant upon exposure to heat must be possible). Therefore, they must be weighed using a calibrated weigher while being filled (observe the Pressure Vessel Code).



208_086



Technical Service

General information on function influencing factors

Mechanical faults (e.g. damage to the compressor) can reduce the cooling capacity of the air conditioner, as can chemical or physical influences.

The refrigerant in particular can have an effect on the functioning of the air conditioner by virtue of its properties. Therefore, a knowledge of general relationships is also important to everyday servicing, and not only for the specialists working at the service station for air conditioners.



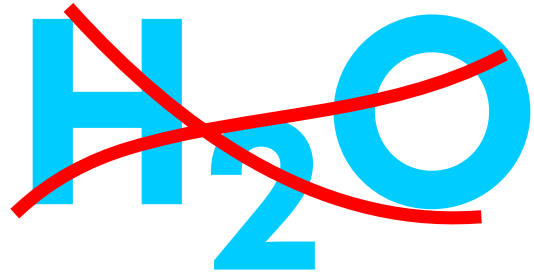
Refrigerant and moisture

Only small amounts of water can be dissolved in the liquid refrigerant. However, refrigerant vapour and water vapour will mix in any proportion.

If the drier in the fluid tank or collecting tank has already absorbed 6 - 12 grammes of water, – i.e. a relatively small quantity, – it may not function properly depending on type. Any existing water is entrained into the refrigerant circuit. This water reaches the nozzle of the expansion valve or the restrictor and freezes.

This will reduce the cooling output of the air conditioner.

Water will damage the air conditioner irreparably because it combines with other impurities to form acids at high pressures and high temperatures.

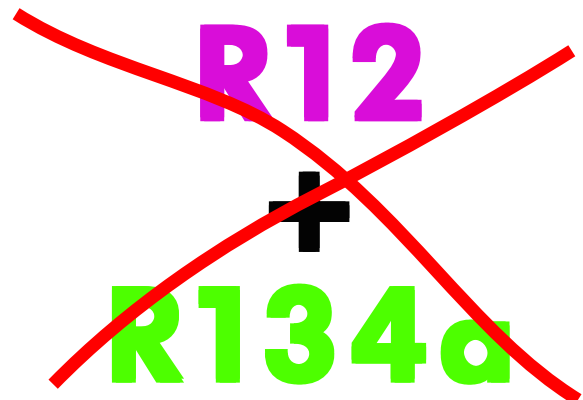


Refrigerant + refrigerant

Refrigerants may not be mixed with one another (their chemical and physical properties are different and they contain different oils).

Only the refrigerant specified for a particular air conditioner may be used.

Air conditioners which can no longer be supplied with R12 according to the ordinance prohibiting the use of halogens must be converted in compliance with special guidelines.



Refrigerants and plastics

Refrigerant can dissolve certain plastics. These dissolved plastics can be deposited in the expansion valve or at the restrictor after they cool down.

The valve will become obstructed.

Therefore, always use original spare parts at seals.

Refrigerants and metals

Refrigerant R134a is chemically stable in its pure state. It does not attack iron and aluminium.

Contamination of the refrigerant, e.g. with compounds of chlorine, however, can lead to certain metals and plastics being attacked. This can result in obstruction, leaks or deposits at the compressor piston. Therefore, always use R134a compatible original spare parts.

For this reason, air conditioners can only be converted from refrigerant R12 to R134a, including refrigerant oil, according to special guidelines of the manufacturer (retrofit-process).

Refrigerant circuit and impurities

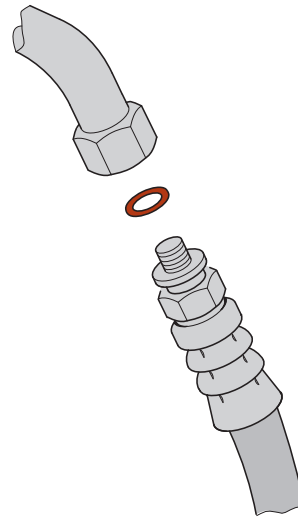
A refrigerant circuit filled with refrigerant R134a can be cleaned:

in order to remove impurities, moisture or old refrigerant, the refrigerant circuit is cleaned with dried compressed air and then demounted with nitrogen.

This is necessary when

- the refrigerant circuit was opened during its normal lifetime (e.g. after an accident),
- there is doubt regarding the amount of refrigerant oil contained in the circuit,
- the compressor has to be replaced due to internal damage.

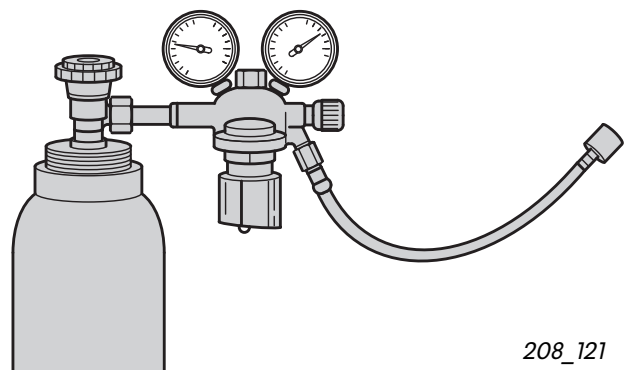
The gas mixture emerging from component parts of the refrigerant circuit must be drawn off using workshop suction apparatus.



208_120

Always use original spare parts.

**Conversion from
refrigerant R12 to R134a**



208_121



Technical Service

Fault diagnosis through pressure testing

For service work, there are terminals for the Service Recycling Station in the low-pressure and high-pressure ranges

- for filling
- for emptying
- for evacuating and
- for pressure testing.

To perform a pressure test, the pressure gauges of the station are connected. The pressure test is performed with the air conditioner switched on.



A pressure test involves intervening in the refrigerant circuit via the service connections.

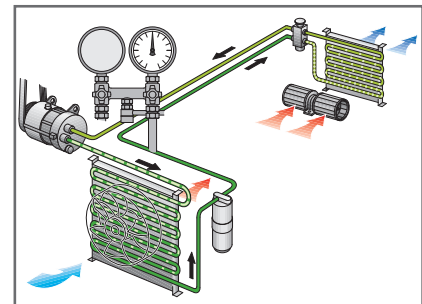
The hoses of the pressure gauges will always contain residual refrigerant. Therefore, pressure tests may only be performed at air conditioner service points by specialist personnel.

The ambient temperature when the engine is not running always affects the pressure in the refrigerant circuit.

Using the test data for the high-pressure side and the low-pressure side, the system can identify whether an air conditioner is operating properly when the engine is running.

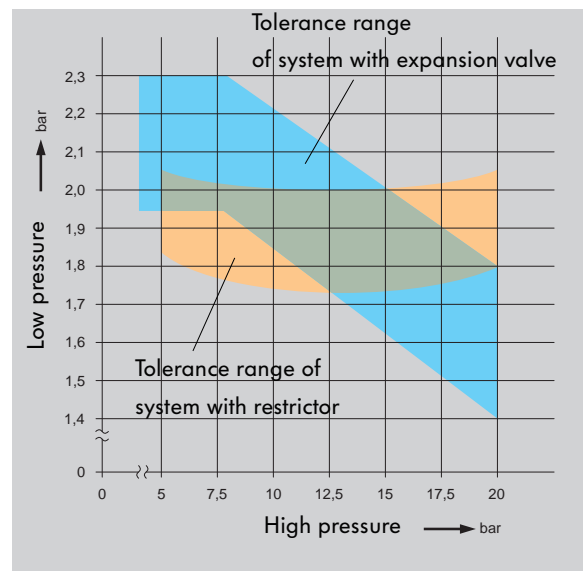
The measured values must be compared with the test data of the vehicle-specific refrigerant circuit according to the Workshop Manual, as they vary greatly from one vehicle type to another.

The pressure diagrams show the tolerance ranges for systems with an expansion valve and systems with a restrictor.

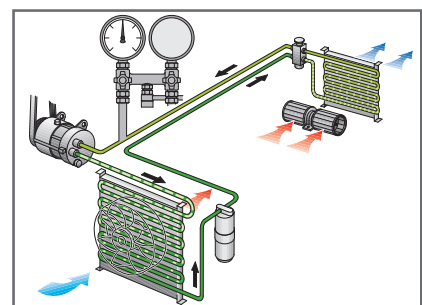


208_010

High-pressure service connection



208_104



208_011

Low-pressure service connection

Fault diagnosis through self-diagnosis

Not all air conditioners have self-diagnostic capability.

Self-diagnosis is used very little in the case of manual air conditioners (they have either no or very few sensors/actuators/control units).

In some manual air conditioners, however, the circuit for the compressor and the sensors of the safety cut-out are registered by the self-diagnosis.

Automatic air conditioners with control units usually have self-diagnostic capability.

The address word for the self-diagnosis:

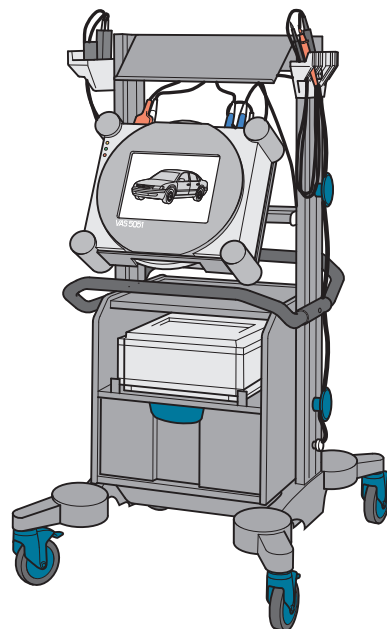
08 - Air conditioner/heating electronics

Self-diagnosis can be performed with Vehicle Diagnostic, Testing and Information System VAS 5051, with Vehicle Systems Tester V.A.G 1552 or with Fault Reader V.A.G 1551.

Faults which impair the operation of an automatic air conditioner are stored in the fault memory of the air conditioner control unit. In some systems, e.g. CLIMATRONIC, faults of this type are indicated on the display unit when the ignition is switched on (all the symbols flash for several seconds).



The self-diagnosis functions and the self-diagnosis procedure are explained in detail in the Workshop Manual for the heating and air conditioning system of the vehicle type. Self-diagnosis can be performed by any workshop, because the refrigerant circuit is not affected by this procedure (i.e. it is not opened).



202_002



208_122





Key cooling system terminology

The cooling system air-conditions the vehicle interior using the laws of physics. A chemical medium, the refrigerant, is used for heat exchange.

The principles of cooling engineering are easier to understand with a knowledge of the key terms:

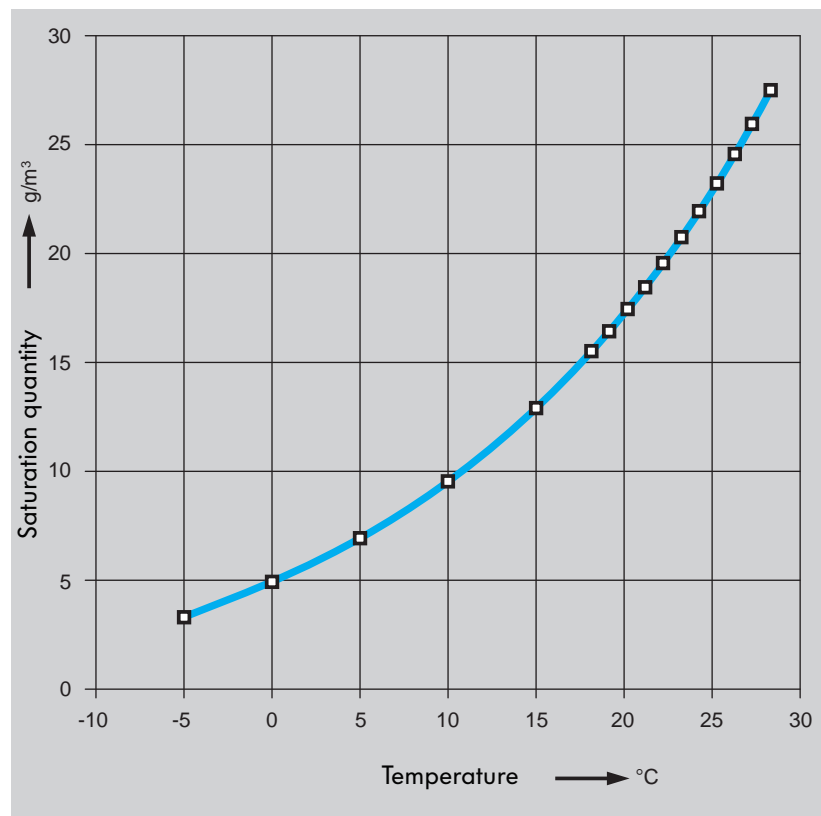
Heat	→ an energy form	<ul style="list-style-type: none">– measurable by the temperature in degrees– by the quantity of energy in Joules (calories) can be stored or
	states can change or	<ul style="list-style-type: none">= slight temperature rise (heat absorption)= slight temperature decrease (heat dissipation)= always propagates towards lower temperatures.
Cold	→ is in fact only a low degree of heat. Temperatures below the freezing point of water are generally referred to as cold.	
Critical point	→ above this point, there is no interface between liquid and vapour. A substance is always in a vapour state above the critical point. If a gas is heated above the critical point, liquefaction will no longer be possible.	
Boiling point	→ The temperature at which a substance changes from a liquid to a gas. The boiling point is pressure-dependent; the boiling point increases as pressure increases.	
Dew point	→ the temperature at which the saturation point is reached as the result of cooling of a gas with a specific water vapour content. When the gas cools down further, some of its vapour content precipitates on the cooling surface in the form of a "condensate".	
Condensation	→ this time the change of state is from a gas to a liquid.	
Refrigerant	→ the chemical medium used for the heat exchange process. Depending on the pressure and temperature conditions, the refrigerant exists in a gaseous or liquid state in the air conditioner. The refrigerant cools down when it expands.	
Cooling through expansion	→ if pressurised gas can suddenly expand via a valve, — it will cool down in the process, e.g. when deflating the tyres. The pressurised air flowing out of the valve is cool.	

Water vapour content of the air



Saturation quantity of water vapour in air at
100% relative humidity and normal air pressure

Temperature °C	Quantity (g/m ³)
-5	3.25
0	4.85
5	6.80
10	9.41
15	12.84
18	15.39
19	16.32
20	17.32
21	18.35
22	19.44
23	20.61
24	21.81
25	23.07
26	24.41
27	25.79
28	27.26



208_103

Absolute atmospheric humidity

→ (g/m³) is the water content in 1 m³ of air.

Relative atmospheric humidity

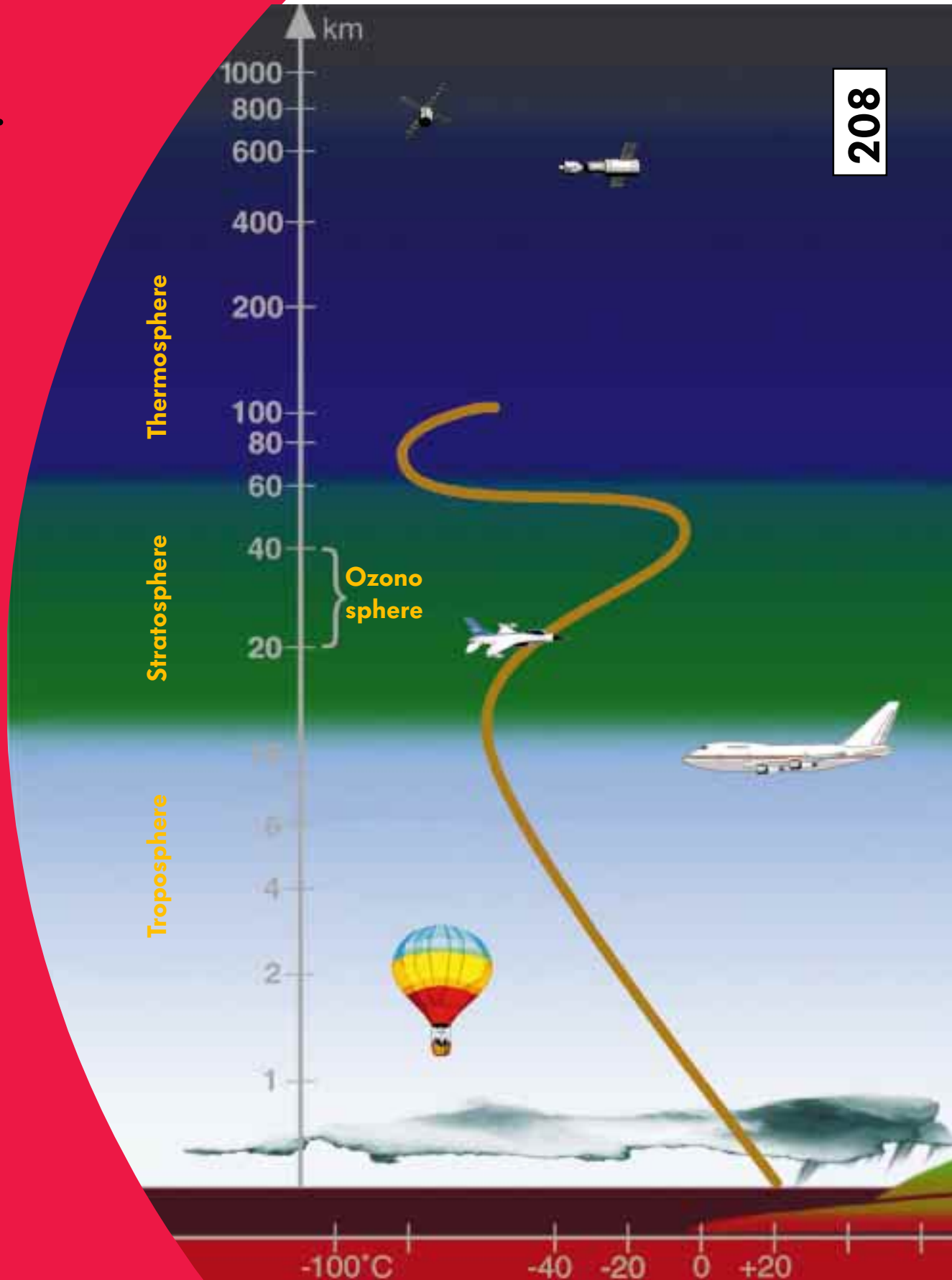
given in %, the ratio of water vapour quantity in the air to max. possible
→ water vapour quantity in air.

re table

→ The table shows how many g of water per m³ the air can hold at various temperatures. 100% saturation is shown. The higher the temperature, the larger the quantity of water in the air.
The rule of thumb is: at a temperature of 10 to 30 °C, the water content in the air in g/m³ is roughly the same as the temperature in °C.

Service.


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