Software Requirement Specification For Metro Amsterdam HVAC System

Release History

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Revision Table

Revision	Date	Revised Sections, Description, Reason for changes
01	2010-9-21	Create the first issue
02	2010-11-01	Modify slumber mode and emergency mode description. Modify set point temperature calculation
03	2011-01-31	Update according to the document '2011_01_31_SFRT_comments on K97A SRS issue 2.doc'
04	2011-6-11	Update the damper control logic
05	2012-2-11	3.3.6 add the premode out conditions; 6.3.3 add "10min elapsed after unit heater off"
06	2017-7-19	Change the speed requirment of "Station mode" from 5km/h to 10 km/h "Slumber mode" add "The ventilation will be in operation only when the heater needs to operate."

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Content

1 ABBREVIATIONS AND DEFINITIONS

AC	Alternate current
AI…	Analogue input with number
APSE	Auxiliary Power Supply Equipment
AQ...	Analog output with number
CDR	Condenser
CDF	Condenser Fan
CPR	Compressor
DQ...	Digital output with number
DI...	Digital input with number
DF…	Internal variable to indicate fault information
ESF	Supply Air Fan emergency ventilation
F	Fault signal
FAS	Fresh air temperature sensor
FPC	FAIVELEY controller
HVAC	Heating Ventilation and Air Conditioning
INV	(emergency) Inverter
INVOK	(emergency) Inverter OK signal
KM	General contactor name
MLOK	Main line power supply OK feedback
MONA	FAIVELEY Service Software
MVB	Multi-function vehicle bus
PID	proportional–integral–derivative
RAS	Return air temperature sensor
SAS	Supply air temperature sensor
TBD	To Be Decided
t°	temperature
T_e	Ambient air temperature
T_d	Duct (supply) air temperature
Tic	Set point value
TCMS	Train control and monitor system

I / O	Input / Output
0L	Signal logically 0
1L	Signal logically 1
SAF	Supply Air Fan
SFRT	SHANGHAI FAIVELEY Railway Technology Co., Ltd
LP	Compressor Low Pressure switch
HP	Compressor High Pressure switch
UH	Unit heater
Ti	Average of Compartment air T° & Return air T°
TCN	Train Communication Network
VCU	Vehicle Controller Unit
Z_TMT_...	Internal variable to start test mode by MONA user

2 Introduction

2.1 Objective

The objective of this software requirement specification is to specify the function of the Saloon air conditioning system required for Amsterdam metro HVAC system.

2.2 HVAC unit components

Saloon unit:

The main components of the Saloon unit are:

- Two compressors with low and high pressure switch
- Two condenser fans
- Two supply air fans with low and high speed respectively
- One electrical heater divided into 2 stages, with safety elements
- Three temperature sensors
- Two liquid line solenoids and two hot gas bypass solenoids
- Two fresh air dampers and one return air damper

2.3 Control system

An FPC08 digital controller is used for temperature regulation. All functions of the air-conditioning system are regulated automatically and the air-conditioning system is also monitored automatically.

Supply air, recirculation air and external temperature sensors and pressostats and thermostats transfer the information to the controller which generates control commands for the switching elements.

If the temperature of the recirculation air deviates from that setting at the controller, with the system switched on by the mode switch or signal via train bus, the air-conditioning system is switched automatically in cooling or heating mode. The supply air ventilator is ON, thus it is ensured that the air is filtered and enriched with fresh air in any case.

The control of the HVAC unit is linked to the TCMS via CAN interface for the purpose of diagnosis and status information.

3 General control

3.1 Reference documents

Software must follow the requirements of the following documents:

- Za537189 Operation Manual Service Program Mona
- TI_KS97_Ver 4 Technical information for Air Conditioning System
- KS97_SQAP_01 Software Quality Assurance Plan
- KS97A000.000A.S4 Electric diagram for HVAC System

3.2 Network topology of HVAC controllers

The network topology of the HVAC controllers is as following:

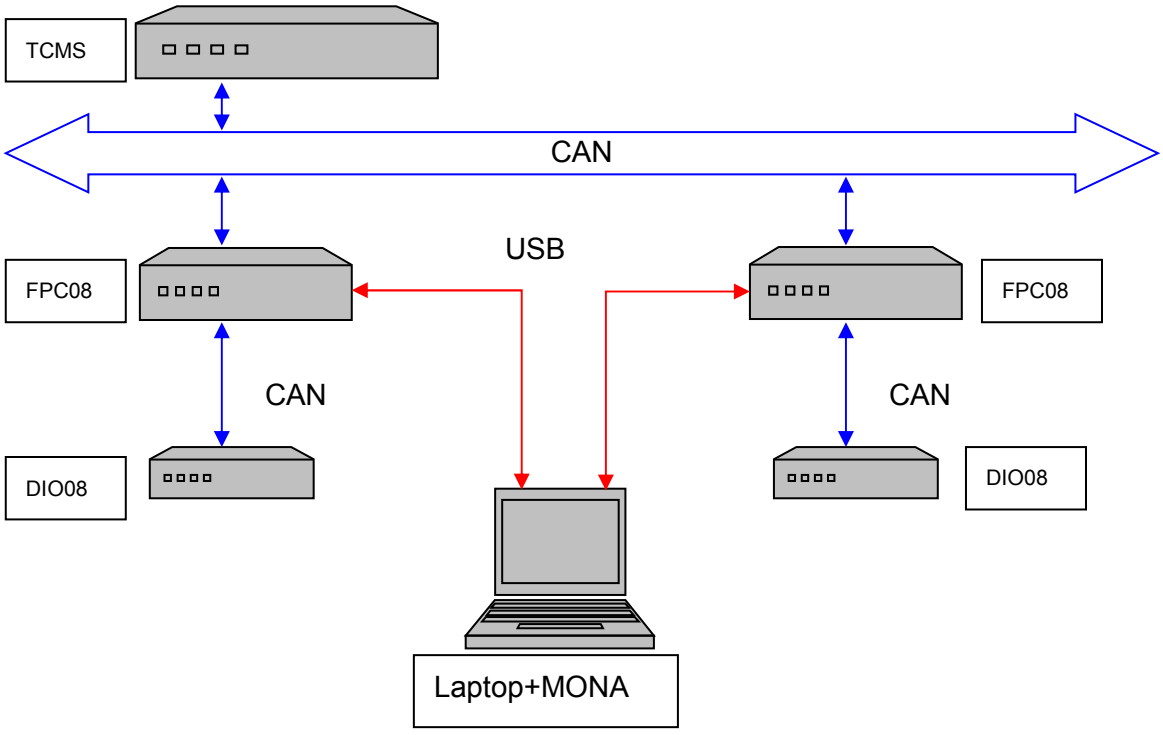


Figure 3-1: Network topology

3.3 General operation

3.3.1 General functions

Main function of the control system is ensuring adequate comfort regarding room temperature, supply air temperature and air volumes in accordance with the requirements. Changing conditions such as different outside temperature, solar radiation, humidity, and changes of supply voltage are to be compensated.

Furthermore the control system has to monitor the proper function of all components and has to transfer detailed diagnosis information to the central diagnosis system in cases of faults. Dangerous conditions are to be prevented.

HVAC controller FPC and TCMS will communicate via CAN network. FPC shall send the status of the HVAC unit as well as the outside temperature and the interior temp to TCMS.

Service functions such as software-download, the start of test-modes or signal recording are to be feasible via the USB-interface. For maintenance purpose FAIVELEY offers the special developed Maintenance software Mona.

3.3.2 HVAC start up self-test mode

A self-test is performed when the controller is powered on for the first time and test mode is not activated by MONA. Self test sequence will be activated once each time after the controller is powered ON for the 1st time.

In this process, the controller tests all temperature sensors, tests the train bus system initialization and etc.

Controller also tests the dampers from open to close, and check the feedback. After the damper check, then check the emergency ventilation mode.

Then the controller records the result of self-test. After self test process, the controller switches to the mode selected by the mode switch.

3.3.3 Test mode realized by MONA

Each component can be tested with FAIVELEY maintenance software called MONA. The detail method of test mode realized by MONA is described in the control function description of each component in the next chapters such as supply fan, condenser fan, compressor, and so on.

During test mode, the system fault information light shall flash ON.

3.3.4 Operation modes

This section gives an overview of how to define operation mode and status signal, and also internal status. Three kinds of signals can affect the operation mode of HVAC unit. They are:

- Signals from TCMS via CAN
- Signals from hardwired inputs
- Signals from maintenance software MONA

Although the signals from TCMS can affect the operation mode more frequently, the signals from maintenance software and from hardwired inputs have higher priority. See below:

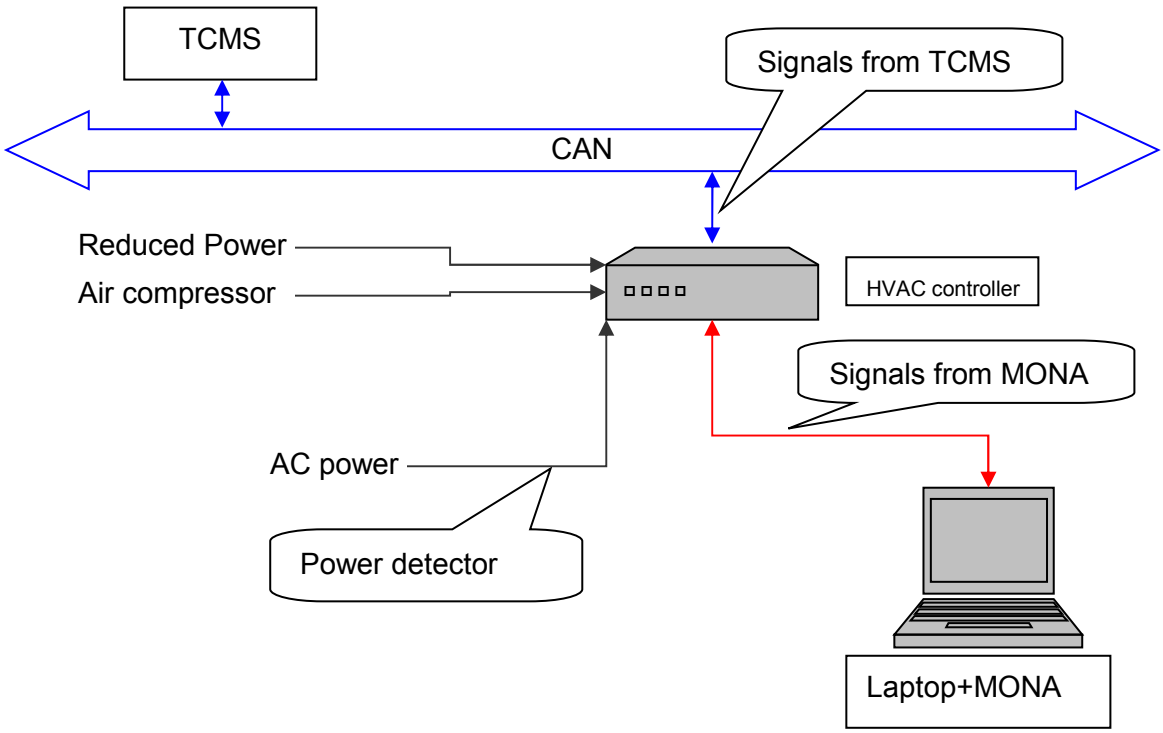


Figure 3-2: Signals affecting the operation modes

In case of testing, commissioning and maintaining, FPC communicates with a laptop running maintenance software MONA. Compared with signals from hardwired inputs, signals from MONA have the highest priority. FPC can detect the link with MONA automatically and set ‘Z_MONA_CONNECTED’=1L, send signal ‘ACTIVE_MONA’=1L to TCMS.

An internal variable ‘Z_SMLEVEL’ can be set from MONA directly. IF ‘Z_SMLEVEL’=9 (default), MONA just supervise the situation of FPC, can’t affect FPC to change operation mode. But if ‘Z_SMLEVEL’ is set to 0, FPC will be controlled by MONA only

and will set the internal status ‘M_MTN’ =1L, sends signal ‘ACTIVE _MTN’ =1L to TCMS.
For the detailed description of maintenance software MONA, refer to chapter 7.

The control of the HVAC unit is separated into following modes:

- Self test procedures during startup
- Test mode via Mona
- OFF mode (Hardwired AC power OK signal)
- Emergency mode (according to the signal from the power detector)
- Only ventilation mode
- Slumber mode
- Station mode (when the train speed < 10km/h)
- Center station mode
- Automatic mode

In “Automatic mode”, control of ventilation or cooling or heating is dependent on the temperature set point and temperatures of return air, supply air and fresh air.
Starting sequence of HVAC module is:

- Supply air fans
- Condenser fans
- Compressors

The controller starts relevant modes depending on train bus information, temperature (inside and outside), Furthermore the controller receives feedback from the components and derives the current operation condition. The controller classifies failures and errors are stored in event memory. Operating conditions and error messages will be sent from the digital controller to the train system via train bus.

OFF mode

If the AC power supply for unit is not OK or the TCMS send the “OFF” signal to the HVAC controller, the HVAC will run in Off mode. Only the controller is powered. Ventilation and air conditioning are forbidden. If the OFF mode is active, the TCMS system receives all available signals, such as tem peratures.

Automatic mode

In automatic mode, the HVAC unit will be completely controlled by the controller. Cooling, heating and ventilation are allowed. HVAC unit performs according to the

defined temperature regulation. The set point of the passenger compartment temperature can be adjusted to the value 17~21°C via CAN bus.
According to the calculation of cooling, heating or ventilation requirement, the HVAC controller set the unit in proper sub modes:

- Ventilation
- Half cooling
- Full cooling
- Heating
- Pre-cooling and Pre-heating

According to the calculation of return air and fresh air, there are two cooling modes can be set by controller.

- Half cooling mode: when the calculated value is from 5%...50% of cooling needing, the HVAC unit will run with one compressor;
- Full cooling mode: when the calculated value is over 50% for cool needing, the HVAC unit will run with two compressors;
- During pre-cooling and Pre-heating the fresh air dampers are closed and the units are running with 100% return air until the set point is reached (may limited by a time frame);
- When there is heating needing, the HVAC will turn to “Heating” mode, the compressor will be stopped and heater be started;
- When there isn’t cooling and heating needing, the HVAC will turn to “Ventilation” mode, the HVAC system will stop the compressor, heater, condenser fan, only the supply air fan is running which used to provide fresh air.

The refrigerant circuit is equipped with a hot gas bypass regulator. When the cooling demand is under a level causing the evaporation pressure and temperature to be under a certain unwanted value, the bypass regulator opens allowing hot gas to flow directly into the evaporator and raises evaporation pressure to an acceptable level. The suction (evaporation) pressure is the control-parameter for the bypass regulator.

Station mode

The TCMS sends the information “train speed”. In order to reduce noise, the HVAC unit will go into low speed of ventilation when the train speed is under a limit (fixed today at 10km/h but it will be adjusted during the noise test on the car). The HVAC unit will go into high speed of ventilation when the train speed is higher than a second limit (not fixed but need to have a hysteresis in order to avoid change too often low / high speed).
The HVAC software sets a maximum running time for low ventilation in station mode. This time must be defined after the climatic tests on the car. For the moment imagine 1 minute but it will be adjusted after the tests. In this mode the cooling capacity will be reduced.

In this mode, the HVAC is running at the compound mode of “Station” and “Automatic”, except that the supply air fans run at low ventilation, other components would act as same as in “Automatic” mode.

Emergency mode

The emergency mode will be activated automatically in case of missing 400V auxiliary power detected by a power detector (AI_04_PWR = 10±2°C) and FPC receives ‘authorization ventilation’ signal. **Time between absence of 400V and 250V available is around of 20 seconds (time parameter by TCMS).**
The fresh air dampers are open and return air dampers are closed. All auxiliary heaters, compressors and condenser fans are switched off. Supply air fans are in operation and they will be powered from train. The voltage and frequency of power supply from train is 250Vac 35Hz.

Slumber mode

The objective of this Slumber mode is to maintain a predefined temperature inside the vehicle.

The temperature set point in this mode is 5°C. SFRT will determine the appropriate T° value to insure an internal temperature greater than 5°C.

The TCMS authorises heating in slumber mode thanks to hardware input “authorization ventilation” of all HVAC saloon and thanks to Can Open signal “authorization ventilation” of both HVAC cab. The parameters of slumber mode are as same as that of normal mode except that:

- The setting temperature is 5°C (will be checked during the climatic tests on the car)
- There is only return airflow (fresh air dampers are closed)
- Cooling is not allowed
- The ventilation will be in operation only when the heater needs to operate.

center station mode

The variable VAC_CCentrStation_<car> will be set to 1L for 1 second when the train gets into central station with a train speed lower than10km/h. After HVAC controller gets this signal (raise edge) from TCMS, the unit will go into central station mode.
Cooling: In this mode the system must switch off the condenser fans and the compressors. The supply air fans
are in low speed of ventilation.

Heating: In this mode the system can work in full heating and the supply air fans are in high speed.
Ventilation: In this mode the system work in low speed only.

The HVAC controller should exit ‘Central Station’ mode when one of the conditions listed below is met:

- When internal temperature is higher than 32°C.
- When the train speed is higher than 10km/h.
- Communication with Can Open is loss.
- If network requests other mode.

3.3.5 Flow chart of operation modes

Here is the flow chart of the operation mode, it is defined the priority of the modes like this.
From highest to lowest priority: SELFTEST>TEST>OFF>Emergency>
Slumber>Automatic> Station.

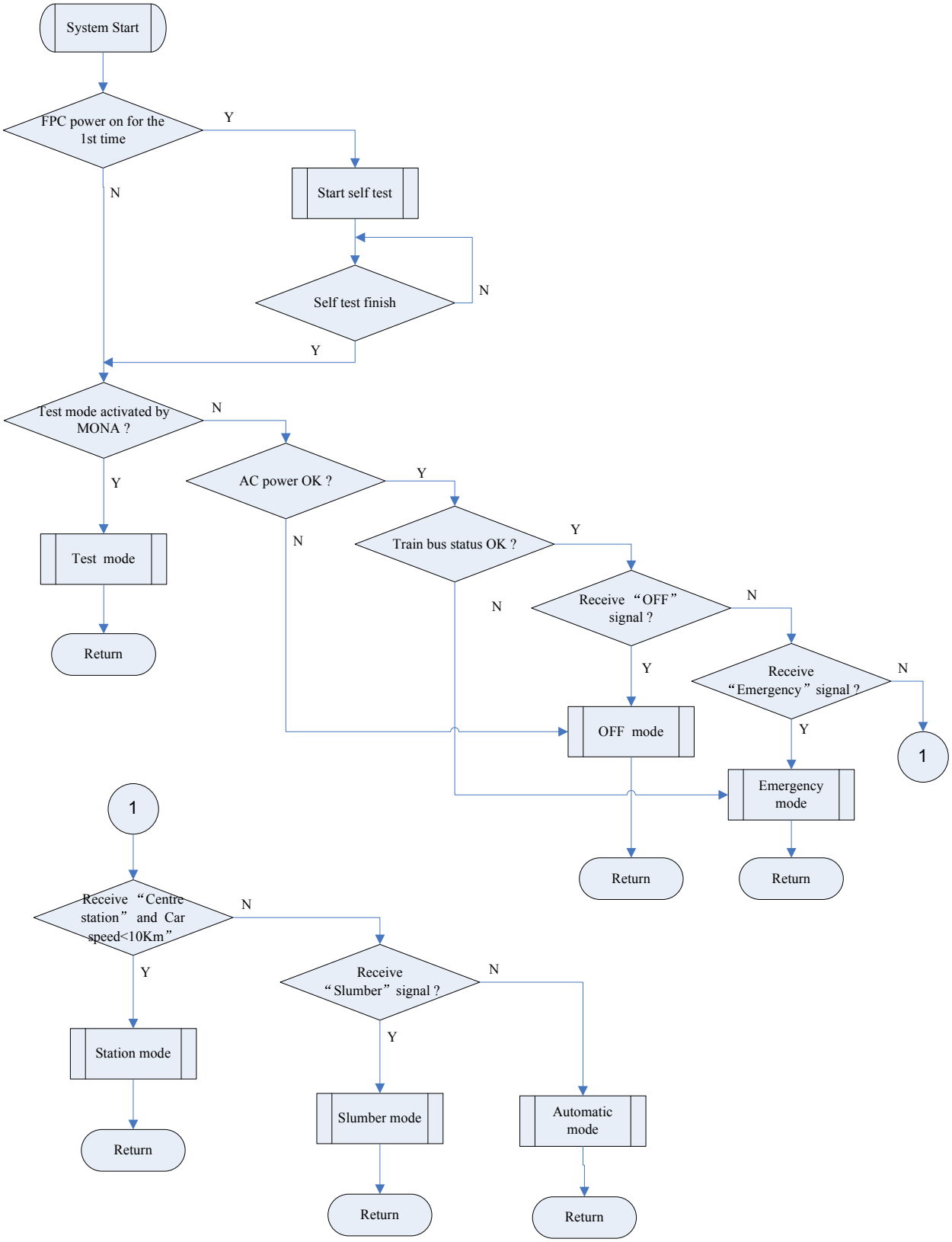


Figure 3-3: General flow chart

3.3.6 HVAC Sub modes under auto mode

In automatic mode, the HVAC unit will be completely controlled by the controller. Cooling, heating and ventilation are allowed. Temperature regulation is calculated according to what is described in chapter 4.1 “internal set point creation”.

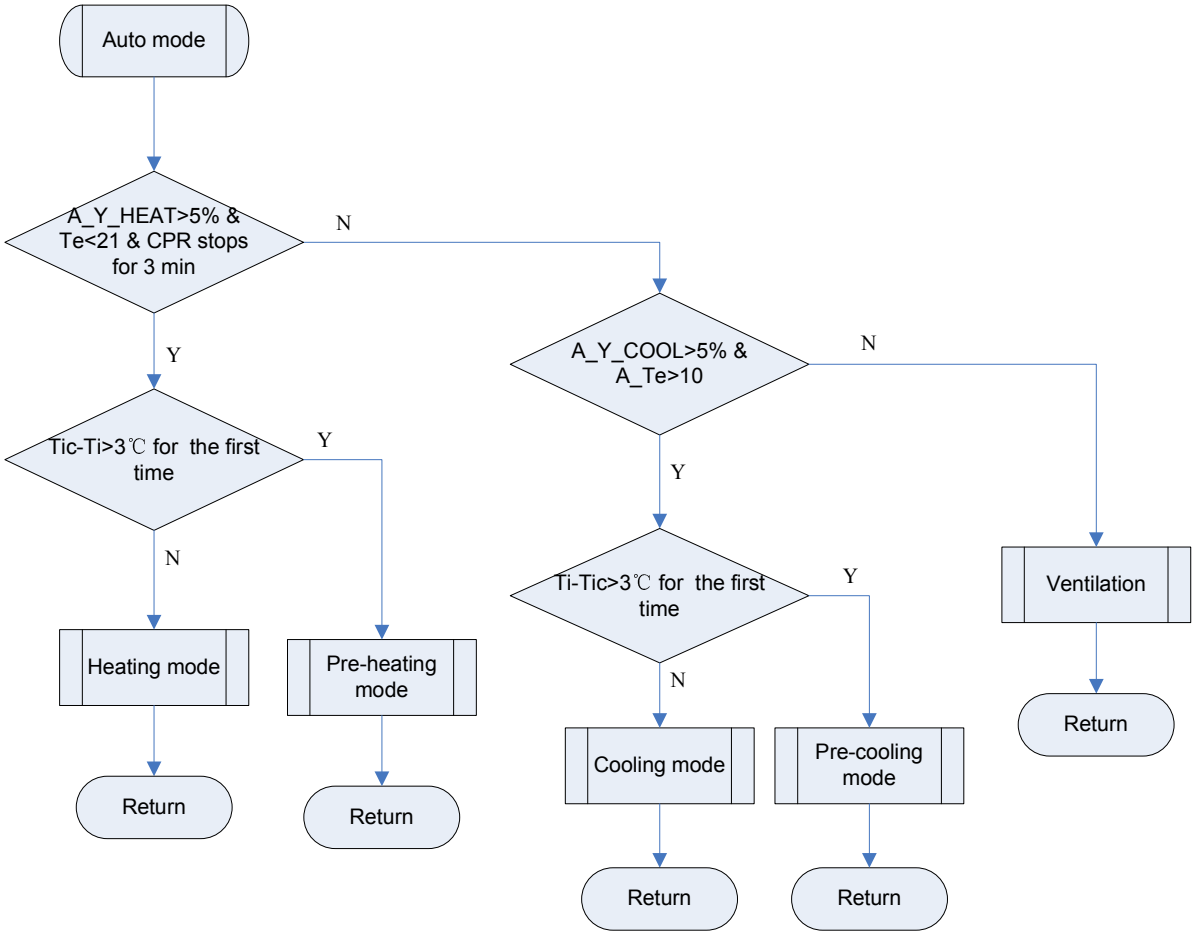


Figure 3-4: Auto mode flow chart

Note:

- It is defined as ventilation mode when all the CPR and heater are stopped.
- It is defined as heating mode when there’s heater works.
- It is defined as cooling mode when the CPR works.
- The set point for the mode transition will be tested when commissioning.
- The system will go to premode when the controller switch to “auto mode” first time after the FPC is power on. During pre-cooling and Pre-heating the fresh air dampers are closed and the units are running with 100% return air until the set point target is reached or time is reached.

i. Precooling: supply air temperature is reached Tic – 2K; or preheating time is elapsed to 60mins;

ii. Preheating: supply air temperature is reached Tic; or preheating time is elapsed to 2hours and 30mins;
As the preheating time exceeds 1hour, if the passenger load more than 25, then leaving preheating; if the passenger load less than 25, then keeping in preheating mode;

3.3.7 HVAC mode related internal variables

Variable name	Description	Function
M_TEST	read	Internal variable test mode for saloon (by MONA)
M_OFF	read	Internal variable off mode
M_AUTO	read	Internal variable auto mode (normal mode)
M_Slumber	read	internal variable slumber mode
M_STN	read	internal variable station mode
M_Cen_STN	read	internal variable center station mode
M_EMC	read	internal variable emergency mode
A_Y_COOL	set	Internal variable cooling needing
A_Y_HEAT	set	Internal variable unit heater heating needing
A_Te	Read, from AI	Internal variable average outside air temperature
A_Ti	Read, from AI	Internal variable average inside air temperature
A_Tic_UIC	set	Internal variable set-point temperature calculated according to UIC553
A_Tic	set	Internal variable set-point temperature after offset has been added

3.3.8 Summary Components' Actions in Related Modes

Mode / components	OFF mode	Emengency mode	Center Station mode	Slumber mode	Station mode	Automatic mode		
						Ventilation	Cooling	Heating
Supply air fan	OFF	ON	Low/ High	ON/ OFF	Low	High/Low	High/Low	High/Low
Condenser fan	OFF	OFF	OFF	OFF		OFF	ON	OFF
Compressor	OFF	OFF	OFF	OFF		OFF	ON	OFF
Heater	OFF	OFF	ON/ OFF	ON/ OFF		OFF	OFF	ON

Damper control			Refer to chapter

Note:

- There are two sub modes in the automatic cooling mode: Half cooling mode, Full cooling mode. In former one, there is only one compressor running, in the latter one, there are two compressors running.
- Pre-heating mode and pre-cooling mode is nearly as same as full heating and full cooling mode, the only difference is that in former mode, the fresh air damper should be closed.
- In station mode, the HVAC runs nearly as same as automatic mode, only difference is that the supply air fan runs at low speed in station mode.
- In center station mode, Cooling: In this mode the system must switch off the condenser fans and the compressors. The supply air fans are in low speed of ventilation. Heating: In this mode the system can work in full heating and the supply air fans are in high speed. Ventilation: In this mode the system work in low speed only.
- In slumber mode, The ventilation will be in operation only when the heater needs to operate. The parameters of slumber mode are as same as that of normal mode except that:

  The setting temperature is 5° C

  There is only return airflow (fresh air dampers are closed)

  Cooling is not allowed

  The ventilation will be in operation only when the heater needs to operate.

3.4 Refrigerant Circuit of the HVAC Unit

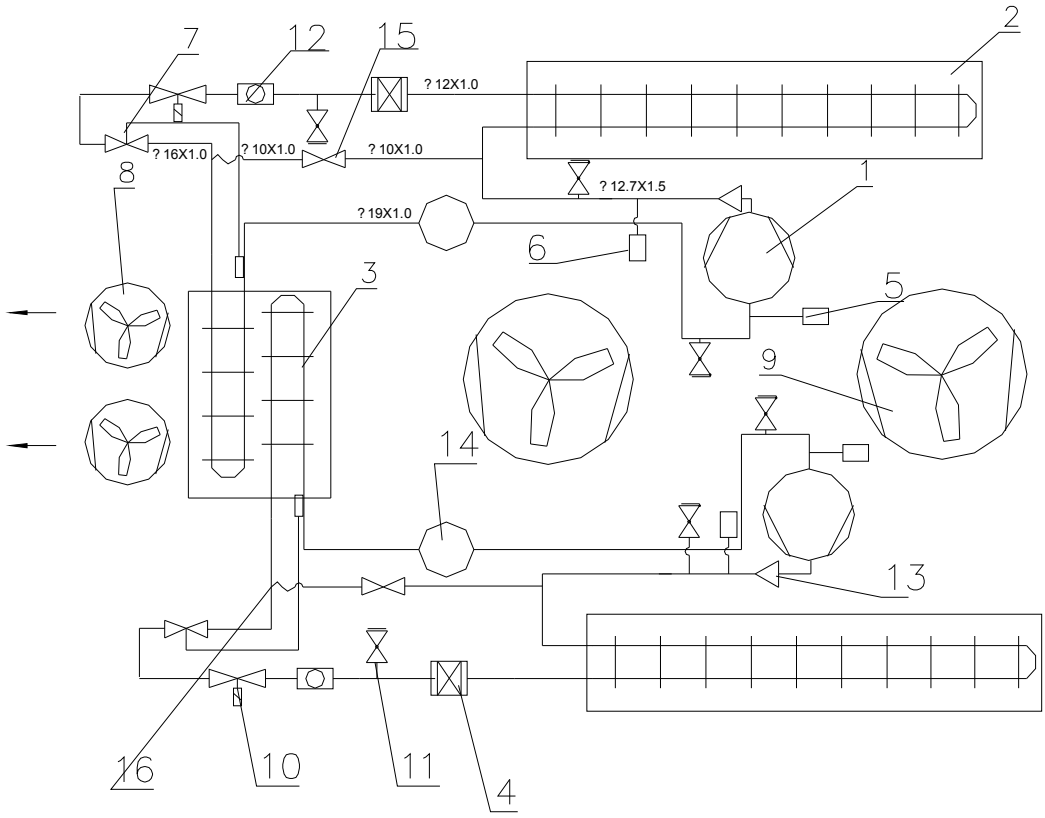


Figure 3-5: refrigerant circuit of saloon unit

No.	Components	Qty	No.	Components	Qty
1	Compressor	2	9	Condenser fan	2
2	Condenser	2	10	Liquid line solenoid valve	2
3	Evaporator	1	11	Charging valve	4
4	Filter drier	2	12	Sight glass	2
5	Low pressure switch	2	13	Check valve	2
6	High pressure switch	2	14	Accumulator	2
7	Expansion valve	2	15	Hot gas bypass solenoid valve	2
8	Supply air fan	2	16	Hot gas bypass capillary tube	2

4 Auto Mode Control Functions

4.1 Internal set point temperature creation

4.1.1 HVAC set point temperature creation

If the HVAC runs at automatic mode, the internal set point (goal temperature) is calculated as following:

If Te >= 10°C, then Tic = 19 + 0.4(Te -10) + offset*

If Te < 10°C, then Tic = 19 + offset

Notes:

Te is ambient air temperature. *Tic* is the set point temperature calculated according to EN 14750-1.

The set point temperature can be adjusted to the value within ±2K related to the defined temperature regulation via CAN bus.

The set point temperature can also be adjusted to the value of 17°C / 18°C / 19°C / 20°C / 21°C via CAN bus. This value will be adjusted per maintenance people. The main difference with the offset is that this value is maintained even if the train is switch off and on. For the offset it is not the case. When we switch off / on the train the offset goes back to 0.

The result is memorized (M_Tic=calculated set point of saloon unit).

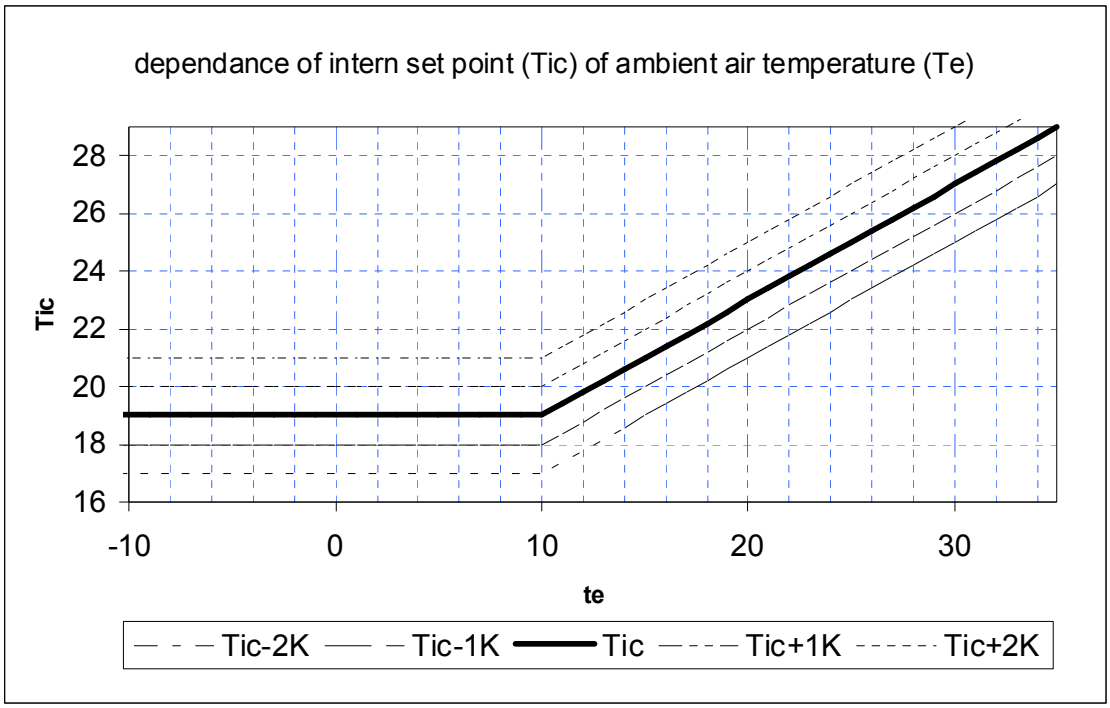
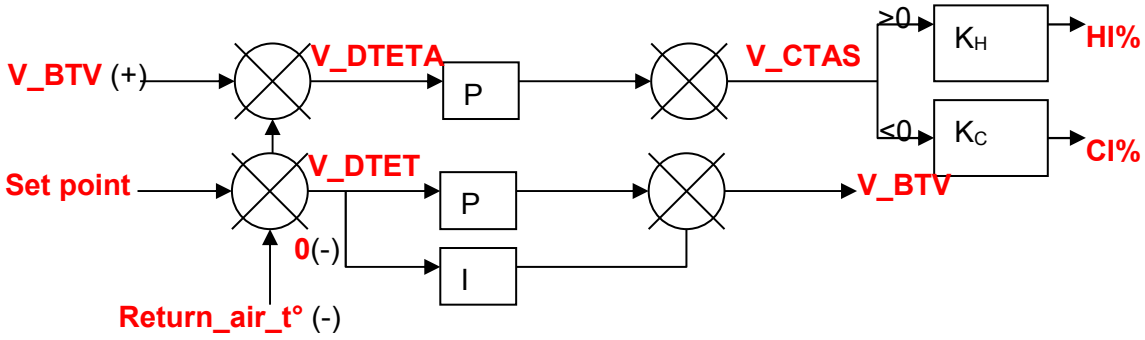


Figure 4-1: Dependance of intern setpoint of ambient air temperature

4.2 Calculation of Cooling / Heating Needing

First, the controller calculates Tic (set point temperature), Ti (inside temperature). Tic is calculated as described above:

The cooling capacity shall be controlled in dependence of the return and ambient (fresh air) air temperature. The calculation is designed as a PID regulator. The main value for calculation is depended on the return air temperature sensor, corrected by ambient temperature (fresh air sensor).



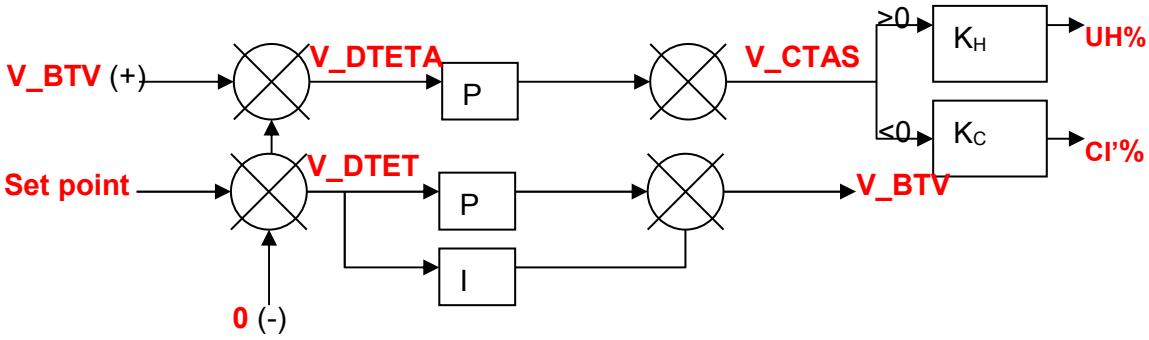
The object is to determine, according to the temperatures of air and the set point, the necessities in warmth or in cold for the air conditioning of the vehicle.

Two functions condition the realization of the heating or the refrigerating: the need, and the tendency.
The object of the needing is to determine ON/OFF for cooling and heating devices.
The object of the tendency is to avoid fast change of mode vent – cool – vent –heat.

Calculated result:

Cooling need: A_Y_COOL

Heating need: A_Y_HEAT



The calculation and the temperature recalculation will be adjusted during the tests.

4.3 Cooling / Heating and Ventilation Mode

4.3.1 Cooling / Half Cooling

In auto mode the controller will decide the HVAC system should be in what sub mode according to all the digital inputs and analog inputs information. The HVAC system is completely controlled by FPC. First, the controller calculates Tic (set point temperature), Ti (inside air temperature). Tic is calculated as described in 4.1.1 “HVAC set point temperature creation”,

By calculating Ti, Tic, cooling needing, and heating needing, HVAC can work in cooling, heating, or ventilation mode. The purpose is to regulate Ti in range of Tic±1.5°C.

1. If cooling need A_Y_COOL <= 5%, compressor shuts down
2. If 50%>=A_Y_COOL > 5%, compressor starts, unit runs in half cooling mode.
3. If A_Y_COOL > 50%, compressor starts, unit runs in full cooling mode

4.3.2 Heating mode

There is a unit heater equipped for each HVAC unit. Heating needing A_Y_HEAT is calculated for unit heater.

If A_Y_HEAT > 5%, and the compressor has stopped for more than 5min, unit heater switches on, heating mode starts. In heating mode, if supply air fan run in low speed, then only 50% heating is presumed.

4.3.3 Ventilation mode

If there is no cooling need, no heating need for the unit heater in auto mode, then the HVAC is in auto ventilation mode and the compressor and heater stop.

4.4 Fault diagnosing

In auto mode, the controller shall diagnose the temperature sensors and the compressor, condenser fan, supply air fan and the unit heater.

Temperature sensor:
Fresh air temperature sensor, If AI_01_FAS >80 or <-20, FAS fault DF_FAS shall be activated and be recorded.
It is similar to the return air temperature sensor and supply air temperature sensor.

Components' fault diagnosing is described in chapter 6 Main components control

5 Software interfaces

5.1 Digital outputs

Digital Outputs		
N°	*Pin*	Function
DQ_01_CPR1	*P3: 5*	Compressor 1 contactor KM11 control
DQ_02_CPR2	*P3: 4*	Compressor 2 contactor KM12 control
DQ_03_CDF1	*P3: 3*	Condenser fan 1 contactor KM13 control
DQ_04_CDF2	*P3: 2*	Condenser fan 2 contactor KM14 control
DQ_05_SAFH	*P3: 7*	Supply air fan high speed contactor KM15 control
DQ_06_SAFL	*P3: 8*	Supply air fan low speed contactor KM16 control
DQ_07_FADO	*P3: 9*	Fresh air damper open
DQ_08_FPCOK	*P3: 10*	FPC OK signal
DQ_31_RADC	*X4: 6* *DIO8:O1*	Return air damper close control, 1L=close RAD
DQ_32_FADC	*X4: 4* *DIO8:O2*	Fresh air damper close control, 1L=close FAD
DQ_33_Y3	*X4: 3* *DIO8:O3*	Hot gas bypass solenoid valve Y3 control
DQ_34_Y4	*X4: 1* *DIO8:O4*	Hot gas bypass solenoid valve Y4 control
DQ_35_ESAF	*X5: 1* *DIO8:O5*	Supply air fan emergency ventilation contactor KM17 control
DQ_36_UH1	*X5: 3* *DIO8:O6*	Unit heater group 1 contactor KM18 control
DQ_37_UH2	*X5: 4* *DIO8:O7*	Unit heater group 2 contactor KM19 control
DQ_38_RADO	*X5: 6* *DIO8:O8*	Return air damper open

5.2 Digital inputs

Digital Inputs		
N°	*Pin*	Function
DI_01_VENT	*P3: 12*	Authorization ventilation signal
DI_02_HP1	*P3: 13*	Compressor 1 high pressure HP1 feedback
DI_03_HP2	*P3: 14*	Compressor 2 high pressure HP2 feedback
DI_04_ESAF	*P3: 15*	SAF emergency ventilation contactor KM17 feedback
DI_05_CPR1	*P3: 16*	Compressor 1 contactor KM11 feedback
DI_06_CPR2	*P3: 17*	Compressor 2 contactor KM12 feedback
DI_07_UH1	*P3: 18*	Unit heater 1 contactor KM18 feedback
DI_08_UH2	*P3: 19*	Unit heater 2 contactor KM19 feedback
DI_31_SAFH	*X6: 4* *DIO8: I1*	Supply air fan high speed contactor KM15 feedback
DI_32_SAFL	*X6: 3* *DIO8: I2*	Supply air fan low speed contactor KM16 feedback
DI_33_LP1	*X6: 2* *DIO8: I3*	Compressor 1 low pressure LP1 feedback
DI_34_LP2	*X6: 1* *DIO8: I4*	Compressor 2 low pressure LP2 feedback
DI_35_FAD	*X7: 2* *DIO8: I5*	Fresh air damper 1&2 feedback, 1L==FAD1&2 in close position
DI_36_CDF	*X7: 3* *DIO8: I6*	Condenser fan 1+2 contactors KM13+KM14 feedback
DI_37_RAD	*X7: 4* *DIO8: I7*	Return air damper position feedback, 1L==RAD in close position
DI_38_UHOV	*X7: 5* *DIO8: I8*	Heater overload feedback

5.3 NTC inputs

NTC Inputs		
N°	Pin	*Function*
AI_01_FAS	P2: 6, 13	*Fresh air temperature sensor input*
AI_02_RAS	P2: 8, 7	*Return air temperature sensor input*
AI_03_SAS	P2: 10, 11	*Supply air temperature sensor input*
AI_04_PWR	P2: 12, 5	*Power status detection*
AI_05	P2: 14, 9	*Reserved*
AI_06	P2: 16, 4	*Reserved*

6 Main components control

6.1 Supply air fan control

6.1.1 Description of SAF function

Supply air fan is the main component of the HVAC system. HVAC system can't work without supply air fan which is checked through the circuit breaker. SAF can work at all modes except off mode.

6.1.2 Internal variables related to SAF

Variable name	Description	Function
DI_01_VENT	ON=1L, DI	AUTHORIZATION VENTILATION SIGNAL
DI_31_SAFH	ON=1L, DI	SAF high speed OK
DI_32_SAFL	ON=1L, DI	SAF low speed OK
DQ_05_SAFH	ON=1L, DO	SAF high speed contactor control
DQ_06_SAFL	ON=1L, DO	SAF low speed contactor control
M_TEST	read	HVAC unit test mode
M_OFF	read	HVAC unit off mode
M_AUTO	read	HVAC unit auto mode
M_STN	read	HVAC unit station mode
M_EMC	read	HVAC unit emergency mode
M_Slumber	read	internal variable slumber mode
M_Cen_STN	read	internal variable center station mode

6.1.3 SAF operating condition

When HVAC system starts and there isn't "HVAC OFF" command, supply air fan will start. The reason is that air volume is very important for HVAC system.

- When HVAC runs at "Station" mode, the SAF will runs in low speed for a maximum time of 1 minute.
- When fresh air temperature is higher than 45C, the SAF will runs in low speed;
- When passenger lower than 50, the SAF will runs in low speed;
- SAF shall be switched off when it receives 'off' command from TCMS
- In slumber mode, The ventilation will be in operation only when the heater needs to operate.
- In center station mode, Cooling: In this mode the system must switch off the condenser fans and the compressors. The supply air fans are in low speed of ventilation.

Heating: In this mode the system can work in full heating and the supply air fans are in high speed.
Ventilation: In this mode the system work in low speed only.

6.1.4 SAF fault diagnosing

The running of SAF will be checked during all the running time of SAF. Detail fault diagnosing is as following:

Code or name	Description	Reason of failure	Gravity(*)
DF_SAFH	High speed supply air fan fault	- Thermal overload protection QF05 triggers - Temperature protector FR01 triggers - Or feedback of contactor KM15 is missing	1
DF_SAFL	Low speed supply air fan fault	- Thermal overload protection QF05 triggers - Temperature protector FR02 triggers - Or feedback of contactor KM16 is missing	1

Note: for the information of gravity, please refer to the chapter 6.3.2.

6.2 Condenser fan control

6.2.1 Description of condenser fan function

Condenser fan is part of the cooling unit.

Each condenser fan is protected by a thermal overload protection, integrated in the feeding of the contactor.

Triggering of the thermal protection also can cause a failure of condenser fan contactor. That's the reason for restart of the condenser fan some times after having taken a break.

6.2.2 Internal variables related to CDF

Variable name	Description	Function
DI_01_VENT	ON=1L, DI	AUTHORIZATION VENTILATION SIGNAL
DI_36_CDF1	ON=1L, DI	CDF 1+2 contactors feedback
DQ_03_CDF1	ON=1L, DO	Condenser fan 1 contactor control
DQ_04_CDF2	ON=1L, DO	Condenser fan 2 contactor control
M_TEST	read	HVAC unit test mode
M_OFF	read	HVAC unit off mode
M_AUTO	read	HVAC unit auto mode
M_STN	read	HVAC unit station mode
M_EMC	read	HVAC unit emergency mode
M_Slumber	read	internal variable slumber mode
M_Cen_STN	read	internal variable center station mode

6.2.3 CDF operating conditions

Condenser fan can be started when following cases are met:

- The HVAC is running in "Cooling" mode
- The SAF is running
- There isn't any fault for CDF

The condenser fan starts 2sec before the compressor and stops 2sec after the compressors stops.

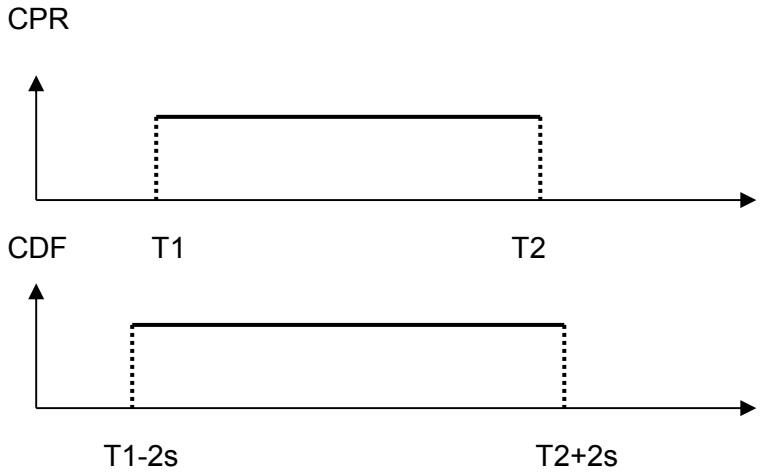


Figure 6-1: start time between CDF and CPR

6.2.4 CDF switching OFF conditions

Condenser fan can be shut down in any one of following cases:

- The condenser fan contactor must be shut off if compressors stopped
- Thermo protection fault or contactor fault detected
- Supply air fan is stopped
- It receives 'off' command from TCMS
- In centre station mode or slumber mode

6.2.5 CDF fault diagnosing

Code or name	Description	Reason of failure	Gravity
DF_CDF1	Condenser fan 1 fault	- Thermal overload protection QF03 triggers - Or feedback of contactor KM13 is missing	2
DF_CDF2	Condenser fan 2 fault	- Thermal overload protection QF04 triggers - Or feedback of contactor KM14 is missing	2

6.3 Compressor control

6.3.1 Description of compressor function

Each cooling circuit consists of one compressor; additionally there is high pressure switch (hard wire connected), low pressure switch and some specific mechanical cooling parts (dryer, capillary, sight class).

The HP switch protects the circuit against over heating and destroys.
The controller FPC supervises LP switch.
Thermo protection of compressor is integrated in the feeding of CPR contactor.
Thermo protection can also cause a failure of compressor contactor.
That's the reason for restart of compressor some times after having taken a break.

Each compressor is allowed to start 6 times per hour.
For symmetrical operation, it is defined a restart release only after 10 minutes.
The minimum of delay after switching off is set to one minute.
Purpose is to forbid frequent starting of the compressor.

The running of the compressor is depended on the cooling capacity calculated by the controller. (Internal calculation) The solution regarding a unit is:
0-5%: compressors stop
5-50%: only one compressor is allowed (This value can be regulated)
51-100%: both compressors are allowed

6.3.2 Internal variables related to CPR

Variable name	Description	Function
DI_01_VENT	ON=1L, DI	AUTHORIZATION VENTILATION SIGNAL
DI_02_HP1	ON=1L, DI	HP1 feedback OK
DI_03_HP2	ON=1L, DI	HP2 feedback OK
DI_33_LP1	ON=1L, DI	LP1 feedback OK
DI_34_LP2	ON=1L, DI	LP2 feedback OK
DI_05_CPR1	ON=1L, DI	Compressor 1 feedback OK
DI_06_CPR2	ON=1L, DI	Compressor 2 feedback OK
DQ_01_CPR1	ON=1L, DO	Compressor 1 contactor control
DQ_02_CPR2	ON=1L, DO	Compressor 2 contactor control
M_TEST	read	HVAC unit test mode
M_OFF	read	HVAC unit off mode
M_AUTO	read	HVAC unit auto mode

Variable name	Description	Function
M_ST	read	HVAC unit station mode
M_EMC	read	HVAC unit emergency mode
M_Slumber	read	internal variable slumber mode
M_Cen_STN	read	internal variable center station mode

6.3.3 Start and regulation of the compressor

The HVAC unit will send compressor starting request to TCMS if following conditions meet:

- The HVAC is running in “Cooling” mode
- SAF is running properly
- 4min has elapsed after last start
- 30sec has elapsed after switching off of the corresponding CPR
- There isn’t any fault for CPR
- 10min has elapsed after unit heater stopped

Both compressors have the same opportunity to start each time half cooling is required from ventilation mode. The other CPR will start if then full cooling is required.

6.3.4 Switching off condition of CPR

Compressor would be shut down under the following conditions:

- The HVAC isn’t running in “Cooling” mode
- The condenser fan is stopped
- Any fault of the compressor
- It receives ‘off’ command from TCMS
- In case the outside temperature is below 10°C
- There is high or low pressure fault detected
- 1 or 2 CDF fail
- 1min has elapsed after the compressor run
- In centre station mode or slumber mode

Notes:

1. LP switch event is neglected for 120s during start-up of the compressor.
2. Error message due to high pressure, if there is more than 3 times, the compressor stops until the service restart ("OFF" mode)
3. Error message due to low pressure, if it keeps active 120s after the compressor starts up, and if there triggers more than 10 times per hour, the compressor stops until the service restart ("OFF" mode)

6.3.5 CPR Fault Diagnosing

The running of CPR will be checked during all the running time of CPR. Detail fault diagnosing is as following.

Diagnosis Code	Description	Reason of failure	What's happen?
5	CPR1 thermo/contactor fault SW address: DF_CTH1	- Thermal overload protection triggers - Or feedback of contactor KM11 is missing	CPR1 stops running temporarily for 1min. CPR1 is forbidden when the fault is active. The fault can only reset by power off the FPC08 if the event happens 3 times. Information is sent to TCMS.
6	CPR1 high pressure switch fault SW address: DF_CHP1	- The refrigerant pressure inside CPR1 cooling circuit is too high	CPR1 stops running temporarily for 1min. CPR1 is forbidden when the fault is active. The fault can only reset by power off the FPC08 if the event happens 4 times. Information is sent to TCMS.
7	CPR1 low pressure switch fault SW address: DF_CLP1	- The refrigerant pressure inside CPR1 cooling circuit is too low - The fault is ignored 120s during start-up of CPR1	CPR1 stops running temporarily for 1min. CPR1 is forbidden when the fault is active. The fault can only reset by power off the FPC08 if the event happens 6 times.

Diagnosis Code	Description	Reason of failure	What's happen?
			Permanent fault is sent to TCMS.
8	CPR1 fault	- One of fault 5, 6, 7 is active	----
9	CPR2 thermo/contactor fault SW address: DF_CTH2	- Thermal overload protection triggers - Or feedback of contactor KM12 is missing	CPR2 stops running temporarily for 1min. CPR2 is forbidden when the fault is active. The fault can only reset by power off the FPC08 if the event happens 3 times. Information is sent to TCMS.
10	CPR2 high pressure switch fault SW address: DF_CHP2	- The refrigerant pressure inside CPR2 cooling circuit is too high	CPR2 stops running temporarily for 1min. CPR2 is forbidden when the fault is active. The fault can only reset by power off the FPC08 if the event happens 4 times. Information is sent to TCMS.
11	CPR2 low pressure switch fault SW address: DF_CLP2	- The refrigerant pressure inside CPR2 cooling circuit is too low - The fault is ignored 120s during start-up of CPR2	CPR2 stops running temporarily for 1min. CPR2 is forbidden when the fault is active. The fault can only reset by power off the FPC08 if the event happens 6 times. Permanent fault is sent to TCMS.
12	CPR2 fault	- One of fault 9, 10, 11 is active	----

6.4 Unit heater control

6.4.1 Description of unit heater function

Every unit is equipped with one unit heater which is controlled by a solid status relay. Unit heater is applied to supply warm air into the cab in heating mode.

Overload protection input can also cause a failure of unit heater and cause a restart of unit heater some times after having taken a break.

6.4.2 Internal variables related to unit heater

Variable name	Description	Function
DI_01_VENT	ON=1L, DI	AUTHORIZATION VENTILATION SIGNAL
DI_38_UHOV	ON=1L, DI	Heater overload
DQ_07_UH	ON=1L, DO	Heater control
M_TEST	read	HVAC unit test mode
M_OFF	read	HVAC unit off mode
M_AUTO	read	HVAC unit auto mode
M_STN	read	HVAC unit station mode
M_EMC	read	HVAC unit emergency mode
M_Slumber	read	internal variable slumber mode
M_Cen_STN	read	internal variable center station mode

6.4.3 Start condition of unit heater

To start the heater in auto mode, following conditions must be available:

- The HVAC is running in “Heating” mode;
- 5 min has elapsed since the compressors stopped;
- SAF is running properly;
- There isn’t any fault for heater.

6.4.4 Unit heater operating conditions

Unit heater, in another word, is fresh air pre heater. Function of the unit heater is to prevent cold outside air blowing directly into the carriage.

- If A_Y_HEAT <= 5%, unit heater shuts down

- If 5% < A_Y_HEAT <= 100%, unit heater runs as following

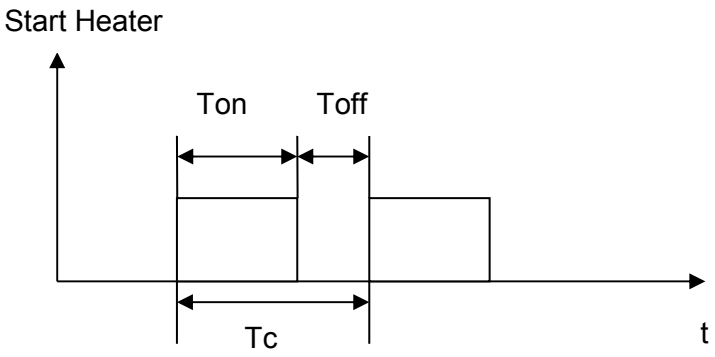


Figure 6-2: running time of the heater

Ton and Tc are internal timers. Tc is valued by the programmer.
The ON time ratio of heater **Ton / Tc = A_Y_HEAT%** is to be tested.

6.4.5 Switching off condition of unit heater

Unit heater must be shut down under the following conditions:

- The HVAC isn't running in "Heating" mode
- Any fault of SAF
- Any fault of unit heater
- It receives 'off' command from TCMS

Notes:

1. Over t° / over load protection event is neglected for 5s during start-up of the unit heater;
2. Error message due to over load (over t°) protection, if there is more than 3 times, unit heater stops until the service restart.

6.4.6 Unit heater fault diagnosing

The running of unit heater will be checked during all the running time of unit heater.
Detail fault diagnosing is as following:

Code or name	Description	Reason of failure	Gravity

DF_UHOV	Unit heater over temperature	- Unit heater overload	2
DF_UH1	Unit heater 1fault	- QF06 triggers - Unit heater 1 contactor is missing when DQ_36 is on	2
DF_UH2	Unit heater 2fault	- QF06 triggers - Unit heater 2 contactor is missing when DQ_37 is on	2

6.5 Fresh air damper control

6.5.1 Description of Fresh Air Damper Functions

As a function of the modes, the fresh air damper has to turn into two different positions CLOSE and OPEN.
A Belimo motor controls the return air damper, there is one device per unit. The powerless position is defined as close position.

6.5.2 Internal Variables Related to Fresh Air Damper

Variable name	Description	Function
DI_01_VENT	ON=1L, DI	AUTHORIZATION VENTILATION SIGNAL
DI_35_FAD	ON=1L, DI	Feedback of FAD, Fully close =1L
DQ_07_FADC	ON=1L, DO	Fresh air damper 1&2 open control
DQ_32_FADC	ON=1L, DO	Fresh air damper 1&2 close control
M_TEST	read	HVAC unit test mode
M_OFF	read	HVAC unit off mode
M_AUTO	read	HVAC unit auto mode
M_STN	read	HVAC unit station mode
M_EMC	read	HVAC unit emergency mode
M_Slumber	read	internal variable slumber mode
M_Cen_STN	read	internal variable center station mode

6.5.3 First move – calibration of damper

When self test processing, the damper wound be opened to fully opened status, then close it. This startup test is defined as calibration for every damper.
The startup sequence of dampers is described following (using one damper for example):

1) Open the damper from totally close to totally open position (DQ_07_FADO =1L) by running a constant time (35s add extreme time such as 5s, the time wound be adjusted when commissioning).
2) Close the damper for a constant time (35s add extreme time such as 5s, the time would be adjusted when commissioning) to assure the damper in totally closed position (DQ_32_FADC =1L) then check the feedback of the damper (DI_35_FAD=1L), if it already exits, error signal is generated.
3) The final position of start up sequence for all dampers is totally opened.

In the case of fresh air dampers failure, the running of the dampers is not influenced. If the controller or the AC power is switched off, the fresh air dampers would be opened.

6.5.4 Operation condition of fresh air damper

Take in account the different positions for different modes.

Mode and Condition	Fresh air damper position
M_TEST	Close ~ Open
M_OFF	NA
M_AUTO (*)	See damper control table below
M_PreC	0%OPEN
M_PreH	0%OPEN
M_Slumber	0%OPEN
M_EMC	100%OPEN

Note:

*: Here, the mode “M_AUTO” means the sub-modes under “M_AUTO” mode except “M_PreC” and “M_PreH”.

6.6 Return air damper control

6.6.1 Description of return air damper function

As a function of the modes, the return air damper has to turn into two different positions CLOSE and OPEN.
A Belimo motor controls the return air damper, only the saloon unit has one return air damper. The powerless position is defined as close position.

6.6.2 Internal variables related to return air damper

Variable name	Description	Function
DI_01_VENT	ON=1L, DI	AUTHORIZATION VENTILATION SIGNAL
DI_37_RAD	ON=1L, DI	Feedback of RAD, fully close=1L
DQ_31_RADC	ON=1L, DO	Return air damper close control
DQ_38_RADO	ON=1L, DO	Return air damper open control
M_TEST	read	HVAC unit test mode
M_OFF	read	HVAC unit off mode
M_AUTO	read	HVAC unit auto mode
M_STN	read	HVAC unit station mode
M_EMC	read	HVAC unit emergency mode
M_Slumber	read	internal variable slumber mode
M_Cen_STN	read	internal variable center station mode

6.6.3 Operation condition of return air damper

Take in account the different positions for different modes.

Mode and condition	Return air damper position
M_TEST	Close ~ Open
M_OFF	NA
M_AUTO (*)	See damper control table below
M_PreC	100%OPEN
M_PreH	100%OPEN

Mode and condition	Return air damper position
M_Slumber	100%OPEN
M_EMC	0%OPEN

Note:

*: Here, the mode “M_AUTO” means the sub-modes under “M_AUTO” mode except “M_A_VENT”.

The return air damper can be closed by (DQ_31_RADC =1L) during M_VENT=1L,.The feedback of damper should change from 1L to 0L (DI_37_RAD =0L), after the closing signal is generated for about 15 seconds. If the feedback does not change , that means the damper fails, then repeat start two times again (DQ_31_RADC =1L). If the failure resist, set DF_RAD =1L. This information is given to TCMS.

Damper control form

Te	Passenger load	Supply Fan speed	Air flow rate	RAD open	FAD open
-20°C~-5°C	<50	high	500m3/h	90°	23° open
-5°C~26°C					
26°C~45°C					
45°C~47°C					

Te	Passenger load	Fan speed	air flow rate	RAD	FAD
-20°C~-5°C	>50	high	1340m3/h	25°	90°
-5°C~26°C	50<P<111	high	1340m3/h	25°	90°
-5°C~26°C	111<P<150	high	1800m3/h	15°	
-5°C~26°C	>150	high	2004m3/h	12°	
26°C~45°C	>50	high	1340m3/h	25°	90°
45°C~47°C	>50	low	850m3/h	25°	90°

6.7 Main components’ supervision

There are listed the table of running time and numbers of start regard the follow devices:

Slot (MONA)	Slot (Internal)	Function	Remarks	
1	0	Supply fan high speed	SAFH	
2	1	Supply fan low speed	SAFL	

Slot (MONA)	Slot (Internal)	Function	Remarks	
3	2	Condenser fan 1	CDF1	
4	3	Condenser fan 2	CDF2	
5	4	Compressor 1	CPR1	
6	5	Compressor 2	CPR2	
7	6	Unit heater 1	UH1	
8	7	Unit heater 2	UH2	
9	8	Emergency ventilation	ESAF	
10	9	Hot gas bypass valve Y3	Y3	
11	10	Hot gas bypass valve Y4	Y4	
12	11	Reserved	Reserved	
13	12	Reserved	Reserved	
14	13	Reserved	Reserved	
15	14	Reserved	Reserved	
16	15	Reserved	Reserved	

6.8 Diagnosis code

6.8.1 Diagnosis code

The diagnosis code is listed below; any others would be added or modified during commissioning if needed.

Code number	Function (event)	Remark Intern	gravity	Name
1	Supply fan high speed contactor KM15 fault or thermo protector FR01 fault	1	1	DF_SAFH
2	Supply fan low speed contactor KM16 fault or thermo protector FR02 fault	2	1	DF_SAFL
3	Supply fan emergency ventilation contactor KM17 fault or circuit breaker QF05 fault	3	1	DF_ESAF

Code number	Function (event)	Remark Intern	gravity	Name
4	400V AC power line fault	4	1	DF_400VAC
5	CPR1 contactor KM11 or thermo protector QF01 fault	5	2	DF_CTH1
6	Compressor 1 low pressure LP1 fault	6	2	DF_CLP1
7	Compressor 1 high pressure HP1 fault	7	2	DF_CHP1
8	One or more of DF_CTH1, DF_CLP1 and DF_CHP1 are active	8	2	DF_FAIL_CPR1
9	CPR2 contactor KM12 or thermo protector QF02 fault	9	2	DF_CTH2
10	Compressor 2 low pressure LP2 fault	10	2	DF_CLP2
11	Compressor 2 high pressure HP2 fault	11	2	DF_CHP2
12	One or more of DF_CTH2, DF_CLP2 and DF_CHP2 are active	12	2	DF_FAIL_CPR2
13	Condenser fan 1 contactor KM13 or circuit breaker QF03 fault	13	2	DF_CDF1
14	Condenser fan 2 contactor KM14 or circuit breaker QF04 fault	14	2	DF_CDF2
15	Unit heater 1 KM18 or breaker QF06 fault	15	2	DF_UH1
16	Unit heater 2 KM19 or breaker QF06 fault	16	2	DF_UH2
17	Unit heater overload fault	17	2	DF_UHOV
18	Fresh air damper fault	18	3	DF_FAD
19	Return air damper fault	19	3	DF_RAD
20	Fresh air temperature sensor fault	20	3	DF_SEN_FAS
21	Return air temperature sensor fault	21	3	DF_SEN_RAS
22	Supply air temperature sensor fault	22	3	DF_SEN_SAS
23	The serial number of FPC08	23	15	FPC_SN

6.8.2 Description

Classification of Gravity is valid for the device which is described. The gravity of the error description in the following section is same.
If more faults come together, please check the chapter of function

Description of Gravity:

[1]…Serious fault (Subsystem fault), maintenance after current turn required
[2]…Medium fault (Subsystem reduced load), maintenance after service required,
[3]…Slight fault (Component fail, unit OK), maintenance required,
[15]…Event supervision, no fault

Procedure for fault gravity generation (take in account special position of ventilation):

- If a component fail, a slight fault is generated (failure of sensor, fan, flap, detector, heater)
- If a subsystem works with reduced load, a medium fault is generated (failure of cooling, one supply fan, one emergency fan)
- If a subsystem fault a serious fault is generated (failure of ventilation, emergency ventilation, emergency inverter)

7 Maintenance Software- MONA

7.1 What's MONA?

MONA is maintenance software, dedicated for the supervision of the HVAC systems. It connects on any FPC controller and provides powerful maintenance & diagnosis functions to our customers, such as:

- Displaying a concrete real-time overview of the system, including working modes, temperature survey, and quick fault sum-up.
- Recording interesting signals during an unlimited time, with off-line "replay" functions
- Exhaustive event memory management including event contexts
- Supervision of HVAC component (running time, number of starts) during the complete life of the device.
- Test mode control
- Parameter changing
- I/O visualization
- Output forcing
- <F> Can bus control
- Download of application software

7.2 Communication principles

7.2.1 Physical Layer

MonA uses the USB maintenance link of the FPC controller. On the other side, it should be connected to any USB port of a PC computer. It requires a standard USB cable.

One unique FPC may be connected on this link.

Via USB interface it is possible to download the user software into FPC08 and to start the service program MonA.

7.2.2 Data link layer

The exchange mechanism is based upon Master/Slave communication. The master is the PC computer, and the slave the FPC target controller.

Request / Response: [slv][fc][id][pn][No.][info(?)][crc(2)].

[slv] : FPC number (always 1).

[fc] : Function code, refers to the requested function.

[id] : identifier of the frame (always 0).

[pn] : packet numbering. (always 0).

[No.] : size of the [info(?)] data in bytes.

[info] : information data, size according to the requested function.

[crc] : CRC16 of the frame, performed on the complete frame.

7.2.3 Application layer

Three communication access points are available in Mona.

1) Direct access

Some functions (checksum control, application version) are realized by direct function call.

2) Reserved variables

All generic functions such as Event Memory management, can bus control, component supervision… requires reserved variables. These may be forced and read. This is intended to avoid re-configuration for each new project.

3) Application variables

For project specific functions (overview, recording, test-modes), all variables can be read without any constraints by direct call in the symbol file (appli.tst) of the project.

Remark: For test modes, rules should be respected while naming the variables, see below.

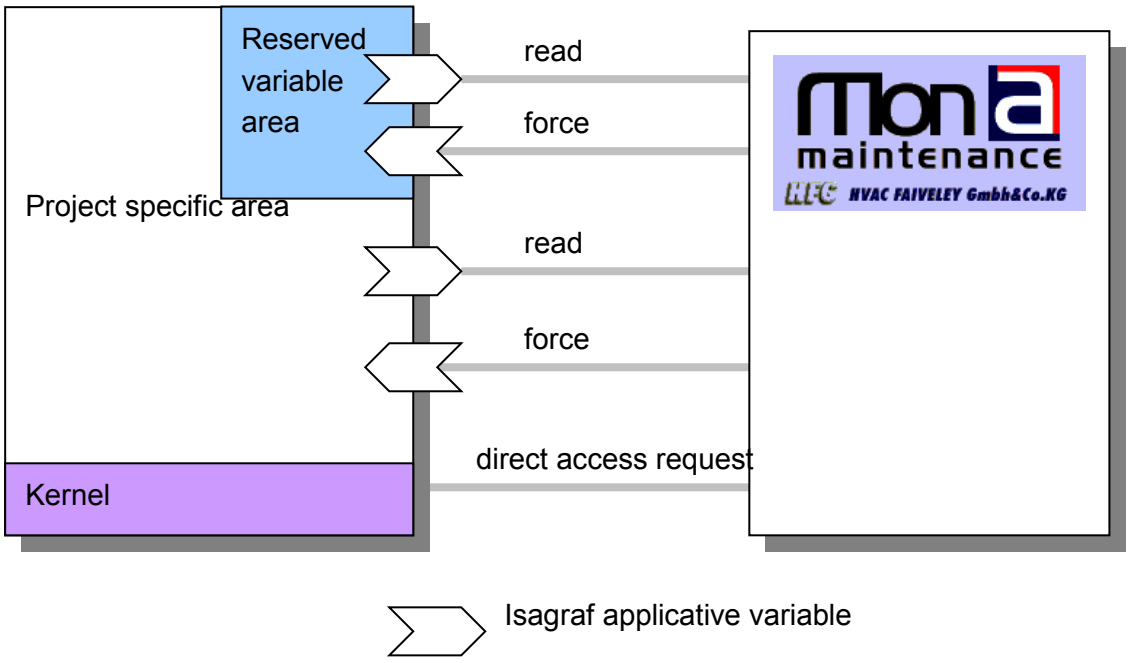


Figure 7-1: communication access points of Mona

The application software is compatible with current operating platforms, for example, Windows 98, NT, ME, 2000 & XP. The exact functionality shall be coordinated with the customer. Diagnostic group signals, which are defined later, can be transmitted from the HVAC via MVB-Interface to the leading VCU.

8 CONTROLLER FPC08 & DIO8 – TECHNICAL DATA

8.1 Technical data of controller FPC08

FAIVELEY TRANSPORT

HVAC Controller FPC08
Technical Data

POWER SUPPLY

- **Operating Nominal Voltage**
  - 24V DC (LV version)
  - 36 to 48V DC (MV version)
  - 72 to 110V DC (HV version)
- **Range**
  - Acc. to EN50155 : 0,7Un to 1,25Un.
- **Voltage Interruption**
  - Class S1.
- **Power**
  - Max 12 W.

CONTROLLER KERNEL

- **Architecture**
  - Biprocessor : 16 bits µP + DSP.
- **Memories**
  - Program : Flash 1MBytes. Downloadable by RS232 link.
  - User : 4kBytes Eeprom.
  - Event Memory : Dedicated Flash 512kBytes.
- **Real Time Clock**
  - On power supply loss, D/T kept 3 weeks (at 20°C).

INPUT / OUTPUT INTERFACES

- **Temperature Sensor Analog Inputs**
  - Number : 6
  - Type : NTC 5kΩ at 25°C
  - Range : -40°C to +125°C (-40/257°F)
  - Resolution : 0,2K
  - Precision : 1K on –10°C to 70°C
  - Diagnosis : open / short circuit detection
- **Analog output**
  - Range : 0 to 10VDC
  - Output imp : 100Ω±10%
  - Resolution : 40mV
  - Precision : 0,1V
- **PWM output**
  - Range : External Supply Voltage Max 24V.
  - Frequency : 5Hz to 20kHz
  - Duty cycle : 0 to 100%
  - Freq.Precision : 0,1Hz
  - Power (Max) : 1.5W
- **Digital Inputs**
  - Number : 8 (2 galv. insulated groups)
  - Input current : 5mA for HV version
10mA for LV & MV version
- **Digital Outputs**
  - Number : 8 (2 galv. insulated groups)
  - Type : Relay (Normally Open)
  - Switching voltage : Max 150VDC / 250VAC
  - Switching capacity : Max 50W per output
  - Switching current : Max 2A on resistive load

MAINTENANCE & DIAGNOSIS CAPABILITIES

- **Service Interface**
  - Type : RS232 (Sub-D-9 poles)
  - Data rate : 4,8k to 115,2 kBit/s
- **Event Recording**
  - Memory type : Non volatile (dedicated Flash 512kB)
  - Data saved : Complete snapshot of the system + user configurable data.
- **HVAC Component Supervision**
  - Permanent supervision of main HVAC actuators (working hours and start count).
- **Maintenance & Diagnosis tool**
  - Through Faiveley's mon-E PC software :
  - Graphic and realistic overview of the HVAC system
  - Direct to Disk recording of all signals
  - Test mode control

COMMUNICATION, NETWORK, TRAIN BUS INTERFACES

- **CAN bus interface**
  - Design compliant with Bosch® specifications.
  - Data format : 2.0A - 2.0B (optional).
  - Data rate : Max 1MBits/s
  - Medium type : Twisted pair acc to ISO11898
  - Connections : 2xSub-D-9 poles Male & Female
  - Termination resistor : Included. Active by bridge connector.
- **RS485 bus interface**
  - Design compliant with EIA485 standard.
  - Type : 2 wire model.
  - Termination resistor : Included. Active by bridge connector.
  - Bias resistors : Pull up&down resistor included. Active by bridge connector.
- **Optional network interface (optional)**
  - LON® 78,8k FTT-X1 PC104 with Lonmark® capabilities.
  - MVB Siemens PC104. Class 1.3.
  - MVB Duagon D114 PC104. Class 1.x.

ENVIRONMENTAL CONDITIONS

- Temp° Range : -25°C to 70°C (-13/158°F) Class T3
- Relative humidity : Max. 95%. 75% average.
- Shock & vibration : Acc to EN61373. Cat 1 - Class B.
7,9 / 3,5 / 5,5 m/s² between 5 & 150 Hz / 5h.
Shocks : 30 m/s² during 30 ms

CE - ELECTROMAGNETIC COMPATIBILITY

All conducted / radiated emission and susceptibility compliant with EN50155 & EN50121-3-2.

MECHANICAL DATA

- Housing : Stainless steel
- Dimensions : 370 x 135 x 45 mm
- Weight : 1.7kg (all options mounted)
- Connectors : Wago 734 Serie.
- Protection class : IP20.
- Fire & smoke class : NFF-16-101, UL94 / CEI 60695-1.

8.2 Technical data of controller DIO8

Faiveley TRANSPORT

DIO8- LV & HV
Technical Data

POWER SUPPLY

- Operating Nominal Voltage
  - 24 VDC (LV Version) — FTL Ref Nr : 9081411
  - 72-110 VDC (HV Version) — FTL Ref Nr : 9082172
- Range
  - Acc to EN50155 : 0,7 Un to 1,25 Un
- Voltage interruption
  - Classe S1
- Power
  - Max 4W

CONTROLLER KERNEL

- Architecture
  - 80C51 Core Architecture Microcontroller
- Memories
  - Flash : 64 KB (intern µC)
  - RAM : 256 Byte (intern µC)
  - EEPROM : 2 KB (intern µC)

INPUT / OUTPUT INTERFACE

- Digital Outputs

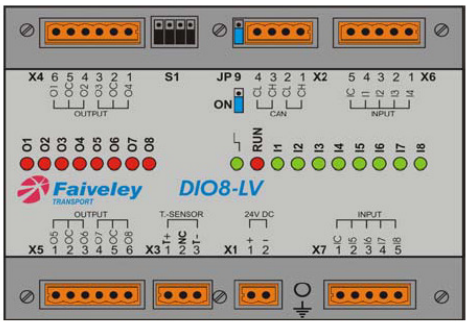
Number :	8 (2 galv. insulated groups)
Type :	Relay (Normally Open)
Switching voltage :	Max. 30VDC /250VAC
Switching capacity :	Max : 50W per output
Switching current:	Max : 2A on resistive load

- Digital Inputs

Number :	8 (2 galv. insulated groups)
Input current :	Min : 10mA

- Temperature Sensor Digital Input

Number :	16
Type :	DS18B20
Range :	-55°C to +125°C (-67/257°F)
Resolution :	0,1 K
Precision :	0,5 K on -10°C to +70°C
Diagnosis :	Open / short circuit detection



COMMUNICATION, NETWORK

- **CAN bus interface**

Design compliant with Bosh® specifications

Data format :	2.0A – 2.0B (optional)
Data rate :	Max 1 Mbits/s
Medium type :	Twisted pair acc to ISO11898
Connections :	2 poles Wago connector
Terminal Resistor :	Included. Active by bridge

MAINTENANCE & DIAGNOSIS CAPABILITIES

- **Service interface**
  - → CAN — Max 1 Mbits/s
- **Maintenance & diagnosis tool**

Through Faiveley's standard Maintenance PC software : MODUL-SPY
- Graphic and realistic overview of Modul Syst.
- Direct to disk recording of all signals
- Test mode / service control

- **Modul Component Supervision**

Permanent supervision of main HVAC actuators (working hours and start count)

ENVIRONMENTAL CONDITIONS

Temp. Range :	-40°C to +70°C (-40/185°F) Class T2
Relative Humidity	Max. 95%, 75% average
Schock & Vibration	Acc to EN61373 Cat 1 – Class B

CE – ELECTROMAGNETIC COMPATIBILITY

All conducted / radiated emission and susceptibility compliant with EN50155 & EN50121-3-2

MECHANICAL DATA

Housing :	Stainless steel
Dimensions :	160 x 120 x 50 mm
Weight :	0,7 Kg (all option mounted)
Connectors :	Wago
Protection class :	IP20
Fire & smoke class :	UL94 V0

9 Resistance value of the NTC temperature sensor

°C	0	1	2	3	4	5	6	7	8	9	10
-30	88 500	43 200	99 300	105 200	113 400	120 300	128 000	136 400	146 400	156 800	167 000
-20	48 535	51 450	54 550	57 850	61 400	65 200	69 520	73 600	78 200	83 150	88 500
-10	27 665	29 215	30 865	32 620	34 490	36 475	38 590	40 845	43 245	45 805	48 535
- 0	16 325	17 185	18 095	19 055	20 080	21 165	22 310	23 530	24 825	26 200	27 665
0	16 325	15 515	14 750	14 025	13 345	12 695	12 085	11 505	10 960	10 440	9 950
10	9 950	9 485	9 045	8 625	8 230	7 855	7 500	7 160	6 840	6 535	6 245
20	6 245	5 970	5 710	5 460	5 225	**5 000**	4 786,5	4 583,5	4 388,5	4 203,5	4 028,5
30	4 028,5	3 861,5	3 701,5	3 548,5	3 403,5	3 265,0	3 133,5	3 008,5	2 888,5	2 773,5	2 663,3
40	2 663,3	2 558,5	2 458,5	2 363,5	2 271,5	2 185,0	2 100,5	2 020,0	1 945,0	1 871,5	1 801,5
50	1 801,5	1 733,5	1 670,0	1 608,0	1 549,5	1 493,0	1 439,0	1 387,0	1 337,5	1 289,5	1 244,0
60	1 244,0	1 200,0	1 158,0	1 117,5	1 078,5	1 041,5	1 005,5	971,0	938,0	906,5	876,0
70	876,0	846,5	818,0	791,0	765,0	739,5	715,5	692,0	670,0	648,5	627,5
80	627,50	607,50	588,50	570,00	552,00	535,00	518,00	502,00	486,85	472,00	457,65
90	457,65	443,85	430,50	417,65	405,15	393,35	381,65	370,50	359,65	349,35	339,15
100	339,15	329,50	320,15	311,00	302,15	293,65	285,50	277,50	269,85	262,50	255,15
110	255,15	248,35	241,50	235,00	228,65	222,50	216,65	210,85	205,35	200,00	194,65
120	194,65	189,65	184,85	180,00	175,30	170,85	166,55	162,35	158,25	154,30	150,47

Between 0 and 70 °C, the accurate is less than 0,2°K