Variable Capacity Commercial

Operation Detail

Model Numbers

CRV290T-T / EVA290T-T
CRV330T-T / EVA330T-T
PKV290T-T
PKV330T-T
PKV290T-L/R
PKV330T-L/R

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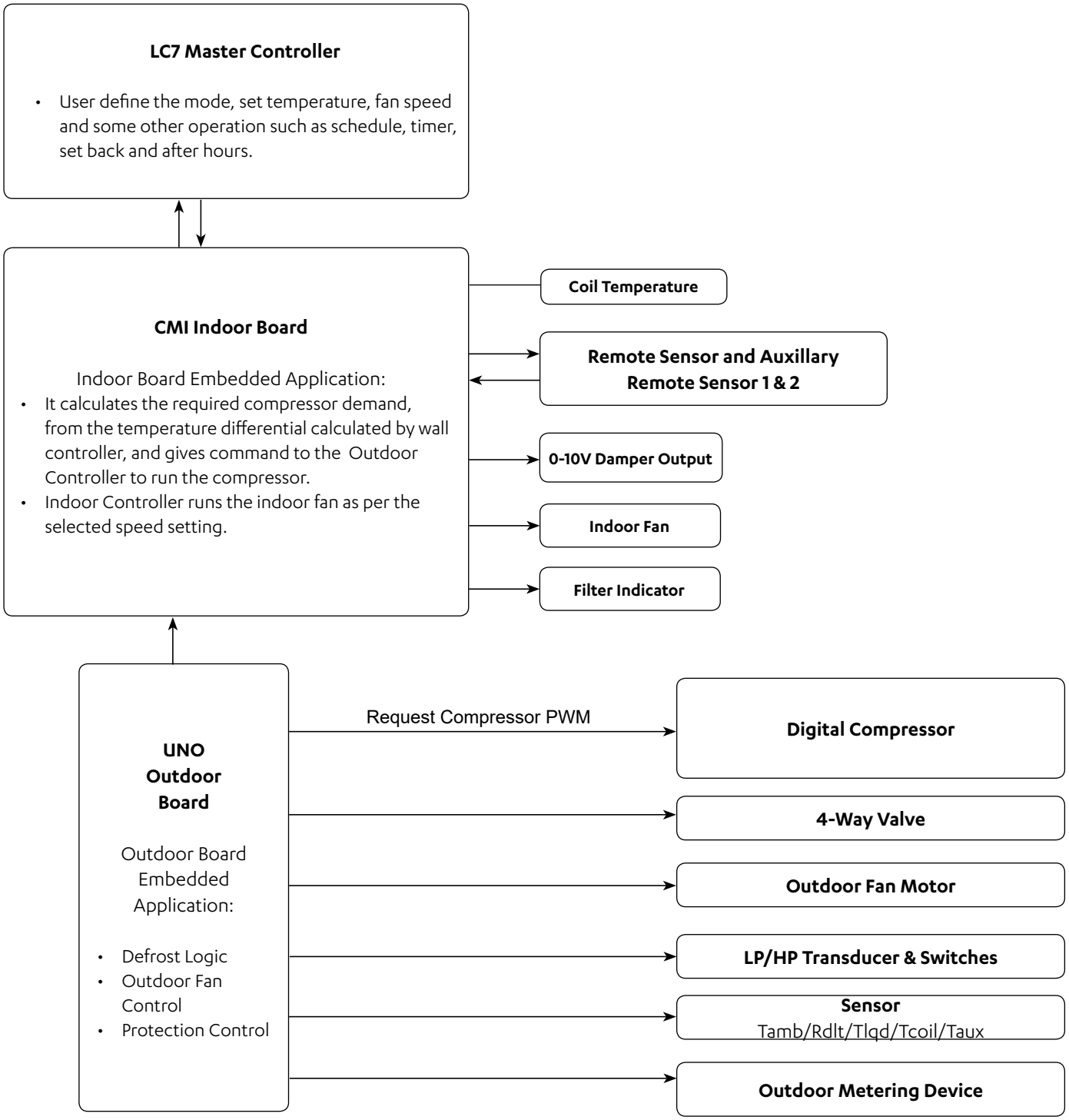
Table of Contents

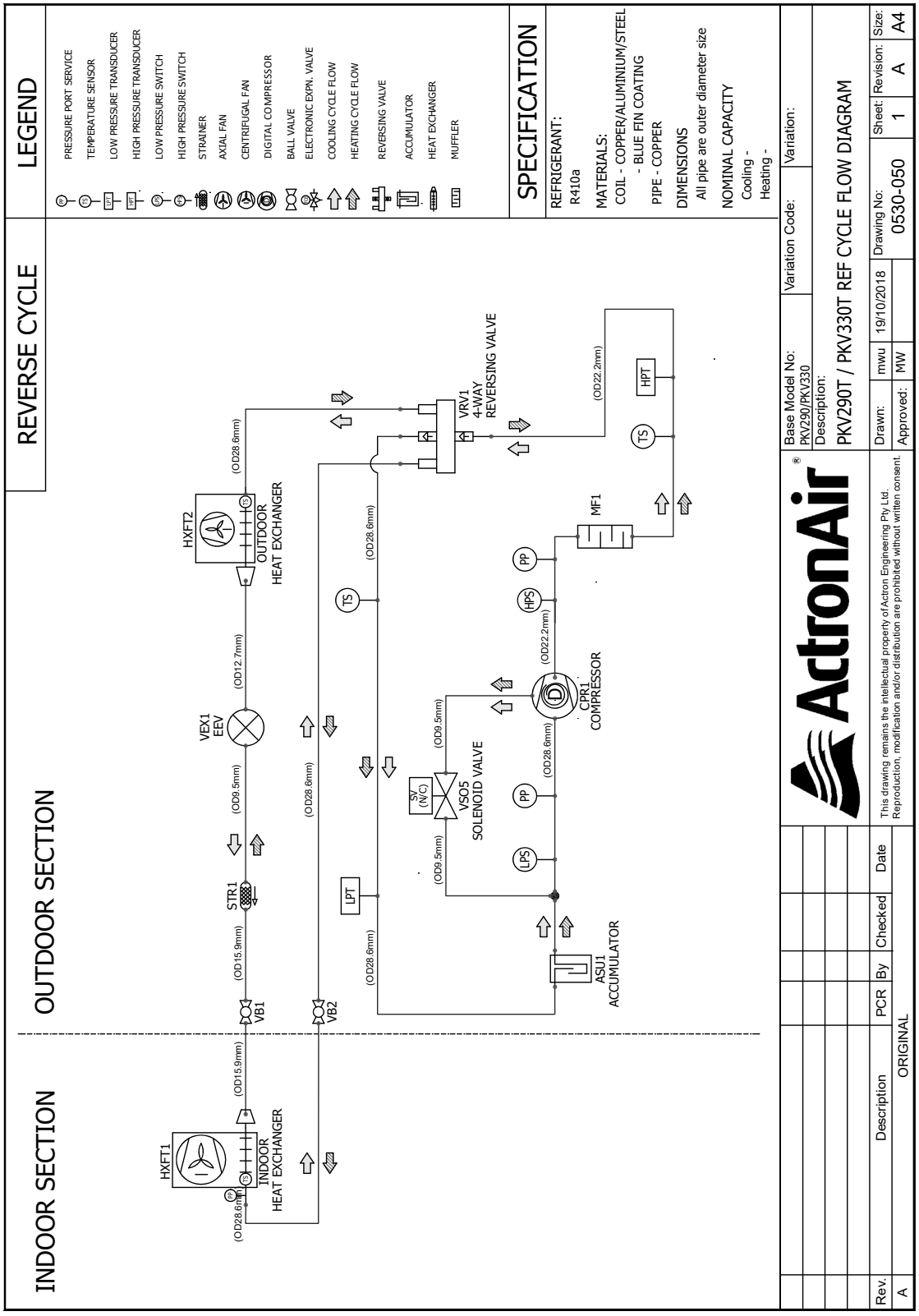
01. System Control Flow Chart / Normal Operation Table & Important Register Default Values

01.01. System Control Flow Chart:

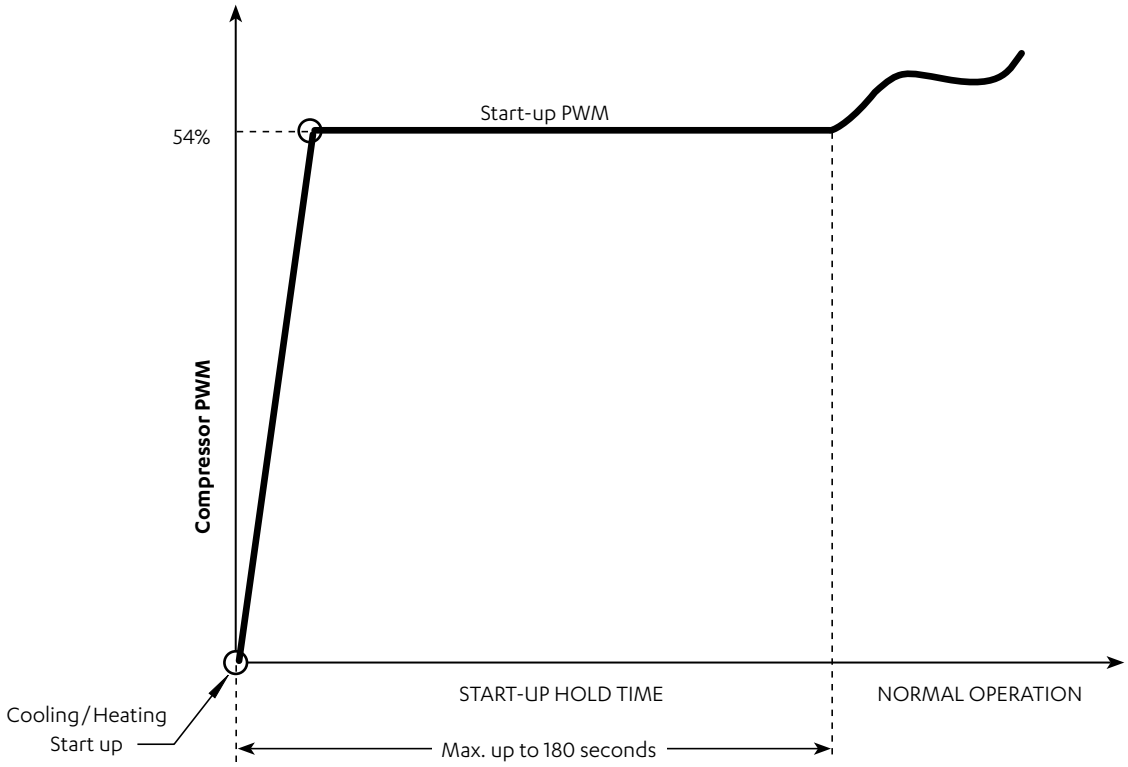


01.02. System Refrigeration Circuit:

01.02.01. Split Unit & Package



02. Start-up sequence:



Compressor start-up speed: When the compressor starts up from idle, the compressor follows a start-up sequence which is defined by the UNO board. It will run the compressor on start-up PWM and keep running until the start-up hold time is finished.

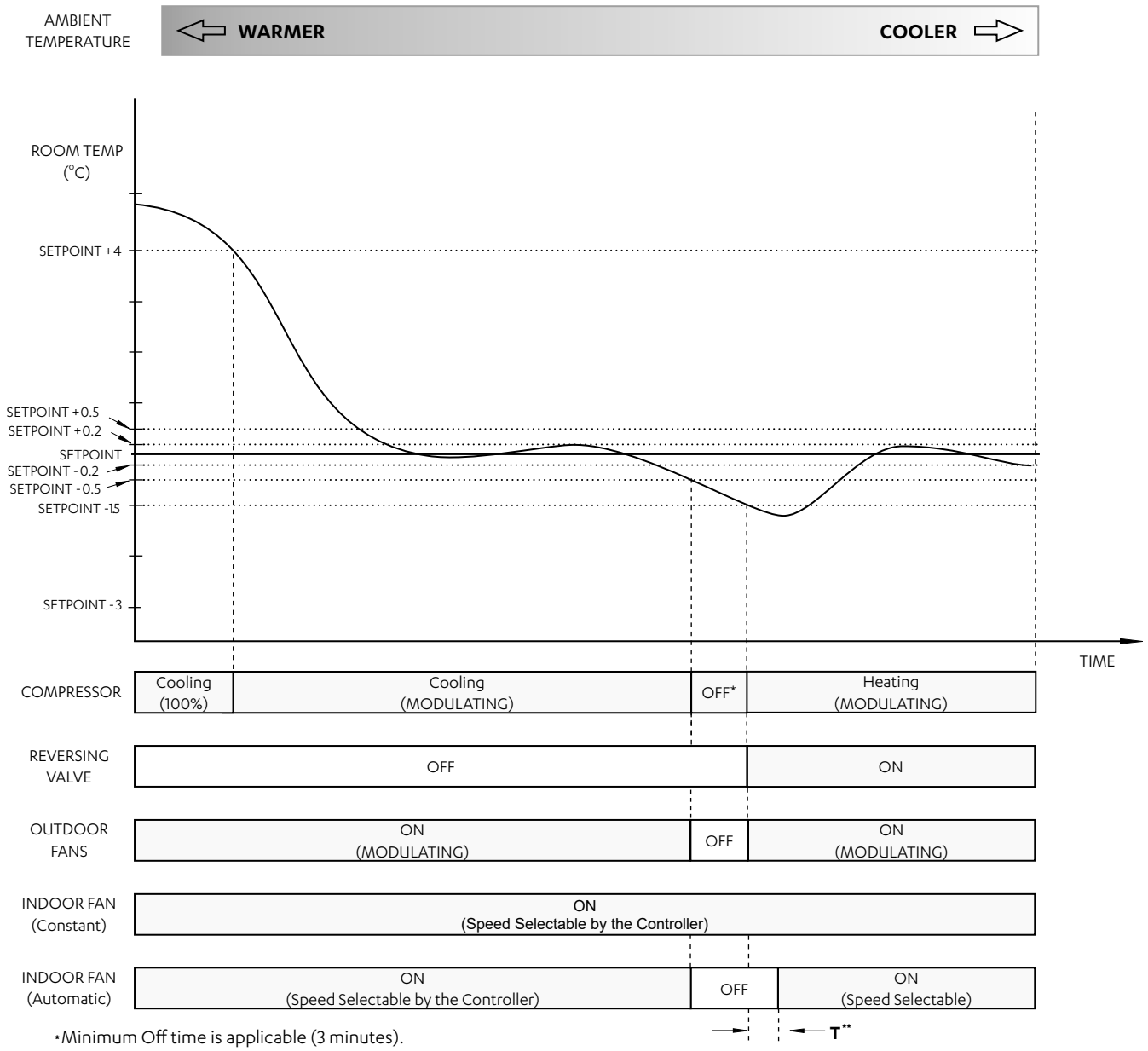
Start-up hold time maximum value can be 180 seconds.

Fresh Start Mode

If the compressor cycles off for more than 2 hours, or if the system is turned ON via wall controller or main power. Then the compressor will load and unload at 75% PWM for approximately 36 seconds during start up.

03. Description of Basic Operation

03.01. Auto Cool - Auto Heat Mode Operation Time Chart



*Minimum Off time is applicable (3 minutes).

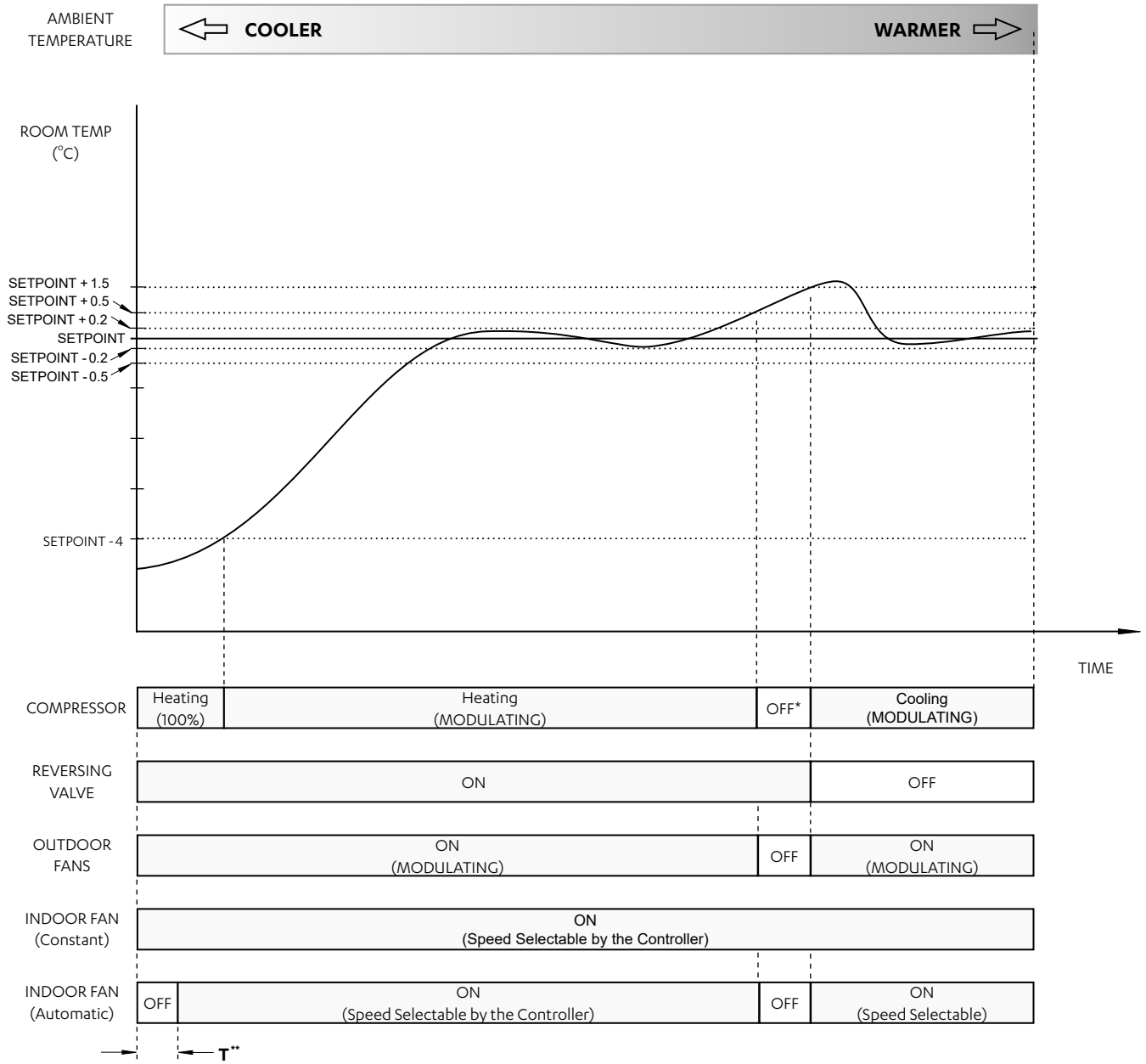
**Waits for either 46 seconds or until the Indoor Coil reaches 24°C, which ever occurs first.

In Auto Cool Mode, when the compressor is running at low capacity, the unit may turn off occasionally.

This is due to a built-in 16-minute timer, which is activated when the capacity drops below 30%. If the capacity remains less than 30% for longer than 16 minutes, the unit will cycle off. The unit will remain off for a minimum of 3 minutes or until the room temperature is 0.2°C away from the set point temperature. If during the 16 minute period the capacity increases to above 30% the 16-minute timer is reset.

This function has been included to save energy by cycling the unit off and allowing the temperature to swing slightly when the capacity demand is minimal.

03.02. Auto Heat - Auto Cool Mode Operation Time Chart



*Minimum Off time is applicable (3 minutes).

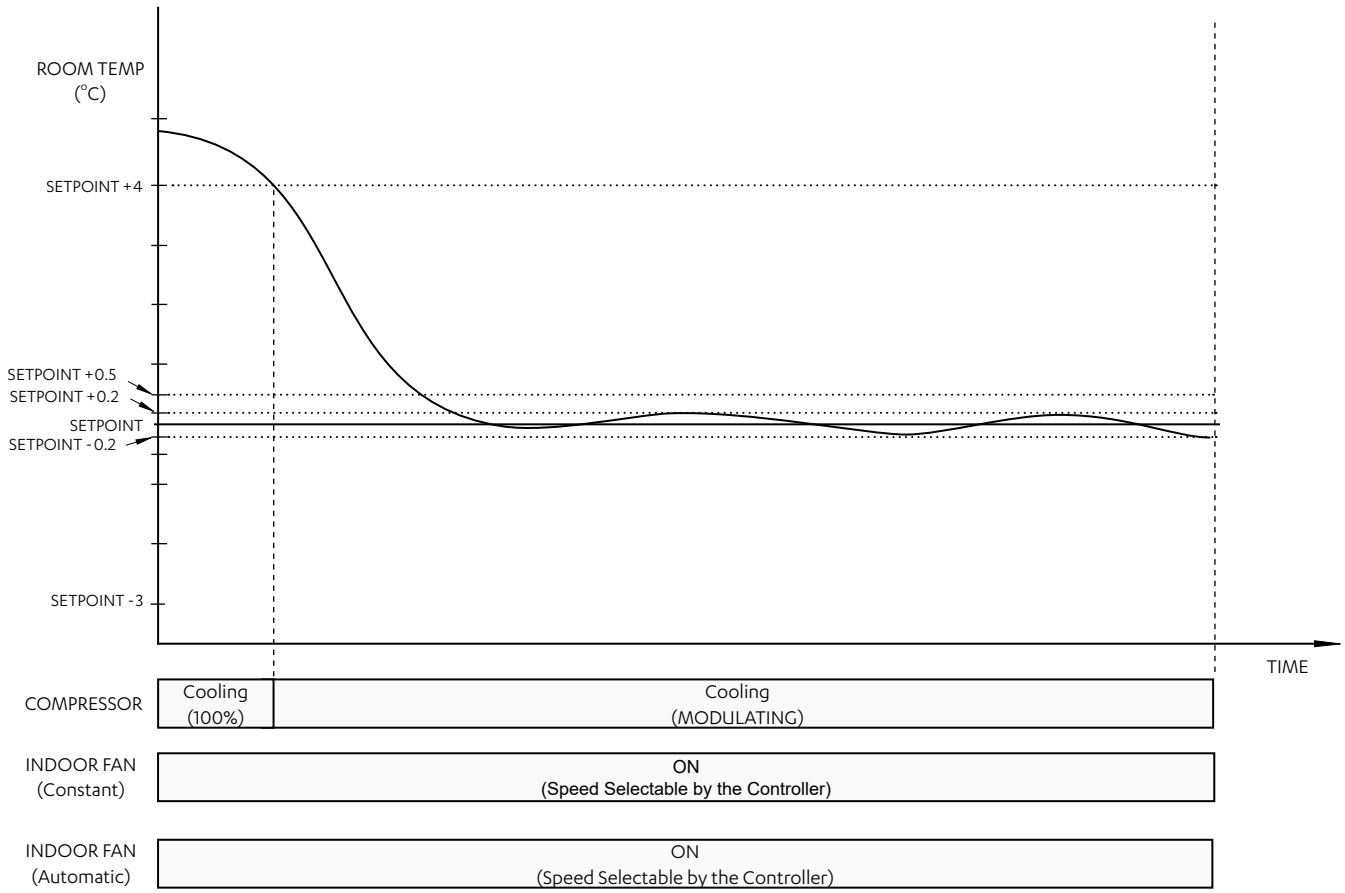
**Waits for either 46 seconds or until the Indoor Coil reaches 24°C, which ever occurs first.

In Auto Heat Mode, when the compressor is running at low capacity, the unit may turn off occasionally.

This is due to a built-in 16-minute timer, which is activated when the capacity drops below 30%. If the capacity remains less than 30% for longer than 16 minutes, the unit will cycle off. The unit will remain off for a minimum of 3 minutes or until the room temperature is 0.2°C away from the set point temperature. If during the 16 minute period the capacity increases to above 30% the 16-minute timer is reset.

This function has been included to save energy by cycling the unit off and allowing the temperature to swing slightly when the capacity demand is minimal.

03.03. Cooling Cycle Time Chart

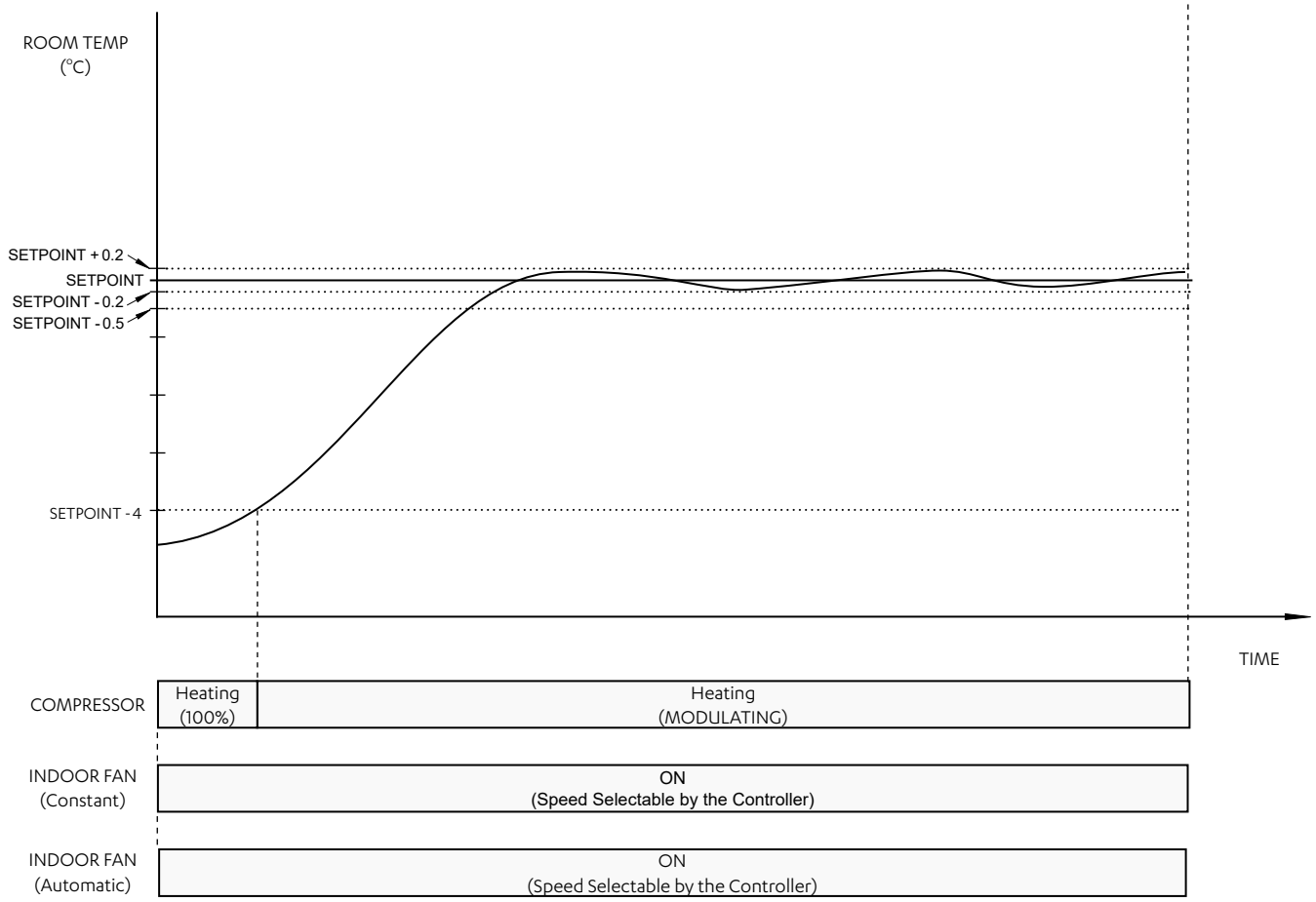


In Cool Only Mode, when the compressor is running at low capacity, the unit may turn off occasionally.

This is due to a built-in 16-minute timer, which is activated when the capacity drops below 50%. If the capacity remains less than 50% for longer than 16 minutes, the unit will cycle off. The unit will remain off for a minimum of 3 minutes or until the room temperature is 0.2°C away from the set point temperature. If during the 16 minute period the capacity increases to above 50% the 16-minute timer is reset.

This function has been included to save energy by cycling the unit off and allowing the temperature to swing slightly when the capacity demand is minimal.

03.04. Heating Cycle - Hot Start Operation Time Chart



NOTE: When the unit starts under fresh start mode, the indoor fan time delay changes from 45 to 76 seconds.

In Heat Only Mode, when the compressor is running at low capacity , the unit may turn off occasionally.

This is due to an in-built 16-minute timer, which is activated when the capacity drops below 50%. If the capacity remains less than 50% for longer than 16 minutes, the unit will cycle off. The unit will remain off for a minimum of 3 minutes or until the room temperature is 0.2°C away from the set point temperature. If during the 16 minute period the capacity increases to above 50% the 16-minute timer is reset.

This function has been included to save energy by cycling the unit off and allowing the temperature to swing slightly when the capacity demand is minimal.

This function also helps to reduce the cold draft effects caused when the capacity is so low that the air coming from the indoor unit does not carry much heat.

04. Outdoor Fan Control:

The UNO outdoor board sets the based on the outdoor fan speed based on the outdoor coil temperature. The outdoor coil temperatures have thresholds, with hysteresis applied to avoid frequent fan speed changing.

Control by outdoor coil:

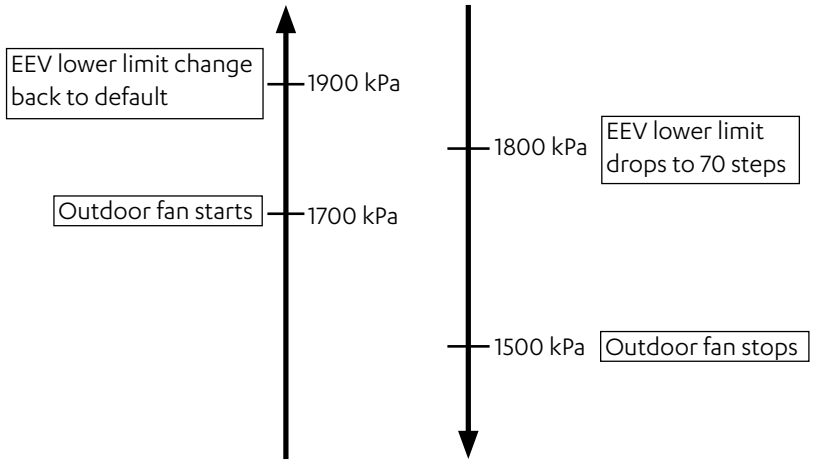
Whenever system starts, the outdoor fan must start on high speed for 5 seconds. After the 5 seconds, it will follow the corresponding cooling or heating logic tabulated below.

Mode of Operation	Outdoor coil sensor temperature, **˚C**	Change fan speed
Cooling	**˚C** ≤ 36°C	Low
	36°C < **˚C** ≤ 40°C	Low or Medium (depending on last setting)
	40°C < **˚C** ≤ 44°C	Medium or High (depending on last setting)
	˚C ≥ 44°C	High
Heating	**˚C** ≥ 7°C	Low
	4.5°C ≤ **˚C** < 7°C	Low or Medium (depending on last setting)
	2.5°C < **˚C** ≤ 4.5°C	Medium or High (depending on last setting)
	˚C ≤ 2.5°C	High

04.01. Other control rules:.

- Outdoor fan is controlled by outdoor coil temperature value. If coil temperature is faulty or open/short circuit, then the logic will automatically abide by the high pressure control.
- While changing the outdoor fan speed between High, Medium, Low Speed, there is a minimum delay of 500 milliseconds when switching the relays. i.e. switch off the current relay, wait for 500 milliseconds and then switch ON the other relay. Note: swiching delay must be 500 milliseconds, e.g. first relay off wait for 500 milliseconds, then turn on next.
- Outdoor fan controlled by defrost logic has the highest priority.
- Outdoor fan is off when compressor is off.
- If night mode is enabled, outdoor fan maximum speed is limited at medium speed during normal operation.

04.02. Outdoor fan special control during low ambient condition:



To assist and allow for safe compressor operation for low ambient cooling, the outdoor fans are controlled in such a way to help build a high head pressure. For instances when the outdoor ambient temperature is less than and equal to 7°C and the system requests for cooling, the system will undergo a special startup sequence. Startup will take place as normal, except the outdoor fans will not be initiated upon the initial EXV calibration. The logic will wait until the HP saturation temperature reaches 24°C before outdoor fans will be initiated and be controlled by OD coil temperature.

05. Adaptive Demand Defrost Logic:

05.01. Adaptive Demand Defrost

The "Adaptive Demand Defrost" offers better defrost performance by having "AIT" (Adaptive Interval Time. The adaptive interval time can increase or decrease the interval time (time between defrosts) automatically to suit the local conditions. This prevents the unit from entering unnecessary defrost mode, which will improve the heating performance of the system.

05.01.01. Definition:

Interval Time - minimum time set by the controller before the system will proceed to 3 minutes confirmation time if OD temperature fall to -5˚C or below.

1. Interval Time during start up (initial interval time)
   Interval Time (1st Cycle) = 30 minutes (default)
2. Second Cycle Interval Time
   Interval Time (2nd Cycle) = 30 minutes +/- algorithm of cycle 1st defrost duration
3. Third Cycle Interval Time
   Interval Time (3rd Cycle) = 30 minutes +/- algorithm of cycle 1st defrost duration +/- algorithm of cycle 2nd defrost duration
4. Fourth Cycle Interval Time
   Interval Time (4th Cycle) = 30 minutes +/- algorithm of cycle 1st defrost duration +/- algorithm of cycle 2nd defrost duration +/- algorithm of cycle 3rd defrost duration

Confirmation Time = 3 minutes countdown timer to monitor if OD coil temperature is still -5˚C or 500kPa.

Defrost Duration = the period where the system switch to cooling mode until the OD coil temperature registers +10˚C or if 10 minutes maximum defrost period has elapsed.

05.01.02. Example of R-410a Defrost Cycles:

1st Defrost Cycle:

30 mins + 3 mins (if OD Coil Temp is -5˚C or 500kPa) = **defrost**

10 mins or + 10˚C (OD Coil Temp) = **defrost termination**

2nd Defrost Cycle:

30 mins +/- algorithm of 1st defrost duration + 3 mins (-5˚C or 500kPa) = **defrost**

10 mins or + 10˚C (OD Coil Temp) = **defrost termination**

3rd Defrost Cycle:

30 mins +/- algorithm of 1st defrost duration +/- algorithm of 2nd defrost duration + 3 mins (-5˚C or 500kPa) = **defrost**

10 mins or + 10˚C (OD Coil Temp) = **defrost termination**

4th Defrost Cycle:

30 mins +/- algorithm of 1st defrost duration +/- algorithm of 2nd defrost duration +/- algorithm of 3rd defrost duration+ 3 mins (-5˚C or 500kPa) = **defrost**

15 mins or + 15˚C (OD Coil Temp) or 1800 kPa= **defrost termination**

Cycle goes back to 1st cycle and repeats (interval time will be continuously accumulated).

NOTES:

- During interval period (any cycle), if the coil temperature drops to -15˚C or below, the system will check the remaining interval time:
  - If the remaining interval time is >20 mins, it will be reduced to 20 minutes and proceed to 3 minutes confirmation time.
  - If the remaining interval time is <20 minutes, the remaining interval time will be kept.
- Maximum accumulated interval duration is 90 minutes.
- Minimum accumulated interval duration is 20 minutes.

05.01.03. Adaptive Demand Defrost - Ice Clearing Cycle

Sometimes, after extended cold weather operation, solid ice may form on the outdoor coil that can not be removed by the standard defrost termination of 10 minutes or +10˚C. To help get rid of this ice, the defrost termination could be lengthened and the temperature raised. But this would mean the system will remain in defrost operation longer than what is required on most occasions.

The Ice Clearing Cycle built into the adaptive demand defrost logic is a simple feature that applies a longer defrost time and temperature termination of 15 min. and +15˚C or 1800kPa, respectively on every 4th defrost cycle. The benefit of this feature is, it helps prevent solid ice building up after multiple defrost cycles.

Adaptive Demand Defrost Algorithm Table

Adaptive Demand Defrost System additional interval time before next defrost operation, as shown in table below.

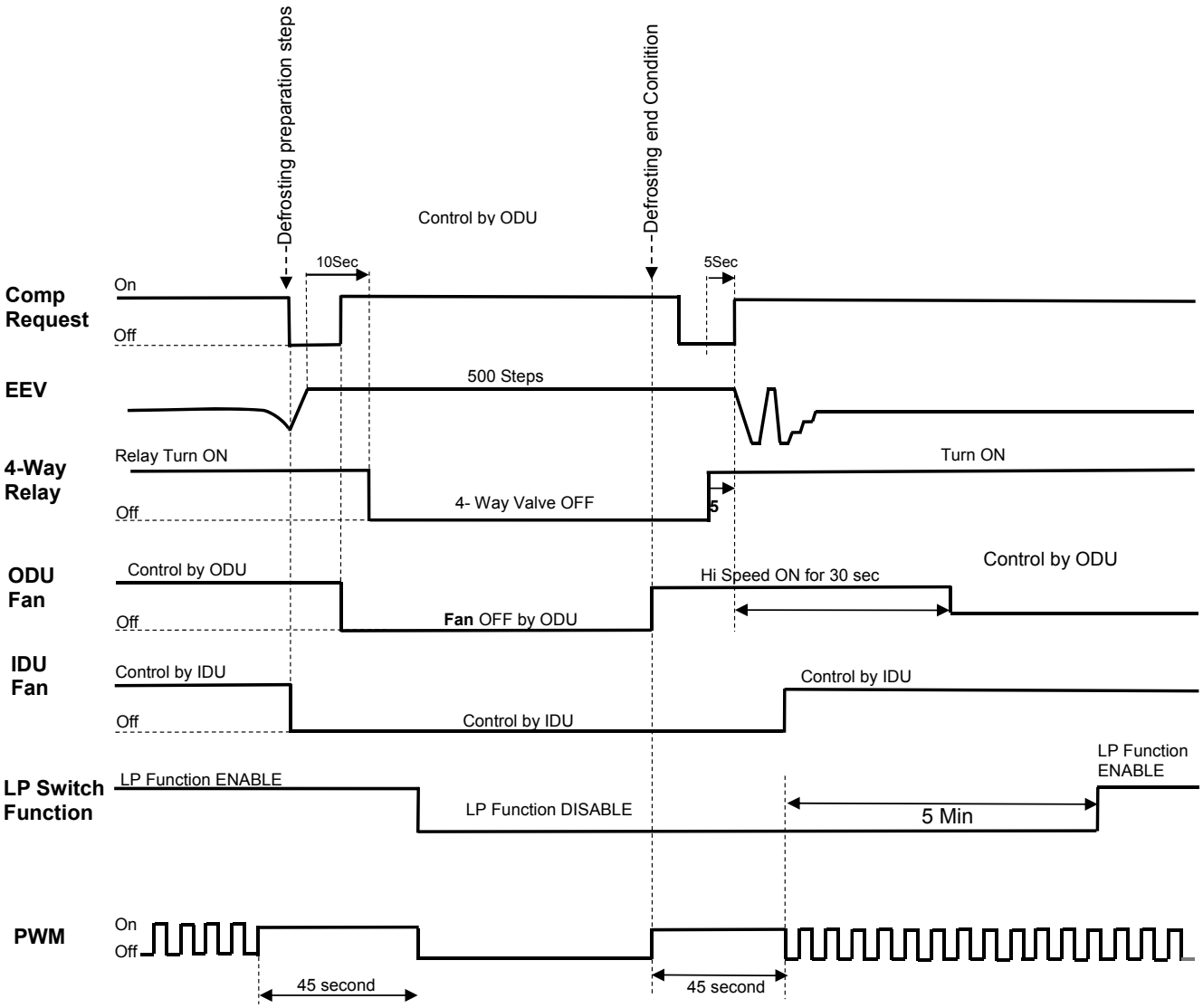
Recorded Defrost Duration (mins.)	Additional Time on Next Defrost Interval (mins.)
1	+20
2	+10
3	+7
4	+4
5	+1
6	0
7	-1
8	-4
9	-6
10	-10

Examples:

- If the duration of defrost is 3 minutes (column 1), the system will add 7 minutes to the next interval time before proceeding to 3 minutes confirmation time.
- If duration of defrost is 9 minutes (column 1), the system will deduct 6 minutes to the next interval time before proceeding to 3 minutes confirmation time.

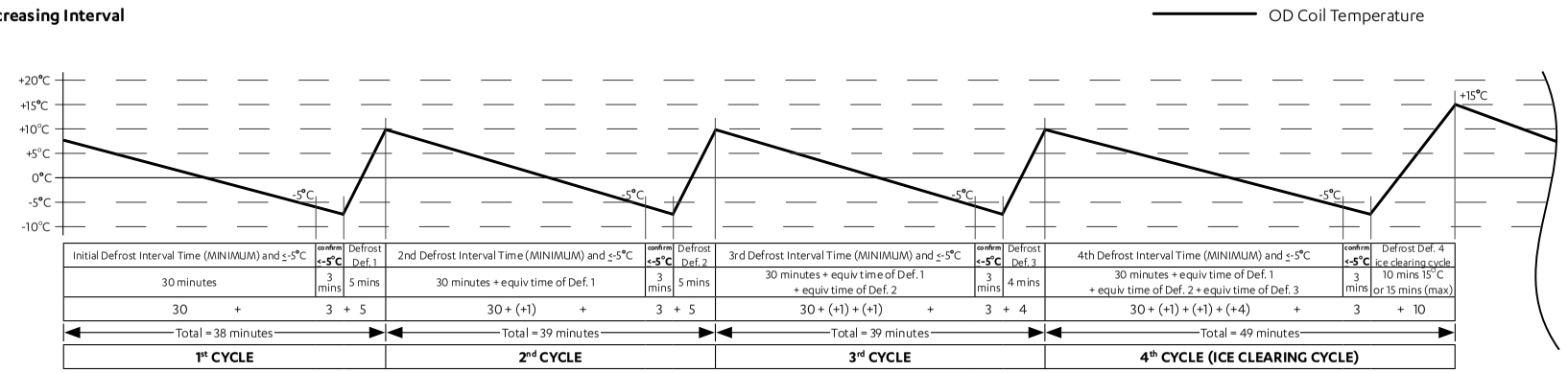
NOTES:

- The Interval time will continuously accumulate.
- The maximum accumulated time is 90 minutes and the minimum is 20 minutes.
- When the unit is turned Off, the system will stop counting the accumulation time. The system will only start counting the accumulation time again when it is switched back into Heating mode.



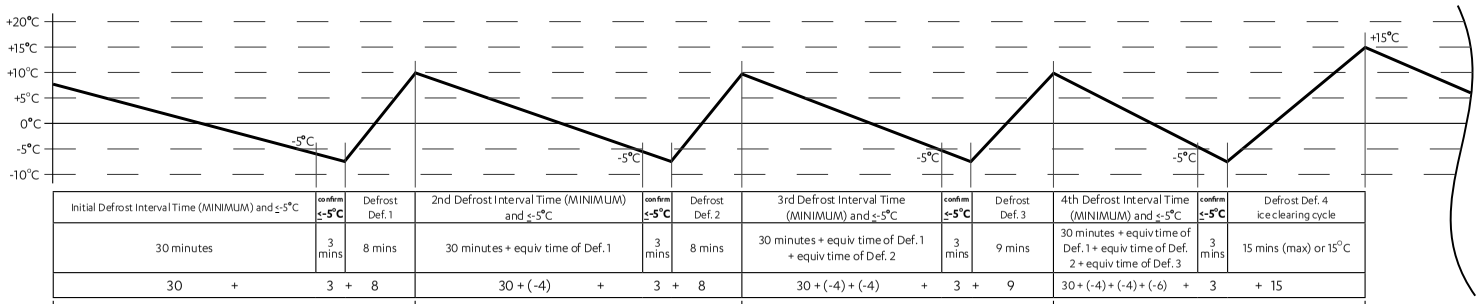
Example of Adaptive Demand Defrost Cycle

Increasing Interval



Initial Defrost Interval Time (MINIMUM) and ≤-5°C	confirm ≤-5°C	Defrost Def. 1	2nd Defrost Interval Time (MINIMUM) and ≤-5°C	confirm ≤-5°C	Defrost Def. 2	3rd Defrost Interval Time (MINIMUM) and ≤-5°C	confirm ≤-5°C	Defrost Def. 3	4th Defrost Interval Time (MINIMUM) and ≤-5°C	confirm ≤-5°C	Defrost Def. 4 ice clearing cycle
30 minutes	3 mins	5 mins	30 minutes + equiv time of Def. 1	3 mins	5 mins	30 minutes + equiv time of Def. 1 + equiv time of Def. 2	3 mins	4 mins	30 minutes + equiv time of Def. 1 + equiv time of Def. 2 + equiv time of Def. 3	3 mins	10 mins 15°C or 15 mins (max)
30 +	3	+ 5	30 + (+1) +	3	+ 5	30 + (+1) + (+1) +	3	+ 4	30 + (+1) + (+1) + (+4) +	3	+ 10
Total = 38 minutes			Total = 39 minutes			Total = 39 minutes			Total = 49 minutes		
1st CYCLE			2nd CYCLE			3rd CYCLE			4th CYCLE (ICE CLEARING CYCLE)		

Decreasing Interval



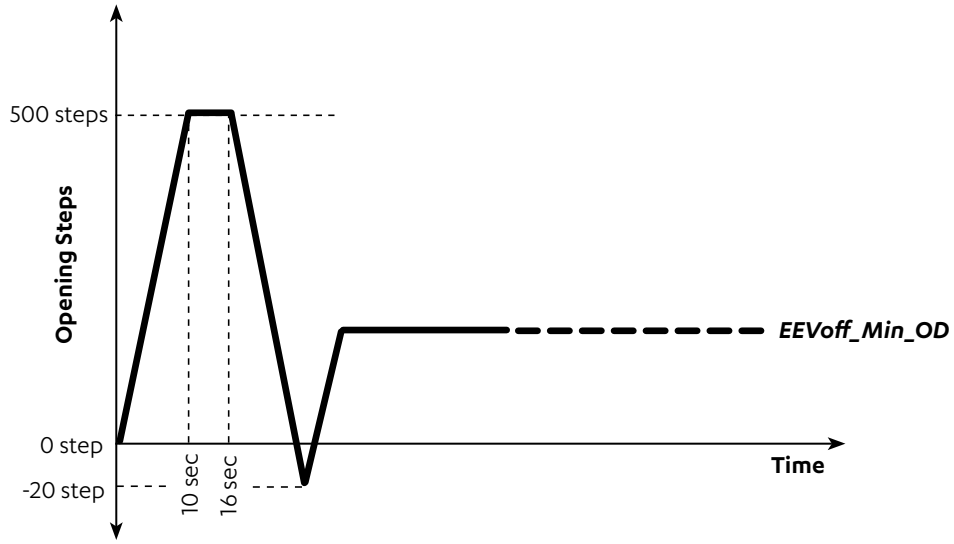
Initial Defrost Interval Time (MINIMUM) and ≤-5°C	confirm ≤-5°C	Defrost Def. 1	2nd Defrost Interval Time (MINIMUM) and ≤-5°C	confirm ≤-5°C	Defrost Def. 2	3rd Defrost Interval Time (MINIMUM) and ≤-5°C	confirm ≤-5°C	Defrost Def. 3	4th Defrost Interval Time (MINIMUM) and ≤-5°C	confirm ≤-5°C	Defrost Def. 4 ice clearing cycle
30 minutes	3 mins	8 mins	30 minutes + equiv time of Def. 1	3 mins	8 mins	30 minutes + equiv time of Def. 1 + equiv time of Def. 2	3 mins	9 mins	30 minutes + equiv time of Def. 1 + equiv time of Def. 2 + equiv time of Def. 3	3 mins	15 mins (max) or 15°C
30 +	3	+ 8	30 + (-4) +	3	+ 8	30 + (-4) + (-4) +	3	+ 9	30 + (-4) + (-4) + (-6) +	3	+ 15
Total = 41 minutes			Total = 37 minutes			Total = 34 minutes			Total = 34 minutes		
1st CYCLE			2nd CYCLE			3rd CYCLE			4th CYCLE (ICE CLEARING CYCLE)		

NOTE: To obtain the equivalent time, use Adaptive Demand Defrost Algorithm Table.

06. EEV Operation

06.01. Initialise or lost step compensation:

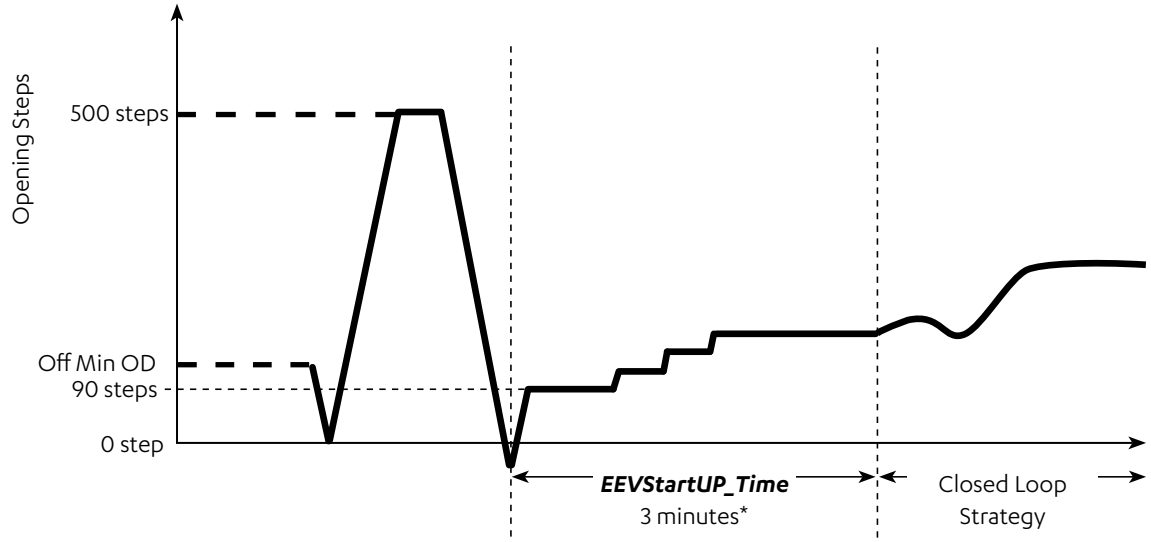
- After power reset or reboot, EEV will first open to 500steps then close to -20steps. Controller will assume this - 20steps as a zero position.
- When the unit is set to OFF mode, the valve will be set to the **EEVOff_Min_OD**. This value is 125steps.



06.02. EEV Start-up characteristics:

Start-up characteristics are defined by these two variables:

EEV Startup_Time: As the unit start in heating or cooling mode, then controller will open the EEV to 500 steps. The EEV will remain open at 500 steps and wait until the pressure in the system stabilizes (differential of 50kPA between HP & LP). Once stabilized, the controller will close the EEV and begin the start-up sequence. The ***EEV Startup_Time*** may take up to 3 minutes, unless a discharge superheating to the pre-defined value is achieved – the controller will enter close loop control.



EEVStartup_Steps: As the compressor starts it open the EEV in steps, opening steps are link with pre-defined conditions. EEV can take maximum 3min to finish the start-up sequence. As the start-up sequence will be finished then SH control logic open or close the EEV.

06.03. Target superheating: define by discharge superheating

- System target superheating is defined by discharge superheat. Controller should maintain a pre-define minimum allowable discharge superheat for cooling/heating separately.
- This logic is available in the SH control loop and starts to operate after **EEVStartup_Time**. If the discharge superheat < Predefined min. allowable DSH, then raise the target superheat value and it should be cap by its max limit.

Tabulated below are the Target SH for the corresponding models.

Model No	Cooling Max. target superheating	Heating Max. target superheating
CRV290T-T / PKV290T-T/L/R	4 k to 10k	2.5k to 4.5k
CRV330T-T / PKV330T-T/L/R		

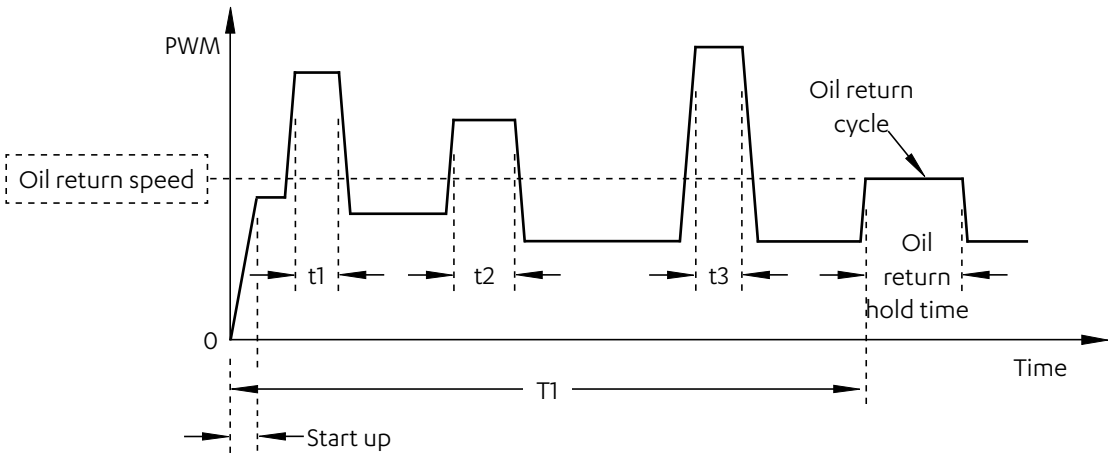
07. Oil return

The compressor needs oil in order to be protected against wear. When running, oil leaves the compressor together with the refrigerant. The rate of oil loss is estimated as a function of compressor speed.

These are the three key control parameters which help to define the oil return cycle in the system.

- THERMO_SETUP_OIL_LOSS_TRIG_TIME_SEC : (**Time**) The oil return is executed if the speed stays below the oil return speed for a defined time.
- THERMO_SETUP_OIL_PWM_STEP : (**%**)The optimum defined oil return speed that can help again to maintain a proper oil level in the compressor.
- THERMO_SETUP_OIL_RETURN_HOLD_TIME_SEC : (**time**) The optimum time duration in which oil return back to compressor.

07.01. Oil Return Cycle: Example 1



Accumulated Time duration: T1≥ Defined Oil loss trig time.

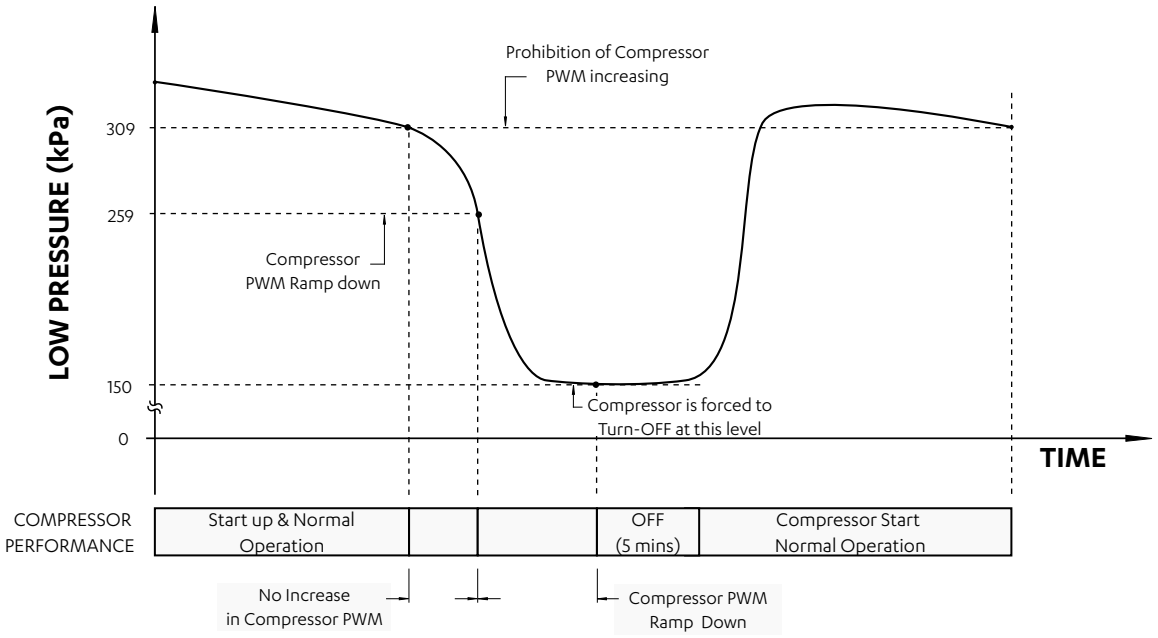
--- t1, t2, t3 are less then Oil return hold time.

08. System Protection

08.01. Low Pressure Protection Control

Low pressure transducer continuously checks system's low pressure during compressor operation. If it crosses its safe limits then controller ramp-down or hold the compressor PWM value to bring back the compressor to the safe or efficient operating envelope area.

Low Pressure Range (kPa)	Compressor Operation
$259 < P_s \leq 309$	Compressor will stop increasing the PWM value
$150 < P_s \leq 259$	Compressor will ramp down the PWM until the pressure goes back to > 259kPa.
$P_s \leq 150$	Compressor will be forced to turn-off and will be allowed to run once again after 5 mins.



08.02. High Compressor Ratio Protection

Controller look after the compresor ratio protection when Low Pressure is in 259 < LP < 812 range.

Low Pressure Range (kPa)	High Pressure Range (kPa)	Compressor PWM Action
292 < LP < 812	2164 < HP < 4040	PWM Ramp Down
303 < LP < 812	2164 < HP < 3833	PWM restricted to Ramp Up

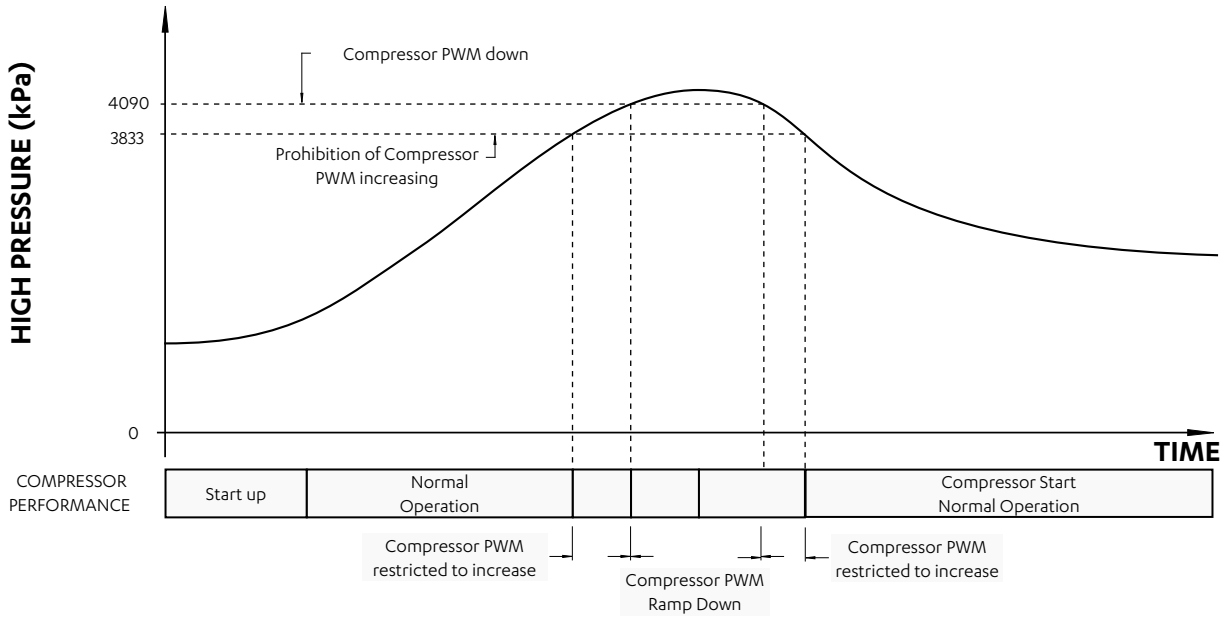
During this protection, logic will check both LP & HP value and decide the action of compressor PWM.

08.03. High Pressure Protection Control

High pressure transducer continuously checks the system's high pressure during compressor operation. Control logic, will control ramp-down or hold the compressor speed to ensure the compressor is safe & operating within envelope area.

Compressor High Pressure Protection control operates as follows:

- Normal compressor operation at Discharge Pressure less than 3833kPa.
- No increase in compressor PWM if Discharge Pressure is greater than 3833kPa.
- Decrease compressor PWM if Discharge Pressure is greater than 4090kPa.



Note: Above logic is applicable when low pressure is below 812 kPa.

08.04. Anti Freeze Protection

To prevent the indoor coil from freezing, anti-freeze protection logic has been designed into the system. If during normal operation, when the indoor coil temperature fall ≤5°C, Anti-Freeze Protection is activated.

During Anti-Freeze Protection:

- System will continue to operate at minimum capacity (20%) to achieve 10°C ID coil temp
- If ID coil temp is ≤ -5°C for 4 minutes, system will turn OFF, only start back if ID coil temp ≥ 13°C.
- Controller uses integral to maintain 7°C coil temperature.
- Anti-freeze will be exit when coil temp ≥ 15°C.
- Coil sensor timeout is 20 sec when connected/diconnected.
- During anti-freeze LC7 controller will flash the "low" speed light flash in every 30second.

08.05. Low Ambient Condition

If the Tamb < 10°c, then compressor PWM value cannot be less than 50%.

Note: Tamb can be selectable via LC7.

08.06. Sump Heating Protection

If the Tamb > 40°c, then compressor PWM value cannot be less than 50%.

Note:

- Tamb can be selectable via LC7.
- If Tamb is failed then Comp PWM ≥ 50%.

09. System Operation

09.01. Indoor capacity control

Indoor software calculates the indoor demand based on the difference between room and set tempearture. PI(Proportional and Integral) control algorithm few other variables on the page below helps to maintain the room temperature as close as possible to set temperature.

09.02. Differentials

Differential is defined as difference between Set Point and Room Temp at an instant of time. Differentials give a system accurate control of Cooling/Heating, to keep the temperature within a set band (difference) from the Set temp.

Cooling differential = (Room temp- Set Temp for Cooling)
Heating differential = (Set Temp – Room Temp for Heating)

The default value & range for the differentials is given on the page below, these values are settable through the LC7.

Note: During Auto mode, the control algorithm will decide the mode based upon differential. After this it will follow the dead-band to restrict the unnecessary change over from Heat to Cool or Cool to Heat.

09.03. Compressor cut-in:

Controller will cut-in the compressor when the differential will be 0.2°C during the Cool\ Heat & Auto thermostat off condition.

Range = 0.2°C to 2°C
Default value = 0.2°C

09.04. Compressor cut-out:

Controller will cut-out the compressor when the differential will be 0.5°C during the Cool \ Heat & Auto mode.

Range = 0°C to 0.5°C
Default value = 0.5°C

09.05. Dead band:

Dead band prevents the system frequently shifting the mode of operation between heat and cool during the Auto mode.

Range: 1°C- 9.9°C, settable through the LC7.
Default value: 1.5 °C

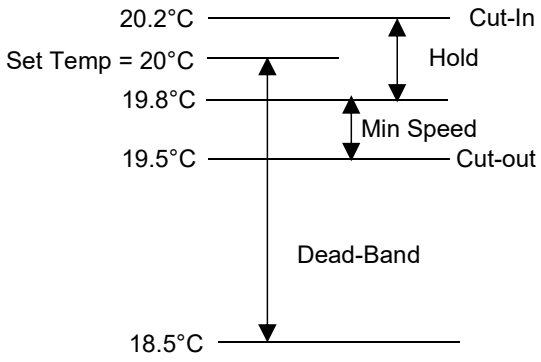
09.06. Compressor hold:

Controller holds the indoor capacity demand calculation PI value when the differential value will be +0.2 to -0.2

09.07. Compressor minimum value:

When the differential value will be +0.2 to -0.2 indoor control hold the demand request to the UNO board. UNO board follow the indoor request and keep running the compressor with requested hold speed.

Diagram which explain about the above terms:



Note: above diagram is applicable for Heating, Cooling, Auto mode.

Note: Once the unit stops because of zero demand request, it must then complete the must off time of 3min before checking for mode and compressor request. This is applicable in all modes including auto. After completing the must-on-timer controller will check the mode and speed request.

09.08. Economy Cycle (Outside Air Damper 0-10V)

Based on settings from the wall controller or BMS, a fixed 0-10V ECON voltage output can be set. This fixed voltage value can be set through the LC7 Wall Controller's Service Menu - 10

Range:0 to 10V
0=> Closed (0%)
10V => Fully open (100%)
Default setting: 2.5V

09.09. Indoor Fan Filter:

The filter clean alarm can be enabled, disabled or reset based on settings from the wall controller or BMS. The filter alarm timer counts down only when the indoor fan is running. Upon countdown to zero, the wall controller will indicate the filter alarm along with the filter notification relay output in the indoor board PCB. Filter related settings can be set through the LC7 Wall Controller's Service Menu - 8

Default: 200 hrs

Setting range: 0 - 990 Hour

10. Fault and Status Codes

Error Codes Display LC7 / ODB	Category	FUNCTION / FAULT
E1	IDU	Indoor Fan RPM feedback Error
E2	IDU	Indoor Coil Sensor Error
E3	IDU	Indoor Room Temperature Sensor Error
E6	ODU	High Discharge Line Temperature
E7	ODU	Outdoor Coil Sensor Error
E8	ODU	Outdoor Discharge Temperature Sensor Error
E9	ODU	LP Switch Trip
E10	ODU	LP Transducer Error
E11	ODU	HP Switch Trip / Phase Sequence Relay Fault
E12	ODU	HP Transducer Error
E18	ODU	Suction Temperature Sensor Error
E22	ODU	Ambient Sensor Error
E50	ODU	Outdoor Board Configuration Error
E51	IDU / ODU	Indoor - Outdoor Communication Error
E52	IDU	Indoor - Wall Controller Communication or Multiple ID on Wall Controller
E56	IDU	No Master Wall Controller Detected

NOTE

When unit is powered up, “boot” will show in 7 segment display of outdoor board for 30 seconds, followed by normal controller status codes.

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That's better. That's Actron.

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