HMH7 Split Outdoor Units

Field Reference Guide

Updated July 2023

Johnson Controls

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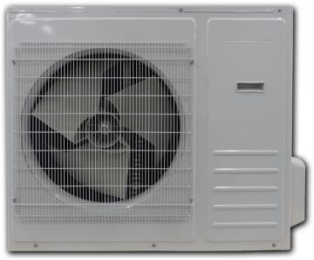
Introduction

Application

The HMH7 horizontal discharge heat pump offers quiet, efficient operation in a compact package. HMH7 outdoor units are matched with approved air handlers. The purpose of this Guide is to provide component-level detail for use during installation and service. It is NOT intended to replace the documentation provided with the product. ALWAYS read and completely understand all requirements provided.



The information provided here is based on the latest available information. As new information becomes available, this Guide updates automatically, whether viewing through the web browser or through the Inkling app.

Model Digit Numbers

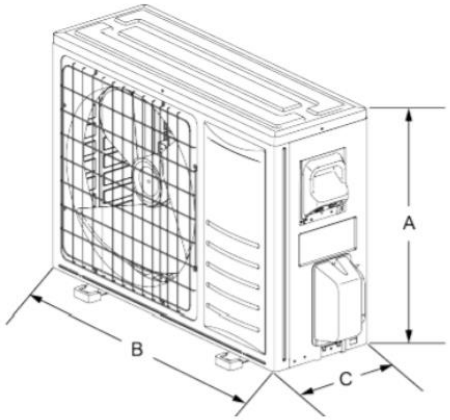
Each digit in the HMH7 model number provides insight as to the product capacity, configuration, and other characteristics. The digit meanings are identified below.

Configuration	H	H = Horizontal discharge
Stages	1	1 = 1 stage
		2 = 2 stage
		3 = 3 stage
		M = modulating
		V = variable capacity
Product Type	C	C = Air conditioner
		H = Heat pump
Efficiency	7	3 = 13 SEER
		4 = 14 SEER
		5 = 15 SEER
		6 = 16 SEER
		7 = 17 SEER
		8 = 18 SEER
		9 = 19 SEER
Voltage	2	2 = 208/230-1-60
		3 = 208/230-3-60
		4 = 460-3-60
Refrigerant	B	B = R-410A
		D = R-454B
Capacity	24	12 = 1 ton
		18 = 1.5 ton
		24 = 2 ton
		30 = 2.5 ton 34 = 3 ton
		36 = 3 ton
		42 = 3.5 ton
		48 = 4 ton
		60 = 5 ton
Generation	1	1 = 1st Generation
		2 = 2nd Generation
Control strategy	S	C = Communicating
		B = Wireless (communicating
		S = Standard (conventional)
		W = Wireless (conventional)
Style	A	A = Style A
		B = Style B

Dimensions

HMH7 dimensional data is provided below, along with refrigerant line connection sizes.

Unit Model	Dimensions (in.)			Refrigerant Connections Service Valve Size (in.)	
	A	B	C	Liquid	Vapor
HMH72B241S	26 3/8	33 7/8	12 1/4	3/8	5/8
HMH72B34/361S	33	33 3/8	13 3/8		3/4
HMH72B481S	54 5/8	37 3/8	13 3/8		7/8
HMH72B601S	54 5/8	37 3/8	13 3/8		7/8



Temperature Limitations

The HMH7 horizontal heat pump has the following outdoor temperature limitations for heating and cooling. Operation outside of these limitations causes capacity issues and possible equipment lockouts.

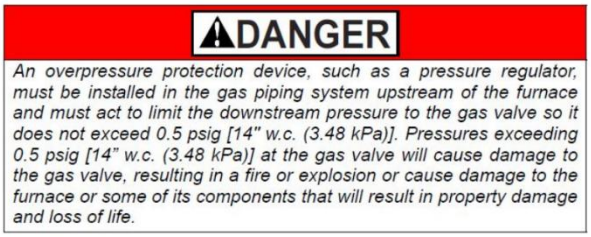
Ambient Temperature Limits	Outdoor Coil °F (°C)	
	DB Cool	DB Heat
Minimum	35 (2)	-5 (-21)
Maximum	122 (50)	75 (24)

02

Safety

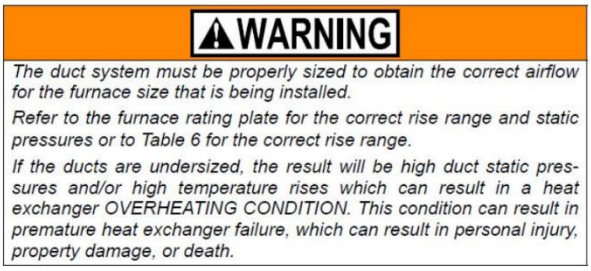
Safety Symbols

Reminder – use this manual in conjunction with the technical literature for each product. This manual Does Not Supersede the Installation Manual and Technical Guide provided with the equipment. Always read and follow all instructions before installing equipment. Understand and pay particular attention to the signal words **DANGER**, **WARNING** or **CAUTION**.



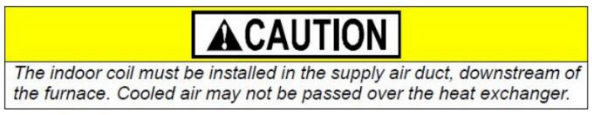
Sample Danger Label

DANGER indicates an imminently hazardous situation which could result in death or serious injury.



Sample Warning Label

WARNING indicates a potentially hazardous situation which could result in death or serious injury.



Sample Caution Label

CAUTION indicates a potentially hazardous situation, which, if not avoided, may result in minor or moderate injury. It is also used to alert against unsafe practices and hazards involving only property damage.

Safety Specific Rules

Follow these specific safety rules for a safe application:

- Air conditioning systems utilizing gas heating can only use natural gas or propane (LP) gasses as an approved fuel. LP applications require installation of the appropriate LP conversion kit. Refer to the unit rating plate or Installation Manual for information on proper inlet and manifold pressures.
- Install air conditioning systems only in locations and positions as specified in the Installation Manual.
- Provide adequate clearances for service, combustion, and ventilation air to the unit. The recommended clearances are specified in the Installation Manual.
- Test for gas leaks as specified in the Installation Manual.
- Only connect the equipment to a duct system which has an external static pressure within the allowable range as specified in the Installation Manual.
- These unites are not to be used for temporary heating or cooling of buildings or structures under construction. Improper installation will shorten equipment life, reduce product efficiency, and void the warranty.
- Always install the systems to operate within the equipment's intended temperature and operating ranges.
- The size of the unit should be based on an acceptable and approved heat load calculation for the structure being conditioned.

Safety Requirements

Follow these safety requirements for a safe application:

- All equipment should be installed in accordance with all national and local building/safety codes and requirements, local plumbing or wastewater codes, and other applicable codes. In the absence of local codes, install in accordance with the most recent National Electrical Code, National Fuel Gas Code and/or Natural Gas and Propane Installation Code (latest editions). Furnaces have been certified to the latest edition of standard ANSI and CSA standards.
- Only approved heat accessories shall be installed on these air conditioning units local.
- Refer to the unit rating plate for the equipment model number, and refer to the Installation Manual for proper air plenum dimensions.
- Provide clearances from combustible materials as listed under Clearances to Combustibles in the Installation Manual and the equipment rating plate.
- Provide clearances for servicing ensuring that service access is allowed for both the burners and indoor fan motor.
- Provides clearances for servicing.
- Failure to carefully read and follow all instructions in this manual and the equipment Installation Manual can result in equipment malfunction, death, personal injury and/or property damage.
- Check the rating plate and power supply to be sure that the electrical characteristics match. All commercial 15 through 25-ton units distributed in North America use nominal 208/230 volts AC, nominal 460 volts AC, or nominal 575 volts AC 3 Phase, 60-Hertz power supply. DO NOT CONNECT THIS APPLIANCE TO A POWER SUPPLY OR A VOLTAGE OTHER THAN THE RANGE SPECIFIED ON THE UNIT DATA TAG.
- The equipment shall be installed so the access panels are readily available, and the electrical components are protected from water infiltration.
- Installing and servicing HVAC equipment can be hazardous due to the electrical and mechanical components. Only trained and qualified personnel should install, repair, or service HVAC equipment. When working on equipment, observe precautions in the manuals and on the labels attached to the unit and other safety precautions that may apply.
- The Installation manual covers minimum requirements needed to conform to existing national standards and safety codes. In some instances, these instructions exceed certain local codes and ordinances. These instructions are required as a minimum for safe installation and operation.

General Awareness

Safety is ALWAYS the primary concern for everyone. On the job injuries can be significantly reduced when proper guidelines are followed. Always be aware of all company, local, state and/or OSHA (Occupational Safety and Health Administration) regulations.

Jobsite Safety

Keeping the job site clean of trash, extra tools and equipment will significantly reduce the chance for injuries. Since each job is unique and has its own hazards, all new workers to the area should be made aware of the location of hire and first-aid equipment, fire escape routes, and other dangers.

Hazardous Materials

Many different chemicals and compounds are used in the service and installation of HVAC systems. Please read the directions and use caution along with PPDs whenever handling these materials. Read and understand the MSDS for all materials used.

Confined Spaces

Never enter or work in a confined space without taking the appropriate precautions. Have someone available outside the space ready to assist or summon help if necessary. Even spaces that seem relatively safe can quickly become hazardous if a pipe were to break and fill the space with refrigerant, steam, poisonous fumes or other gasses. Welding or brazing in a confined space is especially hazardous.

Pressure

High pressures have always been part of the HVAC profession. Wear the proper personal protective devices including safety glasses and gloves. Proper hose ratings and manifolds are required for high-pressure refrigerants.

Electrical Safety

Jewelry should be removed prior to any electrical work being performed. Ensure that the equipment disconnect switch removes the primary power source prior to taking resistance readings or disconnecting any wires or connections. Removal of system power should be verified with the voltage function of a multimeter. All electrical safety guidelines should be always followed. Only trained, qualified technicians should perform electrical maintenance, installation, inspections and troubleshooting of electrical equipment.

Electrocution occurs when a current as low as 6 to 200mA flows through the heart, disrupting its normal operation and causing death. Electrical shock is an injury that occurs because of exposure to an electrical current. Inspect all extension cords and power tools regularly. Fuses and circuit breakers are designed to protect equipment, not people. For personal electrical protection, GFCI or Ground Fault Circuit Interrupters are highly recommended.

Lock-Out Tag-Out

OSHA Standards cover the servicing and maintenance of machines and equipment, in which unexpected energizing or startup of the machines or equipment, or release of stored energy, could cause injury to employees.

These standards establish minimum requirements for the control of such hazardous energy. To ensure safety, put a lock that is tagged with the technician’s name on the electrical disconnect or breaker of the equipment or circuit which is being serviced.

Be aware of others who may be working on the same circuit or other circuits served by the same electrical panel. The technician should also be aware that other technicians may not have used the proper Lock-Out, Tag-Out procedures.

Fire Safety & Burns

While brazing, keep the area clear of combustible material or use a heat shield to help reduce risk of fire.

Check equipment regularly and never try to modify or repair regulators.

While servicing the refrigeration circuit, improper use of equipment and tools can result in serious burns that are associated with refrigerants. This may include frostbite, which is a deep tissue injury. Proper personal protection devices must be in use when servicing the refrigeration system.

Personal Safety

Personal safety always includes remaining aware of the surroundings, using properly maintained tools, and correct use of items designed for personal protection.

Personal Protection Devices (PPD)

- Hard Hat: Hard hats must be worn when there is a danger of head injury.
- Safety Glasses: Eye protection should be worn at all times while on a job site.
- Gloves: Assist in the prevention of serious injury to the hands from serious cuts as well as injuries from high-pressure gasses such as refrigerants. Rubber gloves can protect the technician's hands from chemicals when inspected and worn properly.
- Safety Shoes: Work shoes with steel toes for foot protection. There are also electrical safety shoes that can aid in protecting the technician against electrical shock and/or electrocution. At a minimum, leather work shoes with rubber soles are required.
- Respirator: Used in a confined space where the air can be dissipated by refrigerant which can cause asphyxiation.
- Safety Harness: Used when working above grade level. Ladders must be tied down. Ensure that PPDs provide the intended protection. They should be inspected regularly, used properly and never altered or modified in any way.

Clothing

Rotating and moving components pose a serious risk. Loose fitting clothing and ties should not be worn when servicing rotating equipment. If any clothing becomes entangled in moving parts, serious injury or death is a likely result.

Jewelry

Serious injury or death can result if jewelry contacts an energized circuit or is caught in moving parts. Leave jewelry at home or in your service bag or service vehicle.

Lifting

To avoid back injuries, always adhere to proper lifting techniques. Be aware of personal limitations and seek help with items that are too heavy to safely lift. A back support belt may provide additional protection.

03

Component Familiarization

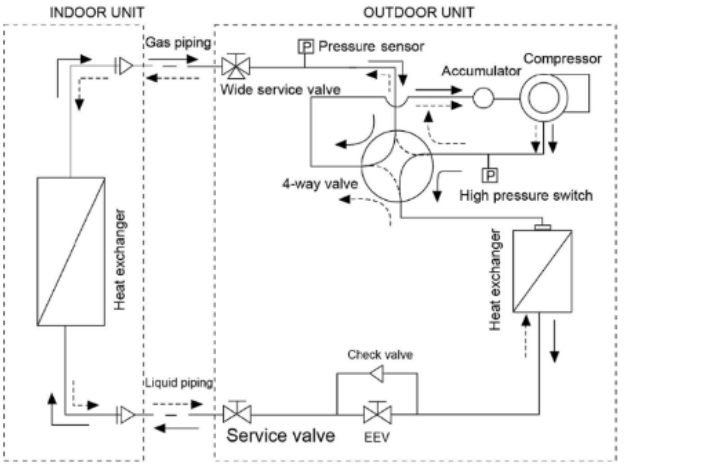
Component Familiarization

Click here to view the HMH7 Introduction and Components video.

Note: Log in to Navigator prior to viewing the video.

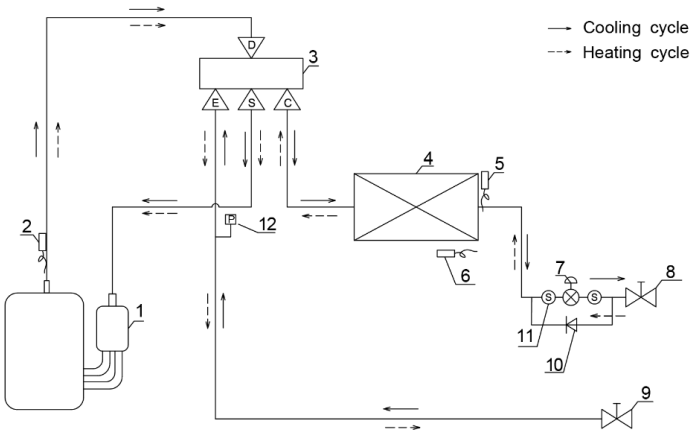
Refrigerant Flow Diagram

The refrigerant flow in heating modes of the HMH7 system is illustrated below. Note the presence of a 4-way valve (reversing valve) and an EEV (electronic expansion valve) in the outdoor unit.



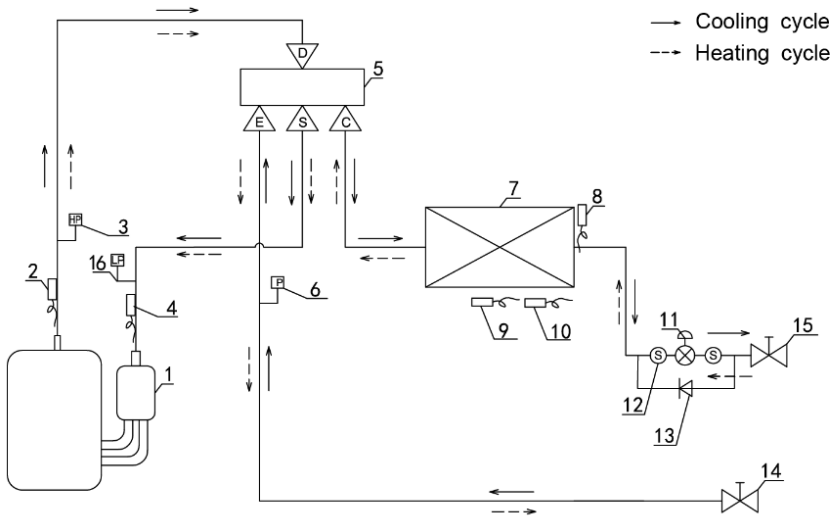
HMH7 Refrigerant Flow Chart

: Outdoor unit - HMH72B24, HMH72B34, and HMH72B36



No.	Description	No.	Description
1	Compressor	7	Electronic expansion valve
2	Discharge temperature	8	Stop valve (liquid)
3	4-way valve	9	Stop valve (vapor)
4	Outdoor heat exchanger	10	One-way valve
5	Coil temperature sensor	11	Strainer
6	Ambient temperature sensor	12	Pressure sensor

Outdoor unit - HMH72B48 and HMH72B60



No.	Description	No.	Description
1	Compressor	9	Coil temperature sensor
2	Discharge temperature sensor	10	Defrost temperature sensor
3	High pressure switch	11	Electronic expansion valve
4	Suction temperature sensor	12	Strainer
5	4-way valve	13	One-way valve
6	Pressure sensor	14	Stop valve (vapor)
7	Outdoor heat exchanger	15	Stop valve (liquid)
8	Ambient temperature sensor	16	Low pressure switch

HMH7 Control Boards

The control boards present on HMH7 systems depend on system capacity.

The 24, 34 and 36 heat pumps use a single control board containing an IPM (Intelligent Power Module) or Drive, contained on the main control board. The 24, 34 and 36 models provide a small display board for fault codes, unit function dip switches, and parameter set-up buttons.

The 48 and 60 heat pumps feature three boards: a main control board, an IPM board, and a voltage filter board. The display is visible on the main control board.

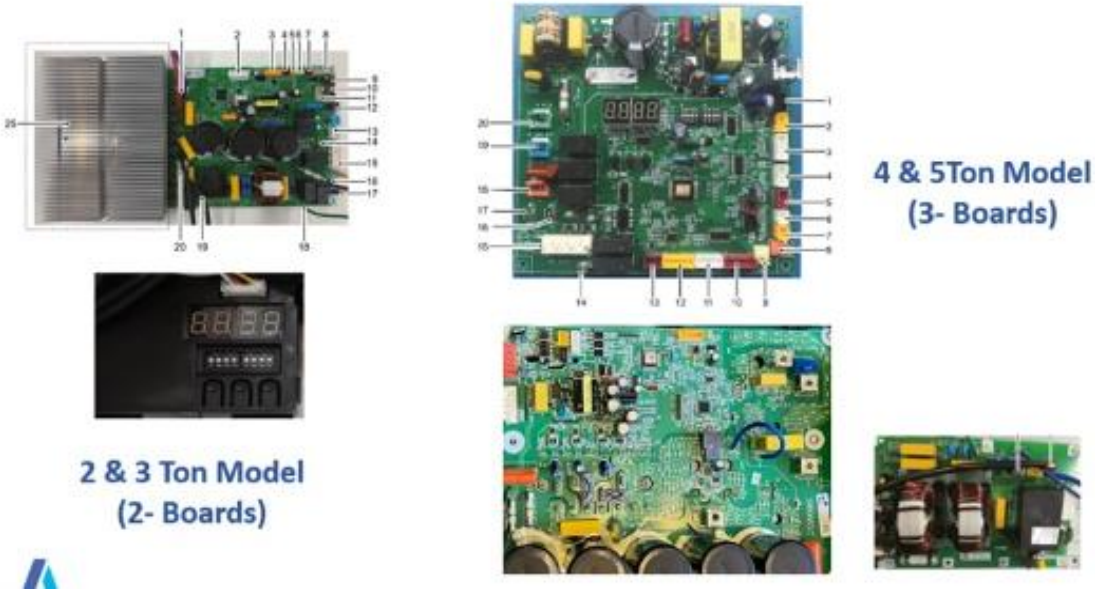
Top Panel Removal (2-3 Ton)

Main Control Board (Under Top Panel)

Control Boards

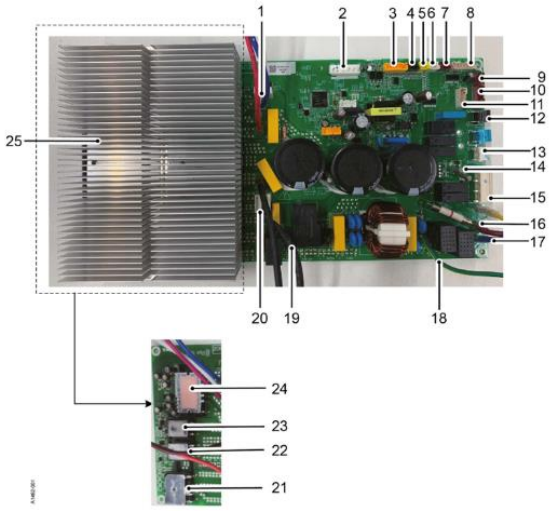
2- and 3-Ton vs 4 and 5 Ton

On the HMH7 2- and 3-ton models, there are 2 control boards that control the operation of the cooling and heating. The 4- and 5-ton models use 3 control boards that control the operation of the cooling and heating.



On the left are the two control boards for the 2- and 3-ton models. On the right are the three control boards for the 4 and 5-ton models.

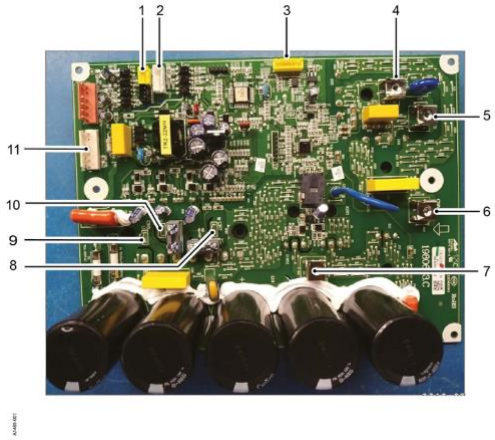
HMH7B24/34/36 Control Board



No.	Description	No.	Description
1	Compressor	14	Heater
2	DC fan	15	SI
3	EE	16	AC power LIN
4	Coil temperature sensor	17	AC power NIN
5	Ambient temperature sensor	18	GND
6	Discharge temperature sensor	19	Reactor L2
7	Overheat protector	20	Reactor L1
8	Electronic expansion valve	21	Rectifier bridge
9	High pressure	22	IGBT
10	SW	23	Diode
11	Computer/checker	24	IPM
12	4-way valve	25	Radiator
13	Electric heating belt		

HMH7B24/36 Control Board and Connections

HMH72B48/60 (IPM) Intelligent Power Module

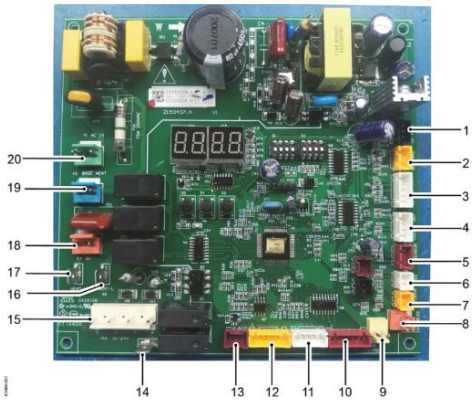


No.	Description	No.	Description
1	DC fan signal	7	Reactor L2
2	IPM-SI	8	Compressor W
3	EE	9	Compressor U
4	NIN	10	Compressor V
5	LIN	11	Driver
6	Reactor L1		

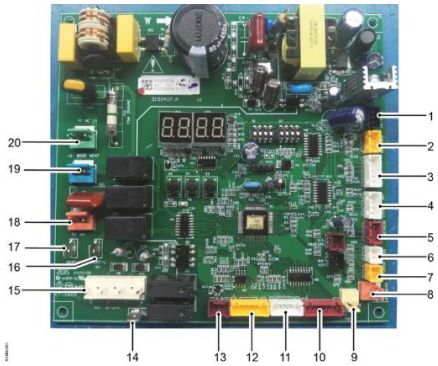
HMH72B48/60 (IPM) Intelligent Power Module (Drive Control Board)

The IPM Drive control is mounted on a metal plate that swings out for easier access. The IPM control sits directly behind the main control board, which is mounted on the opposite side of the metal plate.

HMH72B2448/60 Control Board



No.	Description	No.	Description
1	DC fan Driver1	11	Checker
2	DC fan Driver2	12	EEPROM
3	IPM-SI	13	PTC control signal
4	Defrost/Coil temperature sensor	14	H signal
5	Pressure sensor	15	Communication signal
6	Discharge temperature sensor	16	Electric heating belt
7	Ambient temperature sensor	17	Electric heating belt
8	High pressure switch	18	4-way valve
9	Low pressure switch	19	Base heater
10	Electronic expansion valve	20	AC power



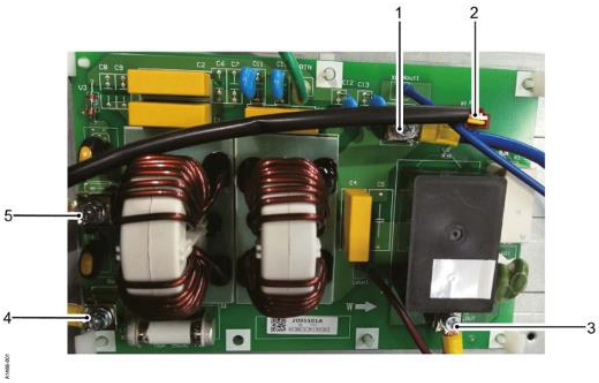
No.	Description	No.	Description
1	DC fan Driver1	11	Checker
2	DC fan Driver2	12	EEPROM
3	IPM-SI	13	PTC control signal
4	Defrost/Coil temperature sensor	14	H signal
5	Pressure sensor	15	Communication signal
6	Discharge temperature sensor	16	Electric heating belt
7	Ambient temperature sensor	17	Electric heating belt
8	High pressure switch	18	4-way valve
9	Low pressure switch	19	Base heater
10	Electronic expansion valve	20	AC power

HMH62B2448/60 Control Board and Connections

The control board for the HMH7-4 and 5 ton

The control board for the HMH7 4- and 5-ton models is located on a swinging metal plate behind the front right access panel. The IPM Drive control is directly behind the metal swinging metal plate.

HMH7 48-60 Filter Board



No.	Description	No.	Description
1	N out	4	LIN
2	PTC control signal	5	NIN
3	L out		

HMH7 48-60 Filter Board

Display Board

The display board is present on a 2- and 3-ton models and is located left of the power and low voltage terminals. It displays both parameter and fault code readings. This board displays both types of readings by using the three buttons below the dip switches. The dip switches initiate system pump down, a forced defrost, and set up as cooling only unit if needed. Smart Energy Management is not used at this time.

These settings appear below. The 4- and 5-ton models contain the display and settings on the main control board.

Display Board on 2 & 3 Ton Models

Setting method 24K/36K

S4 Dip switch setting		S5 Dip switch setting	
Factory setting		Factory setting	
Pump Down Switch		Smart energy management	
Forced defrost		Cooling Only	

See later in Chapter 6 Sequence of Operation, on how these settings can become an important tool while setting up the HMH7 and how to use it also in troubleshooting.

Compressor

The HMH7 heat pump features a 208/230 volt, 3 phase, DC inverter-driven twin rotary compressor. The modulation range is between 25% and 110% capacity.

The HMH7 Twin Rotary Compressor with Accumulator and Crankcase Heater

The twin rotary inverter compressor design reduces friction during operation for smoother rotation with less vibration, resulting in quieter operation.

The rotary compressor modulates speed based upon the frequency received from the control board. The minimum and maximum frequencies are illustrated below, separated by outdoor unit capacity.

Unit	ODU Model No.	Minimum Compressor Frequency (Hz)	Maximum Compressor Frequency (Hz)
24k	HMH72B241S	15	75
36k	HMH72B361S	22	95
48k	HMH72B481S	15	92
60k	HMH72B601S	18	95

Modulating Compressor Frequencies

Extrapolation of the frequency data appears below, assuming linear modulation between 25% and 110% with the frequency ranges stated above.

Accumulator

HMH7 horizontal discharge units contain an accumulator as a part of the compressor assembly. The accumulator prevents liquid refrigerant from returning to the compressor. The accumulator is constructed to allow the liquid refrigerant to drop to the bottom of the cylinder. The suction line is attached to the outlet of the accumulator and pulls vapor from the top of the cylinder, providing additional protection against liquid flood back to the compressor.

Condenser Coil

The HMH7 has a split “fin and tube” style condenser coil. It contains two layered condenser coils, but it functions as a single condenser coil.

HMH7-36 Condenser Coil without Wire Coil Guard

A clean, unobstructed coil maximizes heat transfer capabilities and improves the overall efficiency of the system. During installation, be sure to follow all recommendations regarding minimum spacing and clearances from surrounding structures and other equipment.

Sensors

The HMH7 uses four sensors and a temperature overload inside of the compressor to prevent overheating of the compressor windings. The four sensors include:

- Discharge Line Sensor
- Coil Sensor (Defrost Sensor)
- Outdoor Ambient Sensor
- Suction Sensor

Temperature/resistance data for the thermistors appears below.

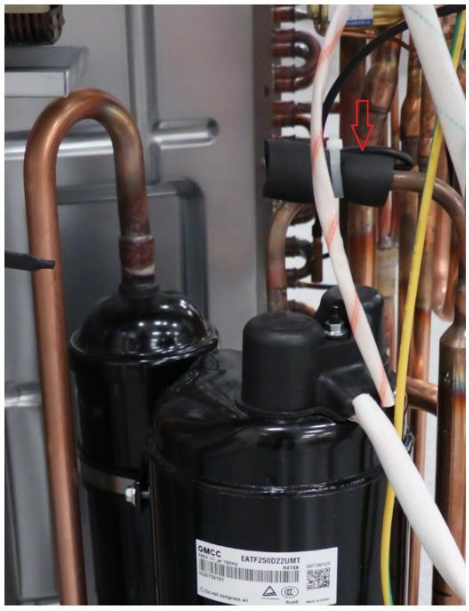
Suction and Discharge Line Sensors

T [°C]	Rmin [kΩ]	Rnom [kΩ]	Rmax [kΩ]	Dev(MIN)%	Dev(MAX)%
-30 (-22 F)	908.2603	985.5274	1065.1210	-7.84	7.47
-15 (5 F)	384.2888	413.3808	442.9105	-7.04	6.67
0 (32 F)	175.4533	187.2500	199.0468	-6.30	5.93
15 (59 F)	85.4114	90.4842	95.5398	-5.61	5.29
30 (86 F)	44.1034	46.4046	48.6960	-4.96	4.71
45 (113 F)	23.9697	25.0632	26.1488	-4.36	4.15
60 (140 F)	13.6400	14.1799	14.7154	-3.81	3.64
75 (167 F)	8.0951	8.3705	8.6440	-3.29	3.16
90 (194 F)	4.9853	5.1292	5.2726	-2.81	2.72
105 (221 F)	3.1632	3.2491	3.3353	-2.64	2.58

Outdoor ambient and coil temperature sensor

T [°C]	Rmin [kΩ]	Rnom [kΩ]	Rmax [kΩ]	Dev(MIN)%	Dev(MAX)%
-30 (-22 F)	60.78	64.77	68.99	-6.16	6.12
-15 (5 F)	29.07	29.97	30.89	-3.00	2.98
0 (32 F)	14.70	15.00	15.29	-2.00	1.90
15 (59 F)	7.804	8.021	8.240	-2.71	2.66
30 (86 F)	4.355	4.550	4.753	-4.29	4.27
45 (113 F)	2.558	2.701	2.850	-5.29	5.23
60 (140 F)	1.551	1.654	1.762	-6.23	6.13
75 (167 F)	0.9676	1.041	1.120	-7.05	7.05
90 (194 F)	0.6188	0.6718	0.7291	-7.89	7.86
105 (221 F)	0.4056	0.4440	0.4859	-8.65	8.62

The discharge line sensor is located on the discharge line leaving the compressor. The discharge line sensor monitors the discharge line temperature to prevent compressor operation when the discharge line temperature becomes excessive.

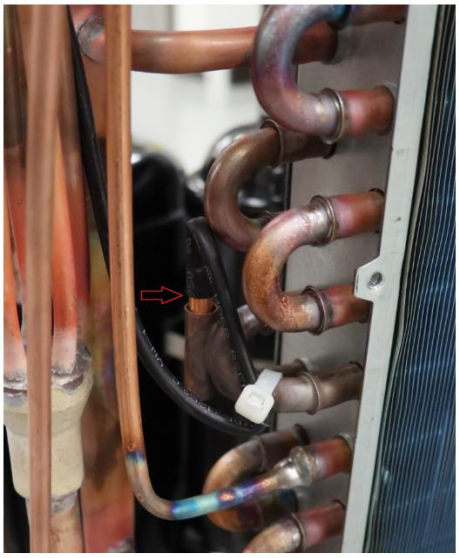


Discharge Line Sensor

The coil sensor monitors the temperature of the refrigerant entering the outdoor coil. The coil sensor relays temperatures to the control board to initiate defrost in the heating mode.

The outdoor ambient sensor monitors the temperature present at the outdoor coil. The outdoor sensor determines modulation speeds compressor and outdoor fan speeds as needed with ambient temperatures. The outdoor sensor senses when the ambient temperatures exceed the unit's application design and reduces system capacity (or eventually locks the unit out) until more desirable temperatures return.

The pressure sensor (3 wire) is in the outdoor unit's suction line (used in cooling mode) and hot gas line (used in heating mode). In the cooling mode, the pressure sensor along with the outdoor sensor provides input for the main control to determine if increased or reduced capacity is needed.


Coil Sensor


Outdoor Ambient Sensor

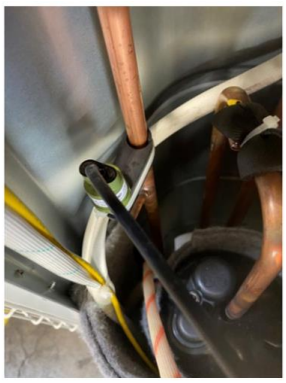
Pressure Switches

4- and 5-Ton Models

The HMH7 4- and 5-ton models have both a high-pressure switch and a low-pressure switch.

The high-pressure switch opens a 600 PSIG and resets or closes back at 464 PSIG. The low-pressure switch opens at 7 PSIG and closes back at 22 PSIG.

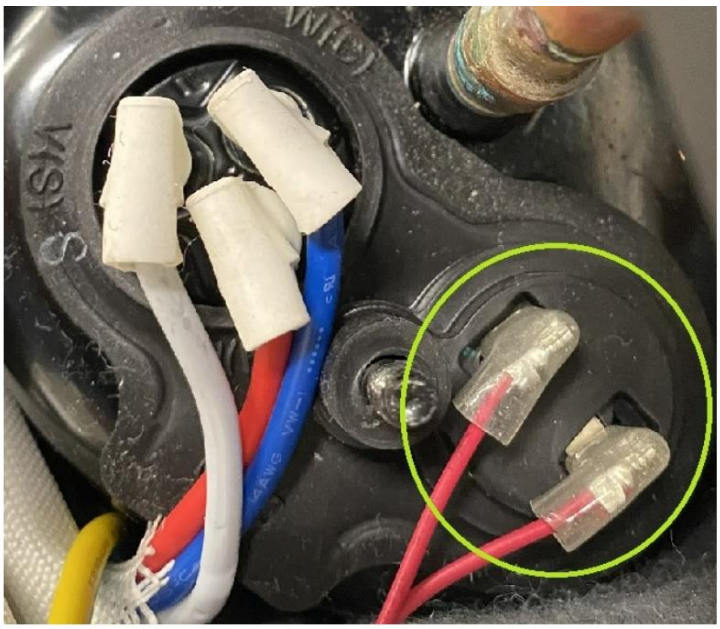
When either the high- or low-pressure switches open the HMH7 heat pump with cycle off. If the high-pressure switch opens the display board will show a fault code 14. If the low-pressure switch opens it will display a fault code 15.



The high-pressure switch is displayed on the left and the low-pressure switch is displayed on the right-hand side.

Compressor Over-Temp Sensor

The HMH7 used a thermo-disc type to protect the compressor from over-heating. This disc is located directly to the right of the compressor's winding connections. This disc opens at approximately **240°F** and resets when the disc cools to 205°F. When this disc opens in an over-heated condition the control board displays a fault code 13.



Compressor Over-Heat Thermo-Disc

Inductor (Reactor)

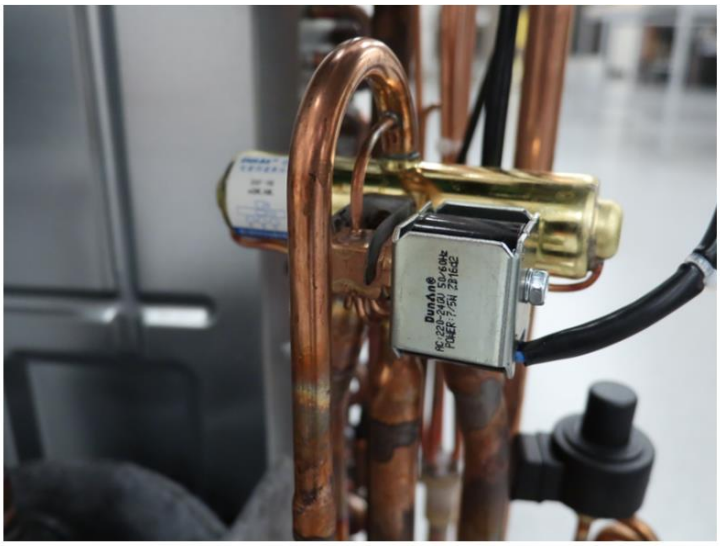
The inductor is identified as a “reactor” in the Installation Manual. The inductor on the HMH7 reduces the inrush current, reduces harmonic waves and improves the power factor.

Inductor (Reactor)

Reversing Valve

(4-Way Valve)

The HMH7 reversing valve (referred to as a 4-way valve in the Installation Manual) switches the direction of flow of refrigerant when heating versus cooling. The reversing valve solenoid is energized in the heating mode on the HMH7; the system operates in cooling mode when the reversing valve is not energized. Note the “B” terminal makes the 24-volt signal to make the reversing valve switch to heat; however, the voltage that energizes the reversing valve’s coil is line voltage (240 volts).



Reversing Valve (4-Way Valve) **Note: The voltage applied to the reversing valve coil is line voltage (240 volt)**

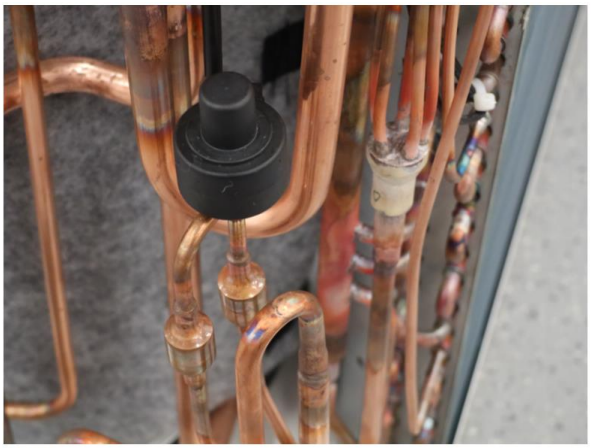
On a call for heat, the reversing valve sends high-temperature, high-pressure vapor from the compressor to the indoor evaporator coil. When the system is in cooling mode, the reversing valve is de-energized the high temperature, high-pressure vapor from the compressor is routed to the outdoor condenser coil.

Metering Devices

The HMH7 heat pump system has two metering devices. The outdoor heat pump uses an Electronic Expansion Valve (EEV) to meter the refrigerant flow in the heating mode. The indoor metering device is a TXV, located in the indoor evaporator coil section, and meters the flow of refrigerant during the cooling mode.

Electronic Expansion Valve (EEV)

The EEV meters the refrigerant flow of refrigerant in the heating mode. The EEV works in conjunction with a pressure sensor and temperature sensor. Both sensors send inputs into the control board which contains an algorithm input to control EEV position. In the cooling mode, the EEV closes fully and refrigerant flows through a check valve that is parallel to the EEV.



HMH7 EEV

Thermostatic Expansion Valve (TXV)

The matched indoor evaporator coil uses a TXV to meter the refrigerant in the cooling mode. The HMH7 systems are recommended for field charging by **WEIGHT ONLY**. The Tech Guide lists the additional charge required to maintain a matched system.

TXV Operating Forces

The TXV has three operating forces that control the flow of refrigerant through the system to maintain suction superheat at the evaporator outlet: one opening force and two closing forces.

Thermostatic Expansion Valve

1. Sensing Bulb Pressure (Opening):

The sensing bulb is the “opening force” of the TXV. It is located at the outlet of the coil, on the suction line, downstream of the header. It is mounted to the top of the suction line and measures the temperature of the suction line. As the load increases on the coil, the superheat and the suction line temperature increases. The sensing bulb pressure increases as the suction line temperatures increase. When the sensing bulb pressure increases, pressure is exerted on the TXV diaphragm. This opens the valve and allows more refrigerant to flow into the evaporator.

2. Spring Pressure (Closing):

The spring pressure is one of the “closing forces” on the TXV. The TXV assemblies on these units have a factory adjusted spring. This spring is non-adjustable. It is located in the body of the valve and exerts pressure on a set of push rods which are in direct contact with the diaphragm within the powerhead assembly. The pressure of the spring and the refrigerant pressure within the coil oppose the sensing bulb pressure.

3. Evaporator Pressure (Closing):

Evaporator pressure is another “closing force” on the TXV. The external equalizer line is a small capillary line that is attached to the top of the suction line at the outlet of the coil and downstream of the sensing bulb. This line allows coil pressure to be applied on the diaphragm. The pressure of the coil and spring oppose the sensing bulb pressure.

Liquid Line & Suction Line Service Valves

The HMH7 provides liquid line and suction line service valves in the center of the right side of the outdoor unit. The refrigerant access cover is perforated removable top for vertical line exit applications. The access cover also has an opening on the right to allow the refrigerant lines to run in a horizontal right direction.

HMH7 Refrigerant Line Access Cover

The outdoor unit is shipped with the service valves in the fully front seated (clockwise) position. The service valves isolate and hold the refrigerant charge in the condensing unit. Refrigerant lines are brazed at the indoor and outdoor connections during installation. The lineset and evaporator coil must be leak tested and evacuated down to 500 microns. After evacuation, the service valves must be fully back seated (counterclockwise). This releases the refrigerant into the lineset and evaporator coil.

The outdoor unit is shipped pre-charged with enough refrigerant for the condensing coil, 15 feet of lineset, and the smallest matched evaporator coil. If a longer lineset, TXV kit, or larger evaporator coil is required, additional refrigerant will have to be added as indicated in the Installation Manual. **Do not use charge adder data from other Ducted Systems products – this information is unique to the HMH7!** The outdoor unit must be matched with the proper indoor unit and coil if the system is to achieve system performance ratings. If the lineset is shorter than 15 feet, it may be required to recover refrigerant to meet the proper charge for the unit.


HMH7 Refrigerant Access Valves

Identify the type of refrigerant the equipment is rated for and use the corresponding manifold gauges and refrigerant when servicing any HVAC equipment. This will ensure proper operation and prevent equipment damage.

Liquid Line Filter Drier

Bi-flow liquid line drier

Packaged within the HMH7AK001 and HMH7AK002 is a bi-flow liquid line drier. The liquid line filter drier traps moisture, acid, and small particles, preventing contaminants from traveling through the system.

Since this liquid line filter drier is bi-flow (filters refrigerant, in both the heating and cooling cycle), the installed direction of the drier is not significant.

A restricted liquid line filter drier is diagnosed by taking a temperature measurement. Allow the system to operate for a minimum of ten minutes and take a temperature measurement on both sides of the drier. If the temperature differs by more than two degrees Fahrenheit, the drier must be replaced.

Caution
Caution must be taken when installing a liquid line filter drier in the system. Take precautions and use an approved heat sink to protect the metering device, new filter drier, and service valves when brazing.

The filter drier must be replaced if the refrigerant system is opened to the atmosphere. When the system is opened to the atmosphere, moisture can enter and contaminate the system causing equipment failure.

Blower Relay Kits

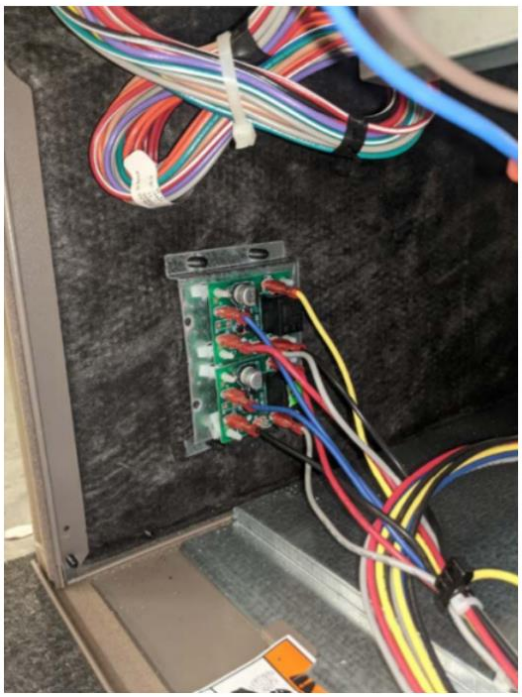
HMH7AK001

When matching the HMH7 with a Ducted Systems Standard ECM air handler, the HMH7AK001 blower relay kit is required to control blower speeds with the HMH7 modulating compressor's speed. This kit contains a bi-flow liquid line drier to be installed during installation. The relay kit should be installed before the field thermostat wiring for the indoor and outdoor control wiring. Proceed to connect the control wiring after the relay kit has been installed. Follow the numbered steps below:

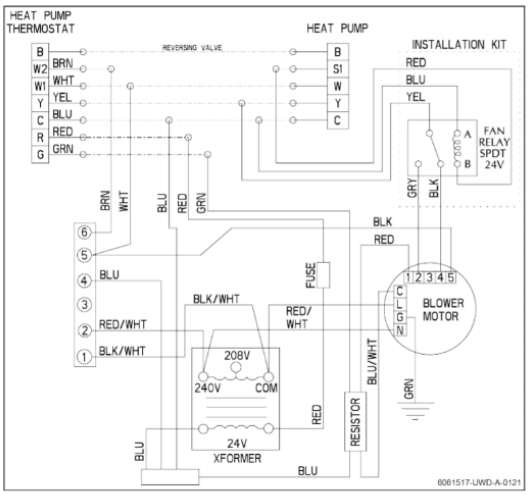
HMH7AK001 Blower Relay Kit Installed

1. When installing the HMH7AK001 Kit, remove the front control panel on the standard ECM air handler.
2. Remove the screw at the front of the control panel that secures the transformer. Do not remove the transformer wiring, move the transformer to allow access to the back panel.
3. Install the relay plate on the right side of the back panel. Use the existing four screw holes to mount the relay plate with #12 screws provided in the kit. With the relay plate installed, reinstall the transformer in its original place.

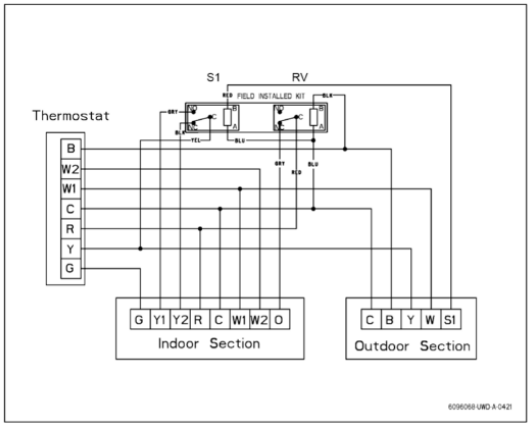
HMH7AK002



When matching the HMH7 with the Ducted Systems premium air handler or gas furnace, the HMH7AK002 relay kit is required. This kit also contains a bi-flow liquid line drier.



HMH7AK001 Wiring Diagram

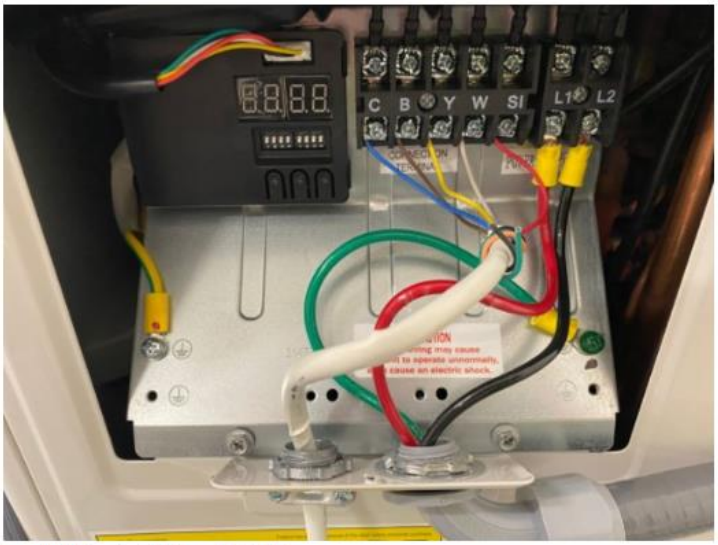


HMH7AK001 Blower Kit Contents

HMH7AK002 Blower Kit Contents

Power and Low Voltage Wiring

All equipment must have a properly rated and sized weatherproof disconnect switch located outdoors and within sight of the unit. Some municipalities may require a licensed electrical contractor to provide the line voltage electrical connections to the condensing unit from the electrical disconnect. All equipment must be protected, either by properly sized time-delay fuses or HACR-rated circuit breakers rated in accordance with the NEC.

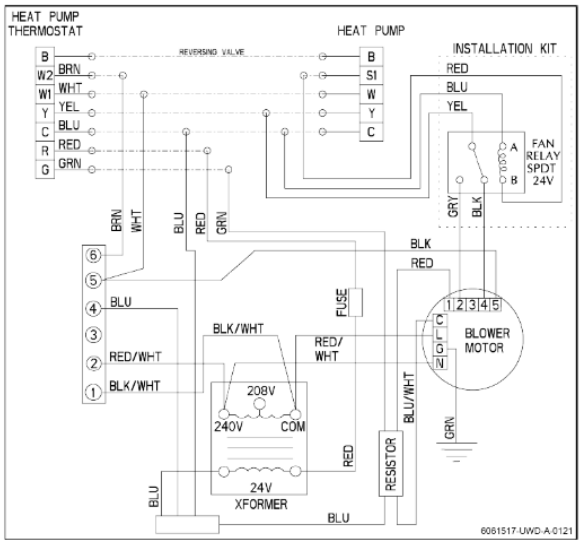


Incoming Wiring: Low Voltage and Line Voltage

On the HMH7, both the low voltage and line voltage or power wiring enters through a designated area above the refrigerant line connections. The low voltage connections labeled C, B, Y and S1 are located on the terminals located next to the display board. The line voltage terminals are located just to the right of the low voltage terminals and are labeled L1 and L2. The grounding terminal is located just below the line voltage terminals and has a green colored screw.

Control Wiring

All control wiring must be installed in accordance with the National Electrical Code and/or local city or state codes, whichever is more stringent. The complete electrical wiring diagram and schematics are located on the unit in the service access panel for reference. 18 gauge or larger control wire is preferred.



HMH7 wired with Standard ECM Air Handler/ with HMH7AK001 Blower Relay Kit

The HMH7 outdoor heat pump has the following terminals: B, S1, W and C. The HMH7 reversing valve (4-way valve) energizes in the heating mode through the “B” input terminal.

The HMH7 uses the “S1” output terminal to energize the coil of the blower relay. When the heat pump is operating in low load conditions and the modulating compressor is operating on lower speeds, the S1 terminal sends 24 volts AC to the blower relay kit which de-energizes the high speed on the indoor blower and energizes the reduced blower speed.

The “W” output terminal energizes the air handler’s first stage electric heat during the defrost mode.

The “Y” input terminal cycles the compressor on in both heating and cooling modes.

The “C” input terminal is the 24-volt common terminal.

Thermostat

Thermostat selection is critical when matching the heat pump with the air handler or furnace. A heat pump thermostat is required with the HMH7 heat pump.

The thermostat has manual selections for the occupant to adjust settings for heating or cooling, and set the indoor fan motor to ON or AUTOMATIC.

Thermostat terminal designations are:

- R – 24 volts AC Hot
- C – 24 volts AC Common
- W1 – Heat Call (First Stage Auxiliary Heat)
- W2 – Second Stage Auxiliary Heating (If necessary)
- Y1 – First Stage Cooling (First Stage heating)
- G – Indoor Fan Operation
- B – Reversing Valve (Energizes in Heating Mode)

If it the responsibility of the installing technician to read and adhere to the equipment and thermostat installation instructions to ensure that the equipment is matched and wired properly.

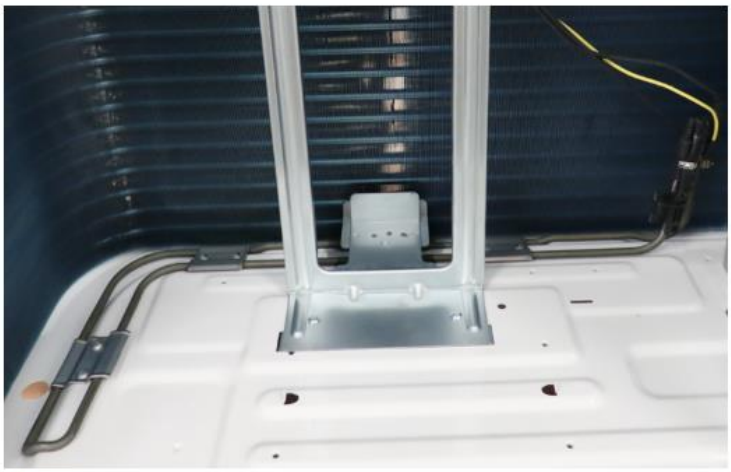
Heating Belt
(Crankcase Heater)

In the off cycle, the refrigerant migrates to the coldest area of the system. If liquid refrigerant reaches the compressor, it mixes with the refrigerant oil in the compressor crankcase, which may lead to compressor lubrication issues. The HMH7 uses a “heating belt” (crankcase heater) to eliminate the migration problem by slightly heating the compressor crankcase.

Compressor Heating Belt (Crankcase Heater)

Base Heater

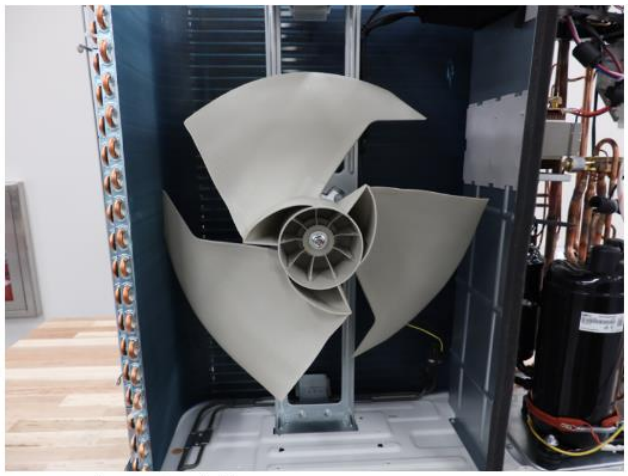
The HMH7 provides an electric heater found in the bottom of the condenser section. This is called the Base Heater and provides heat to the base of the unit to protect ice build-up in cold environments. Power to the heater is provided directly from the main control board.



Base Heater

Condenser Fan Motor

The HMH7 has either one or two condenser fan motors depending on capacity. The two and three-ton models have one condenser fan motor, while the four and five-ton models has two condenser fan motors. The condenser fan motor(s) are DC ECM motors that operate in parallel with the modulated speed of the compressor plus the input of the outdoor temperature sensor.



HMH7 3 Ton Condenser Fan Motor with Blade

HMH7 3 Ton Condenser Fan Motor without Blade

04

Installation

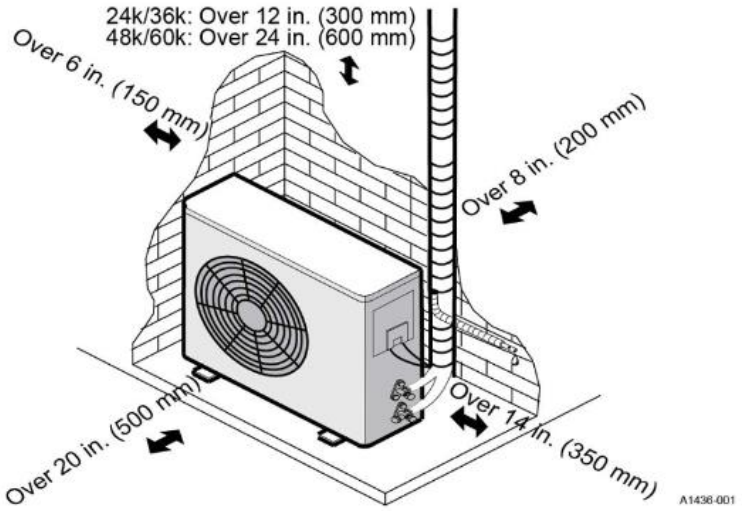
Introduction

Install heat pump units according to all current local, city, state and national laws and code requirements. If the equipment is installed outside of the United States, adhere to all laws and codes within the country. Follow the installation procedures specified in the Installation Manual. If the specifications are exceeded by code, or if code is exceeded by the specifications, adhere to the most restrictive code requirements.

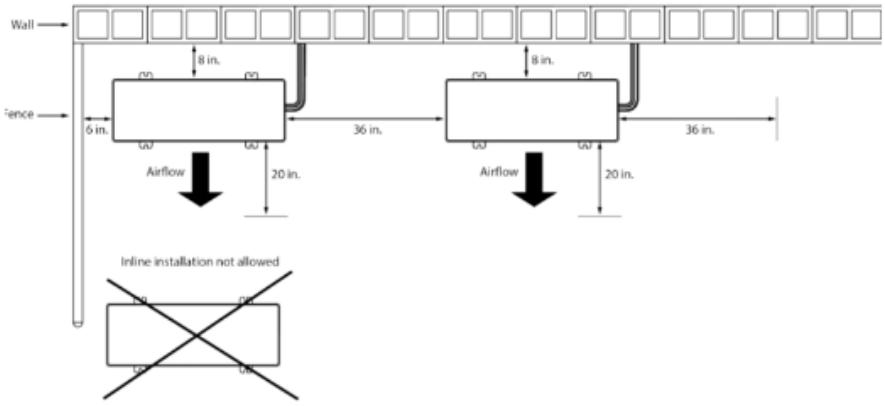
Location & Clearances

The HMH7 heat pump unit must be installed with proper clearances for airflow, servicing, and operation. Proper clearances are described in the Installation Manual that accompanies the unit. As shown in the second illustration, another HMH7 heat pump may not be installed directly in front or behind another HMH7.

Installation should be where operational noises are not objectionable indoors.



HMH7 Clearances



Additional Installation Clearances

Lineset

Refrigeration (ACR) copper is manufactured to meet the installation requirements for heat pumps and air conditioners. The tubing is cleaned internally, dehydrated, and capped at each end. The copper tubing should never be left uncapped for a prolonged period of time. If the copper is open to the atmosphere, moisture can accumulate within the tubing. This moisture can cause oxidation, extended evacuation and cleanup time, and damage to the system by producing acid.

The lineset must be installed where access is permitted to any portion of the equipment that may require future service or repair. Install the lineset with as few bends or elbows as possible to ensure that the refrigerant and oil will flow without being restricted. Use proper bending techniques when installing soft drawn copper. Any copper tubing that is distorted or kinked must be replaced.

Insulate the suction line using closed cell foam rubber with at least ½" wall thickness. Insulation of the liquid line may also be required if the line is exposed to direct sunlight or extreme temperatures, which may cause the refrigerant to flash before entering the metering device.

Model	Maximum Pipe Length (L)	Maximum Height Difference (H)	Additional Refrigerant – Exceeding 15 ft. (4.6 m)
	Ft (m)	Ft (m)	Oz/ft (g/m)
HMH72B24	164 (50)	98 (30)	.38 (11)
HMH72B34 HMH72B36	246 (75)	98 (30)	.38 (11)
HMH72B48, HMH72B60	246 (75)	98 (30)	.60 (17)

Refrigerant Line Limitations

Special Considerations

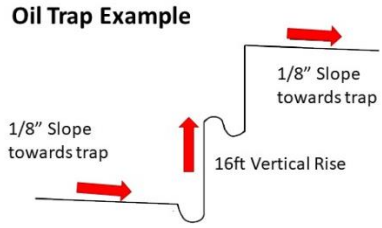
There are special considerations when installing a lineset:

- The use of approved conduit, such as PVC, must be used for all underground piping installations.
- The length of buried lineset must be kept to a minimum.
- The vapor in the suction line can condense during shutdown and cause liquid to flood back on start-up.
- Proper suspension of copper tubing with approved hangers is required to isolate and reduce vibration.
- If the lineset is installed through a wall, an approved protective sleeve and sealing compound must be used to seal the penetration and protect the lineset.

Oil Traps

On the HMH7, when the indoor unit is lower than the outdoor heat pump with the height difference being greater than 16 feet, suction line oil traps are required every 16 feet.

1. To avoid storing too much oil in the oil trap and to ensure better cooling and heating performance, the oil trap must be as short and as straight as possible.
2. The horizontal piping must slope toward the trap or outdoor section at a slope of 1/8 in/ft for proper oil return.



HMH7 Oil Trap Example

Brazing

All evaporator and condenser coil connections are copper-to-copper, which require brazing. Brazing temperatures exceed 800°F. At these temperatures, oxidation will form inside the copper tubing if dry nitrogen is not used to display oxygen during brazing. If oxidation forms, it will be released in the refrigerant flowing through the system during normal operation. If will accumulate in the filter drier and metering device causing improper operation and component failure.


Oxidized Fitting

Condensing units have both liquid and vapor service valves located on the corner post. The service valves are provided with 5/16" flare fittings. In order to connect a service manifold gauge set, a 5/16" to ¼" flare adapter must be used. The manifold set is also used to assist in purging the lineset with nitrogen.

Use heat sinks to prevent heat damage to the service valves, metering devices, filter driers, compressors, and the Microchannel coil. Wrap a wet rag around smaller components to provide protection during brazing. Use heat shields to protect property and equipment, including the structure, painted panels, wiring diagrams, data plates, and aluminum fins.

Braze joints using a phosphorous copper alloy material, such as Silfos 5, or an equivalent brazing alloy with at least 5% silver content. Do not use soft solder.

Silfos 5

When connecting the lineset, use the following procedures:

- Remove the Schrader valve cap and core from the liquid and vapor service valves at the new condensing unit.
- Low-pressure nitrogen must be slowly released through the liquid line service port into the lineset, and out of the vapor service port while brazing. A pressure regulator and safety valve must always be used on the nitrogen tank to ensure only low pressure is applied to the system. Nitrogen must be flowing continually while brazing.
- The liquid line must be brazed to the liquid line service valve on the condensing unit. **The valve body must be wrapped with a wet rag to minimize the amount of heat the valve is exposed to.**
- The plugs/caps must be carefully removed from the evaporator coil connections and the pressure carefully bled off.
- The liquid line must be brazed to the evaporator coil liquid line connection. Dry nitrogen must be flowing through the evaporator coil.
- The Installation Manual must be referred to for detailed instructions regarding the installation of an indoor TXV.
- The grommet must be pulled away from the vapor connection at the evaporator coil. The vapor line is then brazed to the evaporator coil vapor connection. After the brazed connection has cooled gradually, the grommet would be moved back into the original position.
- The vapor valve must be protected with a wet rag and the vapor line connection brazed to the condensing unit. The flow of dry nitrogen must be exiting the system from the vapor service port connection.
- After the connections have been brazed and the joints have cooled gradually, the nitrogen is valved off and removed from the liquid line service port.
- The Shrader valve cores must be replaced in the liquid and vapor valves.
- A leak test must be performed on all of the refrigerant piping connections including the service port flare caps to be sure they are leak tight. The caps should not be over-tightened.

Pressure Testing

The lineset and evaporator coil are pressurized up to 250 psig with dry nitrogen and leak tested with a bubble type leak detector. Do not use refrigerant to purge or leak test the system. Do not exceed the rated test pressure located on the evaporator coil data plate when pressure testing the system (nitrogen charge can be released into the atmosphere).

Evacuation

The vapor line, evaporator coil, and liquid line must be evacuated to 500 microns or less. This will ensure that moisture and non-condensables are evacuated from the system.

Post-Evacuation

On a new installation, after the system has been pressure tested and evacuated, the following procedures must be completed to release the refrigerant into the indoor unit:

- The vapor line (larger line) connection is opened first. Service valves are opened by removing the cap and using a 3/16” hex wrench on the stem, carefully turning counterclockwise until the stem touches the retaining ring. Allow the pressure to equalize. The liquid line service valve may then be opened in the same manner.
- The plunger cap must be finger tight and then tightened an additional 1/12th of a turn.

Note
If there is any chance that liquid refrigerant is present in the compressor crankcase, the crankcase heater should be powered up for 24 hours prior to operating the compressor.

- Replace the caps on the service ports to prevent leaks. Remove the flare caps from the service ports and connect gauges only during start up, and when servicing the system. Approximately ¾ ounce of refrigerant is lost each time gauges are connected. If gauges are connected unnecessarily, the system could become undercharged over an extended period.

Refrigerant Access Valves (Caps Removed)

R-410A Considerations

Polyolester oil (POE) is used with R-410a systems. POE is NOT compatible with mineral (MO) or alkylbenzene oils. It is imperative that proper service practices are performed during installation, particularly in retrofit applications, to ensure there is NO intermixing of the oils.

The MO/AB oils are not miscible with R-410A refrigerant and will be pushed through the system as a liquid blob, which can create a restriction at metering devices, and subsequent pressure fluctuations. POE oil is very hygroscopic, meaning that it readily absorbs moisture (about 15 times faster than mineral oil). This emphasizes the importance of using the necessary tools and installation procedures required for R-410A systems.

Proper installation procedures include, but are not limited to:

- Brazing (with nitrogen purge)
- Pressure testing (with nitrogen up to 250 psig)
- Evacuation (500 microns)
- Purging manifold gauge set (with refrigerant)
- Charging method is by weight only

5/16" to 1/4" Flare Adapter

The HMH7 access valves both suction and liquid have a 5/16” flare fitting. A 5/16” to 1/4” flare adapter will be needed to use your standard hoses for refrigeration manifold gauges. Also Depending on the installation and the model number of the HMH7, the access fittings may be too close to the ground. To get your refrigeration manifold hoses connected to the access fittings a 5/16” to 1/4” adapter may have to be elbowed.

05

Start-up

Introduction

Prior to start-up, all the installation procedures outlined in the indoor and outdoor equipment Installation Manuals must be completed. This included proper installation of the indoor unit, outdoor unit, thermostat, electrical wiring, and accessory kits.

Required Tools & Information

After physical installation is complete, the following tools and instruments are required to properly start-up HMH7 systems:

- Magnehelic gauge, U-tube manometer, or digital manometer to measure static pressure on both the supply and return side of the air distribution system.
- Thermometer or portable digital thermometer to measure the supply air, return air, entering the condenser, liquid line, and suction line temperatures. For best accuracy when measuring temperatures, use thermocouple-type probes.
- Manifold gauge set to measure high side and low side pressures.
- Digital multimeter for various electrical measurements.
- 7mm wrench or a cross point screwdriver to remove service access panels.
- 3/16” Allen wrench for both the liquid line and suction line service valve access.
- 2-5/16” to 1/4” flare fitting adapter for refrigerant hose connections.

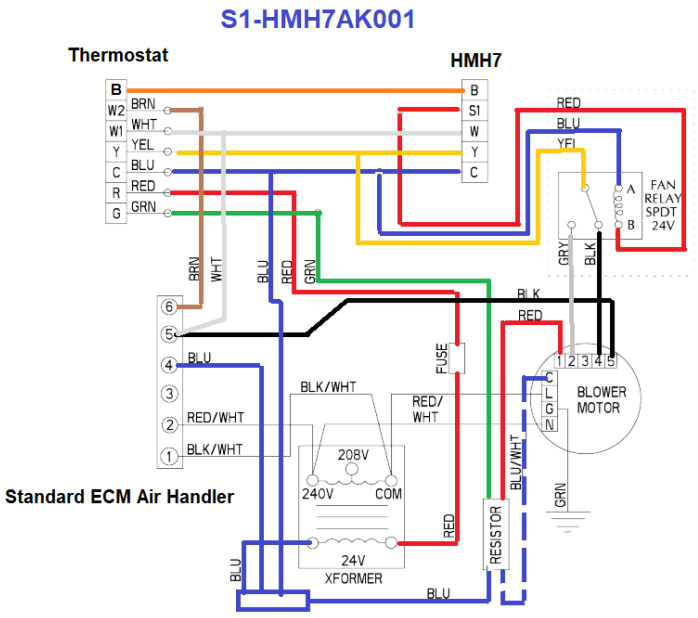
Airflow Setup

The airflow must be set up properly. Outdoor units must be matched with the appropriate evaporator and an air handler or furnace that provides the required airflow. If the duct system is not designed properly, it is not possible to obtain system design efficiency. The blower speed must be selected based on the requirements of the installed system.

Even systems with Standard ECM or Variable ECM blowers have airflow limitations. Most residential systems, including those with variable speed motors, are designed to provide their rated airflow at external static pressures up to .5” w.c. ESP values more than .5” w.c. will result in reduced airflow, greater electrical consumption, and increased system operational sound.

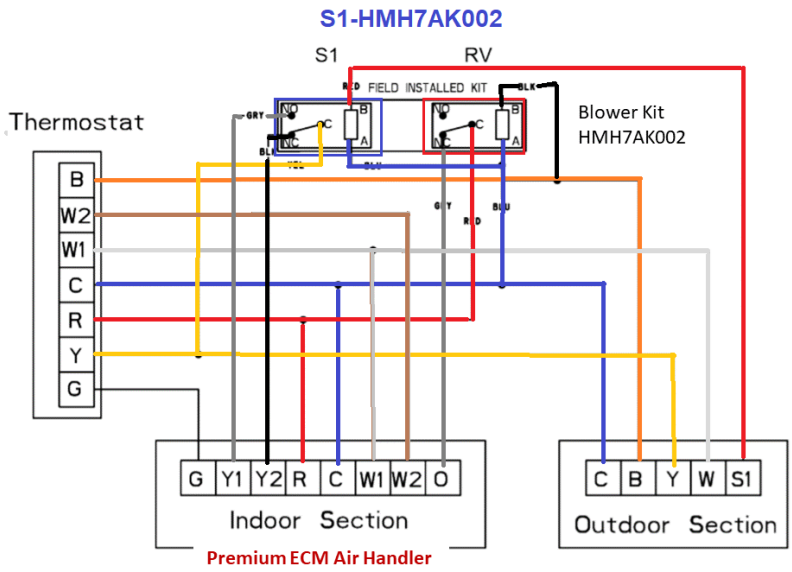
Restrictions in the duct system, such as undersized duct, dirty filters, dirty evaporator coil and closed or blocked registers, will cause the external static pressure to increase.

For the best possible comfort and equipment longevity, the external static pressure (ESP) must be measured and used with the blower charts to determine the best speed to use for the application. Blower charts are located in the furnace or air handler installation manuals.



For optimum performance, 400 CFM (+/- 50 CFM) per ton of cooling capacity is generally used for cooling airflow setup. In high humidity applications, reduced airflow may be desired to remove more latent heat, absorbing moisture from the air. In dry applications, it may be desirable to increase airflow to remove more sensible heat and remove less moisture. Adjustments made to the system must be in accordance with the indoor unit Installation Manual.

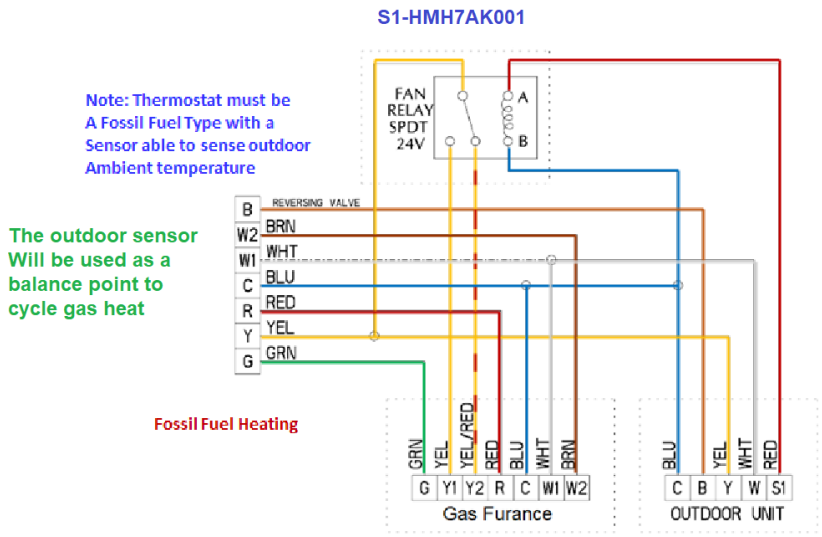
When using the HMH8AK001 blower relay kit for standard ECM motors, the cooling and first stage heating speed is set through the normally closed contacts (black conductor) wired directly to the standard ECM blower motor. Without a call from the S1 conductor to the blower relay kit, the blower speed operates at the blower speed set by the technician. When the modulating compressor on the HMH7 reduces capacity, the S1 terminal sends 24 volts AC signal to the HMH7AK001 blower relay to send the reduced blower speed present on the grey conductor.

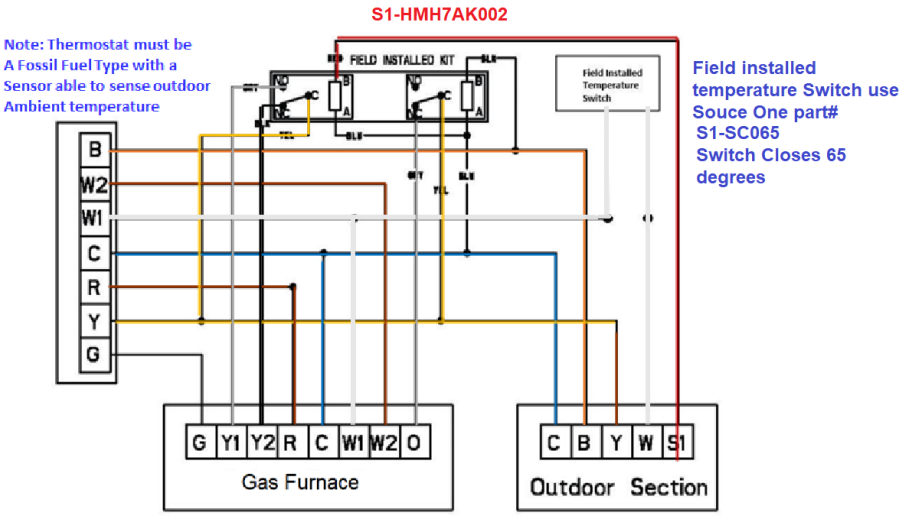


When using the HMH7 heat pump with a premium ECM blower, the kit contains two relays (S1 and RV). When the thermostat is calling for heat, the RV relay sends 24 volts AC to "O" on the indoor section control through the normally closed contacts. At the same time, the S relay sends a call to the "Y2" on the indoor section control through the normally closed set of contacts. The blower motor operates at the Y2 speed setting. If the modulating compressor begins to slow capacity due to lower capacity demands, the S1 energizes and sends 24 volts AC to the S blower relay. The relay switch to the normally open set of contacts will switch 24 volts AC from Y2 to Y1 on the indoor section control, reducing the blower speed. In heating, the "B" signal from the thermostat energizes the relay coil on the RV relay, opening the normally closed contacts to interrupt the 24 volts AC to the "O" terminal on the indoor section control.

When using the HMH7 heat pump with a gas furnace (Dual Fuel Application) Use the S1-HMH7Ak001 relay kit. See the wiring above. The thermostat used in this application, needs to wire in with an outdoor temperature sensor in order to set a balance point to cycle on gas heat. When the outdoor temperature stays above the balance point temperature, the heat pump will produce the heating.

When the outdoor temperature drops below the balance point setting, the gas heat will then provide the heating. Note the HMH7 was designed to be matched with electric heat, so when heat first comes on it will bring on the second stage heating. With a gas furnace for second stage heating in the first minutes of heating the gas heat will run with the heat pump heat.





When using the HMH7 heat pump in a dual fuel application, and you want to eliminate the gas heat from coming on with the heat pump on startup, use a temperature switch S1-SC065, sold by Source One. The temperature switch has a sensor that straps to the vapor line. If the vapor line's temperature reaches 65 degrees F, the Temperature Switch will close its contacts and allows the gas heat to come on. If the vapor line stays above 65 degrees, the gas heat will not cycle on during the first few minutes of startup.

Airflow Calculations

Note
Although the HMH7 is currently limited as to the approved indoor unit matches (such as the ECM air handlers with known blower settings), the general procedures for determining airflow delivery with electric strip heat and gas heat are illustrated below. Always consult the instructions supplied with the indoor unit to make sure the cooling airflow matches the cooling capacity of the outdoor unit.

Electric Heat (Single Phase)

To calculate CFM with electric heat, the number and rating of the energized heating elements must be known. Note the formula to calculate the BTU/h output of a heating element with different voltages applied.

A heating element rated at 5 kw with a 240 volts AC power supply will provide:

Example 1:
5000 watts/240 volts AC = 20.8 amps
240 volts AC/20.83 = 11.52 Ω of resistance
5000 watts X 3.413 BTU/h = 17,065 BTU/h
3 strips X 17.065 BTU/h = 51, 195 BTU/h Output

In example 1, if the BTU/h output is 51,195 and the unit has a 35°FΔT (Temperature Rise), the result is an airflow of 1354.36 CFM.

$$3 \text{ X } 17{,}065 \text{ BTU/h} = \frac{51{,}195 \text{ BTU/h Output}}{1.06 \text{ X } 35°\text{F}\Delta\text{T}} = 1354.36 \text{ CFM}$$

The same heating element will produce less heat if the voltage is decreased. A 5-KW heating element, rated at 240 volts AC, has a resistance of 11.52 Ω. If a heating element has a resistance of 11.52 Ω and a voltage of 208 volts AC is applied, the result is 3755 watts, instead of 5000 watts.

Example 2:
208 volts AC/11.52 Ω of resistance = 18.05 amps
208 volts AC X 18.05 amps = 3755 watts
3755 watts X 3.413 BTU/h = 12,816 BTU/h
3 strips X 12,816 BTU/h = 38,448 BTU/h Output

In example 2, if the BTU/h output is 38,448 and the unit has a 35°FΔT (Temperature Rise), the result is an airflow of 1017.14 CFM.

$$3 \text{ X } 12{,}816 \text{ BTU/h} = \frac{38{,}448 \text{ BTU/h Output}}{1.08 \text{ X } 35°\text{F}\Delta\text{T}} = 1017.14 \text{ CFM}$$

There is a large difference in the BTU/h output and CFM airflow from example 1 to example 2. This difference is produced when the voltage input changes. Proper voltage readings must be used to calculate CFM.

Electric Heat (Three Phase)

To calculate the BTU output of a three-phase electric heating system, the voltage applied to one element is multiplied with the amperage of one leg feeding the element. It is then multiplied by 1.73 (square root of 3).

Example: 460 volts AC X 10 amps X 1.73 = 7,958 watts
7,958 watts X 3.413 BTU/h = 27,160 BTU/h
27,160 BTU/h X 2 Banks of Heater = 54,321 BTU/h

Output:
In this example, if the BTU/h output is 54,321 and the unit has a 45°FΔT (Temperature Rise), the result is an airflow of 1117.72 CFM.

$$2 \text{ X } 27{,}160 \text{ BTU/h} = \frac{54{,}321 \text{ BTU/h Output}}{1.08 \text{ X } 45°\text{F}\Delta\text{T}} = 1117.72 \text{ CFM}$$

Gas Heat

To measure the CFM on a gas heating system, the BTU content of the fuel supplying the furnace must be known. The BTU content may vary depending on the supplier of natural gas. BTU content can be verified by contacting the local utility. In this example, The BTU content of the fuel is 1030 BTU per cubic foot of natural gas.

The formula below determines the CFM produced during heating operation. To calculate CFM, find the BTU output from the heating unit and the temperature rise across the heating section.

$$\text{Formula} \quad \frac{\text{BTU Output}}{1.08 \text{ X Temperature Rise}} = \text{CFM}$$

Formula: 60,000 BTU/h Input X .80 = 48,000 BTU/h Output

If the furnace has a BTU input rating of 60,000 BTU/h and has an 80% Annual Fuel Utilization Efficiency (AFUE) rating, the unit has a 48,000 BTU/h output.

In this example, if the BTU/h output is 48,000 and the furnace has a 45°FΔT (Temperature Rise), the result is an airflow of 987.65 CFM.

$$60{,}000 \text{ X } .80 \quad \frac{48{,}000 \text{ BTU/h Output}}{1.08 \text{ X } 45°\text{F}\Delta\text{T}} = 987.65 \text{ CFM}$$

Temperature Drop

An air conditioning unit that is within normal operating temperatures has approximately an 18°F to 20°F temperature drop across the evaporator coil during cooling. The temperature drop is measured by subtracting the supply air dry bulb temperature from the return air dry bulb temperature. High humidity applications result in a lower temperature drop across the evaporator.

	Return air dry bulb	75°F
Example	Supply air dry bulb	-55°F
	= Temperature Drop	= 20°FΔT - Drop

Physical and electrical data

Outdoor unit model	HMH72B241S	HMH72B341S	HMH72B361S	HMH72B481S	HMH72B601S
Unit supply voltage	208/230 V, 1 phase, 60 Hz				
Normal voltage range (V)	198—253				
Minimum circuit ampacity (A)	15.0	23.0	23.0	36.0	37.0
Maximum overcurrent device (A)	25	35	35	50	50
Minimum overcurrent device (A)	15	23	23	36	37
Compressor type	Twin rotary	Twin rotary	Twin rotary	Twin rotary	Twin rotary
Compressor rated load (A)	11.0	16.1	16.1	26.0	26.5
Compressor locked rotor (A)	20.0	20.0	20.0	38.0	38.0
Crankcase heater (base heater)	Yes	Yes	Yes	Yes	Yes
Factory external discharge muffler	Yes	Yes	Yes	Yes	No
Hard start kit required with TXV	No	No	No	No	No
Fan diameter (in.)	20	20	20	20	20
Fan motor type	ECM	ECM	ECM	ECM	ECM
Fan motor rated HP	1/12	1/6	1/6	1/6	1/6
Fan motor nominal RPM	880	810	810	850	850
Fan motor nominal CFM	1825	2350	2350	3525	3525
Coil face area (sq ft)	14.03	8.30	8.33	14.03	5.99
Coil rows deep	2	2	2	2	2
Coil fins per inch	18	19	19	17	18
Liquid line set outdoor unit (field-installed)	0.375	0.375	0.375	0.375	0.375
Vapor line set outdoor unit (field-installed)	0.625	0.75	0.75	0.875	0.875
Unit charge (lb-oz)	4-7	6-3	6-3	8-15	8-15
Charge (oz/ft)	0.75	0.62	0.62	0.67	0.67
Operating weight (lb)	112	148	148	227	251

Total System Charge

The factory refrigerant charge supplied in the outdoor unit is adequate for the outdoor unit, a 15 ft. (4.6m) line set, and the smallest matched evaporator coil. Some evaporator coil matches may require additional refrigerant charge.

Important
The required refrigerant values shown here are unique to the HMH7 and differ from other Ducted Systems products.

The total system charge is the sum of the condensing unit charge, the evaporator charge, and the recovery or adder charge for the lineset adjustment. The values shown here are unique to the HMH7 and differ from other Ducted Systems products. The total system charge is determined as follows:

1. Determine the condensing unit charge from Tabular Data Sheet.
2. Determine the evaporator coil adjustment from Tabular Data Sheet.
3. Calculate the line charge adjustment using the refrigerant adder in the Physical Data Sheet for the HMH7.
    a. If line length is greater than 15 feet (4.6 m), add refrigerant using the adder listed (.38 ounces/foot) for 2 and 3 tone models (.60 ounces/foot) for the 4 and 5 ton, multiplied by the number of additional feet.
    b. If line length is less than 15 feet (4.6 m), subtract refrigerant using the adder listed (.38 ounces/foot) for 2- and 3-ton models (.60 ounces/foot) for the 4 and 5 ton, multiplied by the number of subtracted feet, by the number of feet the lineset is reduced.
4. The HMH7 requires weighing-in the correct refrigerant charge.
5. The total system charge must be written on the unit data plate with a permanent marker.

Verify the following before evaluating systems operation:

- Indoor airflow is correct for the application, with total external static pressure not exceeding 0.5” w.c.
- All major components are operating including the compressor, outdoor blower motor, and indoor blower motor.
- The evaporator and condensing coils are clean and free of debris.
- The return air filter is clean.
- The supply- air registers are open.
- The system operates in the cooling mode (full) capacity, for a minimum of 10 to 15 minutes.

Outdoor unit	HMH72B241S	HMH72B361S	HMH72B481S	HMH72B601S
Required TXV	BC1	BC1	BC1	BC1
Indoor unit	Additional charge			
AE18B	-	-	-	-
AE24B	-	-	-	-
AE30B	-	-	-	-
AE36 (C,B)	2	9	-	-
AE42C	-	-	-	-
AE43C	-	-	-	-
AE48 (C,D)	-	-	-	-
AE60 (C)	-	-	-	-
AE60 (D)	-	-	7	8
AVC18B	-	-	-	-
AVC24B	-	-	-	-
AVC30B	-	-	-	-
AVC36 (B,C)	2	9	-	-

Refrigerant Adder per Air Handler or Coil

Outdoor unit	HMH72B241S	HMH72B361S	HMH72B481S	HMH72B601S
AVC42C	-	-	-	-
AVC48 (C,D)	-	-	-	-
AVC49 (C)	-	-	-	-
AVC60 (C)	-	-	-	-
AVC60 (D)	-	-	7	8
CF/CM/CU18 (A,B)	-	-	-	-
CF/CM/CU24 (B,C)	-	-	-	-
CF/CM/CU30 (A,B,C)	-	-	-	-
CF/CM/CU36 (B,C,D)	2	9	-	-
CF/CM/CU42 (B,C,D)	-	-	-	-
CF/CM/CU48 (C,D)	-	-	-	-
CF/CM/CU60 (C,D)	-	-	-	-
CF/CM64	-	-	7	8

Refrigerant Adder per Air Handler or Coil

System charge

Outdoor unit model	HMH72B241S	HMH72B341S	HMH72B361S	HMH72B481S	HMH72B601S
Required indoor metering device	**BA1**	**BC1**	**BC1**	**BC1**	**BC1**
Indoor coil model	**Additional charge (oz)**				
AE36(B,C)	5	—	13	—	—
AE60D	—	—	—	13	14
AVC36(B,C)	5	—	13	—	—
AVC60D	—	—	—	13	14
CF/CM/CU36B	5	—	13	—	—
CF/CM36(C,A)	5	—	13	—	—
CF/CM64D	—	—	—	13	14
JHETB24C	—	-11	-11	—	—
JHETB30D	5	4	4	—	—
JHETB36D	5	4	4	—	—
JHETC36D	5	4	4	—	—
JHETC42F	—	26	26	—	—
JHETC60H	—	—	—	4	—
JHETD60H	—	—	—	4	—
JHETD60J	—	—	—	1	15
JHVTB24C	—	-11	-11	—	—
JHVTB36D	5	4	4	—	—
JHVTC36D	5	4	4	—	—
JHVTC42F	—	26	26	—	—
JHVTC60H	—	—	—	4	—
JHVTD60H	—	—	—	4	—
JHVTD60J	—	—	—	1	15
XAFA30D	5	4	4	—	—
XAFB30C	—	-11	-11	—	—
XAFB36D	5	4	4	—	—
XAFC30C	—	-11	-11	—	—
XAFC36D	5	4	4	—	—
XAFC48F	—	26	26	—	—
XAFC60H	—	—	—	4	—

System charge

Outdoor unit model	HMH72B241S	HMH72B341S	HMH72B361S	HMH72B481S	HMH72B601S
Required indoor metering device	BA1	BC1	BC1	BC1	BC1
Indoor coil model	Additional charge (oz)				
XAFD48F	—	26	26	—	—
XAFD60H	—	—	—	4	—
XAFD60J	—	—	—	1	15
XAHB30C	—	-11	-11	—	—
XAHB36D	5	4	4	—	—
XAHC30C	—	-11	-11	—	—
XAHC36D	5	4	4	—	—
XAHC48F	—	26	26	—	—
XAHC60H	—	—	—	4	—
XAHD48F	—	26	26	—	—
XAHD60H	—	—	—	4	—
XAHD60J	—	—	—	1	15
XAUB30C	—	-11	-11	—	—
XAUB36D	5	4	4	—	—
XAUC48F	—	26	26	—	—

System Charge Notes

- For applications requiring a TXV, use the S1-1TVM*** series kit.
- It is necessary to use a TXV kit with these indoor units to obtain system performance.
- Systems matched with furnaces or air handlers not equipped with blower-off delays may require blower time delay kit S1-2FD06700224.
- Do not use CF and CU coils in horizontal applications.
- Charge adders shown above do not indicate that coils are rated for every application. See Table 2 for actual performance for specified system matches. Obtain certified system ratings from www.ahridirectory.org.

Charging

1. Check the unit factory charge listed on the unit nameplate to verify the refrigerant charge for the outdoor unit, the smallest matched indoor unit, and 25 ft of interconnecting line tubing.
2. Verify the TXV and additional charge required for the specific matched indoor unit in the system using Table 4.
3. Add additional charge for the amount of interconnecting line tubing greater than 25 ft at the rate specified in Table 2.
4. For indoor matches requiring additional charge, weigh in the refrigerant for the specific matched indoor unit and the actual lineset length.
5. After weighing in the charge adders for the matched indoor unit and lineset, verify the system operation against the temperatures and pressures in the charging chart for the outdoor unit. Locate the charging charts on the outdoor unit and also in the Service Data Application Guide on www.simplygettingthejobdone.com. Follow the charging procedure in the Installation Manual according to the type of indoor metering device in the system, and allow 10 minutes after each charge adjustment for the system operation to stabilize. Record the charge adjustment made to match the charging chart.
6. For downflow installations and horizontal right installations, some indoor units require additional charging adjustments to ensure correct equipment operation. Refer to the Installation Manual for the outdoor unit.
7. Permanently stamp the unit nameplate with the total system charge, which is defined as follows: total system charge = base charge (as shipped) + charge adder for matched indoor unit + charge adder for actual lineset length + charge adjustments to match the charging chart.

Outdoor unit model	HMH72B241S	HMH72B341S	HMH72B361S	HMH72B481S	HMH72B601S
Unit charge (lb-oz)	4-7	6-3	6-3	8-15	8-15
Charge (oz/ft)	0.75	0.62	0.62	0.67	0.67

Final Steps

It is the technician's responsibility to maintain a safe and clean working environment. It is also important to dispose of any debris and keep the area around the equipment clean.

It is also the technician's responsibility to provide the customer with the user's manual and to explain proper:

- System operation
- Thermostat programming
- Maintenance – filter replacement

The customer must be informed of the importance of regular service to ensure equipment longevity and peak performance.

06

Sequence of Operation

Introduction

This section describes the normal sequence of operation for all models of the HMH7 modulating heat pump.

The sequence of operation may vary depending on additional controls or accessories which may have been installed with the unit. This may include fossil fuel or electric heating.

Always use the existing electrical wiring diagrams that accompany both the indoor and outdoor equipment being serviced. These diagrams will assist in identifying components that are cycled during a specific sequence of operation.

HMH7 Operation

Cooling Operation

1. When the thermostat calls for cooling, 24 volts AC is sent from the Y terminal on the thermostat to the Y terminal on the HMH7 heat pump and to the common (yellow conductor) of the contact on the HMH7AK001 blower relay kit. At the same time, the thermostat sends 24 volts AC through the G terminal that connects to the G wire connection on the standard blower air handler. **Note**: The reversing valve (4-way valve) energizes in the heating mode.
2. When that Y signal is received on the HMH7, the EEV begins to stage closed. The refrigerant in the liquid line flows through a bypass check-valve. The outdoor condenser fan motor energizes. Approximately 5 to 10 seconds after the condenser fan motor starts, the compressor starts and begins to modulate up. While this is taking place on the outdoor unit the indoor unit sends 24 volts AC through the common of the normally closed contacts on the blower relay kit to start the indoor blower motor. Through the relay kit's black conductor, the blower motor operates at the speed previously set up by the technician for the cooling capacity of the system.
3. The HMH7 control board uses the following information to determine the modulation (frequency) speed of the compressor and outdoor fan motor: The outdoor air temperature, the outdoor coil refrigerant temperature and the suction line pressure. Between those inputs, the control board creates an algorithm to determine a system target pressure. If the control board determines that the target pressure is lower than the actual pressure, the control board increases the compressor frequency speed. If the actual pressure is lower than the target pressure, the control decreases the compressor frequency speed. Once the target pressure is maintained the compressor frequency speed stabilizes. One the single outdoor fan motor (2 and 3 ton) models, the outdoor fan motor speed is determined by the control board according to the outdoor coil temperature. If the unit has two condenser fan motors (4- and 5-ton models), the upper fan is controlled just as the single fan motor and the lower condenser fan motor runs approximately 30 to 60 RPMs slower than the upper condenser fan motor.
4. When the thermostat reaches the desired temperature, the thermostat ends the 24-volt AC output to Y and G. if the thermostat has no time delay off on the G circuit the blower cycles off, the compressor modulates down to 0 Hz, and the outdoor fan motor(s) cycles off within 5 seconds of the compressor reaching 0 Hz.

Heating Operation

1. When the thermostat calls for first stage heating, a 24-volt AC is sent to the Y and G terminals. The Y signal will send the 24 volts AC to both the HMH7 Y terminal and the common of the blower relay kit's contact, just as it does in the cooling cycle. Also, the thermostat signal will end 24 volts AC through the B terminal to the B terminal on the HMH7 terminal. Depending on the model of thermostat, the B terminal receives 24 volts AC any time that the thermostat is placed in heat mode. A 24-volt AC signal will come from the "W" terminal on the heat pump board on initial heating start. This signal will be present for the first 2 to 3 minutes of heating operation. The purpose for this is to temper the indoor supply air until the heat pump has had time to warm the air.
2. The reversing valve (4-way valve) is energized and switched to the heating position. The EEV begins to modulate to its beginning metering position. The EEV modulates open and closed to maintain the saturated coil temperature required by the control board. Just as in cooling mode, the control board determines from required modulation frequency based on outdoor coil temperature and discharge pressure. The outdoor fan motor speed is determined by the control board with input from the outdoor coil's temperature (now the evaporator). As with the cooling mode, if this model has two outdoor fan motors, the upper fan motor operates as a single motor and the lower fan motor operates from 30 to 60 RPMs below the upper fan motor speed.
3. If the thermostat has a need for second stage heat, the W or W1 terminal sends 24 volts AC to the air handler white conductor or W1 terminal to energize the first stage of electric heat. If the heat strip kit is above 13 KW of heat, an additional stage of electric heat is energized through the W2 terminal.
4. When the thermostat approaches the desired temperature, 24 volts AC to the W terminal terminates, turning off the electric strip heat. When the final desired temperature is reached, 24 volts AC is terminated on the Y terminal, the indoor blower cycles off, the compressor modulates down to 0 Hz and the condenser fan motor(s) cycles off around 5 seconds later.

Defrost Mode

When the outdoor ambient temperature is lower than 3°C (37.4°F) and the coil temperature sensor detects coil temperature below the outdoor ambient temperature for two minutes, the system enters defrost mode. The reversing valve solenoid is de-energized, and the reversing valve enters the cooling mode, sending hot discharge gas to the outdoor coil. The outdoor fan motor(s) module to 0 Hz (off), and the compressor continues to operate. The W terminal on the HMH7 sends 24 volts AC to the white conductor (W1 terminal) in the air handler. This energizes a stage of electric heat to help temper the cold air during the defrost mode. When the outdoor coil temperature rises above 50°F, the defrost mode terminates.

Anti-Freeze Protection Mode (Cooling)

The outdoor pressure sensor detects the suction line pressures in cooling mode. The pressure sensor prevents the evaporator temperature from dropping below freezing. When the coil temperature becomes too low, the compressor starts Protection mode. When the suction drops below 97 PSIG, the suction pressure is converted to suction temperature automatically. And when the suction temperature is lower than 0°C (32°F), system operation is inhibited.

Discharge Temperature/Pressure Protection

When the discharge line temperature sensor becomes too high, compressor operation is interrupted. Operation is halted near 108°C (226°F), and the compressor is prohibited from modulating up to 98°C (208°F). Operation is halted with discharge pressure over 550 PSIG.

Oil Return Control Mode

When the compressor has operated at a low frequency for a long period of time, the control board increases the compressor frequency speed to ensure oil returns to the compressor. If the compressor frequency is lower than 40Hz, the compressor initiates the oil return sequence after four hours of operation.

Start-up Compressor Time Delay

To allow the compressor time for the refrigerant pressure to equalize, the control board has a 3-minute time delay before allowing the compressor to restart.

Forced Defrost Mode

Set the Dip Switches in the “Forced Defrost Configuration”. Turn the thermostat control to heat and increase the heating setpoint to create a call for heat. The HMH7 will almost immediately go into defrost mode.

Field Settings

Switch procedures are different by model. For 24, 34, and 36 models, the line voltage power must be **on** during the switch setting process. For the 48 and 60 models, the line voltage power must be **off** during the switch setting process. The factory setting, or address, of DIP switch settings in each switch bank are 0000 or off/off/off/off. In the Figure below, ■ indicates the position of each switch.

DIP switch settings for all models

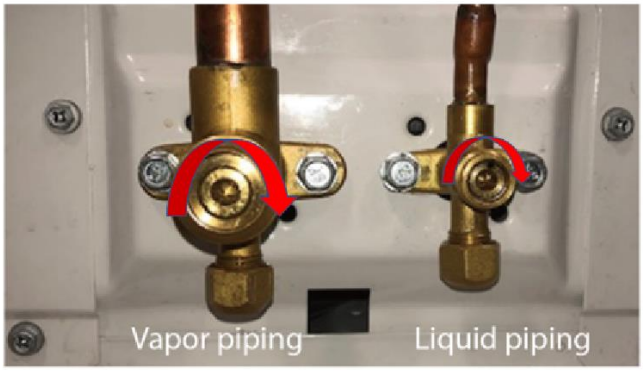
S4 switch bank		S5 switch bank	
Factory setting		Factory setting	
Pump down switch		Capacity high to low	
Forced defrost		Cooling only	

Activating pump-down mode – 24, 34, and 36 models

The compressor runs with a target frequency and without any protection when the frequency rises. The EEV runs with an open setting. The outdoor unit fan runs with the set fan speed.

1. Remove the heating or cooling call from the unit so it is in standby mode.
2. Close the liquid line service valve using a hex head wrench by turning the valve stem fully clockwise until seated as shown in Figure below.
3. Open the maintenance panel.
4. With line voltage applied to the unit, place the unit in pump-down mode by changing the DIP switch setting on the 7-segment display control board S4 switch bank as shown in Figure above. Note that the LED display on the 7-segment display control board displays CLOS.

Unit service valves



First turn the hex wrench clockwise on the liquid valve to close the valve and begin the pump down sequence.
Next turn the hex wrench clockwise on the vapor line valve, at the end of the pump down sequence

After changing the Dip Switch on S4 Switch Bank the display should show CLOS

During Pump-Down the HMH7 will continue to run. Once you see the word "GOOD" displayed close off the Vapor line valve

5. The LED display on the 7-segment display control board starts to show the compressor frequency value until it shows CLOS. After displaying CLOS, the unit continues to run for more time until the LED display shows GOOD. When you see GOOD, close the vapor line service valve using a hex head wrench by turning the valve stem fully clockwise until seated as shown in Figure below.
6. Take the unit out of pump-down mode by changing the DIP switch setting on the 7-segment display control board back to the off position and immediately remove line voltage power from the outdoor unit.

Activating pump-down mode - 48 and 60 Models

The compressor runs with a target frequency and without any protection when the frequency rises. The EEV runs with an open setting. The outdoor unit fan runs with the set fan speed.

1. Remove the heating or cooling call from the unit so it is in standby mode.
2. Remove the line voltage power from the outdoor unit.
3. Close the liquid line service valve using a hex head wrench by turning the valve stem fully clockwise until seated as shown in Figure above.
4. Open the maintenance panel.
5. Place the unit in pump-down mode by changing the DIP switch setting on the main control board S4 switch bank as shown in Figure above.
6. Restore the line voltage power to the outdoor unit.
7. Note that the LED display on the main control board displays **40** and then counts down to zero.
8. When the LED begins to blink zero, close the vapor line service valve using a hex head wrench by turning the valve stem fully clockwise until seated as shown in Figure above.
9. Remove the line voltage power from the outdoor unit.
10. Take the unit out of pump-down mode by changing the DIP switch setting on the main control board S4 switch bank back to the off position.

NOTICE

The refrigerant in systems with linesets in excess of 40 ft cannot be recovered into the outdoor unit and requires recovery with external equipment.

Note: Make sure to switch back the DIP switch setting after the refrigerant recovery operation. If not, the unit enters the refrigerant recovery mode again, after powering on.

48 and 60 Models
Pump Down
40 Second Countdown

Reduced Capacity Mode

The outdoor unit controls have a built-in feature to lower the outdoor unit capacity if required.

Activating lower capacity mode – 24, 34, and 36 models

1. Remove the heating or cooling call from the unit so it is in standby mode.
2. Open the maintenance panel.
3. With the line voltage applied to the unit, place the unit in reduced capacity mode by changing the DIP switch setting on the 7-segment display control board S5 switch bank as shown in Figure above.

Activating lower capacity mode - 48 and 60 models

1. Remove the heating or cooling call from the unit so it is in standby mode.
2. Remove the line voltage power from the outdoor unit.
3. Open the maintenance panel.
4. Place the unit in reduced capacity mode by changing the DIP switch setting on the main control board S5 switch bank as shown in Figure above.
5. Restore the line voltage power to the outdoor unit.

Cooling Only Mode

The outdoor unit controls have a built-in feature to operate the unit in cooling only mode if heat pump operation is never required. When in cooling only mode, the reversing valve B thermostat input is ignored.

Activating cooling only mode – 24, 34, and 36 models

1. Remove the heating or cooling call from the unit so it is in standby mode.
2. Open the maintenance panel.
3. With line voltage applied to the unit, place the unit in cooling only mode by changing the DIP switch setting on the 7-segment display control board S5 switch bank as shown in Figure above.

Activating cooling only mode – 48 and 60 models

1. Remove the heating or cooling call from the unit so it is in standby mode.
2. Remove the line voltage power from the outdoor unit.
3. Open the maintenance panel.
4. Place the unit in cooling only mode by changing the DIP switch setting on the main control board S5 switch bank as shown in Figure above.
5. Restore the line voltage power to the outdoor unit.

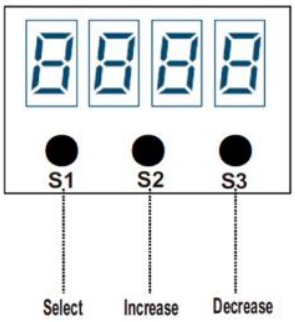
Frequency Lock

Verify System Refrigerant Charge

The HMH7 uses a feature called Frequency Lock. This feature allows you to lock in the outdoor heat pump to the highest frequency allowed. From the factory the variable frequency set in Parameter 42 is set to 24. Parameter 42 allows the HMH7 to drive its frequency to that is determined by the control board. By changing Parameter 42 from 24 to 28, the outdoor unit drives to its highest frequency for that particular model.

After the unit has driven to full frequency you now can verify the refrigerant charge and compare measurements of the HMH7 to the service data provided in the Installation and Technical Guide Manuals.

Next, are the steps needed to set the HMH7 into the frequency lock feature. Remember: The easiest method to take the heat pump out of frequency lock it to disconnect power from the outdoor unit (HMH7) for 30 seconds.



1. Press the S1 Button to make the viewing screen display P.
2. Press the S2 Button until the screen shows P.40.
3. The screen will display 0. Wait 1 second and press S2 and change the display from 0 to 1.
4. Press the S2 to adjust the screen to display P.41.
5. The screen will display 0. Wait 1 second and press the S2 and change the display from 0 to 1.
6. Press the S2 to adjust the screen to display P.42.
7. The screen will display 24.
8. Press the S2 to adjust display from 24 to 28.
9. Disconnect the power to the HMH7 for 30 seconds to remove the frequency lock function.

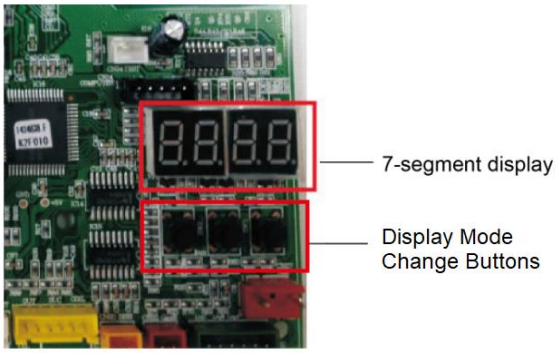
1. The screen should display 24.
2. Press S2 until the display changes to 28.
3. Press S2 and S3 at the same time until the screen displays the word GOOD.
4. Disconnect the power to the HMH7 for 30 seconds to remove the frequency lock function.
1. Make sure there is no heat or cool call on the thermostat.
2. Press S1 to make the viewing screen display P.
3. Press S1 again to change the display from P to H.
4. Press the S2 until the screen displays H7.
5. Press and hold S1 for 3 seconds and then release.
6. The screen should display 24.
7. Press S2 until the display changes to 28.
8. Press S2 and S3 at the same time until the screen displays the word **GOOD**.
9. Disconnect the power to the HMH7 for 30 seconds to remove the frequency lock function.

07

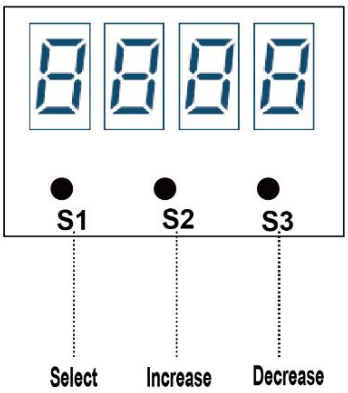
Troubleshooting

Running a Parameter Query

7-segment display query



HMH7 model 7-segment display



There are three buttons on the digital display board:

- Select: Press to display outdoor or indoor unit parameter. P./H.= The parameter of the outdoor unit.
- Increase: Press to increase the number by one. Hold down to increase rapidly.
- Decrease: Press to decrease the number by one. Hold down to decrease rapidly.

Note: The parameter content is automatically displayed after the parameter code is selected for 3 seconds

Parameters - HMH72B24/HMH72B34/ HMH72B36

Parameter code	Description
P.0	Fault codes
P.1	Compressor actual frequency
P.2	Compressor driving frequency
P.4	Compressor target frequency
P.5	Compressor discharge temperature
P.6	Outdoor suction temperature
P.7	Outdoor ambient temperature
P.8	Outdoor coil temperature
P.9	Outdoor defrosting temperature
P.10	IPM module temperature
P.11	Outdoor capacity requirement
P.13	Outdoor DC motor target speed
P.14	AC input current
P.15	AC input voltage
P.16	DC bus voltage
P.17	Compressor phase current
P.18	Frequency limit code

Example:

Setting Parameter #1 to Observe the Compressor Frequency

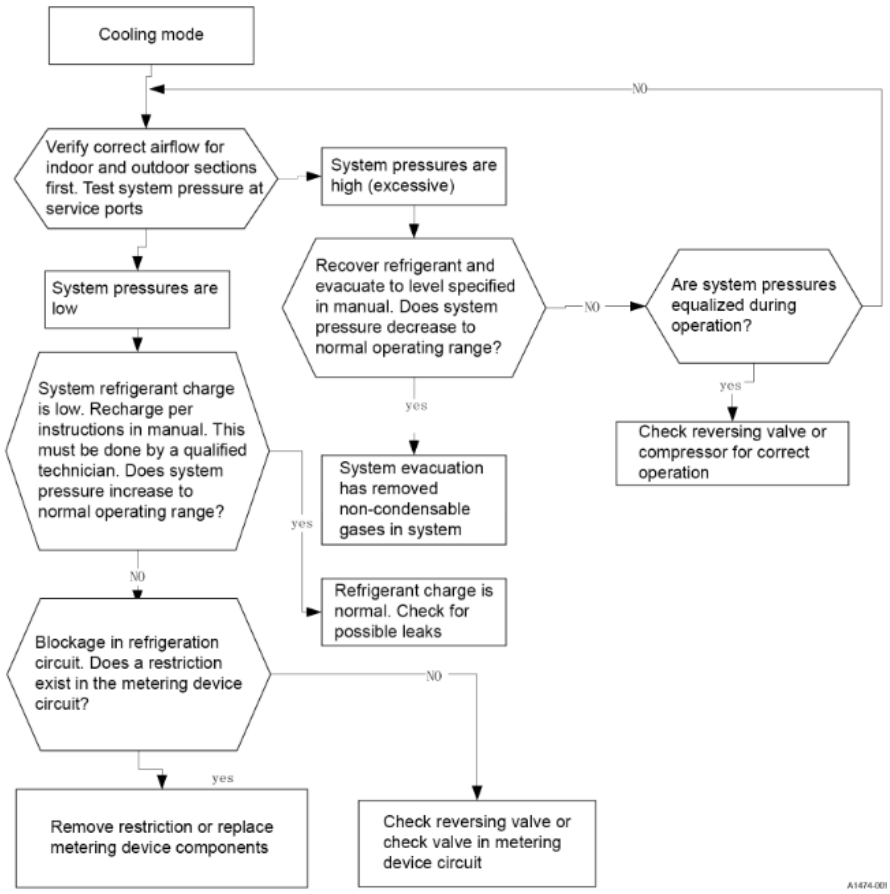
After pressing P1 (Parameter #1) Observing the actual Frequency

Parameters - HMH72B48/HMH72B60

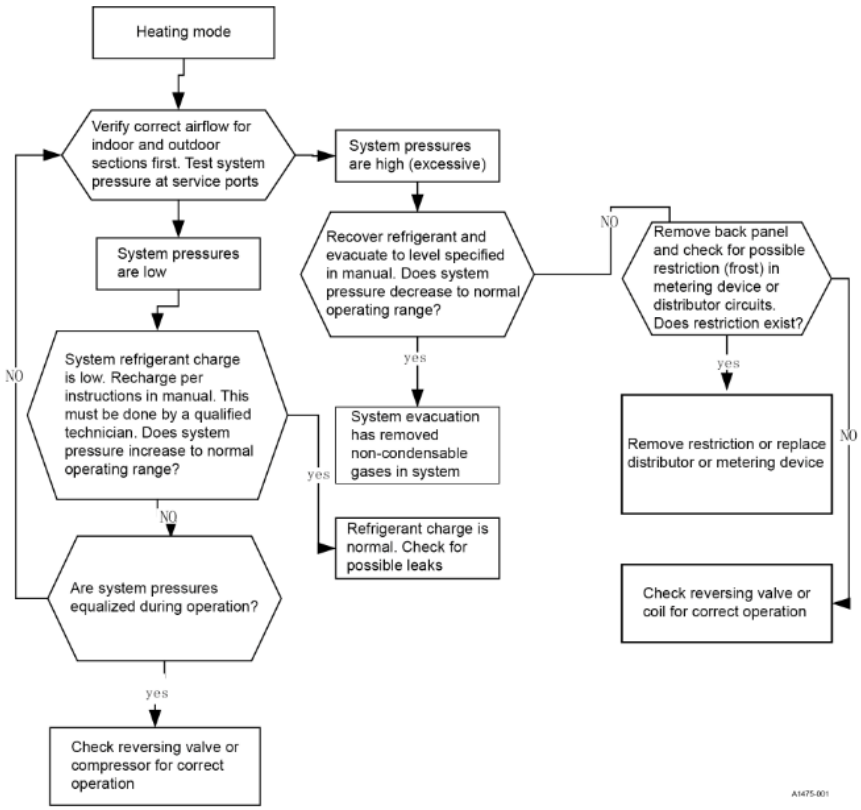
Parameter code	Description
0	Protection code or fault code
P.1	Compressor actual frequency
P.2	Compressor driving frequency
P.4	Outdoor EEV opening
P.5	Outdoor EEV target opening
P.6	Upper DC motor revolving speed
P.8	AC input voltage
P.9	AC input current
P.10	IPM module temperature
P.11	Outdoor capacity requirement
P.12	IPM module fault
P.20	Outdoor ambient temperature
P.21	Outdoor coil temperature
P.22	Outdoor defrost temperature
P.23	Suction temperature
P.24	Discharge temperature
H.1	DSH actual value
H.2	DSH target value
H.3	Target pressure in cooling mode (Actual pressure = the displayed value/100) in MPa
H.4	Target pressure in heating mode (Actual pressure = the displayed value/100) in MPa
H.5	Actual pressure = the displayed value/100 in MPa

Note: Any temperatures that are shown in the parameter list will be shown in Celsius. Any pressures shown in the parameter list will be shown in Megapascals (MPa)

Cooling mode flow chart



Heating mode flow chart



Flash Codes

The HMH7 provides flash codes on the display board (24, 34, and 36 models) or main control board (48 and 60 models) to assist in troubleshooting the system. These codes are illustrated below.

Outdoor Unit Fault Codes

Fault Code	Fault Description	Possible Reasons for Fault	Resolution	Comments
1	Outdoor ambient temperature sensor fault	1. The outdoor ambient temperature sensor has a poor connection. 2. The outdoor ambient temperature sensor has failed. 3. The sampling circuit has failed.	1. Reconnect the outdoor ambient temperature sensor. 2. Replace the outdoor ambient temperature sensor components. 3. Replace the outdoor control board components.	
2	Outdoor coil temperature sensor fault	1. The outdoor coil temperature sensor has a poor connection. 2. The outdoor coil temperature sensor has failed. 3. Sensor circuit failure.	1. Reconnect the outdoor coil temperature sensor. 2. Replace the outdoor coil temperature sensor components. 3. Replace the outdoor control board components.	
3	Unit overcurrent turn-off fault	1. The control board current sampling circuit has failed. 2. Excessive current due to low supply voltage. 3. The compressor has failed. 4. Overload in cooling mode. 5. Overload in heating mode.	1. Replace the electrical control board components. 2. Normal protection. 3. Replace the compressor. 4. See Tables below. 5. See Tables below	
4	EEprom data error	1. EE components fail. 2. EE components control circuit fails. 3. EE components are inserted incorrectly.	1. Replace the board. 2. Replace the outdoor control board components. 3. Reset the EE components.	

5	Cooling freezing protection (the indoor coil temperature is too low) or heating overload (the indoor coil temperature is too high)	1. Indoor unit airflow restriction. 2. The room temperature is too low in cooling mode, or the room temperature is too high in heating mode. 3. The filter is dirty. 4. The duct resistance is too high resulting in low airflow. 5. The selected indoor fan speed is too low. 6. The indoor unit is not installed in accordance with the installation instructions, and the air inlet is too close to the air outlet.	1. Check if the indoor fan, indoor fan motor, and indoor coil function normally. 2. Normal protection. 3. Clean the filter. 4. Correct the duct system. 5. Correct the indoor fan speed. 6. Reinstall the indoor unit referring to the installation instructions to resolve issues.	

7	Communication fault between the indoor unit and outdoor unit	1. The low-voltage cable is connected incorrectly between the indoor unit and the outdoor unit. 2. The low-voltage connection is loose. 3. The low-voltage cable is damaged. 4. The outdoor control board has failed. 5. The low-voltage circuit fuse is open. 6. The low-voltage cable is incorrect.	1. Reconnect the connection cable referring to the wiring diagram. 2. Reconnect the low-voltage cable. 3. Replace the low-voltage cable. 4. Replace the outdoor control board. 5. Check the low voltage circuit and adjust the DIP switch and the short-circuit fuse. 6. Choose a suitable low-voltage cable. Refer to the installation instructions.	

13	Compressors overheat protector device	1. The wiring of the overload protector has a poor connection. 2. Overload protector failure. 3. Low refrigerant charge. 4. Long lineset length applied without additional charge. 5. TXV/EEV valve failure. 6. Outdoor control board failure.	1. Reconnect the wiring of the overload protector. 2. Replace the overload protector. 3. Check the braze joints for leaks and recharge the refrigerant. 4. Add refrigerant. 5. Replace the expansion valve. 6. Replace the outdoor control board.	
14	The high-pressure switch operation or unit is turned off for high-pressure protection	1. The wiring of the high-pressure switch has a poor connection. 2. The high-pressure switch has failed. 3. The outdoor control board is abnormal. 4. Overload in cooling. 5. Overload in heating	1. Reconnect the wiring of the high-pressure switch. 2. Replace the high-pressure switch. 3. Replace the outdoor control board. 4. See Tables below 5. See Tables below	Applies to models with high-pressure switch or pressure sensor.
15	The low-pressure switch protection or unit is turned off for low-pressure protection.	1. The wiring of the low-pressure switch has a poor connection. 2. The low-pressure switch has failed. 3. The refrigerant charge is low. 4. The expansion valve fails in heating mode. 5. The outdoor control board is abnormal.	1. Reconnect the wiring of the low-pressure switch. 2. Replace the low-pressure switch. 3. Check for a refrigerant leak and adjust the refrigerant charge. 4. Replace the expansion valve. 5. Replace the outdoor control board.	Applies to models with low-pressure switch or pressure sensor.
16	Overload protection in cooling mode.	System overload	See Table Below	
17	Discharge temperature sensor fault	1. The wiring of the discharge temperature sensor has a poor connection. 2. The discharge temperature sensor has failed. 3. The sampling circuit is abnormal.	1. Reconnect the wiring of the discharge temperature sensor. 2. Replace the discharge temperature sensor. 3. Replace the outdoor control board.	

18	AC voltage is abnormal	1. The AC voltage is > 275 V or >160V. 2. The AC voltage of the sampling circuit on the drive board is abnormal.	1. Normal protection, check the supply power. 2. Replace the drive board.	
19	Suction temperature sensor fault	1. The wiring of the low-pressure switch has a poor connection. 2. The low-pressure switch has failed. 3. The refrigerant charge is low. 4. The expansion valve fails in heating mode. 5. The outdoor control board is abnormal.	1. Reconnect the suction pressure sensor wiring. 2. Replace the suction pressure sensor. 3. Replace the outdoor control board.	
22	Defrosting sensor fault	1. The wiring of the defrost temperature sensor has a poor connection. 2. The defrost temperature sensor has failed. 3. Sensor circuit failure.	1. Reconnect the wiring of the defrost sensor. 2. Replace the defrost sensor. 3. Replace the outdoor control board.	

43	High-pressure sensor fault	1. The wiring of the high-pressure sensor has a poor connection. 2. The high-pressure sensor has failed. 3. The high-pressure sensor circuit has failed.	1. Reconnect the high-pressure sensor wiring. 2. Replace the high-pressure sensor. 3. Replace the outdoor control board.	
45	IPM fault	Drive or amplifier fault	See Table 13 and Table 14 for drive fault codes.	
46	IPM and control board communication fault	1. The cable between the control board and the drive board has a poor connection. 2. The cable between the control board and the drive board has failed. 3. The drive board failed. 4. The control board has failed.	1. Reconnect the cable between the control board and the drive board. 2. Replace the communication cable between the control board and the drive board. 3. Replace the drive board. 4. Replace the control board.	

47	Excessive discharge temperature fault	1. Low refrigerant charge. 2. Low charge due to extended lineset. 3. Metering system failure. 4. Excessive outdoor ambient temperature.	1. Check for leaks. 2. Correct the refrigerant charge. 3. Replace the metering devices. 4. Normal protection.	
48	Outdoor DC fan motor fault (upper fan motor)	1. The DC fan motor connection is poor. 2. The wiring to the DC fan motor has failed. 3. The DC fan motor has failed. 4. The drive circuit of the upper DC fan motor has failed. 5. Outdoor airflow blockage.	1. Replace the DC fan motor wiring. 2. Replace the DC fan motor. 3. Replace the DC fan motor. 4. Replace the drive board of the fan motor. 5. Resolve the outdoor unit airflow restriction.	
49	Outdoor DC fan motor fault (lower fan motor)	1. The DC fan motor connection is poor. 2. The wiring to the DC fan motor has failed. 3. The drive circuit of the lower DC fan motor has failed. 4. The drive circuit of the lower DC fan motor has failed. 5. Outdoor airflow blockage.	1. Replace the DC fan motor wiring. 2. Replace the DC fan motor. 3. Replace the DC fan motor. 4. Replace the drive board of the fan motor. 5. Resolve the outdoor unit airflow restriction.	
91	Unit stops due to IPM board overheating fault	1. The outdoor ambient temperature is too high. 2. The speed of the outdoor fan motor is too low. 3. The outdoor unit is not installed in accordance with the installation instructions. 4. The supply power is too low.	1. Normal protection. 2. Check the fan motor and replace if necessary. 3. Reinstall the outdoor unit in accordance with the installation instructions. 4. Normal protection.	
96	Low charge	Inadequate system charge	Recover the refrigerant and charge the refrigerant. Refer to the *Tabular Data Sheet.*	

97	4-way valve failure	1. The connecting wiring of the 4-way valve coil is poor. 2. The 4-way valve coil has failed. 3. The 4-way valve has failed. 4. The drive board of the 4-way valve has failed.	1. Repair the wiring of the 4-way valve. 2. Replace the 4-way valve coil. 3. Replace the 4-way valve. 4. Replace the drive board of the 4-way valve.	

Note:
If the indoor unit fails to start or the indoor unit stops after 30 s and the unit does not display the fault code, check the voltage and connection to the control board. Verify Indoor Unit control operation and setup.

Example of a Outdoor Fault Code #13
Compressor Overheat Protector Device

Overload in cooling mode (See fault codes 3,14, and 16 of Outdoor Fault Codes)

No.	Cause	Resolution
1	The refrigerant is excessive.	Recover the refrigerant and recharge the refrigerant referring to the rating label.
2	The outdoor ambient temperature is too high.	Use within allowable temperature range.
3	Short-circuit occurs in the air outlet and air inlet of the outdoor unit.	Adjust the installation of the outdoor unit referring to the installation instructions.
4	The outdoor heat exchanger is dirty.	Clean the heat exchanger of the outdoor unit.
5	The speed of the outdoor fan motor is too low.	Check the outdoor fan motor operation and replace if necessary.
6	The outdoor fan is damaged or blocked.	Check the outdoor fan.
7	The air inlet and/or outlet has been blocked.	Remove the obstructions.
8	The expansion valve or the capillary has failed.	Replace the expansion valve or the capillary.

Overload in heating mode (See fault codes 3 and 14 of Outdoor Fault Codes)

No.	Cause	Resolution
1	The refrigerant is excessive.	Recover the refrigerant, and recharge the refrigerant referring to the rating label.
2	The indoor ambient temperature is too high.	Use within allowable temperature range.
3	Short-circuit occurs in the air outlet and air inlet of the indoor unit.	Adjust the installation of the indoor unit by referring to the installation instructions.
4	The indoor filter is dirty.	Clean the indoor filter.
5	The speed of the indoor fan motor is too low.	Check the indoor fan motor speed setting.
6	The indoor fan is not operating correctly.	Check the indoor fan.
7	The air inlet and/or outlet has been blocked.	Remove the obstructions.
8	The expansion valve or the capillary fails.	Replace the expansion valve or the capillary.

Drive fault code – 24k/34k/36k

Fault Code	Fault Description	Possible Reasons for Fault	Resolution
1	Inverter DC voltage overload fault	1. The power supply input is too high or too low. 2. Drive board fault.	1. Check the power supply. 2. Change the drive board.
2	Inverter DC low-voltage fault		
3	Inverter AC current overload fault		
4	Out-of-step detection	1. Compressor phase lost. 2. Bad drive board components. 3. Compressor insulation fault.	1. Check the compressor wire connection. 2. Change the drive board. 3. Change the compressor.
5	Loss phase detection fault (speed pulsation)		
6	Loss phase detection fault (current imbalance)		
7	Inverter IPM fault (edge)	1. System overload or current overload. 2. Drive board fault. 3. Compressor oil shortage, serious wear of crankshaft. 4. Compressor insulation fault.	1. Check the system. 2. Change the drive board. 3. Change the compressor. 4. Change the compressor.
8	Inverter IPM fault (level)		
9	PFC_IPM IPM fault (edge)		
10	PFC_IPM IPM fault (level)		
11	PFC power detection of failure	1. The power supply is not stable. 2. Instantaneous power off. 3. Drive board failure.	1. Check the power supply. 2. N/A 3. Change the drive board.
12	PFC overload current detection of failure	1. System overload, current is too high. 2. Drive board fails. 3. PFC fails.	1. Check the system. 2. Change the drive board. 3. Change the PFC.

Drive fault code – 24k/34k/36k

Fault Code	Fault Description	Possible Reasons for Fault	Resolution
13	DC voltage detected abnormal	1. The input voltage is too high or too low. 2. Drive board fails.	1. Check the power supply. 2. Change the drive board.
14	PFC LOW voltage detected failure		
15	AD offset abnormal detected failure	Drive board fails.	Change the drive board.
16	Inverter PWM logic set fault		
17	Inverter PWM initialization failure		
18	PFC_PWM logic set fault		
19	PFC_PWM initialization fault		
20	Temperature abnormal		
21	Shunt resistance unbalance adjustment fault		
22	Communication failure	1. Communication wire connection is poor. 2. Drive board fails. 3. Control board fails.	1. Check the wiring. 2. Change the drive board. 3. Change the control board.
23	Incorrect motor parameters	Initialization is abnormal.	Reset the power supply.
26	DC voltage mutation error	1. System overloads, phase current is too high. 2. Drive board fails.	1. Check the power supply to provide stable power supply. 2. Change the drive board.

Drive fault code – 24k/34k/36k

Fault Code	Fault Description	Possible Reasons for Fault	Resolution
27	D axis current control error	1. System overload, phase current is too high. 2. Drive board fails.	1. Check the system to see if it works normally. 2. Check the stop valve to see if it is open. 3. Change the drive board.
28	Q axis current control error	1. System overloads, phase current is too high. 2. Drive board fails.	1. Check the system to see if it works normally. 2. Check the stop valve to see if it is open. 3. Change the drive board.

Drive fault code – 24k/34k/36k

Fault Code	Fault Description	Possible Reasons for Fault	Resolution
29	Saturation error of D axis current control integral	1. Momentary system overload. 2. The compressor parameter is not suitable. 3. Drive board fails.	1. Check the system to see if it works normally. 2. Check the stop valve to see if it is open. 3. Change the drive board.
30	Saturation error of Q axis current control integral	1. Momentary system overload. 2. The compressor parameter is not suitable. 3. Drive board fails.	1. Check the system to see if it works normally. 2. Check the stop valve to see if it is open. 3. Change the drive board.
35	EE data abnormal	Driver board EEPROM is abnormal.	1. Change the EEPROM. 2. Change the drive board.

LED-displayed fault codes - HMH72B24/HMH72B34/HMH72B36

Fault codes are displayed by LED lamps on the outdoor main control board (DC - inverter unitary). Remove the system top cover to expose the indicator LED lamps. There are three LED lamps on the main control board:

• LED1 indicates the fault code represented by a two-digit number.

• LED2 indicates the fault code represented by a single-digit number.

• LED3 indicates an outdoor drive control fault. When LED3 is off, LED1 and LED 2 indicate the main control fault code. When LED3 is on, LED1 and LED 2 indicate the drive control fault code.

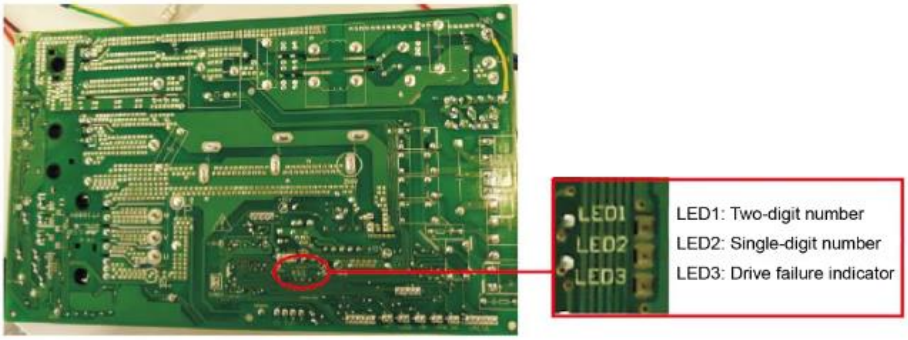
When LED3 is flashing, and LED1 and LED 2 are both off, it indicates the compressor is preheating.

Failures display with 5-s intervals. This means the LED is off for 5 s to report the next fault code.

The system protection code display method is the same as the main control fault code.

LED lamps are off when there is no failure, protection, or preheating.

LED lamps (24,34 and 36 models)



Drive fault code – 48k/60k

Fault Code	Fault Description	Possible reasons for fault	Resolution
1	Q axis current detection, failure in drive control	1. The compressor wire connection is poor. 2. Bad drive board components. 3. The compressor start load is too large. 4. Compressor demagnetization. 5. Compressor oil shortage, serious wear of crankshaft. 6. The compressor insulation has failed.	1. Check the wire of the compressor. 2. Change the drive board. 3. Allow pressures to equalize and then resume unit operation. 4. Change the compressor. 5. Change the compressor. 6. Change the compressor.
2	Phase current detection, failure in drive control	1. Compressor voltage default phase. 2. Bad drive board components. 3. The compressor insulation has failed.	1. Check the compressor wire connection. 2. Change the drive board. 3. Change the compressor.
3	Initialization, phase current imbalance	Bad drive board components.	Change the drive board.
4	Speed estimation, failure in drive control	1. Bad drive board components. 2. Compressor shaft clamping. 3. The compressor insulation has failed.	1. Change the drive board. 2. Change the compressor. 3. Change the compressor.

Drive fault code – 48k/60k

Fault Code	Fault Description	Possible reasons for fault	Resolution
5	IPM FO output fault	1. System overload or current overload. 2. Drive board fails. 3. Compressor oil shortage, serious wear of crankshaft. 4. The compressor insulation has failed.	1. Check the outdoor section system. 2. Change the drive board. 3. Change the compressor. 4. Change the compressor.
6	Communication between drive board and control board fault	1. Communication wire connection is poor. 2. Drive board fault. 3. Control board fault.	1. Check the wiring. 2. Change the drive board. 3. Change the control board.
7	AC voltage, overload voltage	1. The supply voltage input is too high or too low. 2. Drive board fault.	1. Check the power supply. 2. Change the drive board.
8	DC voltage, overload voltage	1. The supply voltage input is too high. 2. Drive board fault.	1. Check the power supply. 2. Change the drive board.
9	AC voltage imbalance	Drive board fails.	Change the drive board.
10	PFC current detection circuit fault before compressor is ON	Bad drive board components.	Change the drive board.

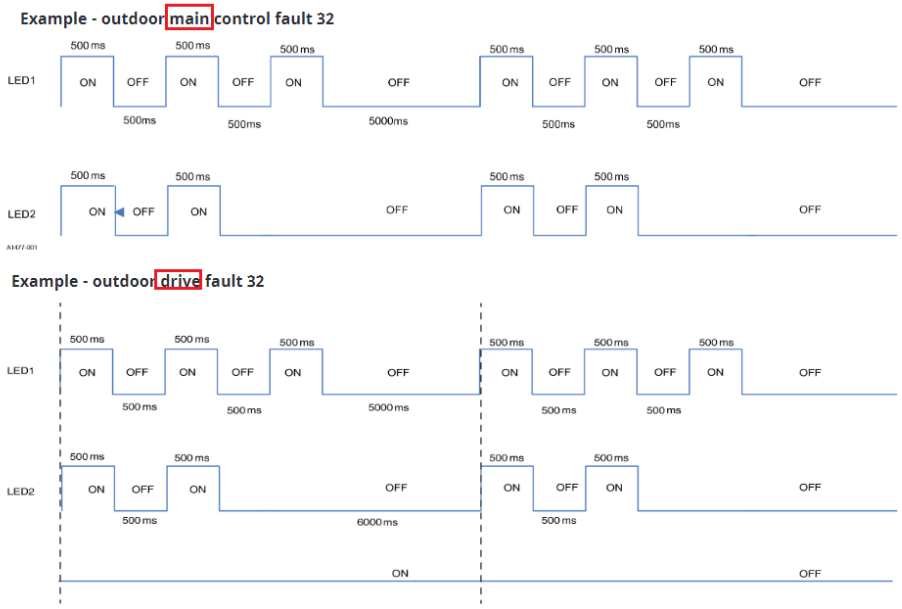
Fault Code	Fault Description	Possible reasons for fault	Resolution
11	AC voltage supply out of range	1. Power supply abnormal, power frequency out of range. 2. Drive board fails.	1. Check the system. 2. Change the drive board.
12	Products if single-phase PFC overcurrent, FO output low level	1. System overload, current is too large. 2. Drive board fault. 3. PFC fault.	1. Check the system. 2. Change the drive board. 3. Change PFC.
	Inverter overcurrent (3-phase power supply outdoor sections)	1. System overload, current is too large. 2. Drive board fault. 3. Compressor oil shortage, serious wear of crankshaft. 4. The compressor insulation has failed.	1. Check the system. 2. Change the drive board. 3. Change the compressor. 4. Change the compressor.
13	Inverter overcurrent	1. System overload, current is too large. 2. Drive board fault. 3. Compressor oil shortage, serious wear of crankshaft. 4. The compressor insulation has failed.	1. Check the system. 2. Change the drive board. 3. Change the compressor. 4. Change the compressor.

Drive fault code – 48k/60k

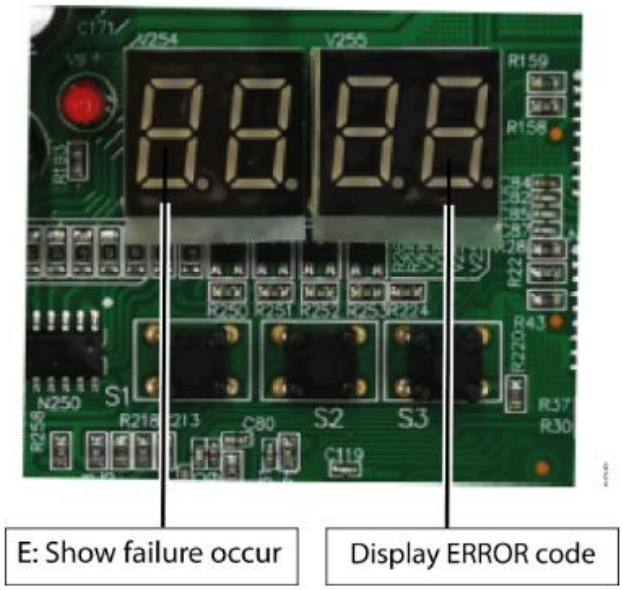
Fault Code	Fault Description	Possible reasons for fault	Resolution
14	PFC overcurrent (single-phase outdoor section)	1. System overload, current is too large. 2. Drive board fault. 3. PFC fault.	1. Check the system. 2. Change the drive board. 3. Change the PFC.
	Phase imbalance, phase loss, or instantaneous power failure (only for 3-phase power supply outdoor sections)	1. The 3-phase voltage imbalance. 2. 3-phase power supply phase lost. 3. The power supply wiring is incorrect. 4. Drive board fault.	1. Check the power supply. 2. Check the power supply. 3. Check the supply wiring connection. 4. Change the drive board.
15	Instantaneous power off detection	1. The power supply is not stable. 2. Instantaneous power failure. 3. Drive board fault.	1. Check the power supply. 2. No fault. 3. Change the drive board.
16	Low DC voltage 200 V	1. The voltage input is too low. 2. Drive board fault.	1. Check the power supply. 2. Change the drive board.

Drive fault code – 48k/60k

18	Drive board read EE data error	1. EEPROM has no data or data errors. 2. EEPROM circuit fault.	1. Change the EEPROM component. 2. Change the drive board.
19	PFC chip receives data fault	Abnormal communication loop	Change the drive board
20	PFC soft start abnormally	Abnormal PFC drive loop	Change the drive board
21	Compressor drive chip could not receive data from PFC chip	Communication loop fault	Change the drive board



Main control fault display - HMH72B48/ HMH72B60



General Troubleshooting & Flow Charts

Malfunction	Possible reasons for malfunction	Suggested action
Outdoor section does not start	1. Power supply failure. 2. Trip of breaker or open fuse. 3. Supplied voltage is too low. 4. Incorrect setting of the thermostat. 5. No power to the thermostat.	1. Check the power supply circuit. 2. Measure the insulation resistance to ground to see if there is any leakage. 3. Check if there is a defective contact or leakage current in the power supply circuit. 4. Check and set the thermostat. 5. Check the thermostat and thermostat wiring.
Compressor starts or stops frequently	The air inlet and/or outlet has been blocked or restricted.	Remove the blockage.
Poor cooling/heating	1. The outdoor heat exchanger is dirty. 2. Air leakage into the conditioned space or excessive load due to persons entering and exiting frequently. 3. Blockage of outdoor heat exchanger. 4. Incorrect temperature setting.	1. Clean the heat exchanger of the outdoor unit. 2. Keep certain air tightness indoors. 3. Remove the blockage. 4. Check and try to set the temperature again.
Sound from deforming parts	During system starting or stopping, a sound might be heard. This is due to thermal deformation of plastic parts.	Note that this is normal and the sound disappears quickly.
Water leakage	1. The drainage pipe is blocked or broken. 2. The insulation of the refrigerant piping is inadequate.	1. Change the drainage pipe. 2. Correct the refrigeration piping insulation.

08

Maintenance

Maintenance

Preventative maintenance is crucial to proper system operation, consumer comfort, and system durability. The technician should provide the owner with the owner-operator maintenance procedures that accompany the equipment. The technician should also discuss maintenance programs to have the system cleaned and serviced on a regular schedule.

It is recommended that the system is inspected once a year by a qualified service person. Air openings and clearance around the unit must not be blocked or obstructed. Structures or shrubs must not obstruct the outdoor unit air discharge.

Since the HMH7 has to be matched with an indoor blower type of unit, the indoor unit needs to have the filters changed regularly. The indoor coil needs to remain clean for good airflow.

The outdoor coil rejects heat from the refrigerant to the outdoor air during cooling operation and in the opposite direction during heating operation. The equipment must have the designed airflow across the coil to maintain system efficiency. The outdoor coil must be kept clean and free of debris. Remove power from the unit when cleaning the coil with water or coil cleaners. Refrain from using excessive pressure (such as with a pressure washer) when cleaning the coil. Approved methods include:

- Coil brushes
- Vacuum cleaner attachments
- Water (not high pressure)
- Non-acid coil cleaners

The outdoor fan motors on the HMH7 are permanently lubricated and require no maintenance.

09

Compressor Modulation Frequency Data

Capacity	24K	36K	48K	60K
25%	15Hz	22Hz	15Hz	18Hz
26%	15.7059	22.8588	15.9059	18.9059
27%	16.4118	23.7176	16.8118	19.8118
28%	17.1176	24.5675	17.7176	20.7176
29%	17.8235	25.4353	18.6235	21.6235
30%	18.5294	26.2941	19.5294	22.5294
31%	19.2353	27.1529	20.4353	23.4353
32%	19.9412	28.0118	21.3412	24.3412
33%	20.6471	28.8706	22.2471	25.2471
34%	21.3529	29.7294	23.1529	26.1529
35%	22.0588	30.5882	24.0588	27.0588
36%	22.7647	31.4471	24.9647	27.9647
37%	23.4706	32.3059	25.8706	28.8706
38%	24.1765	33.1647	26.7765	29.7765
39%	24.8824	34.0235	27.6824	30.6824
40%	25.5882	34.8824	28.5882	31.5882
41%	26.2941	35.7412	29.4941	32.4941
42%	27	36.6	30.4	33.4
43%	29.7059	37.4588	31.3059	34.3059
44%	28.4118	38.3176	32.2118	35.2118
45%	29.1176	39.1765	33.1176	36.1176
46%	29.8235	40.0353	34.0235	37.0235
47%	30.5294	40.8941	34.9294	37.9294
48%	31.2353	41.7529	35.8353	38.8353
49%	31.9412	42.6118	36.7412	39.7412
50%	32.6471	43.4706	37.6471	40.6471
51%	33.3529	44.3294	38.5529	41.5529
52%	34.0588	45.1882	39.4588	42.4588
53%	34.7647	46.04714	40.3647	43.3647
54%	35.4706	46.9059	41.2706	44.2706
55%	36.1765	47.7647	42.1765	45.1765
56%	36.8824	48.6235	43.0824	46.0824
57%	37.5882	49.4824	43.9882	46.9882
58%	38.2941	50.3412	44.8941	47.8941
59%	39	51.2	45.8	48.8
60%	39.7059	52.0288	46.7059	49.7059
61%	40.4118	52.9176	47.6118	50.6118
62%	41.1176	53.7765	48.5176	51.5176
63%	41.8235	54.6353	49.4235	52.4235
64%	42.5294	55.4941	50.3294	53.3294
65%	43.2353	56.3529	51.2353	54.2353
66%	43.9412	57.2118	52.1412	55.1412
67%	44.6471	58.0706	53.0471	56.0471
68%	45.3529	58.9235	53.9529	56.9529
69%	46.0588	59.7882	54.8588	57.8588
70%	46.7647	60.6471	55.7647	58.7647
71%	47.4706	61.5059	56.6706	59.6706
72%	48.1765	62.3647	57.5765	60.5765
73%	48.8824	63.2235	58.4824	61.4824
74%	49.5882	64.0824	59.3882	62.3882
75%	50.2941	64.9412	60.2941	63.2941
76%	51	65.8	61.2	64.2
77%	51.7059	66.6588	62.1059	65.1059
78%	52.4118	67.5176	63.0188	66.0118
79%	53.1176	68.3765	63.9176	66.9176

Capacity	24K	36K	48K	60K
80%	53.8235	69.2353	64.8235	37.8235
81%	554.5294	70.0941	65.7294	68.7294
82%	55.2353	70.9529	66.6353	69.6353
83%	55.9412	71.8118	67.5412	70.5412
84%	56.6471	72.6706	68.4471	71.4471
85%	57.3529	73.5294	69.3529	73.3529
86%	58.0588	74.3882	70.2588	73.2588
87%	58.7647	75.2471	71.1647	74.1647
88%	59.4706	76.1059	72.0706	75.0706
89%	60.1765	76.9647	72.9765	75.9765
90%	60.8824	77.8235	73.8824	76.8824
91%	61.5882	78.6824	74.7882	77.7882
92%	62.2941	79.5412	75.6941	78.6941
93%	63	80.4	76.6	79.6
94%	63.7059	81.2588	77.5059	80.5059
95%	64.4118	82.1176	78.4118	81.4118
96%	65.1176	82.9765	79.3176	82.3176
97%	65.8235	83.8353	80.2235	83.2235
98%	66.5294	84.6941	81.1294	84.1294
99%	67.2353	85.5529	82.0353	85.0353
100%	67.9412	86.4118	82.9412	85.9412
101%	68.6471	87.2706	83.8471	86.8471
102%	69.3529	88.1294	84.7529	87.7529
103%	70.0589	88.9882	85.6588	88.6588
104%	70.7647	89.8471	86.5647	89.5647
105%	71.4706	90.7059	87.4706	90.4706
106%	72.1765	91.5647	88.3765	91.3765
107%	72.8824	92.4235	89.2824	92.2824
108%	73.5882	92.4235	89.2824	92.2824
109%	74.2941	94.1412	91.0941	94.0941
110%	75	95	92	84

