



# Kay Industries

**PHASEMASTER®**

Rotary Phase Converters

## INSTALLATION MANUAL

TYPE PI	Totally Enclosed Converter without controls
TYPE PI-R	Totally Enclosed Converter with integral fused disconnect switch
TYPE PI-A,-AW,-AI	Totally Enclosed Converter with remote start magnetic controls

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MODEL NUMBER	SERIAL NUMBER

## I. CONVERTER CONFIGURATIONS:

These installation instructions apply to the following **Phasemaster®** converter configurations.

Type	Description	Cat No. Format	Connection Drawing
PI	The basic general-purpose converter configuration. It is provided with a lead box with bolted lug or terminal blocks for line and load side connections. This converter requires some type of field supplied and mounted primary disconnect switch for on-off control.	PI-30	0302-PI Page 8
PI-R	Type PI converter with the primary fused disconnect switch built into the converter. This construction includes a large side-mounted wiring compartment that houses the switch, fuses, and input output terminal blocks.	PI-30-R	0302-PIR Page 9
PI-A	Type PI converter with magnetic contactor, power fuses, and timing relay for coordination with unattended cyclical loads. This configuration passes through single-phase power for controls.	PI-30-A	0302-PIA Page 10
PI-AW	This configuration contains the same starting controls as the type PI-A except it does not include a timing relay. The added "W" suffix means the converter is manually started from a hard-wired remote pilot control such as a start-stop pushbutton station.	PI-30-AW	0302-PIAW Page 11
PI-AI	Same as the PI-A except the converter contains an adjustable interval timer that keeps the converter operating for some preset period of time after the most recent equipment operation. It is typically used on elevators, car washes and other applications that are subject to multiple consecutive operations. The timer reduces the need for multiple restarts thus saving wear on controls and stress on the utility supply.	PI-30-AI	0302-PIA Page 10

## ACCESSORIES:

The converter types listed above can be equipped with various accessories that are listed on the nameplate as part of the catalog number. The following suffix letters indicate which accessories are included.

-VS	This is the Load Range Controller feature which automatically adjusts the converter's output voltage up or down to accommodate changes in load. It is particularly helpful in operating very small loads. It also enables the converter to easily handle variable speed drives and CNC equipment without causing overvoltage conditions that could prevent the drive from starting. See the -VS accessory instructions on page 11.
-TC	This is the Thermostatic Control accessory for use on HVAC equipment. It includes a set of control relays and terminal blocks that enable the thermostat control wiring to be rerouted through the converter to start it on demand. <u>Connection diagram is supplied in a supplement to this booklet.</u> A 24 volt input is required for converter operation.
-CL	The converter is equipped with current limiting starting accessory that starts the converter in stages and reduces the starting current demand on the utility supply. This accessory adds an additional contactor to the starting circuit. Factory set timing relays adjust the switching time and sequencing of these contactors. Normally no further adjustments are required in the field. <u>Instructions for this accessory are supplied in a supplement to this booklet.</u>
-L	Indicates the converter is equipped with lightning and surge protection. This feature is normally included on installations that are located in remote areas where lightning strikes and/or line surges are a common event. It functions without adjustment and provides a degree of protection for the converter alone when surges get past all other protective devices upstream from the converter. No special action is required to activate the surge protection. The glowing indicating lamp on the protector indicates it is in working order and operating. No further operating instructions are required.
-BB	Indicates the converter includes a built-in buck boost transformer on the single-phase input side. The transformer is pre-connected for a specific voltage change and does not require any additional wiring.
-OC	Converter is equipped with an output contact to prevent transformers or other downstream devices from being energized until the converter is fully up to speed and producing 3-phase.

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## BEFORE YOU START

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### **CHECK YOUR ACTUAL INCOMING LINE VOLTAGE AND NAMEPLATE VOLTAGE OF YOUR LOAD EQUIPMENT**



Motors and electrical equipment built in North America are rated to operate at 230V  $\pm$ 10%. However, most 3-phase machines manufactured in Europe and Asia are actually designed for operation on 220V systems. Although they are capable of running at voltages up to 10% above 220V (242V), North American utility voltages can legally be as high as 252V. Utility companies generally will not accept responsibility for equipment damage unless the voltage exceeds this level.

If your voltage measures above 240V at any time, it is highly probable that it could go even higher on other occasions depending on the time of day or seasonal power load. This means your equipment is likely to see voltages in excess of 242V coming from the converter. If your machines are designed for European or Asian voltages, you should consider installing a buck-boost transformer AHEAD of the converter to reduce the utility supply voltage. This is particularly important if your machine incorporates a variable speed drive.

The buck-boost transformer will generally eliminate or minimize problems that result from excessive utility supply voltage. Contact Kay Industries for further explanation of this subject and for exact recommendations of the proper size buck-boost transformer for your application.

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Kay Industries has designed the **Phasemaster**<sup>®</sup> Rotary Phase Converter to be installed by anyone having basic electrical knowledge and mechanical skills. If you do not thoroughly understand these instructions, we recommend you obtain the assistance of a licensed electrician.

These instructions are based upon Article 455 of the most recent National Electrical Code (NEC). Although we present a practical set of guidelines for converter installation, we do not intend to supersede or modify the requirements of the NEC or any applicable local codes. We suggest that you consult these references to determine whether your particular installation complies with applicable regulations.

If feasible, it is always a good idea to **temporarily connect the phase converter and the load** to verify performance before proceeding with the permanent installation.

**Whether this is your first phase converter installation or your one-hundredth, there are a few do's and don'ts that you should observe.**

<b>DO:</b>	<b>DON'T:</b>
<b>DO:</b> Install a starter and fuses, or a fused disconnect switch (if your converter does not have internal fuses) after the single-phase circuit breaker but ahead of the converter. This is the best way to provide on-off control.	<b>DON'T:</b> Cut corners by using the circuit breaker for on-off control instead of a fused switch or starter. A breaker is not designed for as many operations as a switch and may wear out prematurely if subjected to many repeated converter starting cycles.
<b>DO:</b> Remove the converter from the skid	<b>DON'T:</b> Bolt the converter down.
<b>DO:</b> Bolt or crimp all connections. Insulate all connections with rubber and plastic tape or heat shrinkable tubing.	<b>DON'T:</b> Use wire nuts or twist type connectors to connect the converter.
<b>DO:</b> Connect all single-phase loads, including controls, only to utility lines L1 and L2.	<b>DON'T:</b> Connect the manufactured leg T3 to any control circuits or to any single-phase loads.

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### III. SIZING THE SINGLE-PHASE SERVICE

It is extremely important to supply the phase converter with an adequately sized 1-phase circuit for the total planned 3-phase load. There are several ways to arrive at the size of the required 1-phase service but the simplest are the, EXPRESS METHOD and by actual CALCULATION.

#### Express Method

As a rule the single fastest way to calculate the necessary circuit size is to provide a MINIMUM of five (5) and preferably six (6) amps of single-phase 240V service for every horsepower or kilowatt of simultaneously operating load. (On this basis a total load of 25 HP should be fed from a 1-phase breaker not smaller than 125A.) This method will assure that virtually any connected load up to the maximum will operate without tripping the single-phase feeder breaker. However, using six (6) amps per horsepower will assure absolute compliance with the extremely conservative requirements of the NEC.

#### Calculation Method

1. Add the total 3-phase full load currents for every load that operates simultaneously. If the equipment nameplate does not show full load amperage, you can estimate that every motor will draw 2.6 amps per horsepower at 230 volts. For example, a 20 HP motor will pull approximately 52A of 3-phase current at full load. If you are operating at 208 or 460 volts you must adjust the current accordingly. Use 2.8 amps/HP for 208 volts and 1.3 amps/HP for 460 volts.
2. Multiply the total 3-phase full load current from Step 1 times 1.732. This is the exact single-phase current that you will draw from your service panel.
3. Multiply the 1-phase current determined in step 2 by the NEC safety margin of 1.25. This is now the **minimum 1-phase service** you will need to operate the load. This is also the minimum ampacity requirement for the 1-phase wire size from the service panel to the converter. This is a conservative way to select your wire and branch circuit size and will assure your compliance with code.

**If you use a breaker of smaller rating than called for by this calculation, it may trip when the converter starts or may be too small to handle the entire planned load.**

To determine the single and 3-phase wire size required, disconnect switch and fuse ratings, refer to the table and diagram on drawing 0302-PI, 0302-PIA.

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### IV. INSTALLATION

**BEFORE YOU CONNECT ANY WIRES  
Be sure all POWER IS OFF at the main panel.**

#### **SELECTING A CONVERTER LOCATION**

Select a location as close as practical to the incoming single-phase service entrance or if you prefer, locate the converter near the three-phase load. You may locate the converter outdoors in any environment.

#### **GENERAL WIRING INSTRUCTIONS (APPLIES TO ALL CONVERTER TYPES)**

Remove the converter from the skid and set it in place on the mounting pads included in the package. **Do not bolt the converter to the floor or any other mounting surface.** Rigid mounting amplifies noise, increases internal vibrations that can loosen terminals and can distort the frame causing the rotor to lock.

If feasible, it is always a good idea to **temporarily connect the phase converter and the load** to verify it is adequate for the load before proceeding with the permanent installation. This can usually be done quickly and may save a great deal of time and labor if an exchange is necessary.

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## TYPE PI CONVERTER

Type PI converters are pre-wired to operate on 230 volts unless ordered otherwise. Do not reconnect the leads in the junction box unless you need to operate the converter on 460 volts input. Many, but not all converters may be field changed to 460V. Consult Kay Industries to determine if your converter can be reconnected. The input voltage of Type PI-A and PI-R converters cannot be changed without additional modifications. Consult Kay Industries if this change is necessary. All phase converters produce three-wire delta output only. ***For four-wire wye output, consult the factory for an appropriate transformer.***

1. Consult Drawing 0302-PI to determine which connection configuration is most appropriate for your application.
2. Mount the fused disconnect switch as close as practical to the converter. Connect the disconnect switch to the single-phase branch circuit wire at the service with wire size not less than shown on Drawing 0302-PI. If the location of the converter is more than 50 feet from the service panel or if using aluminum wire, then increase the wire size appropriately.
3. Connect the load side of your fused disconnect to the converter leads marked L1 and L2 in the junction box. Lead T3 is the manufactured phase. If you are using a three-pole fused disconnect, connect T3 to the third pole on the load side of the switch. If you are using a two-pole disconnect, run T3 directly to the line side of the load disconnect or other load switching device.
4. Connect the single-phase power supply from the line side of your fused disconnect to the L1 and L2 terminals of the load disconnect switch.
5. Ground the converter by attaching the system ground wire to the ground lug in the converter junction box. If you have not grounded your load, do so before proceeding.

**Label all wires "L1", "L2" and "T3" uniformly throughout the entire system. This will avoid confusion in wire tracing should any troubleshooting become necessary later.**

## TYPE PI-R CONVERTER WITH BUILT-IN SWITCH AND FUSES

The Type PI-R converter includes built-in switch and fuses which have been appropriately sized for the load. Determine the proper single and three-phase wire size from the table in drawing 0302-PIR.

The input voltage of Type PI-A and PI-R converters cannot be changed without additional modifications. Consult Kay Industries if this change is necessary. All phase converters produce three-wire delta output only. ***For four-wire wye output, consult the factory for an appropriate transformer.***

Refer to connection drawing 0302-PIR to determine the proper wire size for your converter model.

1. Route all power cables and ground conductor in properly sized rigid or flexible conduit from the phase converter control enclosure to the load and from the service panel to the converter.
2. Connect the appropriate sized single-phase wire size from the service panel Single-Phase input terminals L1 and L2 in the converter control box. Make the necessary penetrations in the converter enclosure and secure the conduits at both ends. If you are using flexible multi-conductor cable instead of wiring in rigid or flexible conduit, be certain to use a suitable strain relief fitting where the cables enter and leave the converter enclosure.
3. Connect the single-phase supply lines L1, L2, and Ground to the input terminal blocks on the converter connection panel. Connect the output cables to the output terminals labeled T1, T2 and T3.

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## TYPE PI-A, -AW, -AI CONVERTER WITH AUTOMATIC CONTROLS

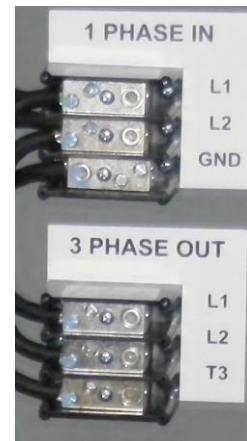
The **Phasemaster**<sup>®</sup> Automatic converter (**Type PI-A,-AW,-AI**) is identical in electrical performance to the non-automatic converter except that it is equipped with magnetic controls that enable it to be started on demand from a remote pilot control device, pushbutton station, or wireless controller. Type **PI-A** and **PI-AW** converters are equipped with a three-position selector switch. Make sure the switch is in the **OFF** position during installation.

Converter wiring is divided into power and control connections. Power connections include the 1-phase input and 3-phase output wiring. Control connections include the control wiring that is responsible for directing the converter to start and stop.

### Power Connections - Applies to All Converter Types

Determine the proper size single-phase branch circuit for the load. Refer to Section II on page 4 for a detailed discussion of the calculations. Refer to the table on drawings 0302-PIA or 0302-PIAW for the recommended single and three-phase wire size. With properly sized cables and conduits in place, you are ready to make the power connections

1. Connect the input power leads to L1 and L2 on the input terminal block in the converter enclosure. Connect the ground (NOT NEUTRAL) wire to the terminal marked "Ground". Tighten all connections securely.
2. Connect the output power cables to the output terminals designated L1, L2, and T3 in the starter panel enclosure. Tighten the terminal blocks securely and label each line with the corresponding phase identification. Later, you may change these connections at the load to obtain the correct rotation, but keep the labels on the cables so that they are marked consistently throughout the system.
3. Be sure that line T3 is not supplying power to any relays or other control components inside the load.



### IMPORTANT SAFETY NOTE TYPE PI-A CONVERTER

The L1 and L2 lines at the 3-PHASE output terminals are always **ENERGIZED** regardless of whether the converter is on or off. This assures the load always has continuous control power available. The L1 and L2 output terminals on the Type PI-AW converter are **ENERGIZED ONLY** when the converter is on.

### Control connections - Type PI-A, -AI

The phase converter must be operating **before** the load can be turned on. This converter control is designed for loads that cycle automatically such as air compressors, air conditioners, sump pumps, etc.

To accomplish this, the converter is energized from some type of pilot switch actuator on the load machine. Examples of this actuator are tank pressure switch on an air compressor or a float switch on a pump. These actuators simply close a contact when the load motor is called upon to run.

The converter is controlled by re-routing this actuator contact to control terminals in the converter. When the actuator contact closes it starts the converter and simultaneously energizes a timing relay that closes an output contact after a short time delay. The output terminals from the timing relay present a dry contact to actually start the load. The time delay period is adjustable and will assure that the converter is started and 3-phase power is available at the load terminals before the load can be started.

### NOTE:

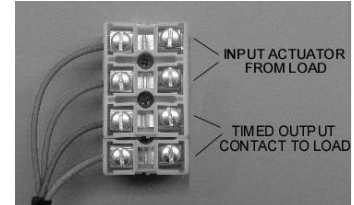
**Start-stop arrangements differ widely among equipment types and manufacturers. There is no single method of connecting them all. You may need to consult the control wiring diagram of your load equipment to determine the best way to inter-connect it with the converter.**

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There are two sets of control terminals located below the power terminals. One pair is labeled **input actuator from load**. The other terminal pair is labeled **timed output contact to load**.

The simplest way to wire the control is to locate the two wires from the actuator switch to that are responsible for starting the load. These leads should be extended and re-routed to the converter's input actuator and timed output contacts. #14 AWG is usually adequate size to extend the control wiring. Two control pairs are required to make the control connections. Route the control pairs between the load and the phase converter control enclosure.

1. Connect one pair from the load's actuator switch to the terminals marked **INPUT ACTUATOR FROM LOAD**. When these terminals are jumped, the converter will start. Note, unless you have specified a low voltage control for the converter, 230 volts will be present across these contacts. The actuator contacts from your pilot control (PLC, float switch, pressure switch, etc.) that turn the converter on and off must be rated for 230 volts.



2. Connect a pair of control wires from the control terminals marked **TIMED OUTPUT CONTACT TO LOAD**. This is a "dry contact" that will close when the converter is up to speed. Connect the opposite end of these wires to any point in the load controller circuit where it can act as an on-off switch. This is usually in series with the load contactor circuit between the contactor coil and the control voltage source. Consult the load control wiring diagram if necessary to determine the best point to break into the control circuit. The "dry contact" from the time-delay relay of the converter will now make and break the load contactor voltage as the converter is turned on and off whenever the load is called for by the load actuator switch.

After tightening all terminals and checking wiring, adjust the time-delay relay to approximately 10 seconds. Turn the selector switch to the "ON" position to check if converter is operating correctly. Move the selector switch to "Auto" to operate the converter from the remote pilot actuator switch.

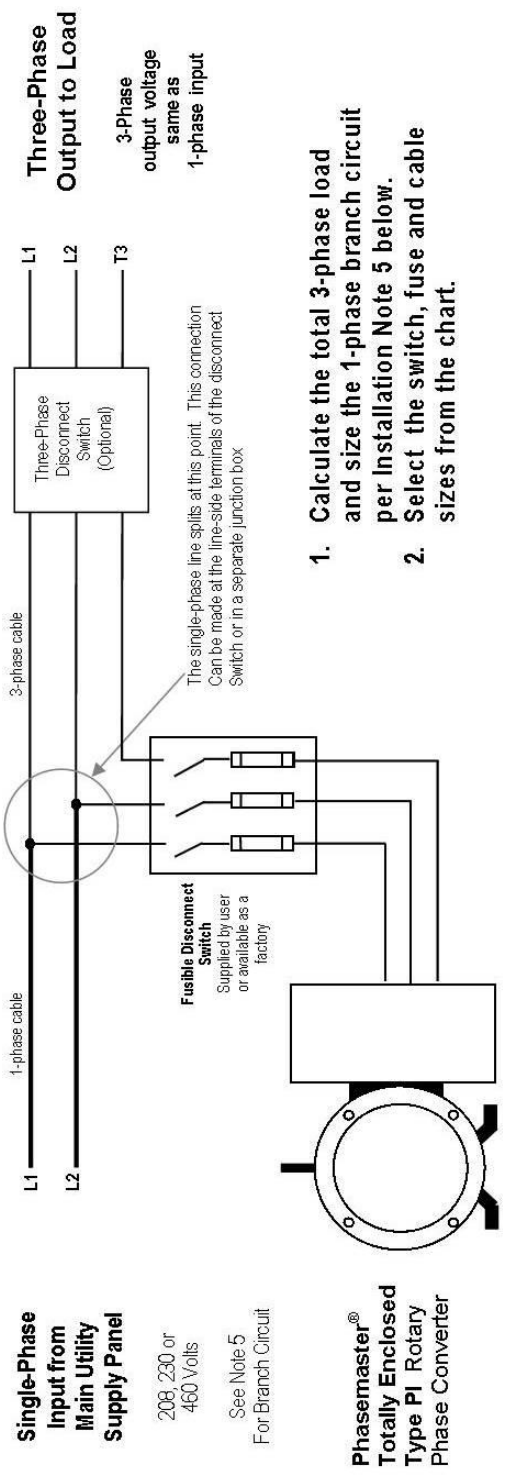
#### **Control checkout**

Start the converter and verify that the load does not become energized until after the converter has reached full speed. If the converter does not reach full speed within ten seconds, there may be problem of excessive utility line voltage drop or inadequate transformer capacity. Refer to the section of the main manual titled **In Case of Trouble**. If the load starts before the converter reaches full speed, increase the time-delay period. The time delay period may be adjusted to any duration as long as the converter is running prior to the load. Once the time delay relay is set up, turn off all power and replace all covers.

#### **Control Connections – Type PI-AW only**

The type **PI-AW** is setup to be started from a remote pushbutton or switch station. The converter does not include a timing relay. The pushbutton or switch must be a maintained contact type. The remote pilot contact must remain closed to keep the converter operating.

Connect a pair of control wires from the pushbutton station to the terminals marked **input actuator**. There is timed output contact on the **Type PI-AW** Move the selector switch to the "Auto" position to control the converter from the remote switch.



1. Calculate the total 3-phase load and size the 1-phase branch circuit per Installation Note 5 below.
2. Select the switch, fuse and cable sizes from the chart.

**DISCONNECT SWITCH AND WIRE SIZE SELECTION CHART \***  
Configuration 1

Model No.	Start HP	230 Volts			460 Volts		
		Switch	Fuse	1-Ph Cable	3-Ph Cable	1-Ph Cable	3-Ph Cable
PI-6	2	30	15	10	12	30	10
PI-10	3	30	20	8	10	30	10
PI-15	5	30	30	8	10	30	15
PI-20	7.5	60	35	6	8	30	15
PI-30	10	60	40	4	8	30	20
PI-40	15	60	60	1	6	30	30
PI-50	20	100	80	1.0	4	60	40
PI-60	25	100	100	3.0	4	60	50
PI-80	30	200	125	4.0	2	60	60
PI-100	40	200	150	2-1.0	1.0	100	80
PI-120	50	200	175	2-2.0	2.0	100	80
PI-140	60	200	200	2-2.0	3.0	100	100

**\*\*Wiring Notes:**

- Conductor sizes are based on type THHN, 90° C, copper conductors in 30° C max. ambient.
- These are minimum recommended sizes for the load motor HP rating indicated.
- For larger loads refer to installation note 5 and increase conductor size accordingly.
- Increase wire size for Aluminum conductors or runs in excess of 50 feet.
- Consult National Electric Code for runs in excess of 50 feet or for aluminum conductors.
- Do not use circuit breakers. See installation Note 2.

**INSTALLATION NOTES**

1. This diagram does not replace or supersede any requirements of local, state or national electric codes.
2. Use only dual element time delay fuses to protect the phase converter.
3. Do not bolt converter to floor. Use vibration pads supplied with unit.
4. Do not connect control circuits to manufactured phase, T3.
5. National Electric Code (NEC) requires single-phase cable and branch circuit to be rated for 250% of three-phase load current.
6. No-load output voltage L2-T3 will exceed L1-L2 by 12-15%. Voltages will balance when load is connected.

**Connection Diagram for Totally Enclosed Phasemaster Rotary Phase Converter with Manual Controls**

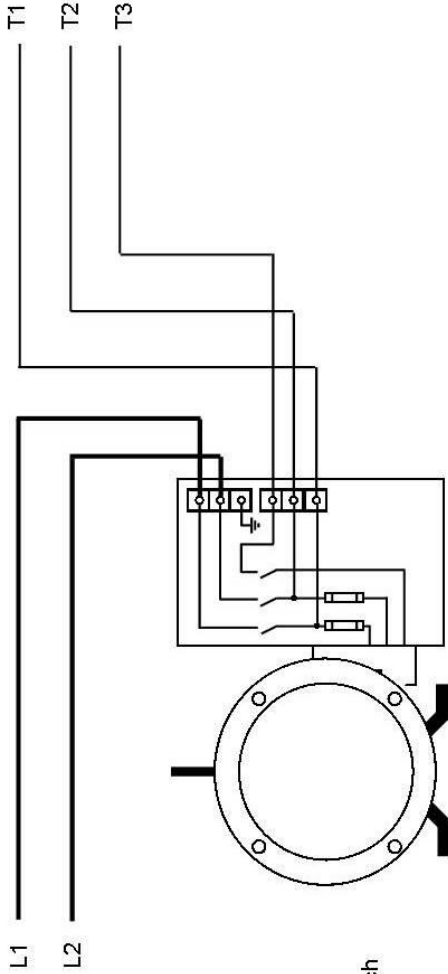
**0302-PI**



Single-Phase  
Input from  
Main Utility  
Supply Panel

208, 230 or  
460 Volts

See Section III Pg 4  
For Branch Circuit Sizing



Three-Phase  
Output to  
Load

Output voltage  
equals  
3-phase  
equivalent of  
input voltage

See Note 4

**Phasemaster® Type PI-R**  
Rotary Phase Converter  
with built-in disconnect switch  
and fuses

WIRE SIZE SELECTION CHART						
Model No.	Start HP	230 Volts		460 Volts		
		Fuse* 1-Ph Cable #10	3-Ph Cable #12	Fuse* 1-Ph Cable #12	3-Ph Cable #12	3-Ph Cable #12
PI-6-R	2	15		7.5		
PI-10-R	3	20	8	10	10	12
PI-15-R	5	30	8	15	10	12
PI-20-R	7.5	35	6	15	8	12
PI-30-R	10	40	4	20	8	10
PI-40-R	15	60	1	30	6	10
PI-50-R	20	80	1.0	40	4	8
PI-60-R	25	100	3.0	50	2	6
PI-80-R	30	125	4.0	60	1.0	6
PI-100-R	40	150	2-1.0	75	2.0	4
PI-120-R	50	175	2-2.0	80	2.0	4

\* Supplied with converter

**Wiring Notes:** This table is based on utilizing the converter at approximately 150% of start rating, it is conservative and applies in 95% of all installations. For total loads exceeding 150% of start rating, contact Key Industries.

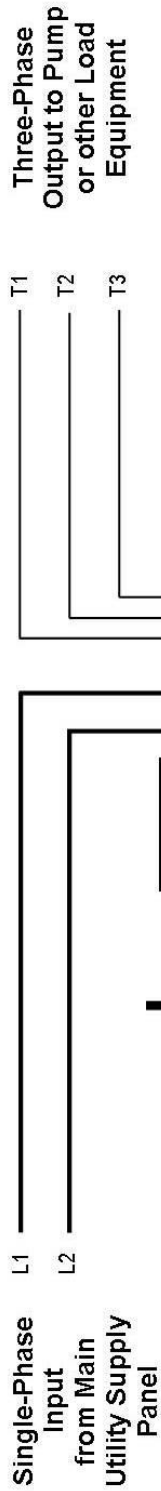
- Conductor sizes based on type THHN, 90° C, copper in 30° C max. ambient. Adjust conductor size accordingly for different wire types.
- Increase wire size for Aluminum conductors or runs in excess of 50 feet.
- Consult National Electric Code for runs in excess of 50 feet or for aluminum conductors.

#### INSTALLATION NOTES

1. This diagram does not replace or supersede any requirements of local, state or national electric codes.
2. Fuses are supplied with converter. Use only dual element time delay fuses as replacements.
3. Do not bolt converter to floor. Use vibration pads supplied with unit.
4. Do not connect control circuits to manufactured phase, T3.
5. No-load output voltage L2-T3 will exceed L1-L2 by 12-15%. Voltages will balance when load is connected.
6. If input voltage exceeds 240V, refer to Section II page 3.

Connection Diagram for Phasemaster PI-R Rotary  
Phase Converter with built-in  
Switch and Fuses

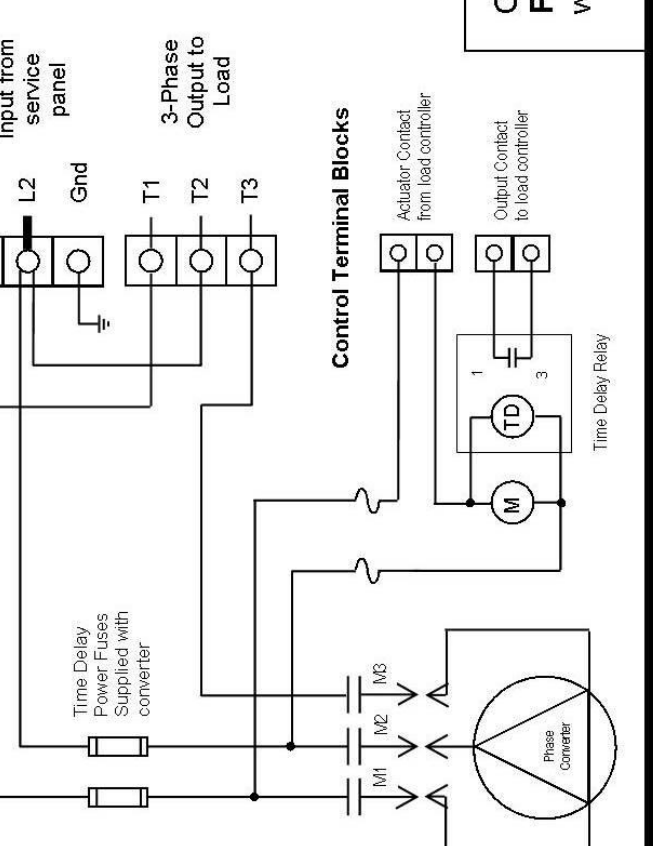
**0302-PIR**



**Phasemaster® Type PI-A Totally Enclosed Rotary Phase Converter with built-in fuses and magnetic controls for remote actuation.**

**Sequence of Operation**

1. Input actuator contact from load controller closes magnetic starter M and energizes timing relay TD.
2. Converter starts and the adjustable timing relay waits 1-5 seconds until converter reaches full speed.
3. Output contacts 1-3 then close allowing the load to start.

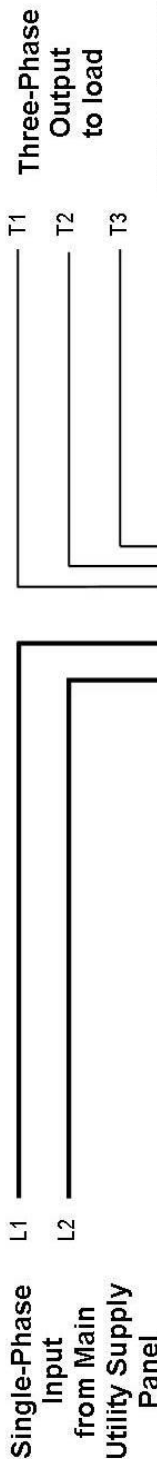


Model No.	230 Volts		460 Volts	
	Fuse* 1-Ph Cable	3-Ph Cable	Fuse* 1-Ph Cable	3-Ph Cable
PH-6-A	2	15	7.5	#12
PH-10-A	3	20	10	10
PH-15-A	5	30	15	10
PH-20-A	7.5	35	15	8
PH-30-A	10	40	20	8
PH-40-A	15	60	30	6
PH-50-A	20	80	40	4
PH-60-A	25	100	50	2
PH-80-A	30	125	60	1.0
PH-100-A	40	150	75	2.0
PH-120-A	50	175	80	2.0

\* Supplied with converter

**Connection Diagram for Type PI-A Phasemaster Rotary Phase Converter with automatic controls**

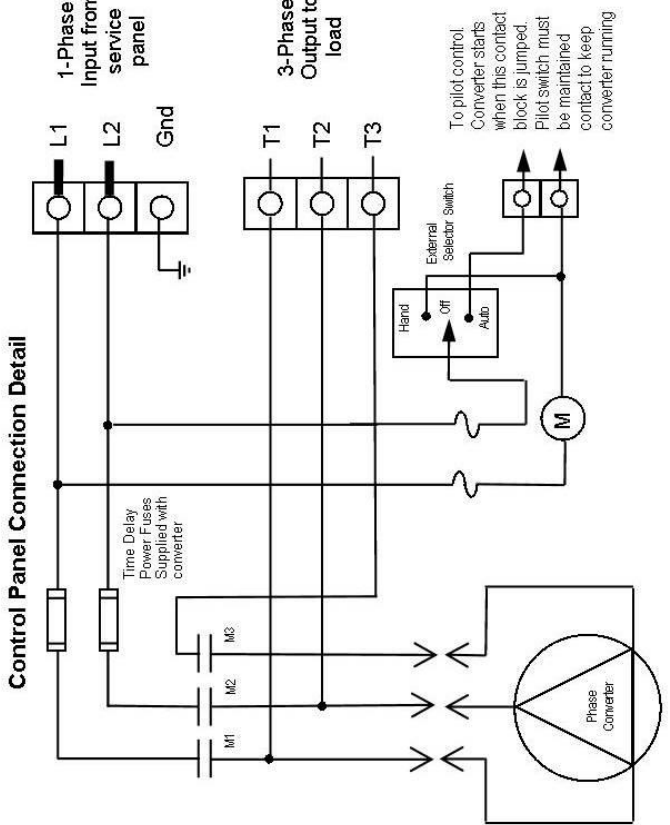
**0302-PIA**



All converter output lines are de-energized until converter is started.

**Single-Phase Service Sizing**

To insure adequate utility supply to the converter and load, it is necessary to size the 240V, 2-pole branch circuit to provide a **minimum** of 5-6 amps of 1-phase service for every simultaneously operating horsepower of connected 3-phase load. For example, a 10HP and 20HP load operating simultaneously will require at least 150-180 amps of 1-phase service.



**WIRE SIZE SELECTION CHART**

Model No.	Start HP	230 Volts			460 Volts		
		Fuse* 1-Ph Cable	3-Ph Cable	#12	Fuse* 1-Ph Cable	3-Ph Cable	#12
PI-6-A	2	15	#10	#12	7.5	#12	#12
PI-10-A	3	20	8	12	10	10	12
PI-15-A	5	30	8	10	15	10	12
PI-20-A	7.5	35	6	8	15	8	12
PI-30-A	10	40	4	8	20	8	10
PI-40-A	15	60	1	6	30	6	10
PI-50-A	20	80	10	4	40	4	8
PI-60-A	25	100	30	4	50	2	6
PI-80-A	30	125	40	2	60	10	6
PI-100-A	40	150	2-10	10	75	20	4
PI-120-A	50	175	2-20	20	80	20	4

\* Fuses supplied with converter  
 \*\* Total HP operating capacity is two times the start rating

**Connection Diagram for Type PI-AW Phasemaster Rotary Phase Converter with automatic controls for remote actuation**

**0302-PIAW**

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## V. OPERATING INSTRUCTIONS FOR LOAD RANGE CONTROLLER (-VS)

The output voltage of the manufactured phase on a rotary converter varies according to the amount of connected load. It starts out from 10-15% higher than the utility supply voltage at no-load and drops into balance with increasing load. It remains there up to full capacity.

This higher no-load output voltage is generally not a problem on most loads since the voltage drops into a balanced state as soon as the load is applied. However, certain types of loads such as variable frequency drives (VFD) may not tolerate the higher no-load voltage. The load range controller remedies this situation by dropping the no-load voltage to a level that can be accepted by the VFD.

It performs the same function for multiple motor loads where the load varies as different size motors come on and off line. The converter is sized for the largest motor, but there are times when only a small portion of the total load is operating. Under this condition, the manufactured phase voltage may be too high and thus can cause nuisance overload tripping of the small motors. When the controller senses this condition, it drops the output voltage and thus reduces the incidence of overload tripping. When the large motor comes on, the controller recognizes it and switches back to the higher operating voltage.

### **Operation:**

The load range control has two operating ranges, HIGH and LOW output. The converter always starts in the HIGH output range and after a seven second delay switches to the LOW range. A red indicating light on the front or side of the converter glows whenever the converter is operating in the LOW output range.

If the converter is unloaded or lightly loaded, it will remain in the LOW range and the indicating lamp will stay on. As converter load is increased, the controller determines if the new current level is too high to carry in the LOW range. When this occurs, the current sensing control switches the converter to the HIGH output range and the indicating lamp goes off.

### **Relay controls:**

**Over/Under current selector:** The white slide switch located in the upper left of the photo must remain to the right in the "I<" position.

**$\Delta$ I and  $\Delta$ T dials:** These controls adjust the pick-up current level and the time to respond to those current changes. Both dials are pre-set at the factory almost fully counter-clockwise between the 1<sup>st</sup> and 2<sup>nd</sup> graduation. The red "fault" light is not actually a fault. It illuminates when the relay's settings are being triggered by the load condition. It operates simultaneously with the external indicating light.



### **Adjustments:**

Some load characteristics and input voltage conditions may require changing the factory settings for the converter to function properly.

Step 1: Turn on the load equipment and try to simulate actual running conditions, no-load, full load, partial load, etc. If every machine runs properly without displaying error messages or tripping offline, no further adjustment is necessary. If a problem appears, especially at light load, proceed to the Step 2.

Step 2: With the converter running and the smallest load applied, rotate the  **$\Delta$ I** current control clockwise in small increments until it is well past the point (approximately one half a graduation) where the red indicator comes on. The  **$\Delta$ T** control normally does not require adjustment.

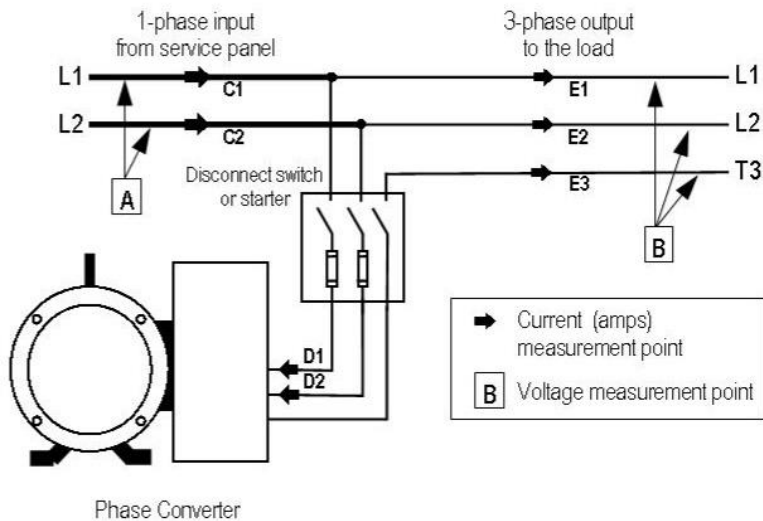
Step 3: Now apply the largest load and readjust the same control counter-clockwise if necessary so that the red indicator goes out but lights again when the large load is removed.

**DO NOT ALLOW THE INDICATOR TO SWITCH ON AND OFF REPEATEDLY** as this can damage the controller. Make certain the settings allow the indicator to stay on or off when it is in the desired operating condition. Contact Kay Industries if you have difficulty achieving this setting.

As long as there is any load connected, the average of the three converter voltages should be within 5% or less in either the HIGH or LOW range.

## VI. CONVERTER CHECKOUT

1. IF YOUR **INCOMING** LINE VOLTAGE EXCEEDS 240 VOLTS, you MAY need to have the utility company reduce the incoming voltage or install a buck-boost transformer to drop the voltage to an acceptable level. Consult Kay Industries on this subject if you have questions about how to proceed. This is particularly true if your equipment is built in Europe or Asia.
2. Start the converter. Small converters (10 HP and below) should reach full speed in about two seconds. Larger units may require up to seven seconds. Every converter is factory tested prior to shipment and is well within these time limits. If the converter takes longer to reach full speed, your line voltage may be dropping which means your service may be inadequate.
3. Check the single-phase utility input supply voltage between L1 and L2 with a voltmeter. It should be 220 to 240 volts on a nominal 230 volt system. In general you should not allow the input voltage to exceed 240 volts on a 230 volt system or 480 volts on a 460 volt system. If the input voltage is too high, the result could be excessive manufactured phase voltage accompanied by load current imbalance.
4. Refer to the diagram below and measure the voltages between L1-L2, L1-T3, and L2-T3 at points A and B with the converter running but with the load equipment turned **off**. These are the no load idle voltages. The L2-T3 voltage is the manufactured phase voltage. It will be higher than the other voltages. All voltage measurements should be taken line-to-line. Line-to-ground voltages **are not** significant measurements of converter performance.
5. The normal output voltage measured between L2 and T3 will range from 260 to 290 volts on a 230 volt system and 490 to 525 volts on a 460 volt system depending upon the input voltage between L1 and L2. This is a **normal** idle condition. There is no danger to the load from the L2-T3 voltage. Although it is somewhat high when there is no load, this voltage will drop when the converter begins to supply power to a load and will balance within 2-5% of the other phase voltages as the converter approaches full load.



Voltage Measurements			
Meter Point	Lines measured	Converter on Load off	Converter on Load running
A	L1-L2		
B	L1-L2		
B	L1-T3		
B	L2-T3		
Current (Ampere) Measurements			
	Amps Measured	No Load	Load Running
C1	Total		
C2	Total		
D1	Converter		
D2	Converter		
E1	Load	0	
E2	Load	0	
E3	Load	0	

6. **Make a record of all voltages at each measurement point and retain these readings in a log for future reference. Large deviations could indicate problems with either the utility supply voltage or the load conditions.**
7. If load motors rotate the backwards, reverse the L-1, L-2 connections at the load.
8. Write down the full nameplate information including model and serial number.

MODEL NUMBER	SERIAL NUMBER

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## VII. OPERATION & MAINTENANCE

The **Phasemaster**<sup>®</sup> converter may operate continuously with or without a load. However, the converter operating temperature and noise level will be higher at no-load than under loaded conditions. The converter will not be damaged nor will it overheat if operated unloaded.

1. **Never start the Phasemaster<sup>®</sup> converter under load.**
2. Wait until the converter reaches full speed before turning on any load.
3. Whenever possible, avoid applying more than one load at the same time.

The converter requires very little maintenance other than periodic inspection of contacts, tightening of all electrical connections and lubrication if supplied with grease fittings.

### **LUBRICATION**

**Phasemaster**<sup>®</sup> converter bearings are pre-packed with a heat, moisture, and rust resisting polyurea based lubricant rated to operate in the temperature range of -35 to +350° F. This initial charge plus a generous additional amount placed in the bearing housing during manufacturing is normally enough to last the lifetime of the bearing. Converters exposed to severe operating conditions of high heat, moisture, dirt or limited ventilation require periodic lubrication. To grease the bearings in a smaller converter not having grease fittings, remove the end-bells and remove the excess grease. Replace it with a generous supply of a compatible lubricant such as MOBIL Polyrex EM. To lubricate a larger converter, inject a small amount of grease slowly into the grease fittings. Do not use high-pressure equipment. Take care not to saturate the windings with grease over an extended time. Remember, this grease goes somewhere when it leaves the bearing. **Lithium based lubricants are incompatible and may cause bearing failure.**

### **INSPECTION**

Inspect the converter periodically to verify the ventilation slots are clear. In dusty or dirty environments, remove the end-bells and clean the windings of excess grease, dust and debris. On Type PI-A or PI-R converters, inspect all power and control components for loose connections and damaged or pitted contacts. Clean, tighten or replace as necessary.

### **MAINTENANCE SCHEDULE**

The **Phasemaster**<sup>®</sup> rotary converter is a highly reliable machine. With this equipment, as with all electromechanical devices, problems do occur. If you experience difficulty, our factory engineers will be happy to assist you by telephone.

This is a suggested maintenance schedule. Your particular application may require more or less frequent attention. We suggest that you begin with this schedule and modify it as needed over time.

Action	Monthly	Semi-Annual	Annual	Bi-Annual
Grease Bearings with Mobil Polyrex EM or an equivalent lubricant rated 185° F			X	
Check voltage L2-T3 and record in log.		X		
Listen for abnormal noise or excessive vibration. Tighten rods and bolts if needed.	X			
Shut down converter and blow out dust and debris from stator.		X		
Open control compartment and inspect power and control connections and contacts. Clean and tighten ALL terminals.			X	
Remove end bells and rotor. Clean Stator. Check bearings for wear. Reassemble using 40 Ft-Lb. torque on all bolts and nuts.				X

## VIII. IN CASE OF TROUBLE

Condition	What to look for	Corrective action
Converter does not start. No sound.	Check power source with a voltmeter. L-1 to L-2 should read 230 volts (or 460 volts in a 460 volt system. If converter does not make any sound it is probably NOT getting power.	Restore power. Reset main breaker and replace with correct size if too small.
	Check the fuses by removing them and testing with a continuity checker or ohmmeter. A better test is to look for a voltage reading on the load side of the fuses with the converter turned on.	Replace fuses if needed.
	Check for loose terminals. Be sure lugs are not crimped on cable insulation.	Tighten or re-terminate as required.
Converter hums but does not start.	Be sure that no load device is starting with the Phasemaster. The converter should be running before any load is placed on it	Turn off all loads and re-start the <b>Phasemaster</b> <sup>®</sup> .
	Be sure that the incoming single-phase lines (L-1 and L-2) are properly connected to L-1 and L-2 in the converter junction box. Do not connect either incoming line to T-3 of the converter.	Connect the power source to L-1 and L-2 in the converter. Connect T-3 to the load only.
	The converter may have failed capacitors. Each capacitor should be checked with an ohmmeter or capacitor tester	Replace any capacitors that are open, bulged or leaking.
	Make sure the rotor moves freely by moving it with a screwdriver or other tool with power off.	Loosen bolts and re-tighten to free rotor. If rotor does not turn freely after doing this, call factory.
Converter attempts to start and breaker trips or breaker trips after converter is started and load is added.	Check the single-phase service calculations in Section III (pg.4) to determine if the breaker feeding the converter is large enough.	Replace with larger breaker if necessary
	Check to be certain of the time-delay characteristics of the breakers. They should have similar characteristics to time delay fuses. Ordinary household type breakers are not suitable.	Replace with delay type breakers or time delay fuses. Do not oversize the breakers
Load(s) always trip overloads during or shortly after startup	Check the line voltage (L-1 to L-2) with an analog voltmeter during start and determine the amount of line voltage drop. Check transformer capacity. If the line voltage drops more than 10% of no load line voltage, take corrective action.	Increase supply line cable size and transformer size if required. Your power company can usually help with transformer problems.
A loud humming noise or chatter comes from the load starting relay.	Check voltage between L-2 and T-3. If voltage remains below 200 volts (for a 230 volt system) or 185 volts (for a 208 volt system) after the motor starts, the converter is too small for the application.	Contact factory for further assistance or possible exchange.
	The manufactured phase T-3 could be connected to the motor starting relay. Check to ensure correct voltage on this relay coil.	Rewire the control coil circuit so that T-3 does not energize the starter coil.
The voltage measured between L-2 and T-3 is about 30-40 volts higher than the line voltage (L-1 to L-2) with no load applied to the <b>Phasemaster</b> <sup>®</sup> .	This is a normal condition and verifies correct operation of the <b>Phasemaster</b> <sup>®</sup> . When the load is applied, this voltage will be reduced as the load increases. No damage will occur to properly connected equipment.	This condition requires no action.
Load does not start or run properly.	Check the converter output voltages under load conditions. L1 to L2 should remain within a few volts of 230 or 460. L2 to T3 may drop momentarily below 180 (or 400) but recover to 220 (440) or above.	If the L2 to T3 voltage remains below 210 (420) volts, the converter may be too small for the application. Contact factory for recommendations or possible exchange.
Excessive noise or vibration.	Noise and vibration are usually the result of a resonance caused by a mounting surface that does not support the converter well. These problems also occur when the converter is bolted tightly to any surface.	Be sure to remove the converter from the shipping skid and place it on a substantial floor using the shock absorbing pads supplied with the converter. Do not bolt the converter to any surface.
The three-phase currents are not equal.	If the load comes up to its rated load and none of its three legs exceeds its nameplate F.L.A. rating, there is no problem. If the L1 and L2 legs are significantly higher than the T3 leg (measured at the load input, not the converter input) then a larger converter or correction capacitors may be required.	Consult with factory to review application.
Blown fuses in converter or disconnect switch	Test for failed capacitors. <b>IMPORTANT - SEE NOTE *</b> Check for wires touching ground, loose fuse holder connections	Replace any failed capacitors, correct wiring issues, snug-up fuse holder connections

**\* IMPORTANT! DO NOT ASSUME CAPACITORS ARE DISCHARGED BECAUSE POWER TO CONVERTER IS OFF. MANUALLY DISCHARGE CAPACITORS BEFORE ATTEMPTING SERVICE.**

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**NOTES:** (Purchase date, installation or service date, service issues, etc.)

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### WARRANTY

Kay Industries, Inc. (the manufacturer) guarantees all products of our manufacture against faulty material or workmanship for a period of five years from date of installation or 61 months from date of shipment from factory, whichever period first expires. In addition Kay Industries will replace all defective bearings regardless of cause for the life of the converter.

Any part that you return to us within this warranty period showing unmistakable defect in material or workmanship will be renewed or replaced at our option F.O.B. factory without charge. The final decision that an original defect existed shall rest with the manufacturer.

The liability is limited to the renewal or replacement of the defective part. In no case will Kay Industries be liable for damage or loss incurred because of interruption of service or for consequential damages, transportation, labor or expense required to repair or replace defective parts or units.

Kay Industries will not be responsible if its products have been improperly installed in any way. This warranty shall not apply to any of the manufacturer's products that must be replaced because of normal wear, that have been subjected to misapplication, misuse, neglect, accident or that have been repaired or altered outside of the manufacturer's factory unless expressly authorized by the manufacturer.



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