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Crydom RHP Series

3 Phase Hybrid Solid State Contactor

By Paul Bachman

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ABSTRACT

Solid State Relays and Contactors (SSRs) have been available in one form or the other for over 40 years. Traditional Electromechanical Relays and Contactors (EMRs) as well as Mercury Displacement Relays and Contactors (MDRs) have been available even longer. However, current Environmental regulations now make the future use of Mercury Contactors problematic, and Electro Mechanical Contactors may not offer the required life expectancy or operational characteristics to be suitable replacements for MDRs.



Crydom, a world class supplier of Solid State Relays and Controls, has introduced the **3RHP** family of Hybrid Solid State Contactors¹ to address this market need for both existing applications and new designs.

The **3RHP's** hybrid technology combines the benefits of both SSR and EMR technologies in a unique approach resulting in a Hybrid Solid State Contactor with ratings of up to 50Amps @ 600VAC.

The following sections include a comprehensive description of the **3RHP** operation, ratings, features and benefits as well as accessories and suggestions for both single and three phase application wiring.

Figure 1 - Crydom **3RHP** Three-phase Hybrid Solid State Contactor.

¹ Patent pending



INTRODUCTION

Mercury Contactors offer high switching capacity and long life combined with relatively low cost. Traditional EMR Contactors provide low cost but with somewhat limited life expectancy and certain switching transient issues. Solid State Contactors offer superior life expectancy and no transient issues, but are relatively more expensive and require an external heat sink in higher power applications or elevated ambient temperature environments.

Figure 2 shows a simplified comparison of key attributes for each type of switching technology where 100% equals best available performance of each in typical AC contactor applications.

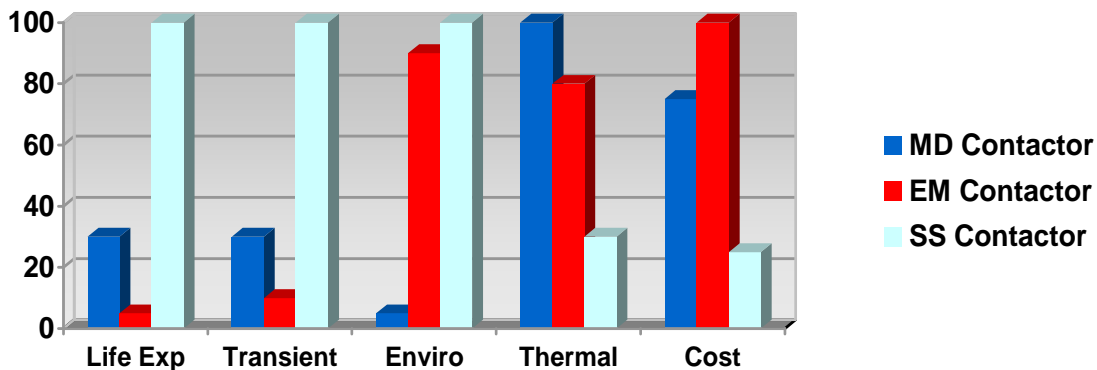


Figure 2 - Attributes of commercially available AC switching technologies.

A quick review of **Figure 2** shows that Solid State Contactors are superior in 3 of 5 categories where as Mercury Contactors and Mechanical Contactors are superior in no more than one category each. Heat generation/dissipation and cost are the Solid State Contactors limitations in comparison to the other contactor types. Reducing heat generation and cost could therefore place the Solid State Contactor in a significantly preferred position relative to the other two AC Contactor switching technologies.

Combining Solid State switching technology with EMR switching technology, thus creating a Hybrid Solid State Contactor, provides a cost effective means of addressing both the known limitations of SSRs as well as EMRs. Solid State Switching provides a nearly unlimited life expectancy with zero transients during make and break transitions, while the EMR contacts eliminate nearly all of the thermal heating associated with SSRs during load current conduction, thus producing a superior performing contactor.

CRYDOM HYBRID SOLID STATE CONTACTOR DESIGN AND OPERATION

The Crydom three-phase Hybrid Solid State Contactor or **3RHP** combines three Solid State switches and one 3 phase EMR Definite Purpose Contactor with proprietary control circuitry. As shown in **Figure 3**, a Solid State switch in parallel with an EMR contact forms each pole of the **3RHP**. When a control signal is applied to the **3RHP** input terminals, all 3 of the Solid State Switches are turned on immediately and simultaneously to connect the load to the 3 phase AC power supply.

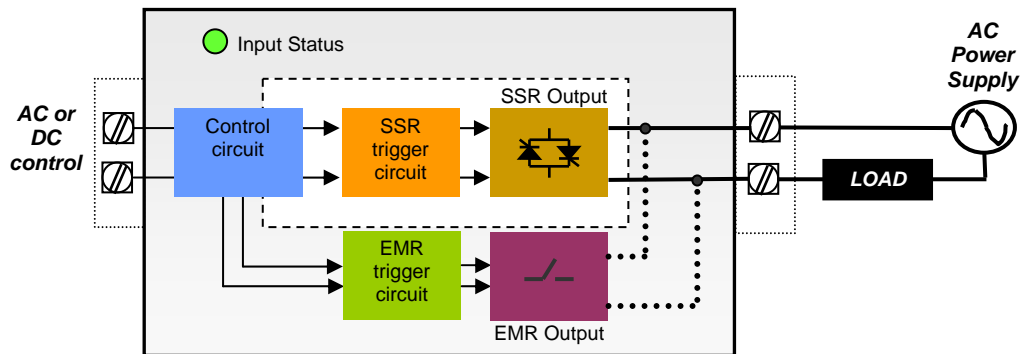


Figure 3 - 3RHP Hybrid Solid State Contactor block diagram (one phase shown).

Power SCRs comprising the three Solid State switches conduct the initial load current and any associated surge currents through their respective phases. The Solid State switching virtually eliminates any arcing and resulting transients that would otherwise be generated by a closing mechanical contact(s). SCRs are ideal for this Solid State switching function due to their typical x10 surge current ratings and contact-less switching.

Furthermore, **3RHP** output switching is instantaneous turn-on rather than zero-crossing. The Solid State outputs switch immediately while the EMR output is dependent upon the inherent delays of the electromagnetic coil and travel time of the contacts. As a result, the actual mechanical contact closure occurs several milliseconds after the solid state output is switched. This eliminates potential phase delays and ensures that the SSR output is fully conducting load current before the EMR contacts close.

At the time the 3 EMR contacts close, the voltage across them is equal to the forward voltage drop across the Solid State Switches (SCRs) which is approximately 1.1 to 1.4 volts. Thus,



there is no arcing or transients generated upon the contact's closure. Once closed, the voltage drop across the contacts is lower than the Solid State switches minimum operating voltage, and therefore they effectively become shorted out and no longer conduct load current. 100% of the load current then flows exclusively through the EMR contacts eliminating any significant power dissipation in the Solid State switches as explained further below.

Solid State switching normally produces power dissipation in the form of thermal heating when load current is being conducted. The power dissipated is calculated by multiplying the output forward voltage drop, typically 1.1 to 1.4 volts, by the load current in amps. For a 3 phase circuit the power dissipation in each phase is added. This power dissipation must be managed to produce reliable performance of a pure Solid State switch or Relay. The **3RHP** completely eliminates this power dissipation and subsequently any heat sink(s) that would have otherwise been required to keep the Solid State switch within its allowed operating temperature range: a major advantage of the **3RHP** Contactor design.

When the **3RHP** is de-energized, the switching sequence is reversed from the turn on process. That is, the EMR coil is de-energized while the internal Solid State switch control signal remains active. Once the coil's magnet field diminishes enough to permit the contact's spring return force to overcome the magnetic field, the contacts begin to open. At the instant this occurs, the voltage across the Solid State switches begins to rise and each phase's Solid State switch (SCR) turns back on immediately. The result is that any arc that would begin to rise is extinguished at a very low value as the Solid State switches turn back on.

The Solid State switches remain on for approximately 1 AC cycle (16 to 20 mSec depending upon line frequency), permitting the EMR contacts to fully open and return to their normally open position. The Solid State switches then stop conducting load current at the next zero current crossing point for each phase, eliminating opening transients typical of EMR contacts. This switching process completely eliminates the electrical noise and mechanical damage to contacts that typically occurs upon contact opening, thus extending the electrical life of the contacts by a factor of at least 10.

An additional feature of the **3RHP** is that it includes an internal over temperature protection circuit which will shut down the control of the **3RHP** in the event the Solid State Switches exceed their allowed temperatures or if the allowed ambient temperature is exceeded, thus protecting the **3RHP** from damage. Note: if the protection circuit is activated, it will automatically reset once the over temperature condition is normalized.

Two accessories, shown in **Figure 4**, are available for use with the Crydom **3RHP** 3 Phase Solid State Contactor, including a **DIN** rail mounting bracket that can be installed on the **3RHP** mounting base (DMB3), and an external auxiliary contact switch (HAC1). The auxiliary switch includes one normally open and one normally closed contact, each rated at 5 amps rms, 600 VAC, 50/ 60 Hz. The external auxiliary contacts permit pilot duty switching and or status indication of open or closed position of the Contactor.

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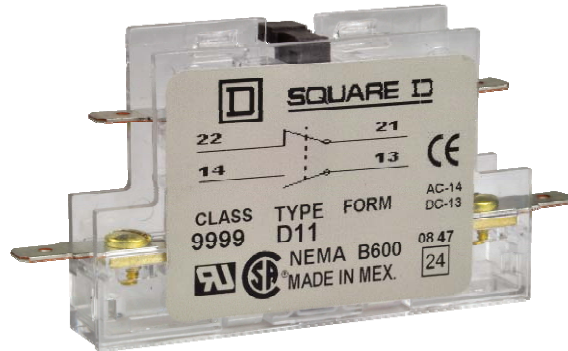


Figure 4a – External Auxiliary contacts (HAC1) for the 3RHP

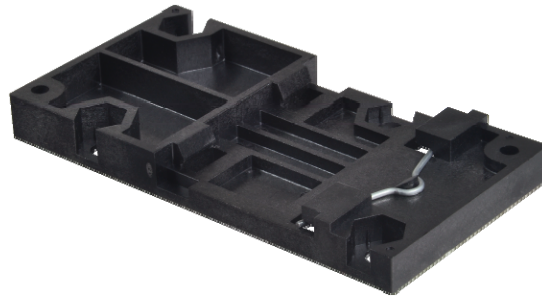


Figure 4b – DIN rail bracket (DMB3) for the 3RHP



CRYDOM 3RHP HYBRID CONTACTOR SPECIFICATIONS

Input: The 3RHP is available in either AC control or unique Logic compatible DC control (see **Figure 5** for p/n). An input status LED indicator is included with all versions.

Part Number Nomenclature

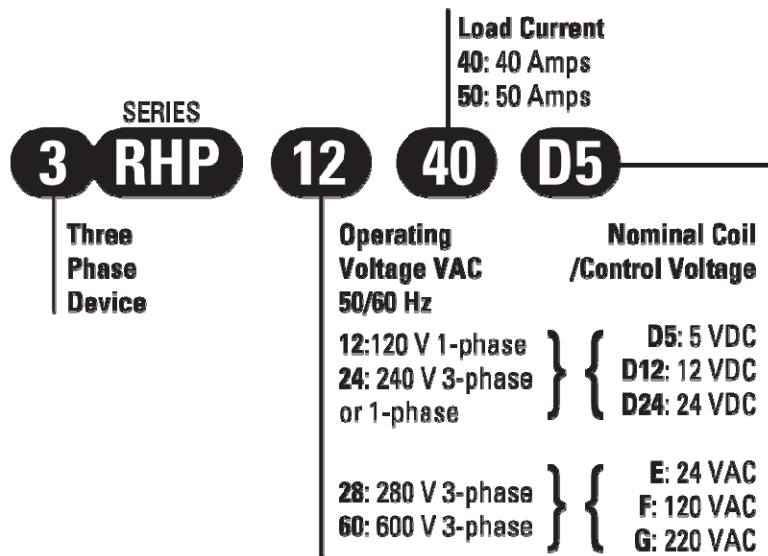


Figure 5 - Nomenclature for AC and DC input

AC inputs include 24, 120 or 220 VAC @ 50 or 60 Hz. AC inputs typically require approximately 7 VA from the control circuit for continuous operation, and approximately 60 VA for “Making” the contact closure.

The DC input versions however, are logic compatible requiring less than 12 mA or 60 to 300 mW from the control circuit depending upon the voltage selected. Power to operate the contactor coil is derived from the AC supply.

The Logic compatible DC control is unique in that most contactors require significantly more power to operate and usually require interceding pilot duty relays and supplies to facilitate their use with DC control systems.



Output: The Crydom **3RHP** 3 Phase Hybrid Solid State Contactor is available for either 40 or 50 amps rms load current @ 280 or 600 VAC 3 Phase operation, 50/60 Hz and includes internal over temperature protection. See **Figure 8** for typical application wiring.

The **3RHP** can also be operated on single phase 120 or 240 VAC, 50/60 Hz supplies at full rated load (see **Figures 9, 10 & 11** for wiring).

General Specifications: Operating temperature of the **3RHP** series is from -20° to 75° C. As shown in **Figure 6**, output derating occurs above 65° C ambient. Max operating frequency is 30 operations/min. @ 50% duty cycle. Life expectancy is > 2 million operations @ full rated load current. Isolation input to output is 4000 VAC.

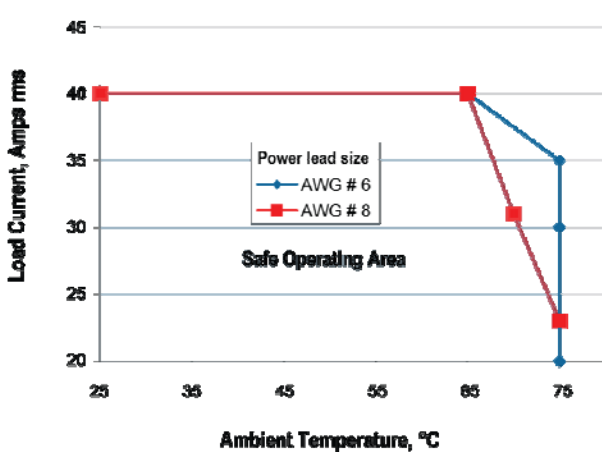


Figure 6a - Derating for 3RHP 40A.

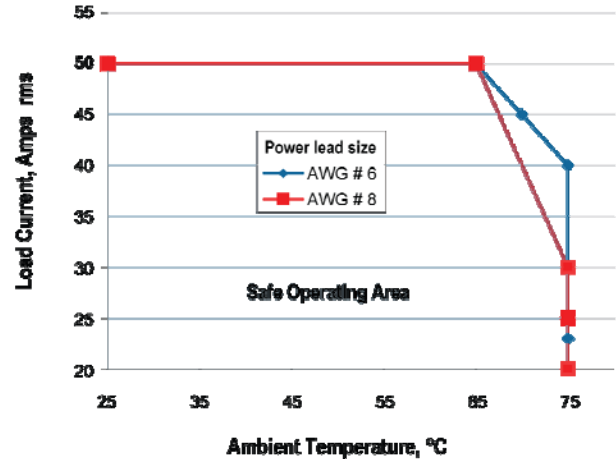


Figure 6b - Derating for 3RHP 50A.

Mechanical dimensions of the 3RHP are presented in **Figure 7**. Notice that the footprint is identical to the industry standard three pole/three-phase Definite Purpose Contactors.

Safety Agency approvals/ratings: CE certified, UL and cUL recognized, UL 508 100K cycle overload endurance tested.

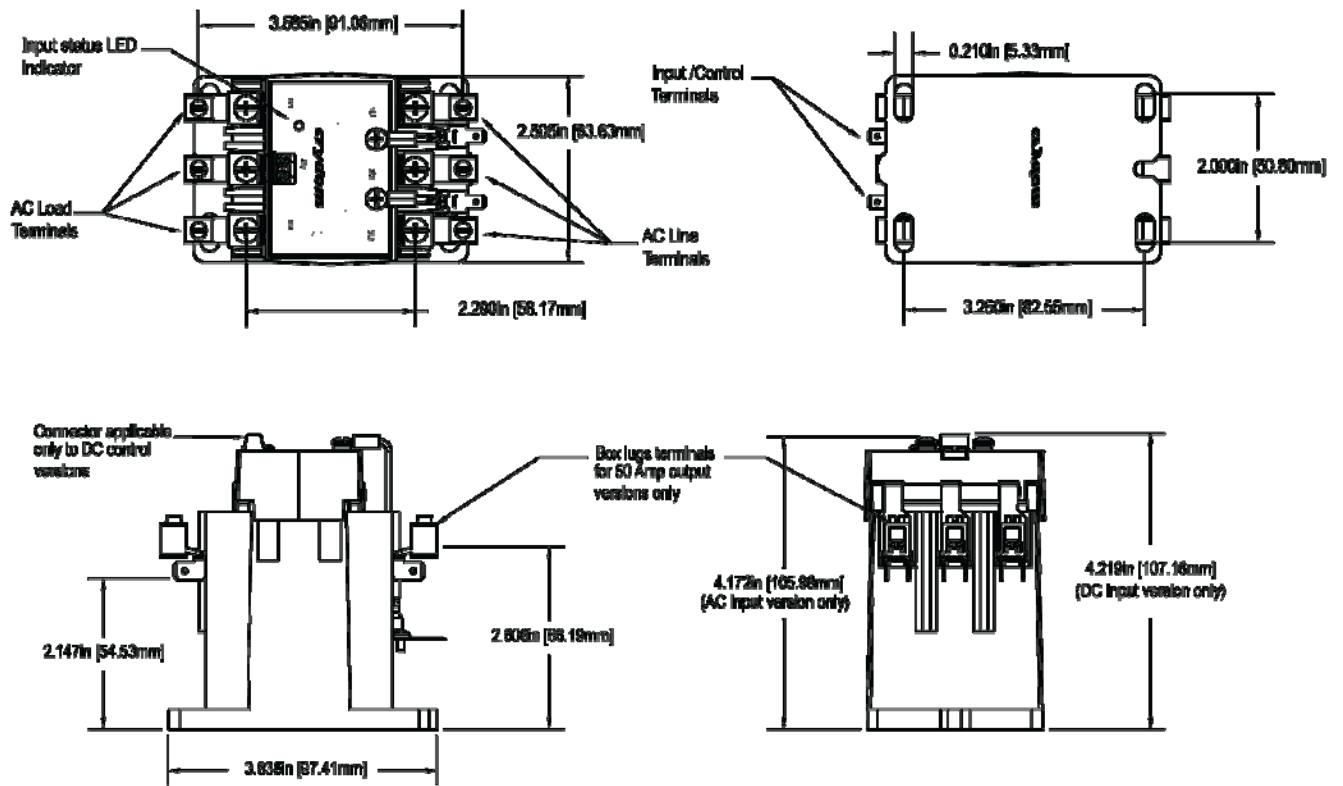


Figure 7 - Mechanical dimensions for 3RHP.

APPLICATION WIRING DIAGRAMS

The following diagrams illustrate typical wiring diagrams for both 3 phase and single phase operation of the Crydom **3RHP** Hybrid Solid State Contactors. Note that special conditions apply when using the **3RHP** with a single phase supply and load(s).

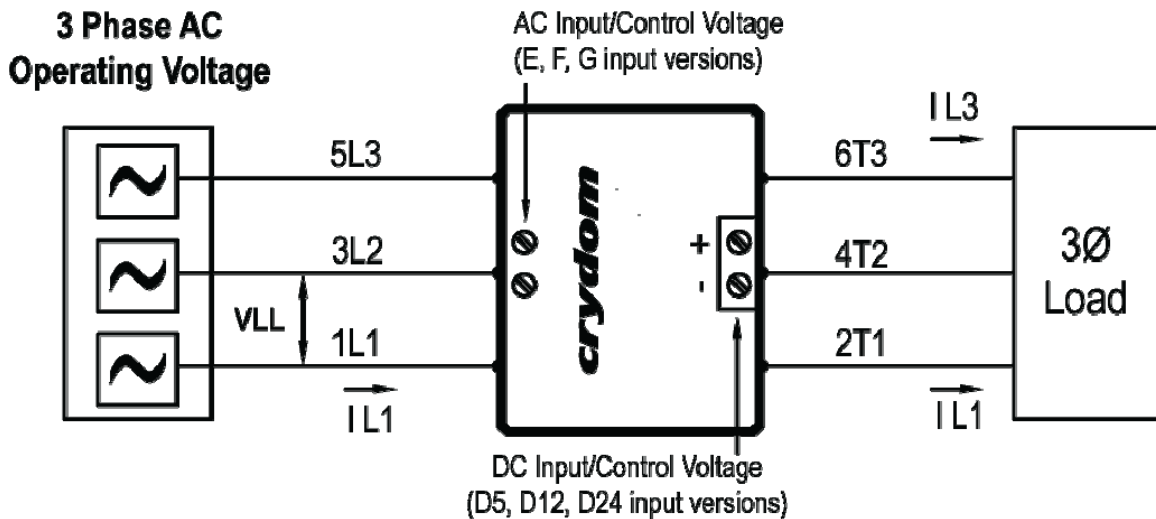


Figure 8 - 220 or 440 VAC Standard 3 phase supply and load.

The Wiring Diagram in **Figure 8** is suitable for use with all AC or DC input **3RHP** Contactors operating on 220 VAC, 50/60 Hz 3 phase AC supplies. It also applies to all AC input **3RHP** Contactors operating on 440 VAC, 50/60 Hz 3 phase AC supplies

The following 3 Wiring Diagrams in **Figure 9, 10** and **11** are suitable for use with all AC or DC input **3RHP** Contactors operating on 120 or 240 VAC, 50/60 Hz single phase AC supplies. Note that the AC line and neutral connections must be wired as indicated for proper operation of the **3RHP** in single phase circuits.

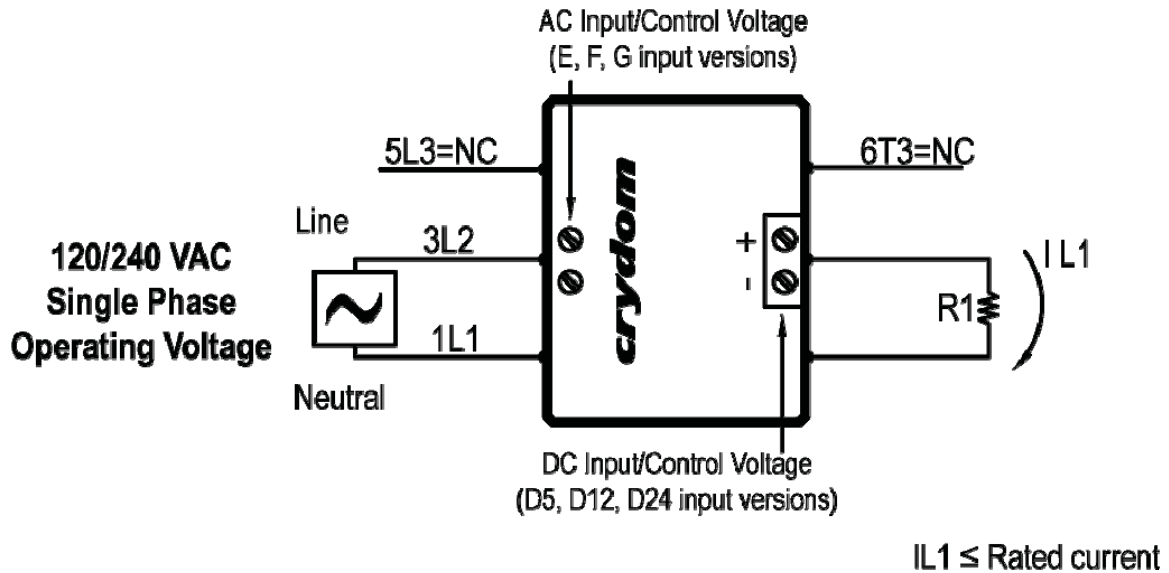


Figure 9 - 120 or 240 VAC Single phase supply with 1 single phase load.

Note: AC supply voltage must be wired to 1L1 and 3L2 as shown for proper operation.

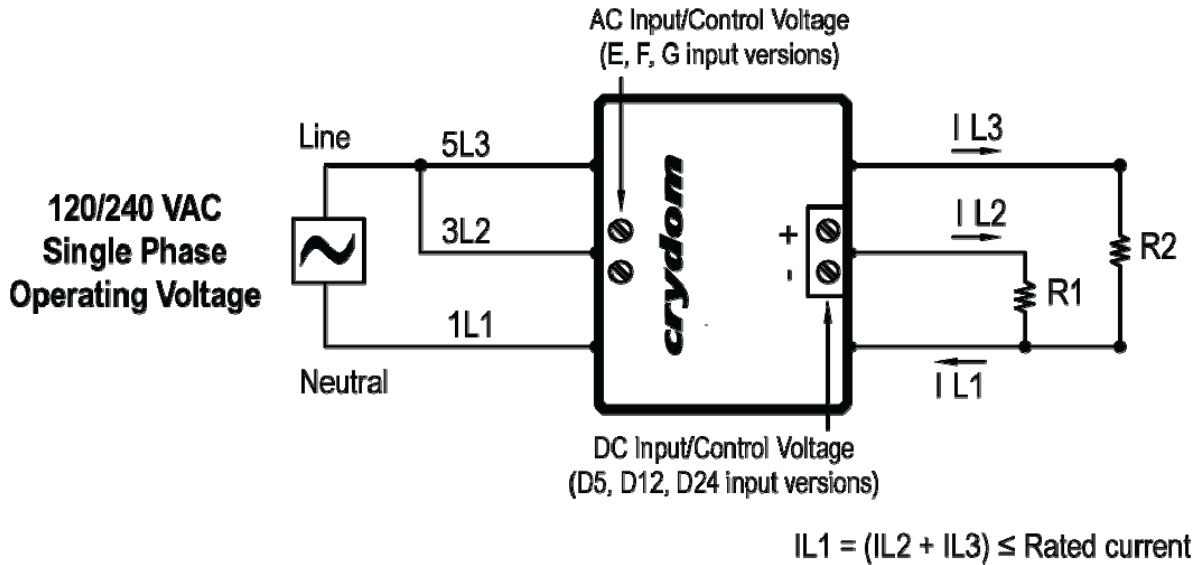


Figure 10 - 120 or 240 VAC Single phase supply with 2 single phase loads.

Note: The Wiring Diagram in **Figure 10** can only be utilized if the total combined load current switched through both poles is < **3RHP** output rating because the neutral/return leg is wired thru the 3rd pole.

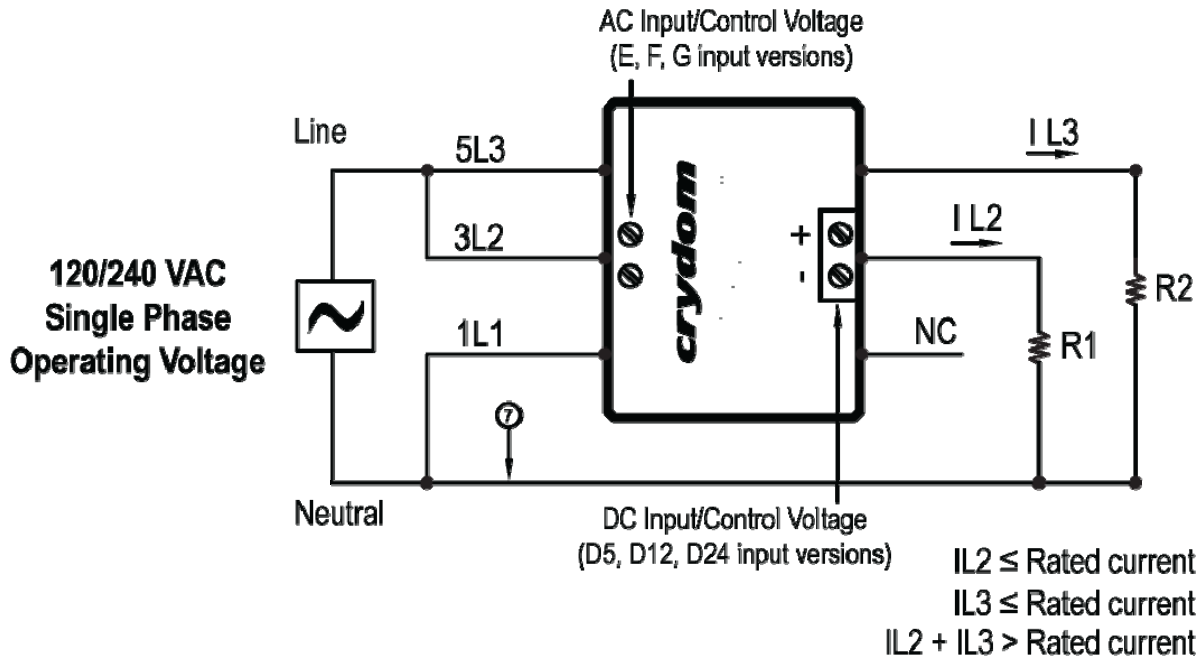


Figure 11 - 120 or 240 VAC Single phase supply with 2 single phase loads where $IL2$ and $IL3$ combined are $> 3RHP$ output rating.

Note: When the combined load currents thru $IL2$ and $IL3$ are $> 3RHP$ output rating, the neutral/return leg must be hard wired around the contactor's 3rd pole to avoid exceeding the **3RHPs** rating.



CONCLUSIONS

The Crydom **3RHP** series of 3 Phase Hybrid Solid State Contactors provide a cost effective alternative to Mercury Displacement Contactors and Relays in many applications. The **3RHP** also can economically be employed in EMR contactor or Relay applications where life expectancy requirements exceed available contactor ratings.

Available **3RHP** logic compatible control inputs also offer a means to eliminate interceding pilot circuitry to simply and cost reduce applications with DC controls.

3RHP Features and Benefits:

- ✓ Life expectancy > 2 million operations at full rated load current.
- ✓ 40 or 50 amps rms load rating @ 280 or 600 VAC, 50/60 Hz, 65 C ambient.
- ✓ 3 Phase or Single Phase operation permitted.
- ✓ Solid State “Make” and “Break”, no arcing or switching transients.
- ✓ No heat sinking required.
- ✓ AC or DC Logic compatible input controls available.
- ✓ Internal over temperature protection included.
- ✓ Industry standard DP Contactor mounting footprint.
- ✓ Available DIN rail bracket.
- ✓ Available external auxiliary N.O & N.C. contacts.
- ✓ CE certified, UL and cUL recognized, UL 508 100K cycle overload endurance tested.

Visit the Crydom, Inc. web site, www.crydom.com, or contact Crydom, Inc. directly for application assistance or any additional information about the **3RHP** Solid State Contactors or any of the other Crydom Solid State Control Products.

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