The Polarization Cell Replacement (PCR) Technical Literature

INTRODUCTION

The Polarization Cell Replacement (PCR) is a solid-state device commonly used in conjunction with cathodically protected structures. The PCR is an ideal replacement for electrochemical polarization cells because the solid-state design eliminates the maintenance requirements and the potentially hazardous electrolytes associated with polarization cells. Furthermore, the operating parameters offer a number of distinct advantages. Because the device has a higher DC blocking voltage, one device can often replace two or more polarization cells. The product is easy to apply because its operating parameters are precisely defined.

This product is available in two different versions to most economically accommodate the two different hazardous location listings which are available. In many applications, these products are used in a hazardous location; hence, the reason for hazardous location listings. All model numbers with a PCR prefix are listed for use in Class I, Division 2 hazardous locations and for Zone 2.

All model numbers with a PCRH prefix are listed for Class I, Division 1, hazardous locations. For more information on the PCRH, please visit the PCRH section on our website, and view the separate PCRH literature.

These products prevent the flow of DC current when the absolute voltage (i.e., the DC plus peak AC voltage) across the terminals is between -3.0 volts and +1.0 volt while simultaneously providing a grounding (or coupling) path for steady-state AC current, if AC current is present. A symmetrical version, which blocks +/-2.0 volts is available as an option. Custom versions with other voltage blocking levels will be considered upon request. These products also provide over-voltage protection to both lightning and AC fault current.

COMMON APPLICATIONS

AC Voltage Mitigation

As an AC mitigation device, the PCR can collapse the steady-state voltage between the connected points to a negligible level by providing continuous AC grounding for pipelines with induced AC while leaving cathodic protection unaffected.

Decoupling Electric Equipment Grounding Systems

When electrical equipment is mounted on a cathodically protected structure, the PCR can provide DC isolation with fault rated AC continuity. As grounding codes apply, the PCR is listed by UL for meeting the requirements of an effective AC grounding path per U.S. and Canadian electric codes.

Insulated Joint Protection

Insulated joints often need over-voltage protection against lightning and AC fault current, and in some cases, steady-state induced AC voltage. Due to the small clearance between opposite sides of the insulated flange, a protective device must provide a low clamping voltage, including the voltage effects of the conductors or bus bars used to connect the product.

Decoupling from Utility Grounding Systems

When a cathodically protected structure is tied into the site grounding grid, CP values may be unacceptably low, due to the bond between the site grounding system and the power company grounding system. The PCR can be installed by the power company at the transformer, to provide DC isolation and AC grounding between the two systems. This minimizes the CP current requirements and allows acceptable CP voltage for protection.

Did You Know?

The PCR has been certified by independent laboratories Underwriters Laboratories and Demko for compliance to worldwide standards and codes, and is certified for use in Div 2 and Zone 2 hazardous locations. For more information on certifications and listings, visit www.dairyland.com
PRODUCT OVERVIEW

AC Fault Current Ratings

Some applications may have conditions where an over-voltage device such as the PCR is subject to fault current. For this reason, the PCR was designed to have AC fault current carrying capability. The PCR will limit the voltage between its connection points to less than 10 volts AC under the maximum fault current ratings listed below.

Four different fault current ratings are offered at 60Hz and 50Hz with the following current-time relationship:

<table>
<thead>
<tr>
<th>AC Fault Current Ratings</th>
<th>(Amps AC-RMS Symmetrical)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>60 Hz Cycles</strong></td>
<td>3.7kA 5kA 10kA 15kA</td>
</tr>
<tr>
<td>1</td>
<td>6500 8800 20000 35000</td>
</tr>
<tr>
<td>3</td>
<td>5000 6800 15000 27000</td>
</tr>
<tr>
<td>10</td>
<td>4200 5700 12000 21000</td>
</tr>
<tr>
<td>30</td>
<td>3700 5000 10000 15000</td>
</tr>
<tr>
<td><strong>50 Hz Cycles</strong></td>
<td>3.5kA 5kA 9kA 14kA</td>
</tr>
<tr>
<td>1</td>
<td>6100 8800 19000 33000</td>
</tr>
<tr>
<td>3</td>
<td>4700 6800 14000 25000</td>
</tr>
<tr>
<td>10</td>
<td>3900 5700 11000 20000</td>
</tr>
<tr>
<td>30</td>
<td>3500 5000 9000 14000</td>
</tr>
</tbody>
</table>

Note: Select a PCR fault current rating that encompasses the fault current available. For more information on sizing for available fault current, view our web article: Determining AC Fault Current.

Steady-State AC Current Ratings

This rating represents the maximum steady-state AC current that is allowed to flow through the device while still blocking the flow of DC current. Two ratings are available for the PCR.

The table represents maximum values. As the DC voltage approaches the maximum blocking voltage rating selected, the allowable steady-state AC current is reduced as shown in Figures 1 and 2.

<table>
<thead>
<tr>
<th>Steady-State Current Ratings</th>
<th>(Amps AC-RMS Symmetrical)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>50/60 Hz Ratings</strong></td>
<td></td>
</tr>
<tr>
<td>Ambient Temp</td>
<td>Standard 45A Rating</td>
</tr>
<tr>
<td>20°C</td>
<td>50A</td>
</tr>
<tr>
<td>65°C</td>
<td>40A</td>
</tr>
<tr>
<td>Optional 80A Rating</td>
<td>90A</td>
</tr>
<tr>
<td></td>
<td>70A</td>
</tr>
</tbody>
</table>

There are a number of applications where a PCR may be required to block DC while simultaneously carrying steady-state AC current. For example, when a pipeline is in the same corridor as an electrical transmission line, steady-state AC voltage is often induced on the pipeline. The PCR can mitigate this voltage by providing a low AC impedance path for AC current to flow to ground while simultaneously preventing the flow of DC current.

The steady-state AC impedance of the PCR at 60 Hz is 9.8 milliohms for the standard 45 ampere rating and 4.9 milliohms for the optional 80 ampere rating. At 50 Hz, the comparable impedances are 11.9 milliohms for the standard 40 ampere rating and 5.8 milliohms for the optional 80 ampere rating. Under an AC fault or lightning current condition, these impedances momentarily become virtually zero. For more information on steady-state current view our web article: Measuring Steady-State AC Current.

DC Blocking Voltage Rating

The standard, and most commonly specified, PCR model has an asymmetrical voltage blocking rating of -3.0 volts to +1.0 volt. Either model can also be furnished with a symmetrical voltage blocking rating of +/- 2.0 volts. Other voltage blocking ratings will be considered upon request.

The reasons for symmetrical and asymmetrical choices are best described with an example. If the PCR is used to provide over-voltage protection for an insulated joint and both sides of the joint are cathodically protected, the DC voltage across the joint will be the difference in voltage between the two cathodic protection systems, normally near zero volts. For this application it is desirable to select the symmetrical +/- 2.0 volt blocking rating. In the event that the cathodic protection system is OFF on one side of the joint, the device can block 2.0 VDC in either direction.

If one side of the insulated joint is cathodically protected and the other side is grounded, then it is preferable to select the asymmetrical version which blocks from -3.0 volts to +1.0 volt since one side has been shifted to a more negative voltage. Whenever one side is referenced to ground, the asymmetrical version is suggested because the CP voltage is situated in the center of the threshold voltage range.

Lightning Surge Current Rating

All models have the same lightning surge current rating which is shown in the following table.

<table>
<thead>
<tr>
<th>Lightning Surge Current Rating</th>
<th>All PCR Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Amperes: 100,000</td>
<td></td>
</tr>
</tbody>
</table>

Note: 8x20 microsecond waveform

Keep the Conductors Short!
The PCR is designed to keep the voltage between the device terminals to a limited value. During lightning conditions, a more important factor than the PCR voltage clamping capability is the voltage developed in the conductors or bus used to attach the device. Use low inductance bus bars or conductors ideally less than 6 inches (150 mm) long for best results. More information on conductor length is available at www.dairyland.com.
FEATURES AND CERTIFICATIONS

Certifications
Underwriters Laboratories (UL) has listed the PCR as meeting the criteria for “an effective grounding path” as defined in Section 250.2 and 250.4(A)(5) of the U.S. National Electrical Code (NFPA 70), thereby enabling its use as an AC grounding device. The PCR is also C-UL listed in Canada as meeting the criteria for “an effective grounding path” as defined in C22.1-12, Section 10-500.

The PCR is also listed by UL as meeting:
- The requirements of a DC isolating/AC coupling device suitable for the isolation of objectionable DC current from cathodically protected systems to ground as defined in NFPA 70 Article 250.6(E) and C22.1-12 Section 10-806.
- An over-voltage protective device, having been tested to the applicable requirements of ANSI C62.11.

Listings specific to hazardous locations are summarized as follows:

The PCR is listed by Underwriters Laboratories (UL) for use in hazardous locations in accordance with NFPA 70 (U.S. National Electric Code), Articles 500-505 for Class I, Division 2, Groups A, B, C, and D. The applicable standard to which the PCR is listed is ANSI/ISA 12.12.01-2011 which deals with non-sparking products to meet Class I, Division 2 requirements. The PCR is also C-UL listed to the above classifications per Canadian code C22.2 No. 213-M1987 (R2008).


Solid-State Design
The PCR is built with proven solid-state components which have an instantaneous response with respect to voltage, thereby initiating voltage clamping immediately when the voltage attempts to exceed the blocking level selected.

ORDERING INSTRUCTIONS

Blocking Threshold
Optional Blocking Threshold Ratings:
- Add “S” for -2/+2
- Add “-4/1” for -4/+1
- Add “-6/1” for -6/+1

AC Fault Current
Choose: 3.7kA
5kA
10kA
15kA
*Alternate Ratings for 10kA

Steady-State Current Rating
Optional: Add “/80A” to choose alternate 80A rating

Compact Connectors
Optional: Add “-CC” to choose compact connectors

Submersible
Optional: Add “-CS2” for NEMA 6P Version

PCR-3.7KA/80A-S-CC-CS2

Fail-Safe
An important safety feature for the PCR is that if subject to AC fault current or lightning surge current in excess of rating such that failure occurs, failure will occur in the shorted mode. In the shorted mode, the unit can carry greater than rated fault current or lightning surge current and still provide an effective grounding (or conducting) path.

Enclosure
The PCR enclosure is made of a light gray fiberglass-reinforced polyester material suitable for outdoor non-submersible applications and is rated NEMA 4X (comparable to IP66). Optionally, the PCR can be supplied as a submersible device with the same dimensions rated NEMA 6P (comparable to IP68).

Terminals
Two-hole spade terminals are standard, but compact connectors and 4 hole NEMA terminals are available. Compact connectors are recommended where necessary to insulate the connections to the PCR after installation (for example, with a user furnished heat-shrink sleeve). Add “CC” to the end of any model number only if compact connectors are required, or “4H” for 4 hole terminals.

PCR terminals have preinstalled 1/2” stainless hardware (bolts, nuts, washers). See Accessories for various attachment options.

Examples:
PCR-10KA (Standard connector)
PCR-10KA-CC (Compact connector)
PCR-15KA-4H (4 hole terminal)

Polarity / Electrical Connection
Polarity marks (+) and (-) are provided near the terminals to aid in proper installation. Connect the (-) to the structure with CP or more negative structure and the (+) to the grounded, or more positive, system.

Size and Weight
Refer to figures 4A-4D for dimensional data. Packaged weight varies from approximately 12-22 pounds (5.5-10kg) depending on model selected.

Number of Operations
Virtually unlimited under maximum ratings, provided the operations are not immediately repetitive.

Energy Requirements
None. The devices are totally passive.

Ambient Temperature
-45º C to +65º C
MOUNTING OPTIONS

The PCR is made to mount on a flat surface (e.g., a wood post, unistrut, panel) with two 3/8” (~10mm) diameter bolts furnished by user; however, a number of optional mounting methods and accessories are available for specific applications.

Mounting Accessories
Numerous mounting accessories are available from Dairyland to aid in the proper installation of the PCR. Detailed accessory information, including complete installation instructions are available on the Dairyland website here: Dairyland Accessories

Specific Installation Guidance
The Dairyland website contains detailed information on the installation methods specific to a given application. For wiring diagrams and/or application guidance, see Dairyland Applications.

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**FIGURE 1** PCR Operating Characteristics @ 43°C
(Standard 45A @ 50/60 Hz)

**FIGURE 2** PCR Operating Characteristics @ 43°C
(Optional 80A @ 50/60 Hz)

**FIGURE 3** DC Voltage vs. DC Leakage Current
(Standard Asymmetrical PCR with -3V / +1V Blocking Voltage)
ALTERNATE TERMINAL
SPECIFIED BY ADDING "-CC" TO ANY PCR MODEL NUMBER

APPLIES TO MODELS:
PCR-3.7KA, PCR-5KA & PCR-10KA @ 60HZ
PCR-3.5KA, PCR-5KA & PCR-9KA @ 50HZ

ALL DIMENSIONS ARE [mm] AND INCHES
Figure 4B  PCR Outline Dimensions

Alternate terminal specified by adding "-CC" to any PCR model number

Alternate terminal rotated 90 degrees

Applies to model:
PCR-15KA @ 60 Hz
PCR-14KA @ 50 Hz

All dimensions are [mm] and inches
ALTERNATE TERMINAL
SPECIFIED BY ADDING "-CC" TO ANY PCR MODEL NUMBER

APPLIES TO MODELS:
PCR-15KA/80A @ 60 HZ
PCR-14KA/80A @ 50 HZ
* PCR-[3.5KA, 3.7KA, 5KA, 9KA, 10KA]/80A-CS2
but with terminal spacing of 2.5"

ALL DIMENSIONS ARE [mm] AND INCHES
ALTERNATE TERMINAL
SPECIFIED BY ADDING "-CC" TO ANY PCR MODEL NUMBER

APPLIES TO MODELS:
PCR-3.7KA/80A, PCR-5KA/80A and PCR-10KA/80A @ 60 HZ
PCR-3.5KA/80A, PCR-5KA/80A and PCR-9KA/80A @ 50 HZ

Note: Does not apply to models with "CS2" option - See Figure 4C

ALL DIMENSIONS ARE [mm] AND INCHES