



TPR Three Phase Repeater Introduction

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19201 Parthenia Street, Suite J
Northridge, CA 91234

P:818.701.9831

F:818.701.1506



pwxsales@pcslighting.com
www.pcslighting.com

TPR Introduction

PCS is introducing¹ a new PulseWorx UPB product called the TPR Three Phase Repeater. The purpose of the TPR is to allow UPB powerline communication to work on a three-phase powerline. UPB wall switches, keypads, and interface devices are single-phase devices. They connect (or plug in) to a single phase of the powerline and use that single powerline to communicate to other UPB devices on that same phase only². Single-phase devices have no way, on their own, to communicate to UPB devices on any of the other two phases of a three-phase electrical system. The TPR takes UPB communication packets that are generated on a single powerline phase and repeats them onto all three phases. This allows, for example, a UPB device on Phase A to communicate with another UPB device on Phase B or Phase C.

The TPR Three Phase Repeater mounts into a standard three-gang J box and wires in near (or at) the circuit breaker panel to Phase A, Phase B, Phase C, and Neutral. Three bi-color LED indicators (one for each phase) provide an indication of the UPB traffic on each phase of the powerline. A pushbutton switch is provided for setting the UPB receive sensitivity and putting the TPR into Setup Mode.

How does the TPR Work?

The TPR Three Phase Repeater is an overlapping repeater. To get it to repeat, it keys off of a special type of communication packet called a multi-packet (refer to About Multi-Packets). A multi-packet is a communication packet that repeats the same information more than one time. For instance a “Link 1 Activate” command sent in a two-time multi-packet would go out on the powerline as “Link 1 Activate (1of2)” followed immediately by “Link 1 Activate (2of2)”. After receiving the “Link 1 Activate (1of2)” on a single phase, the TPR will automatically transmit the “Link 1 Activate (2of2)” on all three phases. The TPR overlaps its transmission right on top of the multi-packet being transmitted by the originating device.

How Do Controllers Use the TPR?

Unlike PCS’ earlier three-phase repeating device, the PRR PulseWorx Residential Repeater, the TPR Three Phase Repeater is designed without a host interface (serial port). As long as the home automation controller software uses the multi-packet method of communication it can interface to the three-phase powerline through a standard single-phase PIM – the TPR will take care of getting the information onto all three phases. This gives the TPR a huge advantage over the PRR in that the home automation controller can now be plugged into any available power outlet. It does not need to be located near the repeating device as was the case with the PRR.

Communication Acknowledgement

Some home automation controllers rely on the ACK Pulse as positive confirmation that a communication packet successfully arrived at the destination device. Due to timing constraints, the TPR is not able to repeat an ACK Pulse that was generated from one phase onto all three phases. This type of positive confirmation is not available when using a TPR. It is suggested that home automation controllers that require positive confirmation of a successful communication use the Acknowledgement Response packet in place of the ACK Pulse (refer to About the Acknowledgement Response Packet). An Acknowledgement Response packet can be successfully repeated, by the TPR, onto all three phases.

¹ Estimated Q2 2008

² UPB devices on a single split-phase electrical environment can communicate to both the same and opposite phases.

NOTE: the TPR will generate its own ACK Pulse letting the controller know that it successfully received a multi-packet and it will be transmitting it onto all three phases. With the inherent reliability of the UPB communication method this acknowledgement may be enough to be sure that the packet will arrive successfully at the intended destination.

How does UPStart Use the TPR?

With the use of a TPR, UPStart is now free to interface to the three-phase powerline through a standard single-phase PIM. UPStart is used to talking to single-phase devices using single-packet communication. However, when a TPR Three Phase Repeater is added to the network configuration file UPStart automatically switches to a new mode of communication that uses multi-packets. While in this mode, UPStart will use the TPR to get all of its single-phase packets onto all three phases. It will adjust its timeouts for the longer multi-packets and it will ask the TPR for enumeration results from all three phases. While using the TPR, UPStart will be able to determine which phase each device is connected to as well as to detect which Phase the PIM is plugged into.

About Multi-Packets

A multi-packet is a communication packet that echoes the same information more than one time. For instance a "Link 1 Activate" command sent in a two-time multi-packet would go out on the powerline as "Link 1 Activate (1of2)" followed immediately by "Link 1 Activate (2of2)". The UPB message structure has provisions for sending either a two-time, three-time, or four-time multi-packet.

Multi-packets are distinguished from single-packets by the CNT (count) field. The CNT field is a 2-bit field in the packet header control word that tells everyone how many times the same information is going to be echoed. A single-packet has the CNT field set to 00 to indicate that the information is not being echoed. A two-time multi-packet has the CNT field set to 01 to indicate that the information is being echoed once. A three-time multi-packet has the CNT field set to 10 to indicate that the information is being echoed two more times. A four-time multi-packet has the CNT field set to 11 to indicate that the information is being echoed three more times.

Also in the packet header control word is a 2-bit field called the SEQ (sequence) field. This field is used to mark each individual packet of a multi-packet with an ascending sequence number. The first packet always has a SEQ of 00 to indicate "1ofN". The second (echo) packet always has a SEQ of 01 to indicate "2ofN". The third (echo) packet always has a SEQ of 10 to indicate "3ofN". The fourth (echo) packet always has a SEQ of 11 to indicate "4ofN".

Most UPB devices on the market today are set at the factory to transmit using two-time multi-packets. Using UPStart, any device can be configured differently to use three-time multi-packets, four-time multi-packets, or even just single-packets.

The PIM Powerline Interface Module can be commanded to transmit a multi-packet simply by specifying the UPB communication packet with a non-zero CNT field. After the specified packet is transmitted, the PIM's Core automatically takes care of updating the SEQ field and transmitting the echoing packets.

About the Acknowledgement Response Packet

The Acknowledgement Response packet is a special communication packet whose purpose is to give positive confirmation that a destination device successfully received a communication packet. Transmitters request an Acknowledgement Response packet by setting the MSG-bit in the packet header control word. UPB devices³ will automatically transmit an Acknowledgement Response packet after successfully receiving any communication packet addressed to them with the MSG-bit set.

The Acknowledgement Response packet has a Message Data ID of 0x80 and has the following syntax:

MDID	Arg1
0x80	MM

Where MM is the MDID of the successfully received communication packet.

How does the TPR compare with the PRR?

PCS originally addressed the three-phase electrical environment by developing a three-phase repeating device called the PRR PulseWorx Residential Repeater. Although a very good device, the PRR had some inherent drawbacks that the TPR overcomes. Table 1 outlines some of those drawbacks and how the TPR solves them.

Subject	PRR Drawback	TPR Solution
Core Firmware	The PRR is built with the Generation I UPB Core. Gen I can sometimes have trouble receiving in severe powerline noise.	The TPR is built with the Generation II UPB Core. Gen II handles powerline noise much better and has adjustable receive sensitivity.
Host Location	The Host (or UPStart) must be located within 50' of the PRR which is installed near the main electrical panel.	The Host (or UPStart) is free to be plugged into any available power outlet through a single-phase PIM.
Host Protocol	The PRR sends the host a special type of Pulse Report that contains three-phase information. All hosts need to be designed to handle this special type of report. There is no Message Mode built into the PRR. Most home automation controller software uses Message Mode.	The Host interfaces to a standard PIM which supports both Pulse Mode and Message Mode. The Host just has to switch to using multi-packets and it can now interface to all three phases.
Repeat Key	The PRR will only repeat Repeater Packets (REPRQ field is non-zero). All devices that transmit Normal Packets (by default) have to be specially configured (with UPStart) to now use Repeater Packets instead.	The TPR will only repeat multi-packets. UPB devices factory default to use a two-time multi-packet. No special UPStart configuration is required.

³ Not available in Generation I UPB devices.

Subject	PRR Drawback	TPR Solution
Repeat Delay	The PRR is a sequential repeater. After the Repeater packet is completely transmitted on the powerline the PRR then transmits an entire Normal packet onto all three phases. This can take a long time.	The TPR is an overlapping repeater. At the same time as the Multi-Packet is being transmitted on one phase the TPR is transmitting the multi-packet onto all three phases. This reduces the time that signals are on the powerline.

Table 1: The TPR Solves Many PRR Drawbacks

Special Notes About Generation I Devices

In late 2007, UPB device manufacturers started releasing a new and improved generation of UPB products called Generation II UPB. The TPR Three-Phase Repeater was designed around that same time and was specifically intended for use with Generation II UPB devices. There are some issues that should be noted that make the use of the TPR with older Generation I devices more difficult.

In order for the TPR's overlapping repeating mechanism to work properly in a two-way conversation both the Request and the Response need to be made with multi-packets. Generation II UPB devices have no problem with this. If a Request comes in on a multi-packet then the Response goes out using a multi-packet.

Unfortunately, Generation I UPB devices use only single-packets for their Response packets. This means that Generation I UPB devices can not be used with the TPR to perform a two-way conversation. The (multi-packet) Request will get onto all three-phases but the (single-packet) Response will only go to devices on the same phase as the responder.

Also keep in mind that Generation I devices do not support the Acknowledgement Response packet. This means that neither the ACK Pulse nor the Acknowledgement Response methods of receiving positive confirmation will work with Generation I UPB devices in a TPR three-phase environment.

Please note that Generation I UPB devices will work just fine in a TPR three-phase environment to send/receive (multi-packet) Command packets for controlling the on/off/bright/dim states. These command packets are one-way and do not require a Response packet. If you absolutely have to use Generation I UPB devices and you need to perform two-way conversations then make sure that both the requester and the responder are on the same powerline phase.



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