

# Universal Powerline Bus



## Powerline Interface Module (PIM) Description

V 1.6

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## 1. Scope

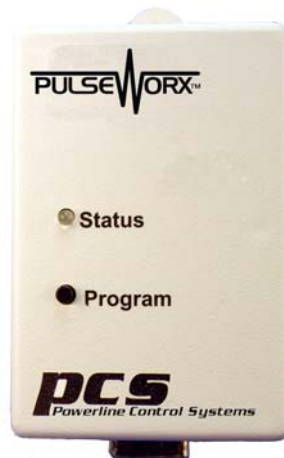
The document describes the Powerline Control Systems' (PCS) Powerline Interface Module (PIM). Included in this document are descriptions of the PIM and PIM connections, PIM/Host Serial Communications, PIM Setup Registers, PIM Pushbutton operation, and PIM Status LED operation. Examples of PIM/Host Serial Communication are also included.

In order to fully understand some of the concepts discussed herein, the reader should have a good understanding of the UPB Communication Method, the UPB System Model and the UPB Message Structure (as presented in the [UPB System Description](#) document).

## 2. PIM Overview

The Powerline Interface Module (PIM) is a plug-in module designed to interface a host computer device to the powerline communications of the Universal Powerline Bus (UPB). UPB communication is a method, developed by PCS, to reliably communicate command and control information on a standard 60Hz AC electrical powerline. The PIM communicates to a host computer device via a standard RS-232 serial cable running at 4800 baud.

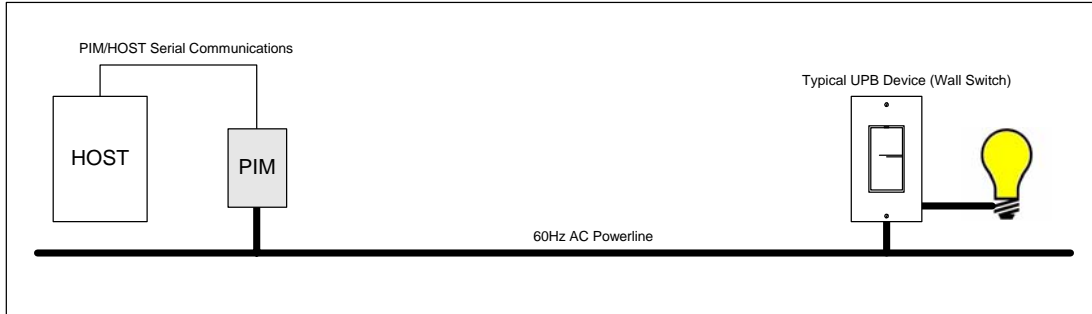
The PIM can be used to both transmit information onto the UPB (powerline) and to receive information from the UPB.



**Figure 1: The Powerline Interface Module (PIM-R)**

## 2.1 PIM/Host Serial Communications

The PIM can be used to both transmit information onto the UPB (powerline) and to receive information from the UPB. The PIM uses RS-232 serial communications between it and the host device to both receive commands from the host and to send responses and reports to the host (see Figure 2).



**Figure 2: PIM/Host Communication Diagram**

All PIM/Host communications are done serially at 4800 baud in the “N-8-1” format. All PIM/Host communications shall consist of ASCII characters. All PIM/Host communications shall end with a Carriage Return (<cr>) character. The remaining sections describe the PIM/Host serial communications in detail.

## 2.2 Modes of Operation

The PIM has two different modes of operation: Pulse Mode and Message Mode. Pulse Mode gives more detailed information as to what is happening on the powerline but it also requires more overhead from the Host to maintain it. Message Mode is more suited to users who only want to deal with valid UPB messages. The user has to choose which mode of operation best suits their needs.

### 2.2.1 The Message Mode

The general philosophy of the Message Mode is to only report to the Host when a valid UPB Message has been received. The Host is also informed when the PIM accepts commands from the Host and when the PIM has completed a UPB transmission.

### 2.2.2 The Pulse Mode

The general philosophy of the Pulse Mode is to not “hide” any UPB information from the host. Instead of only communicating with the host device when a valid UPB Message has been received, the PIM informs the host of every UPB Pulse that it detects on the powerline. The PIM not only informs the host of the value (0, 1, 2, or 3) of the UPB Pulse, but it also informs the host of the relative strength (or energy) of that UPB Pulse. This, of course, places a much higher burden on the host device (to assemble the received UPB Pulses into a complete

UPB Message and to validate it) but it also allows the host device the freedom (and power) to make intelligent decisions based on what is currently happening on the powerline.

To aid the host in determining the start and end of a UPB Communication Packet, the PIM sends special messages when it receives the Preamble Pulses and the ACK Pulse.

### 2.2.3 Setting the Mode of Operation

The Message Mode is the factory default mode of the PIM. This means that every PIM (v4.15 and above) that comes from the manufacturer is already configured to operate in Message Mode. Pulse Mode can be enabled by writing bit #1 of Setup Register 0x70 to a logical 0. Once a PIM is set to a particular mode of operation it will stay in that mode even if power is removed (i.e. the Setup Registers are non-volatile).

If a PIM is in the Pulse Mode and you want to set it into the Message Mode there are two ways to do that. One is to write bit #1 of Setup Register 0x70 to a logical 1 using the “Write PIM Registers” command as outlined in section 7.4 (Example 4: Writing/Reading PIM Setup Registers). Here is an example of the command in ASCII format:

```
<ctl-W>70028E<cr>
```

The other way to set the PIM into the Message Mode is to have the user manually set the PIM back to its Factory Defaults using the PIM’s Program pushbutton as follows:

Step	Operation
1	Press the Program pushbutton <b>five</b> times quickly in a row.
2	The LED should start to blink green to indicate it is in Setup Mode.
3	Press the Program pushbutton <b>ten</b> times quickly in a row.
4	The LED should start to blink red to indicate that Factory Defaults have been set.
5	Press the Program pushbutton <b>two</b> more time.
6	The LED should stop blinking to indicate that it is ready for normal operation.

## 3. Receiving UPB Messages

### 3.1 Message Mode

In the Message Mode of operation, the PIM sends “UPB Message Reports” to inform the host whenever it has received a complete and valid UPB Message. Section 6.1 describes the format of “UPB Message Reports” and section 7.1 shows an example of receiving a UPB packet in Message Mode.

### 3.2 Pulse Mode

In the Pulse Mode of operation, the PIM sends “UPB Pulse Reports” to inform the host whenever it has detected a valid UPB Pulse. The host can use these reports to build them into a received UPB Message and take action accordingly. It is up to the host device to validate the checksum and other fields of the received UPB Communication Packet. Section 6.2 describes the format of “UPB Pulse Reports” and section 7.2 shows an example of receiving a UPB packet in Pulse Mode.

A special “Dropped UPB Message “ Pulse Report is sent by the PIM in the case where it begins receiving a UPB Message but then the message ends prematurely (loss of signal, noise, etc.).

## 4. Transmitting UPB Messages

The host can send a “Transmit UPB Message” command (refer to Table 5) to request the PIM to transmit a valid UPB Message onto the powerline. It is up to the host device to pass a valid UPB Message to the PIM for transmission. The PIM will validate this message and send back either a “PIM Accept” or a “PIM Error” response. The PIM will then transmit the UPB Message on the powerline.

### 4.1 Message Mode

In the Message Mode of operation, the PIM will send one of two possible serial messages whenever it finishes a UPB transmission. An “Ack Response” is used to indicate that the UPB transmission is complete and that an Ack Pulse was received. A “Nak Response” is used to indicate that the UPB transmission is complete and that an Ack Pulse was not received.

### 4.2 Pulse Mode

In the Pulse Mode of operation, the PIM will send “UPB Pulse Reports” back to the host to indicate each UPB Pulse that was transmitted and also to inform the host of the presence or absence of an ACK Pulse at the end. Section 6.2 describes the format of “UPB Pulse Reports” and section 7.3 shows an example of transmitting a UPB packet in Pulse Mode.

## 5. Reading/Writing PIM Setup Registers

In addition, the PIM (like all UPB devices) has a block of 256 non-volatile registers, known as Setup Registers, which can be read from and/or written to using PIM/Host Communications (see section 7.4 - Example 4: Writing/Reading PIM Setup Registers).

### 5.1 PIM Setup Registers

The PIM, like all UPB devices, has a block of 256 non-volatile registers, known as Setup Registers, which can be read from and/or written to. Currently, the PIM only uses a small portion of its available Setup Registers as defined in Table 1. All other Setup Registers are reserved at this time (set to 0xFF) and should not be written to.

Setup Registers Field Name	Reg #	Factory Defaults (Hexadecimal)	Description
Network ID (NID)	0x00	FF	Unique identifier for the UPB Network this device communicates on.
Module ID (MID)	0x01	30	Unique identifier for this UPB device.
Network Password	0x02 – 0x03	1234	Password designed to keep unauthorized users from accessing the Setup Registers of this device.
UPB Options (UPBOP)	0x04	00	Identifies unique UPB options that are enabled for this device.
UPB Version (UPBVER)	0x05	01	Identifies the version of the UPB specification this device conforms to.
Manufacturer ID	0x06 – 0x07	0001	Unique identifier of the manufacturer of this UPB device (PCS).
Product ID	0x08 – 0x09	0030	The manufacturer's unique product identifier for this UPB device.
Version Number	0x0A – 0x0B	Current Firmware Version (i.e. 0415)	The manufacturer's unique version number of this Product ID.

Setup Registers Field Name	Reg #	Factory Defaults (Hexadecimal)	Description
Serial Number	0x0C – 0x0F	00000000	Serial Number
Reserved1	0x0F – 0x6F	All FF's	Unused. Reserved for future.
PIM Options	0x70	FF	See TBD
Reserved2	0x71 – 0xF8	All FF's	Unused. Reserved for future.
Signal Strength	0xF9	00	Signal strength of 1 <sup>st</sup> 16 pulses of the last received UPM Message.
Noise Floor	0xFA	00	Noise Floor of the powerline taken from the last 128 AC half-cycles.
Noise Counts	0xFB – 0xFF	All 00's	Raw Noise Count values used to produce the Noise Floor.

Table 1: PIM Setup Registers

### 5.1.1 PIM Options Register

Setup Register 0x70 is the PIM Options Register. It has various bits and fields that are used to enable and disable various features of the PIM as described in Table 2 below:

Bit(s)	Name	Description
0	Idle Pulse Report Filter	In Pulse Mode, this bit determines if Idle Pulse Reports are sent to the host. 1 = No Idles sent; 0 = Idles sent
1	PIM Mode	This bit determines which mode of operation the PIM is in: 1 = Message Mode; 0 = Pulse Mode
2 - 7	Unused	These bits are reserved for future use.

Table 2: PIM Option Definitions



## 6. PIM/Host Serial Communication Messages

The following section describes the PIM/Host Serial Communication Messages that have been implemented. These messages have been broken up into four separate classifications:

1. UPB Message Reports (Message Mode Only)
2. UPB Pulse Reports (Pulse Mode Only)
3. Host-To-PIM Commands
4. PIM-To-Host Responses

### 6.1 UPB Message Reports (Message Mode Only)

While in the Message Mode, the PIM will send the Host serial messages called Message Reports whenever it receives a valid (good checksum) UPB Message on the powerline. A description of the Message Report is given in the following table.

UPB Message Report	Syntax	Description
Message Report	'P"U'UU..KK<Cr>	Used to report a valid UPB Message was received.  UU..KK = A Valid UPB Message (see Note #1 below).

**Table 3: UPB Message Reports**

Note #1: The format for a valid UPB Message (UU..KK) is described in the [UPB System Description](#) document.

## 6.2 UPB Pulse Reports (Pulse Mode Only)

While in the Pulse Mode, the PIM will send the Host serial messages called Pulse Reports to inform the Host of what is currently happening on the UPBus. These reports are sent in real-time (i.e. as each UPB Pulse is received). All UPB Pulse Reports are four characters long with a carriage return as the last (4<sup>th</sup>) character.

UPB Pulse Report	Report Characters				Description
	1	2	3	4	
Received a Start Pulse (or Noise)	'X'	E <sup>[1]</sup>	'F'	<cr>	Used to inform the Host that the UPBus is no longer Idle (A UPB Pulse is present). This can be due to either the start of a UPB Communications Packet or noise.
Received a Sync Pulse	'R'	E <sup>[1]</sup>	'F'	<cr>	Used to inform the Host that the PIM received a Sync Pulse and is about to start receiving a UPB Message.
Received a Data Pulse 0	'0'	E <sup>[1]</sup>	S <sup>[2]</sup>	<cr>	Used to inform the Host that the PIM received a Data Pulse in Position #0 (Value = 0).
Received a Data Pulse 1	'1'	E <sup>[1]</sup>	S <sup>[2]</sup>	<cr>	Used to inform the Host that the PIM received a Data Pulse in Position #1 (Value = 1).
Received a Data Pulse 2	'2'	E <sup>[1]</sup>	S <sup>[2]</sup>	<cr>	Used to inform the Host that the PIM received a Data Pulse in Position #2 (Value = 2).
Received a Data Pulse 3	'3'	E <sup>[1]</sup>	S <sup>[2]</sup>	<cr>	Used to inform the Host that the PIM received a Data Pulse in Position #3 (Value = 3).
Received an ACK Pulse	'A'	E <sup>[1]</sup>	U <sup>[3]</sup>	<cr>	Used to inform the Host that the PIM received a valid ACK Pulse at the end of the UPB Message.
Received a NAK Pulse	'N'	E <sup>[1]</sup>	U <sup>[3]</sup>	<cr>	Used to inform the Host that the PIM did not receive a valid ACK Pulse at the end of the UPB Message.
Dropped UPB Message	'D'	E <sup>[1]</sup>	S <sup>[2]</sup>	<cr>	Used to inform the Host that the PIM did not receive a valid Data Pulse when one was expected.

UPB Pulse Report	Report Characters				Description
	1	2	3	4	
UPBus Idle	'-'	E <sup>[1]</sup>	'F'	<cr>	Used to inform the Host that the UPBus is Idle (no Pulses are present). This report, by default, is not generated but can be enabled by writing bit #0 of Setup Register 0x70 to a logical 1 using the "Write PIM Registers" command as outlined in section 7.4.
Transmitted a Pulse	'T'	V	S <sup>[2]</sup>	<cr>	Used to inform the Host that the PIM transmitted a UPB Pulse. V = Pulse Value ('0' – '3').

**Table 4: UPB Pulse Reports**

<sup>[1]</sup> The E in the 2<sup>nd</sup> character in Table 4 is a representation of the relative Energy of the UPB Pulse. It is represented as an ASCII character between '0' and 'F' where '0' represents a non-existent Pulse, '1' represents a very weak Pulse and 'F' represents a very strong Pulse.

<sup>[2]</sup> The S in the 3<sup>rd</sup> character in Table 4 is a representation of the relative sequence of the UPB Pulse. This character will increment from '0' to '9' and then from 'A' to 'F' and then back to '0' again as each Pulse Report is sent.

<sup>[3]</sup> The U in the 3<sup>rd</sup> character in Table 4 is a representation of the relative sequence of the UPB ID Pulse. It is normally sent as an 'F' however, in the case of an enumeration, it will increment from '0' to '9' and then from 'A' to 'F' and then back to '0' again as each Pulse Report is sent. This can be used by the host to make sure it gets all 256 Pulse Reports needed for the enumeration operation.

### 6.3 Host-To-PIM Commands

Host-To-PIM Commands (Table 5) are serial messages that travel from the Host to the PIM to request that the PIM perform some sort of action. Host-To-PIM Commands vary in length depending on how much information needs to be transferred. The PIM can be commanded to either transmit a UPB Message or to read or write its Setup Registers.

NOTE: All characters in Table 5 are in ASCII Hex encoding except for the following:

<Cr>	=	Carriage Return character (0x0D)
<Ctl-T>	=	DC4 character (0x14)
<Ctl-R>	=	DC2 character (0x12)
<Ctl-W>	=	ETB character (0x17)

Host-To-PIM Command	Command Syntax	Description
Transmit UPB Message	<Ctl-T>UU..KK<Cr>	<p>Used to request the PIM to transmit a given UPB Message onto the UPBus.</p> <p>UU..KK = A Valid UPB Message (see Note #1 below).</p> <p>The PIM will check this message for a proper checksum. If it fails the checksum test it will respond to the Host with a "PIM Error" response. If it passes the checksum test, the PIM will respond to the Host with a "PIM Accept" response and transmit the message onto the UPBus.</p> <p>The PIM will start sending "Transmitted a Pulse" reports to the Host until the UPB message ends followed by either a "Received an ACK Pulse" report or a "Received a NAK Pulse" report.</p>

Host-To-PIM Command	Command Syntax	Description
Read PIM Registers	<Ctl-R>RRNNKK<Cr>	<p>Used to read one or more PIM Setup Registers.</p> <p>RR = Starting Register Number, NN = Number Of Registers, KK = Checksum.</p> <p>The PIM will check this message for a proper checksum. If it fails the checksum test it will respond to the Host with a "PIM Error" response. If it passes the checksum test, the PIM will read the specified registers and report them to the Host in a "PIM Register Report" response.</p>
Write PIM Registers	<Ctl-W>RRVV..KK<Cr>	<p>Used to write one or more PIM Setup Registers with the given value(s).</p> <p>RR = Starting Register Number, VV = Value(s) To Write (Note #2), KK = Checksum.</p> <p>The PIM will check this message for a proper checksum. If it fails the checksum test it will respond to the Host with a "PIM Error" response. If it passes the checksum test, the PIM will write the given Value(s) to the specified Register(s) and indicate completion with a "PIM Accept" response.</p>

**Table 5: Host-To-PIM Commands**

Note #1: The format for a valid UPB Message (UU..KK) is described in the [UPB System Description](#) document.

Note #2: Any amount of Values (from 1 to 16) can be supplied to write a block of Setup Registers.

## 6.4 PIM-To-Host Responses

PIM-To-Host Responses (Table 6) are serial messages that travel from the PIM to the Host to inform the Host of the status of the previous Host-To-PIM Command.

PIM-To-Host Response	Syntax	Description
PIM Accept	'P'A'<cr>	Used to inform the Host that the PIM accepted the previous command.
PIM Busy	'P'B'<cr>	Used to inform the Host that the PIM rejected the previous command because it was busy.
PIM Error	'P'E'<cr>	Used to inform the Host that the PIM rejected the previous command because it found an error in it.
PIM Register Report	'P'R'RRVV<cr>	Used to inform the Host of the contents of the PIM Registers previously requested by a "Read PIM Registers" command.  RR = Starting Register Number, VV = Value(s) Read [Note #1].
Ack Response	'P'K'<cr>	Used to inform the Host that the UPB transmission is complete and an Ack Pulse was received. (Message Mode)
Nak Response	'P'N'<cr>	Used to inform the Host that the UPB transmission is complete and an Ack Pulse was not received. (Message Mode).

**Table 6: PIM-To-Host Responses**

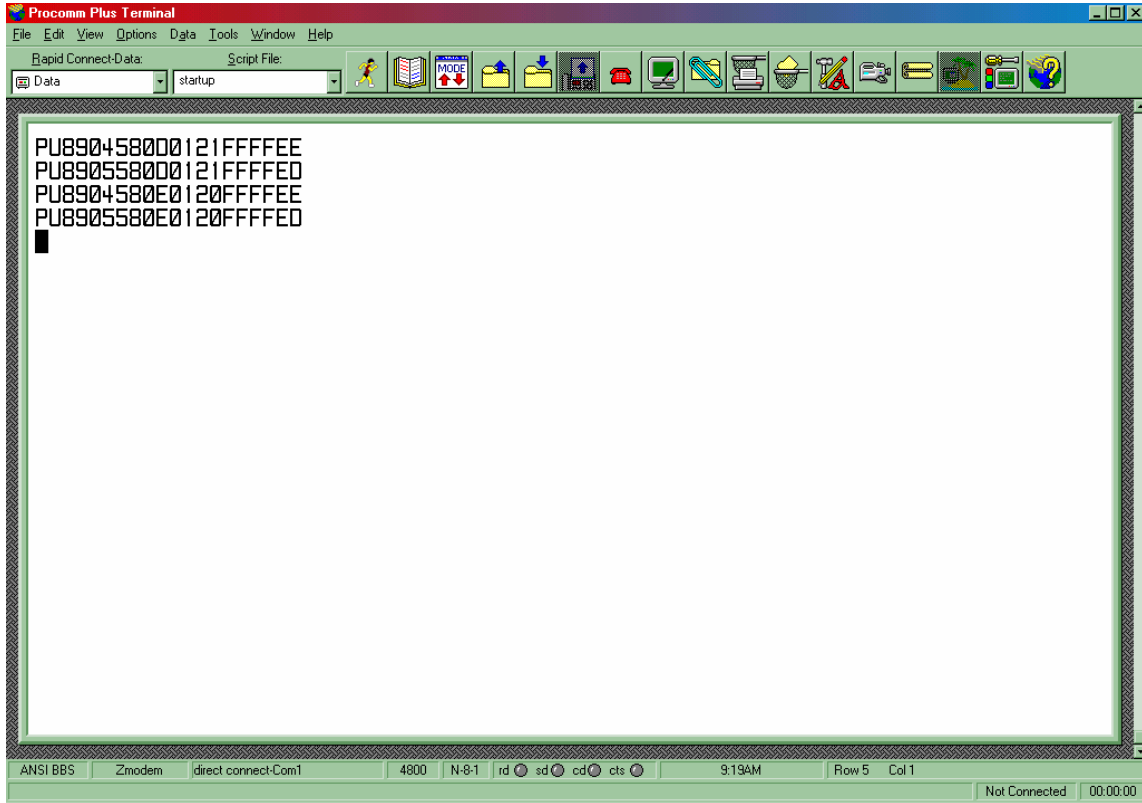
Note #1: Any amount (from one to sixteen) of Values (VV) can be returned when reporting a block of Setup Registers.

## 7. PIM/Host Serial Communication Examples

In order to better understand PIM/Host Serial Communication, some examples have been provided below. In these examples, the PIM/Host Serial Communications have been captured on a PC running Procomm Plus Terminal at 4800 baud N-8-1. Screen shots of the Procomm Plus Terminal have been provided to help get an understanding of what messages the PIM sends to the host. The Procomm Plus Terminal converts all serial communications to ASCII representation and converts all carriage returns to a combination of a carriage return and a line feed. This results in each PIM/Host Serial Communication message being displayed on a separate line of the Procomm Plus Terminal.

## 7.1 Example 1: Receiving A UPB Message (In Message Mode)

When the PIM receives a valid UPB Message it will send a UPB Message Report to the host device indicating that it has received a message. The screen shot in Figure 3 shows the UPB Message Reports that the PIM sent to the host as it received four UPB Messages.



**Figure 3: PIM/Host Communications - Receiving A UPB Message (In Message Mode)**

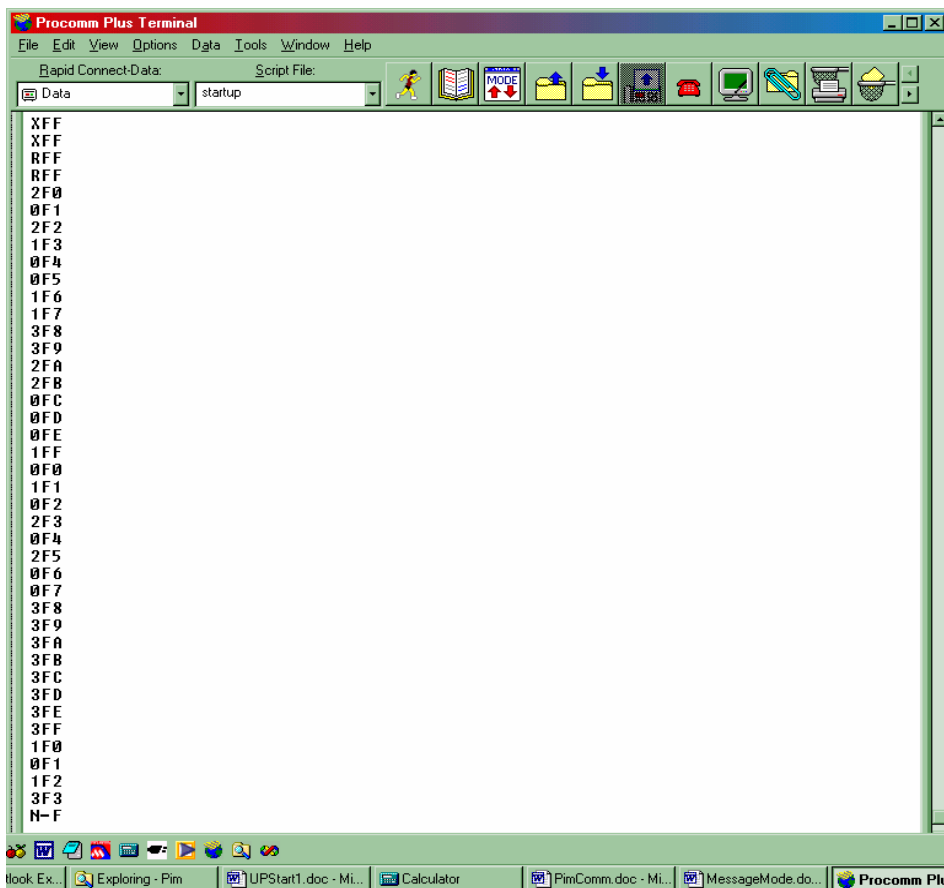


## 7.2 Example 2: Receiving A UPB Message (In Pulse Mode)

When the PIM detects a UPB Communication Packet on the powerline it will send UPB Pulse Reports to the host device indicating exactly what pulses were seen on the powerline. In this example, the following UPB Message was transmitted by a remote UPB device and received by the PIM.

UPB Message = 89 05 FA 01 12 20 FF FF 47

The screen shot in Figure 4 shows the UPB Pulse Reports that the PIM sent to the host as it received this UPB Message. In studying Figure 4, we will pay particular attention to the first character of each UPB Pulse Report. This first character indicates what type (value) of UPB Pulse was received by the PIM. The second character indicates the relative strength (energy) of the received UPB Pulse and is not discussed in this example.



**Figure 4: PIM/Host Communications - Receiving A UPB Message (In Pulse Mode)**

As seen in the screen shot, the first four UPB Pulse Reports that the PIM sent were X-X-R-R. These UPB Pulse Reports indicate that the PIM received a valid Preamble to a UPB Communications Packet. The Preamble is always transmitted as 2-1-1-2 but, since the PIM may not yet be synchronized to the transmitter, the PIM represents it as characters X-X-R-R.

The next 36 UPB Pulse Reports represent the 9 bytes of the UPB Message. Each UPB Pulse Report represents two bits of the UPB Message. For example, looking at the first 4 of these 36 UPB Pulse Reports, we see that the PIM received a 2-0-2-1 which, represented in hexadecimal, is 0x89. This is the first byte of the UPB Message shown above.

NOTE: The Pulse Reports come in “real-time” and a UPB Communications Packet can terminate improperly for a variety of reasons. When a UPB Communications Packet terminates prematurely, the PIM will send a “Dropped UPB Message” Pulse Report to the host.

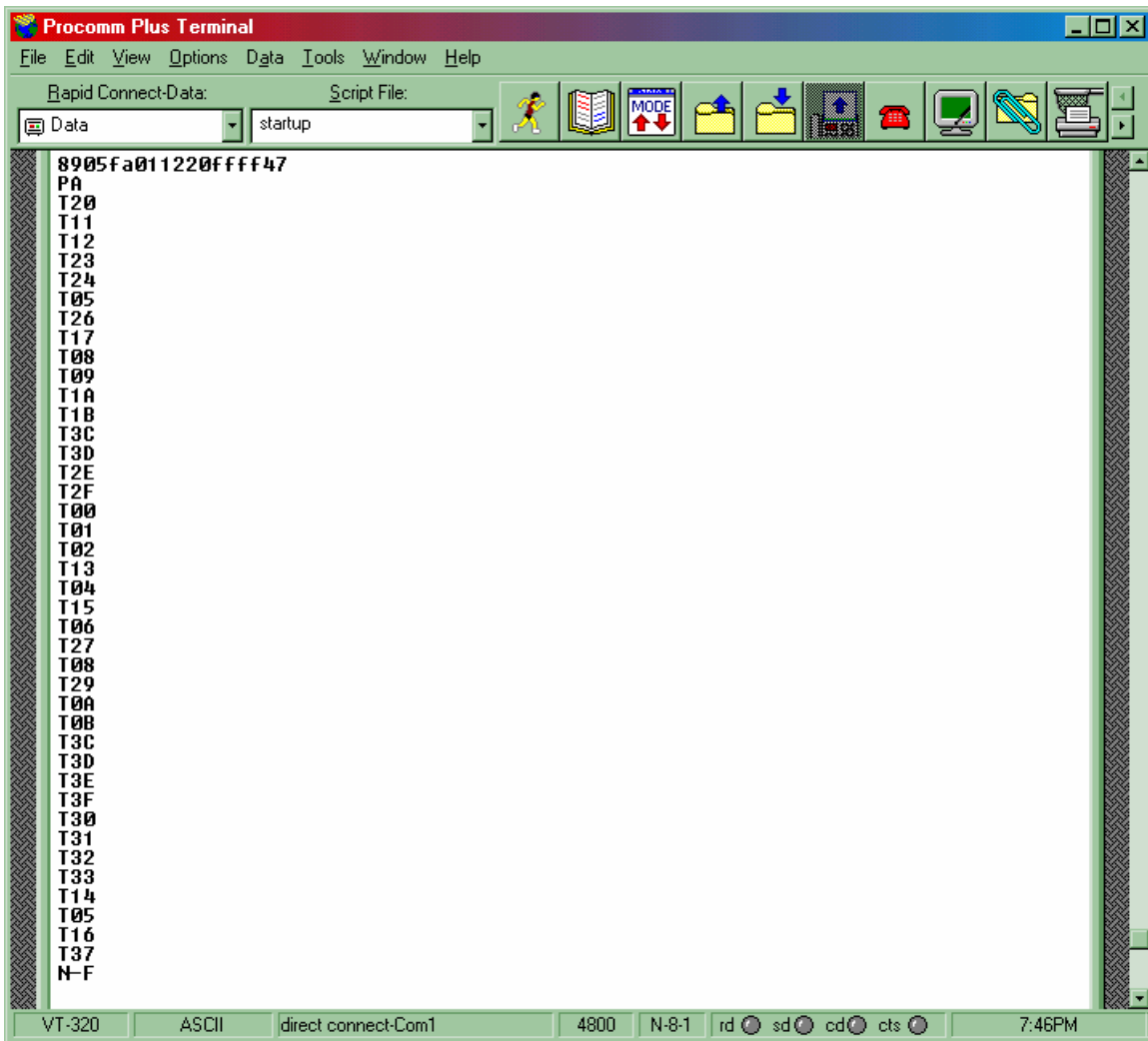
The last UPB Pulse Report that the PIM sent was an ‘N’, which indicates that the PIM did not see an ACK Pulse on the powerline after the UPB Message ended. Had there been a receiving device that sent an ACK Pulse the PIM would have sent an ‘A’ in the UPB Pulse Report instead. In fact, a UPB Pulse Report with a value of either ‘N’ or ‘A’ can be used as an indication of the end of a UPB Communications Packet.

### 7.3 Example 3: Transmitting A UPB Packet

The host can request the PIM to transmit a UPB Communication Packet onto the powerline by sending it a valid "Transmit UPB Message" command (see Table 5). In this example, the PIM was sent a "Transmit UPB Message" command to request it to send the following UPB Message.

UPB Message = 89 05 FA 01 12 20 FF FF 47

The screen shot in Figure 5 shows the PIM-To-Host Responses and the UPB Pulse Reports that the PIM sent back to the host as it received this command and transmitted the UPB Communication Packet onto the powerline.



**Figure 5: PIM/Host Communications - Transmitting A UPB Communication Packet**

As seen in the screen shot, the first line after the “Transmit UPB Message” command is a “PA” (PIM Accept) response indicating that the PIM accepted the command (checksum was good). If there were something wrong with the command (checksum, etc.), the PIM would have responded with a “PE” (PIM Error) instead.

The next four lines (2-1-1-2) are UPB Pulse Reports that indicate that the PIM transmitted a valid Preamble byte of the UPB Communications Packet.

The next 36 UPB Pulse Reports represent the 9 bytes of the UPB Message. Each UPB Pulse Report represents two bits of the UPB Message. For example, looking at the first 4 of these 36 UPB Pulse Reports, we see that the PIM transmitted a 2-0-2-1 which, represented in hexadecimal, is 0x89. This is the first byte of the UPB Message shown above.

The last UPB Pulse Report that the PIM sent was an ‘N’, which indicates that the PIM did not see an ACK Pulse on the powerline after the UPB Message ended. Had there been a receiving device that sent an ACK Pulse the PIM would have sent an ‘A’ in the UPB Pulse Report instead. In fact, a UPB Pulse Report with a value of either ‘N’ or ‘A’ can be used as an indication of the end of a UPB Communications Packet.

## 7.4 Example 4: Writing/Reading PIM Setup Registers

The PIM (like all UPB devices) has a block of 256 non-volatile registers, known as Setup Registers, which can be read from and/or written to. In this example, a value of 00 will be written to Setup Register #0 (using the “Write PIM Registers” command) and then all 128 Setup Registers will be read (using the “Read PIM Registers” command).

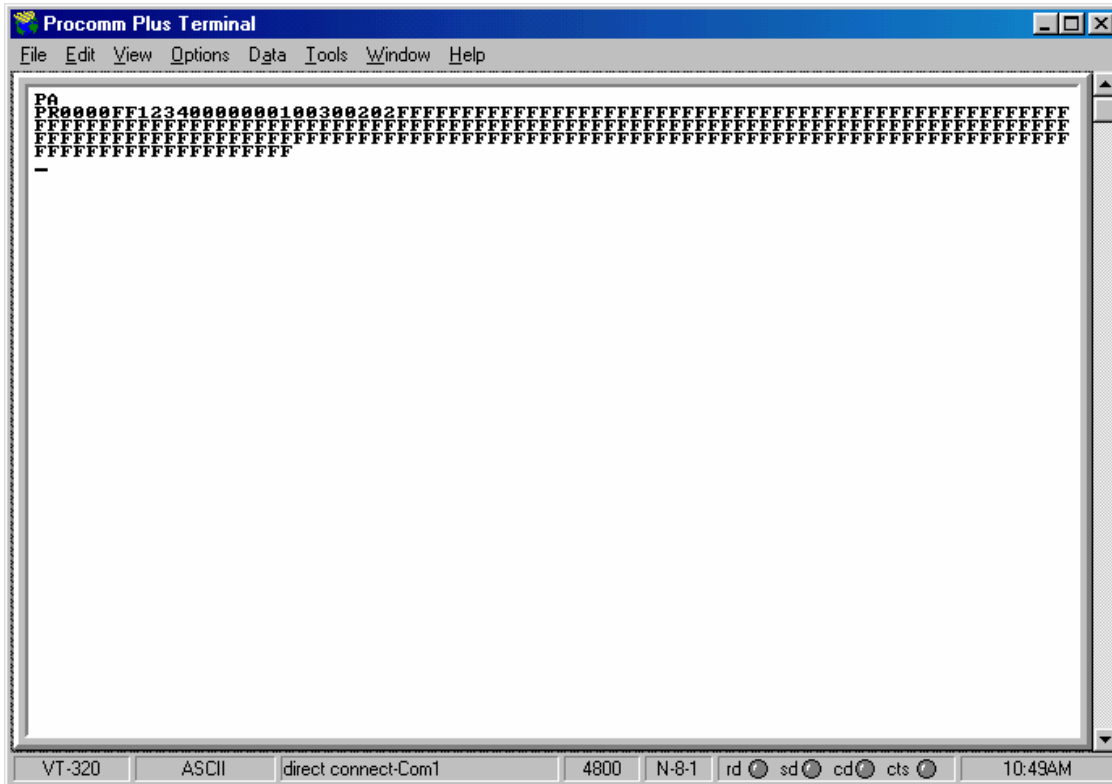
The “Write PIM Registers” command (see Table 5) has the form:

<ctl-W> 00 00 00.

The “Read PIM Registers” command (see Table 5) has the form:

<ctl-R> 00 80 80.

The screen shot in Figure 6 shows the PIM-To-Host Responses that the PIM sent back to the host as it received the two commands. The first line after receiving the “Write PIM Registers” command shows that the PIM sent back a “PA” (PIM Accept) response indicating that the PIM accepted the command. If there were something wrong with the command (checksum, etc.), the PIM would have responded with a “PE” (PIM Error) instead.



**Figure 6: PIM/Host Communications – Writing/Reading PIM Setup Registers**

The following lines after the PIM Accept response shows that the PIM sent back a “PIM Register Report” (see Table 6) that included the values of 128 Setup Registers starting at Register #0.

Note that Setup Register #0 contains the value 0x00 indicating that the previous “Write PIM Registers” command was successful. Note also that Setup Registers 0x0A and 0x0B contain the value 0x0202 indicating that the PIM firmware version is 2.02.

## 7.5 Example 5: Receiving UPB Noise

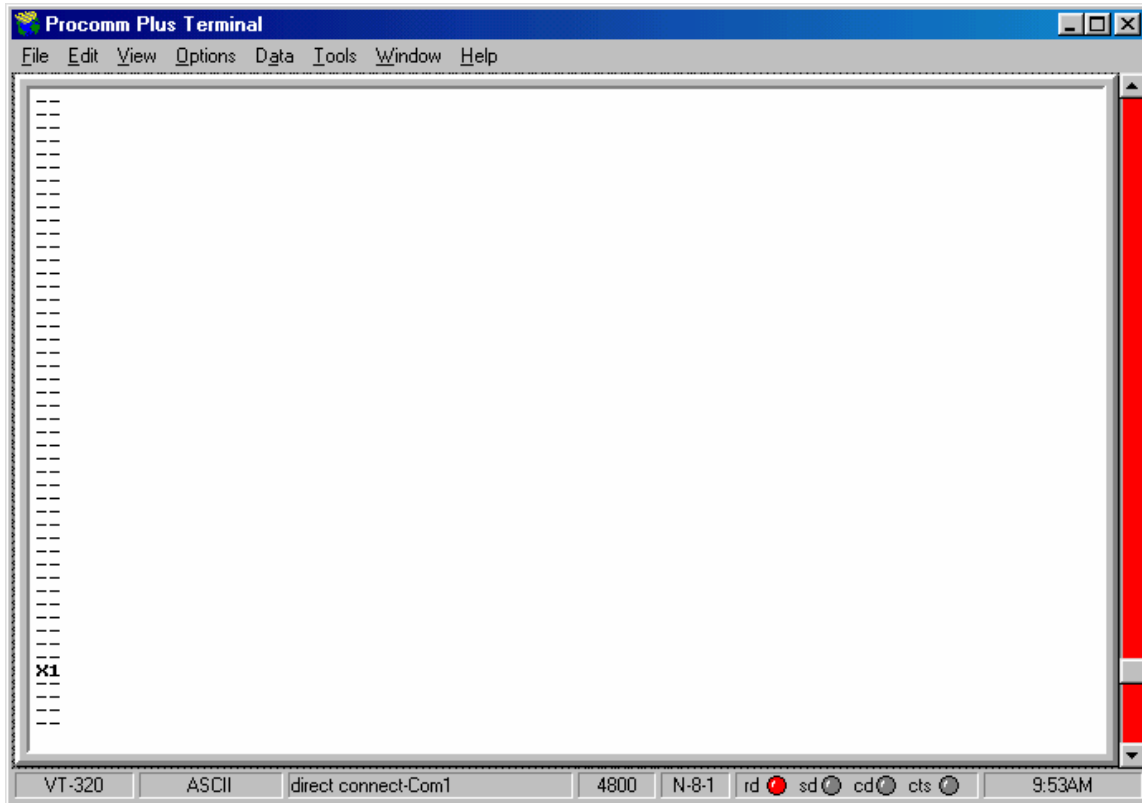
The host can use the PIM to make measurements of the amount of UPB Noise that is currently on the powerline. UPB Noise is defined as any UPB Pulse that is on the powerline that is not part of an actual UPB Communications Packet. This powerline noise can be caused by many sources including fluorescent ballasts, electric motors, light switches, etc.

The PIM will identify a UPB Noise Pulse as a UPB Pulse Report with a value of 'X'. Since this same UPB Pulse Report could be sent as an indication of the start of a valid UPB Communications Packet, the host should make the distinction that it is actually noise by verifying that the rest of a UPB Communications Packet does not follow it.

UPB Noise measurements can be performed in many different fashions. One possible method is for the host to monitor for UPB noise over a set period of time (e.g. 1 second). A count of noise reports in that set period of time can then be an indication as to the relative noise on the powerline. Another method would be to enable UPBus Idle Reports and count the ratio of the number of noise reports to the number of idle reports as an indication as to the relative noise on the powerline. The E value (signal strength) of the noise reports can also factor into your noise calculations.

In this example writing 0x00 to the PIM's Setup Register 0x70 activated the Pulse Mode of operation and enabled UPBus Idle Reports. While UPBus Idle Reports are enabled, the PIM sends one UPB Pulse Report every AC half-cycle (or 8.33mS). The host can now easily identify UPB Noise as any UPB Pulse Report with a value of 'X' that is not followed by a UPB Communications Packet.

The screen shot in Figure 7 shows the UPB Pulse Reports that the PIM sent to the host as it detected one UPB Noise Pulse on the powerline. As seen in the screenshot, the PIM was sending the host many UPBus Idle Reports ("-F") and then one UPB Pulse Report with a value of 'X' that was followed by another UPBus Idle Report. The E value for the noise pulse in this example was 1, which is a relatively weak pulse.



**Figure 7: PIM/Host Communications – Receiving Powerline Noise**



## 8. PIM LED Indicator

The PIM has a bi-color (red/green) LED indicator on its front panel (labeled “Status”) that is used to indicate the current status of the PIM.

### 8.1 LED Indication of Firmware Version

When power is first applied, the PIM will use the status LED to indicate the version of the firmware it is running. It will do this by blinking the LED four times. Each blink will either be red or green. The four blinks will be such as to indicate the binary value that matches the least significant digit of the firmware version. A blink of red shall indicate a binary “zero” and a blink of green shall indicate a binary “one”. As an example, if the firmware version is 4.15, then the LED will indicate the binary value for 5, which is zero-one-zero-one. The PIM will therefore blink its LED four times upon power-up: red-green-red-green.

### 8.2 LED Indication of UPB Status

The PIM will also use its LED to indicate the status of the UPB network. Whenever the PIM transmits a UPB message, it will indicate so by pulsing the status LED red. Whenever the PIM receives a valid UPB message, it will indicate so by pulsing the status LED green. Whenever the PIM receives a rejected UPB message, it will indicate so by pulsing the status LED black (off).

### 8.3 LED Indication of Special Modes

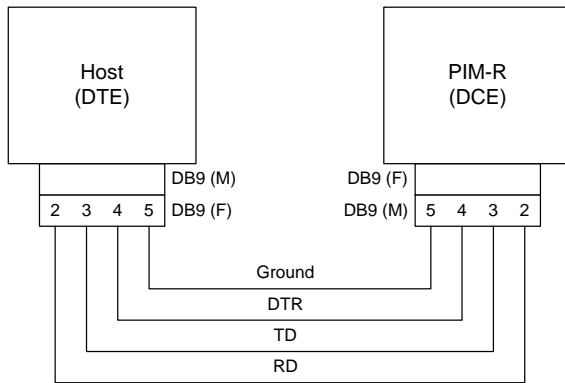
The PIM has two special modes that it can be put into: SETUP Mode and Factory Default Mode. When the PIM is in SETUP Mode it will indicate so by blinking its status LED alternately between green and black. When the PIM is in Factory Default Mode it will indicate so by blinking its status LED alternately between red and black.

## 9. PIM Cables

The PIM comes in two different versions depending on the serial interface. The PIM-R has an RS-232 serial interface and the PIM-U has a USB serial interface.

### 9.1 PIM-R Cable Diagram

The PIM-R connects to the Host computer via a 4-wire serial cable which terminates into a DB-9 male connector at the PIM side and a DB-9 male connector at the Host computer side as shown in Figure 8 below.

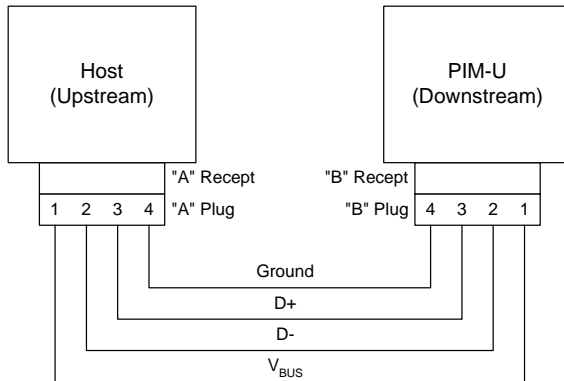


**Figure 8: PIM-R Wiring Diagram**

**NOTE:** The PIM-R requires positive voltage (anywhere from +5V to +12V) supplied on the DTR line. The PIM-R does not use the DTR line for the normal flow control purposes it was intended for by RS-232. The serial interface of the PIM-R contains two opto-isolator circuits that need to be powered by an isolated dual voltage power supply. Rather than add an isolated power supply inside of the PIM-R we require the DTE to supply the positive and negative voltages. The positive voltage is obtained from pin 4 (DTR). All PC's and laptops normally keep pin 4 in the "Space (positive voltage)" state. The negative voltage is derived from pin 3 (TD) which is normally in the "Mark (negative voltage)" state. A special charge pump circuit within the PIM maintains the negative voltage during the brief periods when the TD signal goes to the "Space (positive voltage)" state.

## 9.2 PIM-U Cable Diagram

Figure 9 shows the cable diagram for the PIM-U.



**Figure 9: PIM-U Wiring Diagram**