

# Universal Powerline Bus



## X-10<sup>®</sup> To UPB<sup>™</sup> Migration Document

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## 1. Overview

### 1.1. Scope

The Universal Powerline Bus (UPB) is a revolutionary new method of communicating command and control messages over the existing AC electrical powerline. Besides its unique physical method, that gives it excellent communication reliability, UPB defines a whole new powerful protocol for communicating on the powerline and controlling UPB compatible devices.

The UPB protocol is very powerful and it can be somewhat difficult to understand at first. With UPB, you can still do everything that you are used to doing with other existing powerline communications protocols plus a whole lot more.

This document describes how to use the UPB protocol to do the same basic device control that is possible with the X-10 powerline communication protocol. Since many people in the home automation industry are already familiar with the X-10 powerline communication protocol, this type of study can be very helpful in learning to migrate over to the UPB protocol.

A basic description of the UPB communication method, message structure, and communication protocol is covered. Then a study of how to use both the X-10 protocol and the UPB protocol to perform basic device control is provided. We end with an explanation of how to assign device addresses to devices in both protocols.

For a more thorough explanation of the UPB protocol please refer to the [UPB System Description](#) document on the Powerline Control Systems web site ([www.pcslighting.com/UPBDocumentation.htm](http://www.pcslighting.com/UPBDocumentation.htm)).

## 2. Review Of The Protocols

### 2.1. Physical Methods

In the X-10 protocol, transmissions are synchronized with the zero-crossings on the AC powerline. One bit of information can be transmitted each zero crossing. A binary '1' is represented by a 1 mS long burst of 120 KHz, near the zero-crossing point of the AC. A binary '0' is represented by the lack of the 120 KHz burst.

In the UPB protocol, transmissions are synchronized with the zero-crossings on the AC powerline. Two bits of information can be transmitted each zero crossing. The binary values of '00', '01', '10', and '11' are represented by a large pulse generated in one of four positions near the zero-crossing point of the AC.

Note: The physical communication methods employed by X-10 and UPB are so different from each other that there is absolutely no problem with both systems communicating on the same powerline simultaneously.

### 2.2. Device Addressing

In the X-10 protocol, each device can be assigned one of sixteen possible House Codes ("A" – "P") and one of sixteen possible Unit Addresses ("1" – "16") giving it a total of 256 devices that can be addressed on a single powerline. Section 4 describes how device addresses are assigned. The House Code is used to separate a group of devices in one house from another group of devices in another house. Devices will only accept X-10 messages that have their own House Code embedded in them. There can only be as many as sixteen different devices on each House Code. Each device will only accept X-10 messages that have their own Unit Address embedded in them. The exception to this rule is for the "All Units On", "All Units Off", and "All Lights Off" commands that don't require a Unit Address match.

In the UPB Protocol, each device can be assigned one of 255 possible Network IDs (1 – 255) and one of 250 possible Unit IDs (1 – 250) giving it a total of 63,750 devices that can be addressed on a single powerline. Section 4 describes how device addresses are assigned. The Network ID is used to separate a group of devices in one network (or house) from another group of devices in another network. Devices will only accept UPB Communication Packets with their own Network ID embedded in them. The UPB protocol also defines a special Network ID value of 0 (called the Global Network ID) that all devices accept. There can be as many as 250 different devices on each Network ID. Each device will only accept UPB Communication Packets that have their own Unit ID embedded in them. The UPB protocol reserves the Unit ID values from 251 to 255 for special purposes not covered in this document. The UPB protocol also

defines a special Unit ID value of 0 (called the Broadcast ID) that all devices accept.

The X-10 protocol makes no special provisions for the addressing of scenes or channels. The UPB protocol, however, makes special provisions for the addressing of scenes and channels called Link IDs. These advanced features of the UPB protocol are out of the scope of this document however.

### 2.3. Device Commands

The X-10 protocol defines sixteen different commands (although some are reports). Each command corresponds to one of the sixteen possible Function Codes. The commands and reports necessary for basic device control are listed in Table 1 below.

Function Code	Command	Command Description
0101010110	All Units Off	Turn off all modules on this House Code.
0101011010	All Units On	Turn on all modules on this House Code.
0101100110	On	Turn on a module.
0101101010	Off	Turn off a module.
0110010110	Dim	Dim a module's light output one step.
0110011010	Bright	Brighten a module's light output one step.
0110100110	All Lights Off	Turn off all lamp/lighting modules on this House Code.
1010011010	Status = On	Reports that this module is on.
1010100110	Status = Off	Reports that this module is off.
1010101010	Status Request	Requests a module to send a Status Report.

Table 1: X-10 Basic Device Control Commands

The UPB protocol has space for 256 different commands and reports. Each command (or report) corresponds to one of the 256 possible Message Data IDs. The commands and reports necessary for basic device control are listed in Table 2 below.

MDID	Command	Command Description
00100010	Goto	Requests the receiving device(s) to go to a specified Level at a specified Rate.
00100011	Fade Start	Requests the receiving dimming-type device(s) to go to a specified Level at a specified Rate.
00100100	Fade Stop	Requests the receiving dimming-type device(s) to stop fading and stay at their current level.
00110000	Report State	Requests the receiving device to report its current state information in a Device State Report.
10000110	Device State Report	Returns the current state of a device.

Table 2: UPB Basic Device Control Commands

## 2.4. The X-10 Message Structure

A complete X-10 data block is composed of a Start Code (SC), followed by a House Code (HC), followed by a Key Code. The Start Code is the special 4-bit sequence of 1110. The House Code is 8 bits long consisting of four complementary bit-pairs. The Key Code is 10 bits long consisting of five complementary bit-pairs. The Key Code may be either a Unit Address (UA) or a Function Code (FC) depending on whether the message is an address or a command. Unit Addresses always end with the complementary bit-pair value of '01' and Function Codes always end with the complementary bit-pair value of '10'. Each data block is sent twice, with a three powerline cycle Gap between each pair of data blocks. For a complete discussion of all X-10 messages, please refer to the X10 Wireless Technology, Inc. web site ([www.x10.com/support](http://www.x10.com/support)).

For example, to turn on an X-10 module assigned to House Code “A”, Unit Address “2”, the following data stream would be sent on the powerline, one bit per zero crossing.

First send the address (for A-2) twice:

1110	01101001	1010100101
<b>START</b>	<b>HOUSE “A”</b>	<b>UNIT “2”</b>
1110	01101001	1010100101
<b>START</b>	<b>HOUSE “A”</b>	<b>UNIT “2”</b>

Next, wait for three cycles (six zero-crossings):

000000  
**Gap**

Then, send the command (for “A-ON”) twice:

1110	01101001	0101100110
<b>START</b>	<b>HOUSE “A”</b>	<b>FUNCTION “ON”</b>
1110	01101001	0101100110
<b>START</b>	<b>HOUSE “A”</b>	<b>FUNCTION “ON”</b>

Lastly wait for three cycles (six zero-crossings) before sending the next block:

000000  
**Gap**

There are exceptions to this format. For example, the Bright and Dim codes do not require the three-cycle Gap between consecutive commands. For a complete discussion of all X-10 messages, please refer to the X10 Wireless Technology, Inc. web site ([www.x10.com/support](http://www.x10.com/support)).



## 2.5. The UPB Message Structure

A complete UPB Communication Packet is made up of a Preamble Byte, Packet Header, Message Data, and Checksum. The Preamble Byte is the special 8-bit sequence of 10010110. The Packet Header is a 5-byte field consisting of a 2-byte Control Word, and a single byte each for a Network ID, a Destination ID, and a Source ID. The Message Data is a variable length (0 to 18 byte) field that contains the actual payload of the packet. UPB Messages start with a Message Data ID (MDID) byte and (a variable number of) Argument bytes. The Checksum is a single byte, used for packet integrity checking, that is computed by summing up all of the other bytes (except the Preamble Byte) and taking the 2's complement of the result. For a complete discussion of all UPB messages, please refer to the Powerline Control Systems web site ([www.pcslighting.com/UPBDocumentation.htm](http://www.pcslighting.com/UPBDocumentation.htm)).

For example, to turn on a UPB device assigned to Network ID 1, Unit ID 2, the following data stream would be sent on the powerline, two bits per zero crossing.

First send the Preamble Byte and Packet Header:

10010110	00001001	00000000	00000001	00000010	11111111
<b>Preamble</b>	<b>Control Word</b>		<b>NID</b>	<b>DID</b>	<b>SID</b>

Next, send the Message Data (for the "Goto 100% at Fade Rate 0" command):

00100010	01100100	00000000
<b>MDID ("Goto")</b>	<b>Level (100%)</b>	<b>Rate (0)</b>

Lastly, send the computed Checksum for this Packet:

01101111  
**CHK**

The Control Word in the above example was set specifically for transmitting a Direct Packet one time without requesting any acknowledgement from the receiver. The Control Word can be used to enable many advanced features of the UPB protocol that are out of the scope of this document. For a complete discussion of all UPB options, please refer to the Powerline Control Systems web site ([www.pcslighting.com/UPBDocumentation.htm](http://www.pcslighting.com/UPBDocumentation.htm)).

### 3. Controlling Devices

Both the X-10 and UPB protocols can easily be used to perform basic on, off, bright, dim control of their respective devices. The UPB protocol has many additional advanced features built in for doing such other things as controlling scenes and channels and links but these features are not covered in this document. This section describes how to perform basic device control using both protocols.

#### 3.1. Turning A Device On

Both the X-10 and UPB protocols can be used to command a device to “turn on”. With the X-10 protocol, it is up to the receiving device to determine how to turn itself on (what level and fade rate to use). With the UPB protocol, the transmitting device can specify a level (between 0% and 100%) and an optional fade rate to use in turning on.

##### 3.1.1. The X-10 Method

Using the X-10 protocol, a device is turned on by using the “On” command with the device’s House Code and Unit Address embedded in it. The syntax for this command (assuming a House Code of “A” and a Unit Address of “2”) is shown below:

SC	HC	UA	SC	HC	UA	Gap	SC	HC	FC	SC	HC	FC	Gap
1110	“A”	“2”	1110	“A”	“2”	-	1110	“A”	“On”	1110	“A”	“On”	-

When a receiving device (with a matching House Code/Unit Address) gets this command it will turn on.

##### 3.1.2. The UPB Method

Using the UPB protocol, a device is turned on by using the “Goto” command in a Direct Packet with the device’s Network ID and Unit ID embedded in it. The “Goto” command specifies the level to go to in the ARG1 byte (e.g. 0x64 or 100) and the fade rate to be used in the ARG2 byte (e.g. 0 or Snap). The syntax for this command (assuming a Network ID of 0x01 and a Unit ID of 0x02) is shown below:

Control Word	NID	DID	SID	MDID	ARG1	ARG2	CHK	
09	00	01	02	FF	22	64	00	6F

When a receiving device (with a matching Network ID/Unit ID) gets this command it will turn on to the specified level at the specified fade rate.

### 3.2. Turning A Device Off

Both the X-10 and UPB protocols can be used to command a device to “turn off”. With the X-10 protocol, it is up to the receiving device to determine how to turn itself off (what fade rate to use). With the UPB protocol, the transmitting device can specify a level (between 0% and 100%) and an optional fade rate to use in turning off.

#### 3.2.1. The X-10 Method

Using the X-10 protocol, a device is turned off by using the “Off” command with the device’s House Code and Unit Address embedded in it. The syntax for this command (assuming a House Code of “A” and a Unit Address of “2”) is shown below:

SC	HC	UA	SC	HC	UA	Gap	SC	HC	FC	SC	HC	FC	Gap
1110	“A”	“2”	1110	“A”	“2”	-	1110	“A”	“Off”	1110	“A”	“Off”	-

When a receiving device (with a matching House Code/Unit Address) gets this command it will turn off.

#### 3.2.2. The UPB Method

Using the UPB protocol, a device is turned off by using the “Goto” command in a Direct Packet with the device’s Network ID and Unit ID embedded in it. The “Goto” command specifies the level to go to in the ARG1 byte (e.g. 0x00 or 0%) and the fade rate to be used in the ARG2 byte (e.g. 0 or Snap). The syntax for this command (assuming a Network ID of 0x01 and a Unit ID of 0x02) is shown below:

Control Word	NID	DID	SID	MDID	ARG1	ARG2	CHK	
09	00	01	02	FF	22	00	00	D3

When a receiving device (with a matching Network ID/Unit ID) gets this command it will turn off at the specified fade rate.

### 3.3. Brightening A Device

Both the X-10 and UPB protocols can be used to command a device to “brighten”. With the X-10 protocol, a series of commands are sent to start and continue the brightening and the device stops brightening when the series stops. With the UPB protocol, there is a separate command to start the brightening and another command to stop the brightening.

#### 3.3.1. The X-10 Method

Using the X-10 protocol, a device is brightened by using a series of “Bright” commands with the device’s House Code and Unit Address embedded in them. The syntax for this command (assuming a House Code of “A” and a Unit Address of “2”) is shown below. Note that gaps are not required between consecutive “Bright” data blocks.

SC	HC	UA	SC	HC	UA	Gap	SC	HC	FC	SC	HC	FC
1110	“A”	“2”	1110	“A”	“2”	-	1110	“A”	“Brt”	1110	“A”	“Brt”

When a receiving device (with a matching House Code/Unit Address) gets this command it will brighten its light level and continue to brighten its light level until no more “Bright” commands are received.

Note: There are various logical variations of how different devices by various manufacturers respond to multiple “Bright” commands, which can be sent either back-to-back or separate. This aspect of the X-10 protocol and X-10 compatible device operation is rather complex and confusing and beyond the scope of this document.

#### 3.3.2. The UPB Method

Using the UPB protocol, a device is brightened by using the “Fade Start” command in a Direct Packet with the device’s Network ID and Unit ID embedded in it. The “Fade Start” command specifies the level to fade to in the ARG1 byte (e.g. 0x64 or 100%) and the fade rate to be used in the ARG2 byte (e.g. 0x03). The syntax for this command (assuming a Network ID of 0x01 and a Unit ID of 0x02) is shown below:

Control Word	NID	DID	SID	MDID	ARG1	ARG2	CHK
09	00	01	02	FF	23	64	03
							6B

When a receiving device (with a matching Network ID/Unit ID) gets this command it will start fading towards 100% at the specified fade rate.

A device is then stopped from brightening by using the “Fade Stop” command in a Direct Packet with the device’s Network ID and Unit ID embedded in it. The syntax for this command (assuming a Network ID of 0x01 and a Unit ID of 0x02) is shown below:

Control Word	NID	DID	SID	MDID	CHK
07	00	01	02	FF	24
					D3

When a receiving device (with a matching Network ID/Unit ID) gets this command it will stop fading its light output.

### 3.4. Dimming A Device

Both the X-10 and UPB protocols can be used to command a device to “dim”. With the X-10 protocol, a series of commands are sent to start and continue the dimming and the device stops dimming when the series stops. With the UPB protocol, there is a separate command to start the dimming and another command to stop the dimming.

#### 3.4.1. The X-10 Method

Using the X-10 protocol, a device is dimmed by using a series of “Dim” commands with the device’s House Code and Unit Address embedded in them. The syntax for this command (assuming a House Code of “A” and a Unit Address of “2”) is shown below. Note that gaps are not required between consecutive “Dim” data blocks.

SC	HC	UA	SC	HC	UA	Gap	SC	HC	FC	SC	HC	FC
1110	“A”	“2”	1110	“A”	“2”	-	1110	“A”	“Dim”	1110	“A”	“Dim”

When a receiving device (with a matching House Code/Unit Address) gets this command it will dim its light level and continue to dim its light level until no more “Dim” commands are received.

Note: There are various logical variations of how different devices by various manufacturers respond to multiple “Dim” commands, which can be sent either back-to-back or separate. This aspect of the X-10 protocol and X-10 compatible device operation is rather complex and confusing and beyond the scope of this document.

### 3.4.2. The UPB Method

Using the UPB protocol, a device is dimmed by using the “Fade Start” command in a Direct Packet with the device’s Network ID and Unit ID embedded in it. The “Fade Start” command specifies the level to fade to in the ARG1 byte (e.g. 0x00 or 0%) and the fade rate to be used in the ARG2 byte (e.g. 0x03). The syntax for this command (assuming a Network ID of 0x01 and a Unit ID of 0x02) is shown below:

Control Word		NID	DID	SID	MDID	ARG1	ARG2	CHK
09	00	01	02	FF	23	64	03	6B

When a receiving device (with a matching Network ID/Unit ID) gets this command it will start fading towards 0% at the specified fade rate.

A device is then stopped from dimming by using the “Fade Stop” command in a Direct Packet with the device’s Network ID and Unit ID embedded in it. The syntax for this command (assuming a Network ID of 0x01 and a Unit ID of 0x02) is shown below:

Control Word		NID	DID	SID	MDID	CHK
07	00	01	02	FF	24	D3

When a receiving device (with a matching Network ID/Unit ID) gets this command it will stop fading its light output.

### 3.5. Setting A Device To A Specified Level

Both the X-10 and UPB protocols can be used to command a device to set itself to a specified level. With the X-10 protocol, there are 32 different levels (including 0 for off) that can be specified. With the UPB protocol, there are 101 different levels that can be specified (corresponding to 0% to 100%) as well as an optional fade rate can be specified.

#### 3.5.1. The X-10 Method

Using the X-10 protocol, a device is commanded to set itself to a specified level by using the “Preset Dim” command with the device’s House Code and Unit Address embedded in it. The syntax for this command (assuming a House Code of “A” and a Unit Address of “2”) is shown below. Note that the specified Level is a 5-bit value where the lower 4-bits are in the HC field and the upper bit is in the FC field.

SC	HC	UA	SC	HC	UA	Gap	SC	HC	FC	SC	HC	FC
1110	“A”	“2”	1110	“A”	“2”	-	1110	Level	“PSD”	1110	Level	“PSD”

When a receiving device (with a matching House Code/Unit Address) gets this command it will set its level to the specified Level.

Note: depending on the particular X-10 device you are commanding, the method described above may not work to set the device to a desired level. Some X-10 devices do not accept the “Preset Dim” command. Some require multiple “Bright” or “Dim” commands to get them to a desired level. Other X-10 devices require “Level” commands from the X-10 Extended message protocol. This can be very confusing to the programmer because the required method is so device dependant.

#### 3.5.2. The UPB Method

Using the UPB protocol, a device is commanded to set itself to a specified level by using the “Goto” command in a Direct Packet with the device’s Network ID and Unit ID embedded in it. The “Goto” command specifies the level to go to in the ARG1 byte (e.g. 0x32 or 50%) and the fade rate to be used in the ARG2 byte (e.g. 0 or Snap). The syntax for this command (assuming a Network ID of 0x01 and a Unit ID of 0x02) is shown below:

Control Word	NID	DID	SID	MDID	ARG1	ARG2	CHK	
09	00	01	02	FF	22	32	00	A1

When a receiving device (with a matching Network ID/Unit ID) gets this command it will turn on to the specified level at the specified fade rate.

### 3.6. Turning All Units On

Both the X-10 and UPB protocols can be used to command all devices in a house to “turn on”. With the X-10 protocol, it is up to the receiving device to determine how to turn itself on (what level and fade rate to use). With the UPB protocol, the transmitting device can specify a level (between 0% and 100%) and an optional fade rate to use in turning on.

#### 3.6.1. The X-10 Method

Using the X-10 protocol, a set of devices are turned on by using the “All Units On” command with the devices’ House Code embedded in it. The syntax for this command (assuming a House Code of “A”) is shown below:

SC	HC	FC	SC	HC	FC	Gap
1110	“A”	“All UnitsOn”	1110	“A”	“All UnitsOn”	-

When a receiving device (with a matching House Code) gets this command it will turn on.

#### 3.6.2. The UPB Method

Using the UPB protocol, a set of devices are turned on by using the “Goto” command in a Broadcasted Direct Packet with the devices’ Network ID embedded in it. The “Goto” command specifies the level to go to in the ARG1 byte (e.g. 0x64 or 100) and the fade rate to be used in the ARG2 byte (e.g. 0 or Snap). By setting the Destination ID to 0x00, the command is broadcasted to all devices on the network. The syntax for this command (assuming a Network ID of 0x01) is shown below:

Control Word	NID	DID	SID	MDID	ARG1	ARG2	CHK
09	00	01	00	FF	22	64	00
							71

When a receiving device (with a matching Network ID) gets this command it will turn on to the specified level at the specified fade rate.



### 3.7. Turning All Units Off

Both the X-10 and UPB protocols can be used to command all devices in a house to “turn off”. With the X-10 protocol, it is up to the receiving device to determine how to turn itself off (what fade rate to use). With the UPB protocol, the transmitting device can specify an optional fade rate to use in turning off.

#### 3.7.1. The X-10 Method

Using the X-10 protocol, a set of devices are turned off by using the “All Units Off” command with the devices’ House Code embedded in it. The syntax for this command (assuming a House Code of “A”) is shown below:

SC	HC	FC	SC	HC	FC	Gap
1110	“A”	“All UnitsOff”	1110	“A”	“All UnitsOff”	-

When a receiving device (with a matching House Code) gets this command it will turn off.

#### 3.7.2. The UPB Method

Using the UPB protocol, a set of devices are turned off by using the “Goto” command in a Broadcasted Direct Packet with the devices’ Network ID embedded in it. The “Goto” command specifies the level to go to in the ARG1 byte (e.g. 0x00 or 0%) and the fade rate to be used in the ARG2 byte (e.g. 0 or Snap). By setting the Destination ID to 0x00, the command is broadcasted to all devices on the network. The syntax for this command (assuming a Network ID of 0x01) is shown below:

Control Word	NID	DID	SID	MDID	ARG1	ARG2	CHK	
09	00	01	00	FF	22	00	00	D5

When a receiving device (with a matching Network ID) gets this command it will turn off at the specified fade rate.

### 3.8. Turning All Lights Off

Both the X-10 and UPB protocols can be used to command all dimming-capable devices in a house to “turn off”. With the X-10 protocol, it is up to the receiving device to determine how to turn itself off (what fade rate to use). With the UPB protocol, the transmitting device can specify an optional fade rate to use in turning off.

#### 3.8.1. The X-10 Method

Using the X-10 protocol, a set of dimming-capable devices are turned off by using the “All Lights Off” command with the devices’ House Code embedded in it. The syntax for this command (assuming a House Code of “A”) is shown below:

SC	HC	FC	SC	HC	FC	Gap
1110	“A”	“All Lights Off”	1110	“A”	“All Lights Off”	-

When a receiving dimming-capable device (with a matching House Code) gets this command it will turn off.

#### 3.8.2. The UPB Method

Using the UPB protocol, a set of dimming-capable devices are turned off by using the “Fade Start” command in a Broadcasted Direct Packet with the devices’ Network ID embedded in it. The “Fade Start” command specifies the level to go to in the ARG1 byte (e.g. 0x00 or 0%) and the fade rate to be used in the ARG2 byte (e.g. 0 or Snap). By setting the Destination ID to 0x00, the command is broadcasted to all devices on the network. The syntax for this command (assuming a Network ID of 0x01) is shown below:

Control Word	NID	DID	SID	MDID	ARG1	ARG2	CHK	
09	00	01	00	FF	23	00	00	D4

When a receiving dimming-capable device (with a matching Network ID) gets this command it will turn off at the specified fade rate. Non dimming-capable devices will ignore the “Fade Start” command.

### 3.9. Requesting Device Status

Both the X-10 and UPB protocols can be used to command a device to return an indication of its current state. With the X-10 protocol, only an indication as to whether the device is on or off is returned. With the UPB protocol, other information such as light levels, output states, etc. can be returned.

#### 3.9.1. The X-10 Method

Using the X-10 protocol, a device is commanded to return its current state by using the “Status Request” command with the device’s House Code and Unit Address embedded in it. The syntax for this command (assuming a House Code of “A” and a Unit Address of “2”) is shown below.

SC	HC	UA	SC	HC	UA	Gap	SC	HC	FC	SC	HC	FC
1110	“A”	“2”	1110	“A”	“2”	-	1110	“A”	“SR”	1110	“A”	“SR”

When a receiving device (with a matching House Code/Unit Address) gets this command it will transmit a “Status” report. The syntax for this report (assuming a House Code of “A” and a Unit Address of “2”) is shown below.

SC	HC	UA	SC	HC	UA	Gap	SC	HC	FC	SC	HC	FC
1110	“A”	“2”	1110	“A”	“2”	-	1110	“A”	“State”	1110	“A”	“State”

#### 3.9.2. The UPB Method

Using the UPB protocol, a device is commanded to return its current state by using the “Report State” command in a Direct Packet with the device’s Network ID and Unit ID embedded in it. The syntax for this command (assuming a Network ID of 0x01 and a Unit ID of 0x02) is shown below:

Control Word	NID	DID	SID	MDID	CHK
07	00	01	02	30	C7

When a receiving device (with a matching Network ID/Unit ID) gets this command it will transmit a “Device State Report”. The syntax for this report can vary from device type to device type. The syntax for this report assuming a UPB Wall Switch at Level 50% assigned a Network ID of 0x01 and a Unit ID of 0x02 is shown below:

Control Word	NID	DID	SID	MDID	ARG1	CHK
08	00	01	FF	02	86	32

Note that the 0x32 (50 decimal) in the ARG1 byte represents that the Wall Switch is currently at the 50% light level.

## 4. Assigning Device Addresses

Both the X-10 and UPB protocols require that their devices be assigned at least two different addresses. The methods employed to assign these device addresses will be discussed in this section.

### 4.1. The X-10 Method

An X-10 device is usually assigned to one of sixteen possible House Codes by using a rotary dial switch. The dial switch has sixteen positions labeled “A” through “P”. The user simply sets the dial switch to the desired House Code position.

Similarly, an X-10 device is usually assigned to one of sixteen possible Unit Addresses by using another rotary dial switch. The dial switch has sixteen positions labeled “1” through “16”. The user simply sets the dial switch to the desired Unit Address position.

Note: other methods exist for setting the X-10 House Code and Unit Address but the rotary dial switch is the most popular.

### 4.2. The UPB Method

A UPB device is assigned to one of 255 possible Network IDs by writing the desired value directly into its non-volatile Network ID Setup Register. This is usually done with a UPB Setup Tool (like UPStart) but any other UPB-compatible controller can also perform this operation. This section will explain how this is done.

A UPB device is also assigned to one of 250 possible Unit IDs by writing the desired value directly into its non-volatile Unit ID Setup Register. This is usually done with a UPB Setup Tool (like UPStart) but any other UPB-compatible controller can also perform this operation. This section will explain how this is done.

#### 4.2.1. The UPB Setup Registers

All UPB devices have a block of at least 64 non-volatile 8-bit registers, called Setup Registers, which are used to hold all of the configuration information about that UPB device. The first Setup Register (address 0x00) holds the assigned Network ID. The second Setup Register (address 0x01) holds the assigned Unit ID. The definition and purpose of the other Setup Registers is somewhat device dependant. More information about the UPB Setup Registers can be found on the Powerline Control Systems web site.

Note: The term “non-volatile” means that the value in the register stays there even when main power is off.

## 4.2.2. Setup Register Write Protection

In the UPB System Model, all Setup Registers are write-protected by default. While write protection is enabled, the UPB device will reject any attempt to write its Setup Registers by way of the powerline. Each UPB device shall have at least two different methods for disabling write protection: one is by receiving a special password-protected UPB Message and the other is by getting the device in a special mode of operation known as the SETUP Mode.

Note: Write protection shall only be disabled on a temporary basis. Once Setup Register Write Protection is disabled, the UPB device shall start an internal timer that will re-enable write protection after five minutes.

### 4.2.2.1. The SETUP Mode

All UPB devices in the UPB System Model shall implement a special mode of operation, known as SETUP Mode. While in SETUP Mode, Setup Register Write Protection is temporarily disabled allowing Setup Registers to be written using special write/modify UPB Commands and Reports. In addition, the device automatically gets the benefit of having one additional Unit ID called the Setup ID.

### 4.2.2.2. Starting SETUP Mode

Each UPB device shall have at least two different methods for starting SETUP Mode: one is remotely by receiving a special password protected UPB Message and the other is physical - by “touching” the device (usually by some sort of pushbutton press sequence). The UPB System Model does not specify the exact physical method for each device to enter SETUP Mode but it is recommended that it be made in such a way that it is not easily activated by accident. The UPB System Model also recommends that the device manufacturer design a special indication (such as blinking an LED) that identifies to a user that the device is in SETUP Mode.

As an example, the PCS UPB Wall Switch can be put into SETUP Mode by quickly tapping its rocker switch five times in a row. While in SETUP Mode, the PCS UPB Wall Switch blinks its LED green.

### 4.2.2.3. Stopping SETUP Mode

Each device shall automatically time-out of SETUP Mode (and return to Normal Mode) after five minutes of not receiving a UPB Message addressed to it. In addition, a special UPB Message is defined for stopping the SETUP Mode. The device manufacturer can also develop some physical method for stopping the SETUP Mode on their device. When SETUP Mode expires, Setup Register Write Protection is automatically enabled to avoid accidentally keeping a device write-enabled indefinitely.

As an example, the PCS UPB Wall Switch can be taken out of SETUP Mode by quickly tapping its rocker switch two times in a row. While out of the SETUP Mode, the PCS UPB Wall Switch turns its LED solid orange.

**4.2.2.4. The Setup ID**

Once a device is in the SETUP Mode it will accept a special Destination ID value (in addition to its assigned Unit ID) in any Direct UPB Communication Packets it receives. This special ID is called the Setup ID and it has the reserved value of 254. UPB devices that are in the SETUP Mode will accept Direct UPB Communication Packets addressed to Destination ID 254. The Setup ID can be very helpful in identifying a single UPB device that’s Unit ID is unknown.

**4.2.3. The UPB Commands/Reports**

Special UPB commands and reports exist that allow for the reading and writing of a device’s Setup Registers over the powerline. Table 3 summarizes those commands and reports.

Command or Report	MDID	ARG1	ARG2	Other 15 ARGs	Description
Stop SETUP Mode	0x04	-	-	-	Takes the receiving device out of the SETUP Mode.
Get Register Value	0x10	RR	NN	-	Requests a device to return the values in NN Setup Registers (16 maximum) starting with register RR in a Register Value Report.
Set Register Value	0x11	RR	VV	[VV...]	Requests a device to write a list of as many as 16 values (VV) into its Setup Registers starting with register RR.
Register Value Report	0x91	RR	VV	[VV...]	Reports a list of as many as 16 values (VV) read from Setup Registers starting with register RR.

Table 3: The UPB Device Address Commands/Reports

### 4.2.4. The Device Addressing Procedure

The basic procedure for assigning a new Network ID value and a new Unit ID value to a UPB device is summarized in the following steps.

Step 1: First you must have the user put the UPB device into the SETUP Mode. The method to physically put a device into the SETUP Mode varies from device to device. Refer to section 4.2.2.2. – “Starting SETUP Mode” for more details.

Step 2: Next find the one device that is in SETUP Mode. In this example we send a “Get Register Value” command to the Global Network ID addressed to the Setup ID. This command requests the receiving device to return the contents of Setup Registers 0 and 1 in a “Register Value” report.

Control Word	NID	DID	SID	MDID	ARG1	ARG2	CHK	
09	00	00	FE	FF	10	00	02	D4

Step 3: The device that is in SETUP Mode will respond with a “Register Value” report with its old Network ID value (nn) and Unit ID value (uu) in the ARG2 and ARG3 fields.

Control Word	NID	DID	SID	MDID	ARG1	ARG2	ARG3	CHK	
0A	00	nn	FF	uu	91	00	nn	uu	xx

Step 4: We then write the new Network ID value (NN) and new Unit ID value (UU) into the device by sending a “Set Register Value” command to the device’s old Network ID (nn) addressed to the Setup ID. ARG1 specifies the starting register address of 0x00. ARG2 and ARG3 contain the new Network ID and Unit ID values respectively.

Control Word	NID	DID	SID	MDID	ARG1	ARG2	ARG3	CHK	
0A	00	nn	FE	FF	11	00	NN	UU	xx



Step 5: Next, we verify that the new Network ID value (NN) and new Unit ID value (UU) were properly set. We do this by sending a “Get Register Value” command to the new Network ID addressed to the new Unit ID. This command requests the receiving device to return the contents of Setup Registers 0 and 1 in a “Register Value” report.

Control Word	NID	DID	SID	MDID	ARG1	ARG2	CHK	
09	00	NN	UU	FF	10	00	02	xx

Step 6: The device will respond with a “Register Value” report (0x91) with its new Network ID value (NN) and Unit ID value (UU) in the ARG2 and ARG3 fields.

Control Word	NID	DID	SID	MDID	ARG1	ARG2	ARG3	CHK	
0A	00	NN	FF	UU	91	00	NN	UU	xx

Step 7: Finally we take the device out of the SETUP Mode by sending a “Stop SETUP Mode” command (0x04) to the Global Network ID (0x00) addressed to the Broadcast ID (0x00).

Control Word	NID	DID	SID	MDID	CHK	
07	00	00	00	FF	04	F3