

Universal Powerline Bus



UPB 8-Button Controller Firmware Specification

V 1.4

03/16/04

Revision History

Rev	Date	Description
1.4	03-16-04	RLF – Initial release to public.
1.3	-	RLF – Updated Preliminary Release.
1.2	-	RLF – Updated Preliminary Release.
1.1	-	RLF – Initial Preliminary Release.

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1. The 8-Button Controller

The 8-Button Controller is a pushbutton device capable of transmitting Universal Powerline Bus™ (UPB) Commands onto the 120VAC powerline. The 8-Button Controller (Figure 1) contains eight horizontal pushbuttons and eight LED indicators (behind the pushbuttons). The 8-Button Controller is also capable of receiving UPB Commands from the powerline to control its LED indicators. The 8-Button Controller comes in both wall-mount (WMC8) and desktop (DTC8) versions. Except where noted, this specification will treat both versions the same and refer to them as the WMC8.



Figure 1: The 8-Button Controller

1.1. Pushbutton Switches

The WMC8 (Figure 1) has a total of eight momentary pushbutton switches grouped as follows:

- Eight small horizontal pushbuttons referred to as Button E (or Button #1), Button F (or Button #2), Button G (or Button #3), Button H (or Button #4), Button I (or Button #5), Button J (or Button #6), Button K (or Button #7), and Button L (or Button #8).

1.2. LED Indicators

The WMC8 has a total of eight LED indicators that it uses to indicate its current status. The eight LED indicators are placed behind the eight horizontal pushbuttons (E through L) and each illuminates its pushbutton when it is turned on. The LED Indicators can be set to one of four different brightness levels or off.

1.3. UPB Receiver

The WMC8 has UPB Receiver Logic capable of receiving UPB Communication Packets from the powerline.

1.4. UPB Transmitter

The WMC8 has UPB Transmitter Logic capable of transmitting UPB Communication Packets onto the powerline.

1.5. UPB Core Logic

The WMC8 conforms to the UPB System Model as defined in the UPB System Description document. The WMC8 has UPB Core Logic capable of responding to the UPB Core Command Message Set as described in the UPB System Description document.

2. Modes Of Operation

The WMC8 **shall** be capable of being put into any of three different modes of operation: Normal Mode, Setup Mode, and Factory Default Mode.

2.1. Normal Mode

The WMC8 **shall** be able to operate in the Normal Mode. The Normal Mode is the WMC8's default mode of operation. While in the Normal Mode the WMC8 performs all of its normal operations except that Setup Register Write Protection is enabled.

2.2. Setup Mode

The WMC8 **shall** be able to be put into and operate in the Setup Mode. The Setup Mode is a special mode of operation that every UPB device that conforms to the UPB System Model must have. The UPB System Description document describes the Setup Mode in detail. The WMC8 **shall** be able to enter into the Setup Mode by two different methods. One is by receiving a valid "Start Setup Mode" command message over the powerline as described in the UPB System Description document. The other method is by having its pushbuttons physically touched in a special sequence as described in section 4.4.1 "Entering Setup Mode". While in the Setup Mode, the LED indicators **shall** indicate this mode of operation as defined in Section 5.2 – "Special Mode LED Indications".

2.3. Factory Default Mode

The WMC8 **shall** be able to be put into and operate in the Factory Default Mode. The Factory Default Mode is a special mode of operation that, when entered, sets the Setup Registers to their Factory Default values as defined in Table 1 and Table 2. The WMC8 **shall** be able to enter into the Factory Default Mode as described in section 4.4.3 "Entering Factory Default Mode". While in the Factory Default Mode, the LED indicators **shall** indicate this mode of operation as defined in Section 5.2 – "Special Mode LED Indications".

3. UPB Setup Registers

Like all UPB devices that conform to the UPB System Model, the WMC8 **shall** have a set of non-volatile 8-bit registers known as UPB Setup Registers. The WMC8 **shall** have a total of 256 UPB Setup Registers. These registers are used to define and configure how the WMC8 will operate as well as to store other important information as described herein. The WMC8 **shall** allow read/write access to its UPB Setup Registers (except where noted) via special UPB Messages communicated on the powerline. The WMC8's Setup Registers are partitioned into three main groups (the UPBID, the Configuration Registers, and the Scratch-Pad Registers) as described below.

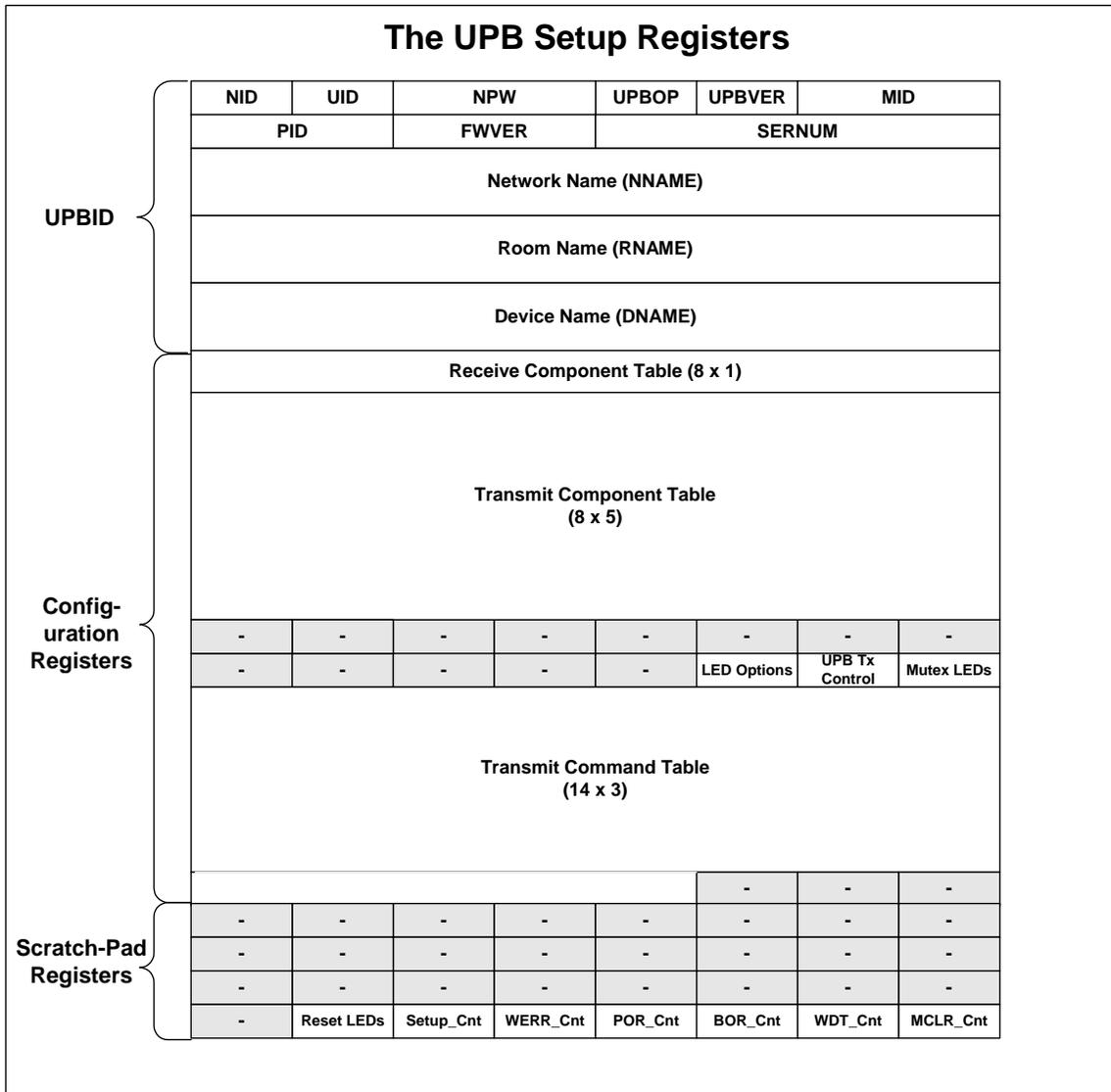


Figure 2: The WMC8 UPB Setup Registers

3.1. The UPBID

The UPBID is a set of 64 non-volatile registers that contains information that uniquely identifies the individual UPB device. The WMC8 **shall** implement the UPBID in the first 64 Setup Registers. Table 1 below describes the Setup Registers that make up the UPBID. This table describes each register’s use as well as its factory default value. The UPB System Description document contains more detailed information about the UPBID.

Setup Register Field Name	Reg. Num.	Factory Default	Description
Network ID (NID)	0x00	255 (0xFF)	Unique identifier (1 – 255) for the UPB Network that this device communicates on.
Unit ID (UID)	0x01	WMC8:013 (0x0D) DTC8:014 (0x0E)	Unique identifier (1 – 255) for this UPB device.
Network Password (NPW)	0x02 – 0x03	4660 (0x1234)	Password designed to keep unauthorized users from modifying the Setup Registers of this device.
UPB Options (UPBOP)	0x04	00 (0x00)	Identifies UPB Options that are enabled for this device.
UPB Version (UPBVER)	0x05	01 (0x01)	Identifies the version of the UPB specification this device conforms to.
Manufacturer ID (MID)	0x06 – 0x07	01 (0x0001) PCS	Unique identifier of the manufacturer of this device.
Product ID (PID)	0x08 – 0x09	WMC8: 13 (0x000D) DTC8: 14 (0x000E)	The manufacturer’s unique product identifier for this device.
Firmware Version (FWVER)	0x0A – 0x0B	Depends on the current F/W version	Identifies the version of firmware in this device.
Serial Number	0x0C – 0x0F	Set by the manufacturer	The manufacturer’s unique serial number for this device.
Network Name (NNAME)	0x10 – 0x1F	“New Network Name”	A human readable (ASCII) name for the UPB Network that this device communicates on.

Setup Register Field Name	Reg. Num.	Factory Default	Description
Room Name (RNAME)	0x20 – 0x2F	“New Room Name”	A human readable (ASCII) name for the Room that this UPB device is installed in.
Device Name (DNAME)	0x30 – 0x3F	“New PCS WMC(8)” “New PCS DTC(8)”	A human readable (ASCII) name for this UPB device.

Table 1: The 8-Button Controller’s UPBID

3.2. The Configuration Registers

The Configuration Registers are a set of non-volatile registers that configure how a device will operate. The WMC8 **shall** implement the Configuration Registers in the next 128 Setup Registers. Table 2 describes the Configuration Registers for the WMC8 application. The table describes each register’s use as well as its factory default value.

Setup Register Field Name	Reg. Num.	Factory Default	Description
Receive Component Table	0x40 – 0x47	See Table 11 for factory defaults	Configuration table containing 8 Receive Component Records used for receiving UPB Link Packets for the 8 LEDs.
Transmit Component Table	0x48 – 0x6F	See Table 7 for factory defaults	Configuration table containing 8 Transmit Component Records used for transmitting UPB Link Packets for the 8 pushbutton switches.
Unused	0x70 – 0x8C	255 (0xFF)	Unused
LED Options	0x8D	47 (0x2F)	Configurable LED options for the 8-Button Controller. See Section 9.1 for details.
UPB Tx Control	0x8E	132 (0x84)	Configurable options for UPB Transmissions. See Section 6.4 for details.
Mutually Exclusive LED Flags	0x8F	000 (0x00)	Bit-mask of which LED Indicators are mutually exclusive. See Section 9.2 for details.

Setup Register Field Name	Reg. Num.	Factory Default	Description
Transmit Command Table	0x90 – 0xBC	See Table 8 for factory defaults	Table with the 3-byte UPB Command Messages that represent each of the 15 Command IDs (CmdIds).
Unused	0xBD – 0xBF	255 (0xFF)	Unused

Table 2: The 8-Button Controller’s Configuration Registers

3.3. The Scratch-Pad Registers

The Scratch-Pad Registers are a set of non-volatile registers that the application can use for any purpose. The WMC8 **shall** implement the Scratch-Pad Registers in the last 64 Setup Registers. Table 3 describes the Scratch-Pad Registers for the 8-Button Controller. The table describes each register’s location and use. Note: there are no factory default values for these registers.

Setup Register Field Name	Reg. Num.	Description
Unused	0xC0 – 0xF8	Unused
Reset LED States	0xF9	Bit-mask to store the states of the LED Indicators before power-down.
Setup Mode Counter	0xFA	Count of number of times this device went into Setup Mode.
WERR Counter	0xFB	Count of number of times this device had a EEPROM Write Error.
POR Counter	0xFC	Count of number of times this device had a Power-On Reset.
BOR Counter	0xFD	Count of number of times this device had a Brown-Out Reset.
WDT Counter	0xFE	Count of number of times this device had a Watchdog Timer Reset.
MCLR Counter	0xFF	Count of number of times this device had a Master Clear Reset.

Table 3: The 8-Button Controller’s Scratch-Pad Registers

4. Pushbutton Switches

The WMC8 has eight Pushbutton Switches that are used to trigger UPB Message transmissions, and to put the WMC8 into special modes of operation. The eight Pushbuttons are grouped as follows:

- Eight small horizontal pushbuttons referred to as Button E (or Button #1), Button F (or Button #2), Button G (or Button #3), Button H (or Button #4), Button I (or Button #5), Button J (or Button #6), Button K (or Button #7), and Button L (or Button #8).

4.1. Pushbutton Events

The WMC8 **shall** be capable of detecting any of the four types of Pushbutton Events defined in Table 4 below on any of its Pushbutton Switches.

Pushbutton Event	Definition
Single-Tap	The switch is pressed for at least 250 mS and then released before 750 mS and left released.
Multi-Tap (Double-Tap)	The switch is pressed for at least 250 mS and then released and pressed again before 750 mS and then released before 750 mS and left released.
Hold	The switch is pressed for at least 750 mS without being released.
Release	The switch is released after a Hold event.

Table 4: WMC8 Pushbutton Events

4.2. Pushbutton Switch Transmit Control

The main purpose of the WMC8 is to transmit UPB Command Messages to other UPB devices. The WMC8 can be configured to transmit UPB Messages when any of the Pushbutton Switch Events listed in Table 4 occur. Refer to Section 6 – “Pushbutton Triggered Transmissions” for details on how to configure the WMC8 for Pushbutton Switch Transmissions.

4.3. Special Pushbutton Linking Transmissions

The WMC8 shall perform special linking command transmissions as described in Section 7 – “Special Linking Transmissions” whenever one of its pushbuttons is pressed five or ten times in a row.

4.4. Pushbutton Switch Mode Control

The Pushbutton Switches **shall** be used to put the WMC8 into different modes of operation. The WMC8 has three different modes of operation (Normal Mode, Setup Mode, and Factory Default Mode) as defined in section 2.

4.4.1. Entering Setup Mode

The WMC8 **shall** enter Setup Mode when both the 'E' Button and the 'L' Button are held down simultaneously for more than 0.5 seconds.

4.4.2. Exiting Setup Mode

Once in the Setup Mode, the WMC8 **shall** exit Setup Mode and enter the Normal Mode when both the 'E' Button and the 'L' Button are held down simultaneously for more than 0.5 seconds.

4.4.3. Entering Factory Default Mode

Once in the Setup Mode, the WMC8 **shall** exit Setup Mode and enter the Factory Default Mode when both the 'F' Button and the 'K' Button are held down simultaneously for more than 0.5 seconds. The WMC8 **shall** exit the Factory Default Mode and return to the Normal Mode after the factory default values have been written.

5. LED Indicators

The WMC8 has eight Light Emitting Diode (LED) Indicators that are placed behind the eight horizontal Pushbuttons (E through L). The purpose of these LED Indicators is for providing visual feedback, for indicating special modes of operation, and for indicating the firmware version number upon power-up.

5.1. LED Visual Feedback

The main purpose of the WMC8 LED Indicators is to provide visual feedback as to what device or scene is currently activated by UPB Messages either transmitted by this WMC8 or by other UPB devices.

5.1.1. UPB Message Transmission LED Feedback

The WMC8 **shall** update its LED Indicators whenever a single horizontal Pushbutton triggers it to transmit one of the UPB Commands listed in Table 5. This table specifies which UPB Commands shall cause the pressed Pushbutton's LED to turn on and which UPB Commands shall cause the pressed Pushbutton's LED to turn off.

Transmitted Commands that cause the pressed Pushbutton's LED to turn:	
On	Off
Activate	Deactivate
Goto (with a Level above 0%)	Goto (with a Level of 0%)
Fade Start (with a Level above 0%)	Fade Start (with a Level of 0%)

Table 5: LED Feedback for Transmitted UPB Commands

5.1.2. UPB Message Reception LED Feedback

The WMC8 **shall** update its LED Indicators whenever it receives and accepts one of the UPB Device Control Commands listed in Table 6. This table specifies which UPB Commands shall cause the linked Pushbutton's LED to turn on and which UPB Commands shall cause the linked Pushbutton's LED to turn off.

Received Commands that cause the linked Pushbutton's LED to turn:	
On	Off
Activate	Deactivate
Goto (with a Level above 0%)	Goto (with a Level of 0%)
Fade Start (with a Level above 0%)	Fade Start (with a Level of 0%)

Table 6: LED Feedback for Received UPB Commands

5.1.2.1. Brightness Of LED Indicators

Whenever an LED indicator turns on the WMC8 **shall** set it to the configured LED Brightness as described in Section 9.1.4 – “LED Brightness”.

5.1.2.2. Mutually Exclusive LED Indicators

Whenever an LED indicator turns on the WMC8 **shall** check its corresponding Mutually Exclusive LED bit and update the other LEDs accordingly as described in Section 9.2 - “Mutually Exclusive LED Register”.

5.2. Special Mode LED Indications

The WMC8 has two special modes that it can be put into: Setup Mode and Factory Default Mode. When the WMC8 is in Setup Mode it **shall** indicate so by blinking its eight LEDs alternately between on and off at a 0.5 second blink rate. When the WMC8 is in Factory Default Mode it **shall** indicate so by lighting up only the ‘E’ and ‘L’ LED Indicators. Whenever the WMC8 exits either special mode above it **shall** indicate so by turning off all of its LED indicators.

5.3. Special Linking LED Indications

Whenever a pushbutton is pressed in such a way as to invoke one of the Special Linking Transmissions described in Section 7, the WMC8 **shall** indicate this condition by blinking that pushbutton’s LED indicator on and off at a 0.5 second rate.

5.4. Firmware Version LED Indication

When power is first applied, the WMC8 **shall** use it’s four middle LEDs (G, H, I, and J) to indicate the version of the firmware it is running. It **shall** do this by lighting up such as to indicate the binary value that matches the least significant digit of the firmware version. As an example, if the firmware version is 4.15, then the LEDs shall light up to indicate the binary value for 5 in the following pattern: G=Off, H=On, I=Off, J=On.

5.5. Power-Up Light Show

Upon power-up and after displaying the firmware version, the WMC8 **shall** perform a Power-Up Light Show. The Power-Up Light Show shall consist of the following steps:

1. Turn on the eight LED indicators one at a time from the top LED down.
2. Turn off the eight LED indicators one at a time from the bottom LED up.
3. Repeat steps 1 & 2 a second time.

5.6. The Reset LED States

Approximately once every 2 seconds the WMC8 **shall** save its current LED on/off states into non-volatile memory as the Reset LED States. When the WMC8 first powers up, it **shall** restore its current LED on/off states to the Reset LED States.

6. Pushbutton Triggered Transmissions

The main purpose of the pushbutton switches on the WMC8 is for triggering the transmission of configured UPB Messages to other UPB devices. The WMC8 can be configured to transmit UPB Messages whenever any of their defined Pushbutton Switch Events occur. This section will describe the various Setup Registers involved with configuring Pushbutton Switch Triggered Transmissions.

6.1. Transmit Components

The WMC8 uses the concept of Transmit Components (as described in the UPB System Description document) for configuring its eight Pushbuttons for Pushbutton Triggered Transmissions. The WMC8 has eight Transmit Components: one for each of the eight Pushbutton Switches (Figure 3).

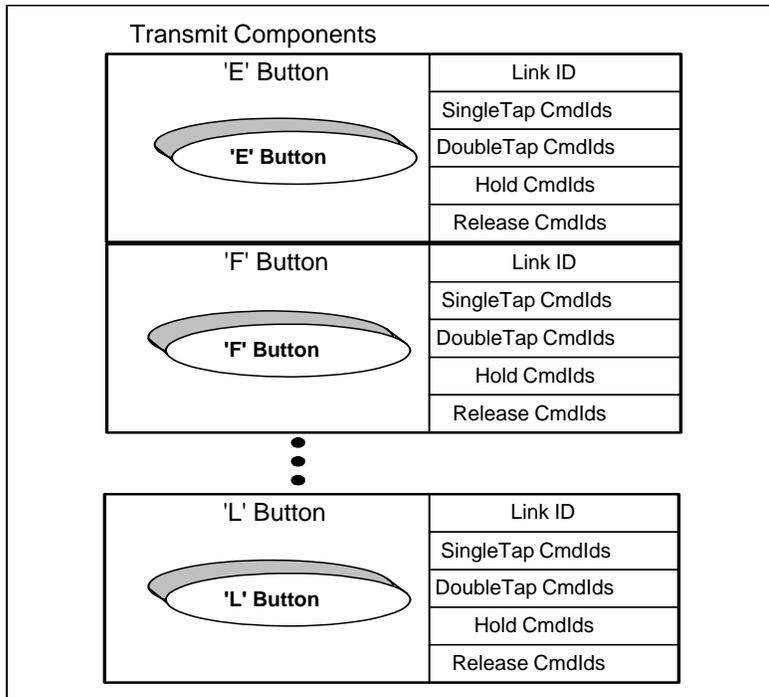


Figure 3: 8-Button Controller's Transmit Components

The WMC8 **shall** implement eight Transmit Components in its non-volatile Configuration Registers as a 40-byte (8 x 5) Transmit Component Table as described in Section 3 – “UPB Setup Registers”.

Setup Register Field Name	Register Numbers	Factory Default Values				
		Link ID	1-Tap	2-Tap	Hold	Release
'E' Button Trigger	0x48 – 0x4C	013 (0x0D)	101 (0x65)	135 (0x87)	050 (0x32)	068 (0x44)
'F' Button Trigger	0x4D – 0x51	014 (0x0E)	101 (0x65)	135 (0x87)	050 (0x32)	068 (0x44)
'G' Button Trigger	0x52 – 0x56	015 (0x0F)	101 (0x65)	135 (0x87)	050 (0x32)	068 (0x44)
'H' Button Trigger	0x57 – 0x5B	016 (0x10)	101 (0x65)	135 (0x87)	050 (0x32)	068 (0x44)
'I' Button Trigger	0x5C – 0x60	017 (0x11)	101 (0x65)	135 (0x87)	050 (0x32)	068 (0x44)
'J' Button Trigger	0x61 – 0x65	018 (0x12)	101 (0x65)	135 (0x87)	050 (0x32)	068 (0x44)
'K' Button Trigger	0x66 – 0x6A	019 (0x13)	101 (0x65)	135 (0x87)	050 (0x32)	068 (0x44)
'L' Button Trigger	0x6B – 0x6F	020 (0x14)	101 (0x65)	135 (0x87)	050 (0x32)	068 (0x44)

Table 7: WMC8 Transmit Component Table

6.1.1. The Transmit Link ID

Each Transmit Component Record **shall** start with a 1-byte Link ID field. Each Transmit Component (Button) can either be assigned a Valid Link ID (from 1 to 254) or an Invalid Link ID (255) or the special code for “Use Last Link” (0). If it is assigned an Invalid Link ID then no Pushbutton Switch Transmissions **shall** take place. If it is assigned a Valid Link ID, however, then it **shall** use that Link ID in the Destination ID field of any configured Pushbutton Switch Transmissions. If it is assigned the special code of 0 then it **shall** use the Last Link ID value in the Destination ID field of any configured Pushbutton Switch Transmissions.

6.1.1.1. The Last Link ID

The WMC8 **shall** keep track of the last Link ID it transmitted or received and accepted on the UPB bus as the Last Link ID. The Last Link ID value **shall** be used in the Destination ID field of any configured Pushbutton Switch Transmissions where the configured Transmit Link ID value is 0.

6.1.2. The Transmit Command IDs

Each Transmit Component record **shall** have four additional bytes that can be assigned two 4-bit Command IDs each. The 4-bit Command ID can range in

value from 0 to 15 and it identifies the type of UPB command to be transmitted by the WMC8. There **shall** be a Transmit Command ID byte corresponding to each of the four defined Pushbutton Switch Events: Single-Tap, Double-Tap, Hold, and Release.

6.1.2.1. Toggling Command IDs

The two halves of the Transmit Command ID byte can be configured in such a way as to implement a Toggling Command ID feature. This feature, if configured, will cause the WMC8 to toggle between the transmissions of two different UPB Messages each time the corresponding pushbutton event occurs. As an example, the WMC8 could be configured to transmit an “Activate” command the 1st time the ‘A’ Button is single-clicked and then transmit a “Deactivate” command the next time the ‘A’ Button is single-clicked.

The two Command ID nibbles **shall** be selected based on the state of the pushbutton’s corresponding LED Indicator. The upper nibble of each Command ID byte **shall** be selected when the associated LED Indicator is off. The lower nibble of each Command ID byte **shall** be selected when its associated LED Indicator is on. This mechanism allows for the Toggling Command IDs mechanism. Assigning a different Command ID code to each half of a Command ID byte essentially enables toggling. Assigning the same Command ID code to each nibble of a Command ID byte essentially disables toggling.

6.2. Using Command IDs

The 4-bit Command ID that gets selected **shall** be used by the WMC8 to determine what UPB Message to build and transmit. If the Command ID value is 15 then no UPB Message **shall** be built or transmitted. If the Command ID value is between 0 and 14 then the WMC8 **shall** use the Command ID as an index into the UPB Transmit Command Table to look-up a three-byte command message to be built and transmitted.

6.3. The UPB Transmit Command Table

The WMC8 **shall** implement a UPB Transmit Command Table in its non-volatile Setup Registers that allows for the customization of up to fifteen 3-byte UPB Messages. Table 8 shows the UPB Transmit Command Table for the WMC8 along with its factory default values. Each three-byte record corresponds to a Command ID value (0 – 14). The WMC8 **shall** use the UPB Transmit Command Table to look-up the three-byte UPB Message to build and transmit onto the UPB bus for the selected Command ID. The UPB Transmit Command Table can be changed with the use of a UPB Setup Tool so that other custom commands can be formed.

Setup Register Field Name	Reg. Num.	Cmd ID	Factory Default	Command Name
Tx Command #0	0x90 – 0x92	0	22 00 FF	Goto Off
Tx Command #1	0x93 – 0x95	1	22 64 FF	Goto On
Tx Command #2	0x96 – 0x98	2	23 00 FF	Fade Down
Tx Command #3	0x99 – 0x9B	3	23 64 FF	Fade Up
Tx Command #4	0x9C – 0x9E	4	24 FF FF	Fade Stop
Tx Command #5	0x9F – 0xA1	5	21 FF FF	Deactivate
Tx Command #6	0xA2 – 0xA4	6	20 FF FF	Activate
Tx Command #7	0xA5 – 0xA7	7	22 00 00	Snap Off
Tx Command #8	0xA8 – 0xAA	8	22 64 00	Snap On
Tx Command #9	0xAB – 0xAD	9	22 00 01	Quick Off
Tx Command #10	0xAE – 0xB0	10	22 64 01	Quick On
Tx Command #11	0xB1 – 0xB3	11	22 00 08	Slow Off
Tx Command #12	0xB4 – 0xB6	12	22 64 08	Slow On
Tx Command #13	0xB7 – 0xB9	13	25 1E FF	Blink
Tx Command #14	0xBA – 0xBC	14	00 FF FF	Null Command

Table 8: The 8-Button Controller’s Transmit Command Table

6.4. The UPB Transmit Control Register

The WMC8 shall have an 8-bit UPB Transmit Control Register implemented in its non-volatile Setup Registers that allows for the further customization of its UPB transmissions. Figure 4 shows the UPB Transmit Control Register and explains the meanings of its various bits and fields. The UPB Transmit Control Register can be changed with the use of a UPB Setup Tool so that the UPB transmit behavior of the WMC8 can be customized.

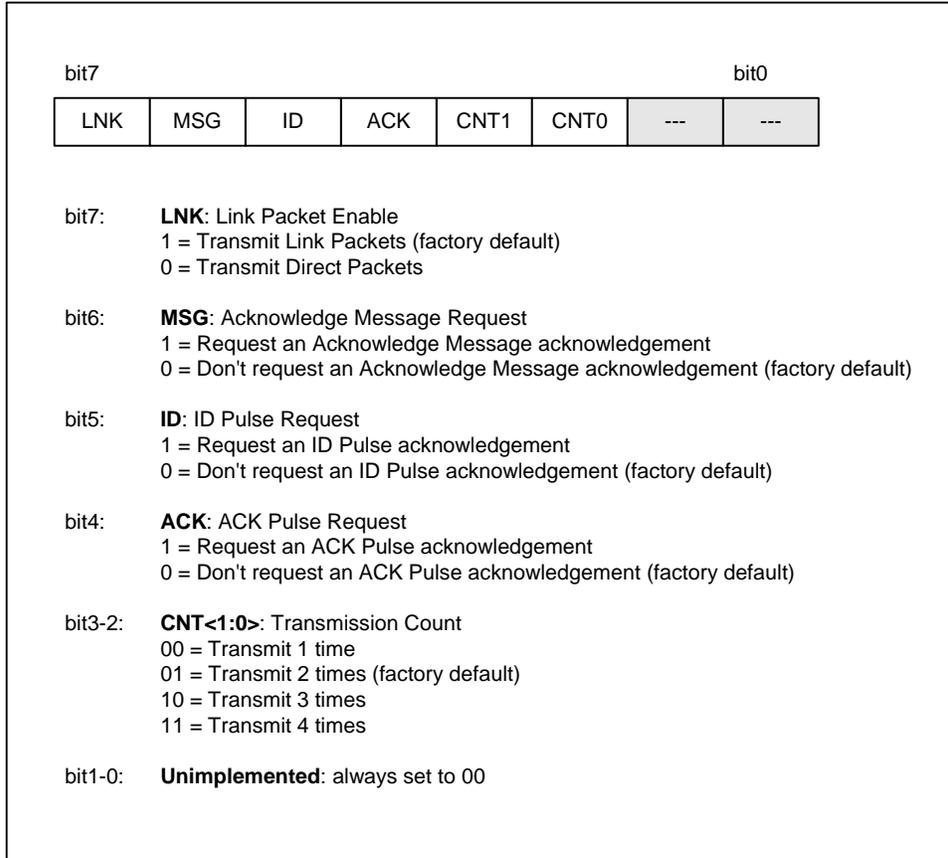


Figure 4: The UPB Transmit Control Register

6.4.1. Link Packet Enable

Bit #7 of the UPB Transmit Control Register is used to configure whether Pushbutton Triggered Transmissions are sent in Link Packets or Direct Packets. If this bit is set to '0' the WMC8 **shall** build and transmit all Pushbutton Triggered Transmissions with the LNK-bit cleared in its Control Word (Direct Packet). If this bit is set to '1' the WMC8 **shall** build and transmit all Pushbutton Triggered Transmissions with the LNK-bit set in its Control Word (Link Packet).

6.4.2. Acknowledge Message Request

Bit #6 of the UPB Transmit Control Register is used to configure whether an Acknowledge Message is requested from the receiver of any Pushbutton Triggered Transmissions. If this bit is set to '1' the WMC8 **shall** build and transmit all Pushbutton Triggered Transmissions with the MSG-bit set in its Control Word.

6.4.3.ID Pulse Request

Bit #5 of the UPB Transmit Control Register is used to configure whether an ID Pulse is requested from the receiver of any Pushbutton Triggered Transmissions. If this bit is set to '1' the WMC8 **shall** build and transmit all Pushbutton Triggered Transmissions with the ID-bit set in its Control Word.

6.4.4.ACK Pulse Request

Bit #4 of the UPB Transmit Control Register is used to configure whether an ACK Pulse is requested from the receiver of any Pushbutton Triggered Transmissions. If this bit is set to '1' the WMC8 **shall** build and transmit all Pushbutton Triggered Transmissions with the ACK-bit set in its Control Word.

6.4.5.Transmission Count

Bit #3 and #2 of the UPB Transmit Control Register are used to configure how many times to transmit a message in a row for each Pushbutton Triggered Transmission event. If this field is set to 00 the WMC8 **shall** transmit any Pushbutton Triggered Transmission one time only. If this field is set to 01 or 10 or 11 the WMC8 **shall** transmit any Pushbutton Triggered Transmission two times or three times or four times respectively.

7. Special Linking Transmissions

Besides performing the Pushbutton Triggered Transmissions described in Section 6, the WMC8 **shall** be capable of transmitting special command sequences useful for adding and deleting links. These command sequences are useful, in a lighting control system, to “link” a pushbutton to another device such as a Wall Switch Dimmer. They are also very useful for storing new preset light levels into devices such as a Wall Switch Dimmer.

7.1. Adding A Link

It is very useful to command another device, such as a Wall Switch Dimmer, to add the Link ID assigned to one of the pushbuttons to its Receive Component Table. When a pushbutton’s Transmit Component and another device’s Receive Component have the same Link ID they are “linked” together. The pushbutton can now send commands to the other device to control it.

Whenever a pushbutton is pressed five times quickly in a row the WMC8 **shall** transmit the command sequence to add that pushbutton’s Transmit Link ID to any device that is in Setup Mode as described in Table 9.

Cmd	Packet	DID	MDID	ARG1	ARG2	Description
1	Direct	254	0B	LID	-	Add Link #LID
2	Link	LID	31	NPWH	NPWL	Store Preset
3	Direct	254	04	-	-	Exit Setup Mode

Table 9: The Add Link Command Sequence

Note that the Add Link command sequence also includes a “Store Preset” command. This means that any device with a Receive Component Link ID that matches #LID will store its current Light Level or State. This means that pressing a pushbutton five times quickly in a row will cause the WMC8 to transmit a command to have all devices linked to that pushbutton store their current Light Levels.

7.2. Deleting A Link

Whenever a pushbutton is pressed ten times quickly in a row the WMC8 **shall** transmit the command sequence to delete that pushbutton’s Transmit Link ID out of any device that is in Setup Mode as described in Table 10 below.

Cmd	Packet	DID	MDID	ARG1	ARG2	Description
1	Direct	254	0C	LID	-	Delete Link #LID
2	Direct	254	04	-	-	Exit Setup Mode

Table 10: The Delete Link Command Sequence

8. UPB Message Receiving

The WMC8 **shall** be capable of receiving UPB messages from the powerline.

8.1. Receive Components

The WMC8 uses the concept of Receive Components (as described in the UPB System Description document) to configure its UPB Link Packet receiving behavior. The WS1D **shall** have eight 1-byte Receive Components implemented in its non-volatile Configuration Registers as shown in Section 3 – “UPB Setup Registers”. All eight Receive Components (referred to as Indicators) are associated with a physical LED indicator behind each horizontal pushbutton. Each Receive Component **shall** have an associated Link ID byte that is used when receiving UPB Link Packets.

Setup Register Field Name	Register Numbers	Factory Default Value
		Link ID
‘E’ Indicator	0x40	013 (0x0D)
‘F’ Indicator	0x41	014 (0x0E)
‘G’ Indicator	0x42	015 (0x0F)
‘H’ Indicator	0x43	016 (0x10)
‘I’ Indicator	0x44	017 (0x11)
‘J’ Indicator	0x45	018 (0x12)
‘K’ Indicator	0x46	019 (0x13)
‘L’ Indicator	0x47	020 (0x14)

Table 11: Receive Component Table

8.1.1. Receiving UPB Link Packets

Whenever the WMC8 receives a UPB Link Packet it **shall** attempt to match its Destination ID to one of the valid Link IDs of its eight Receive Components. If a match is not found then that Link Packet is not for this WMC8 and it **shall** be ignored. If a match is found then the WMC8 **shall** accept the Link Packet for further processing. The particular Receive Component (Indicator) that had the Link ID match is “linked” to this Link Packet.

8.2. Receiving The Core Command Message Set

The WMC8 **shall** be capable of receiving and handling UPB Messages from the UPB Core Command Message Set. The commands in this message set are described in the UPB System Description document.

8.3. Receiving The Device Control Command Set

Besides handling the UPB Core Commands, the WS1D **shall** also receive and handle UPB Command Messages from the set listed in Table 12 to control its LED Indicators. These UPB Commands are from the UPB Device Control Command Set.

MDID (Hex)	Command Name	Command Description
0x20	Activate	Commands the WMC8 to set its linked Receive Component's (Indicator) LED to On.
0x21	Deactivate	Commands the WMC8 to set its linked Receive Component's (Indicator) LED to Off.
0x22	Goto	Commands the WMC8 to set its linked Receive Component's (Indicator) LED either On or Off.
0x23	Fade Start	Commands the WMC8 to set its linked Receive Component's (Indicator) LED either On or Off.

Table 12: The 8-Button Controller's UPB Device Control Commands

8.3.1. Handling The "Activate" Command

When the WMC8 receives and accepts an "Activate" Command message (MDID = 0x20) in a UPB Link Packet it **shall** set its "linked" Indicator LED to On.

8.3.2. Handling The "Deactivate" Command

When the WMC8 receives and accepts a "Deactivate" Command message (MDID = 0x21) in a UPB Link Packet it **shall** set its "linked" Indicator LED to Off.

8.3.3. Handling The "Goto" Command

When the WMC8 receives and accepts a "Goto" Command message (MDID = 0x22) in a UPB Link Packet it **shall** set its "linked" Indicator LED to Off if the specified Level is 0% or it **shall** set its "linked" Indicator LED to On if the specified Level is above 0%.

When the WMC8 receives and accepts a "Goto" Command message (MDID = 0x22) in a Direct Packet it **shall** set the Indicator LED of the specified Channel (1 – 8) to Off if the specified Level is 0% or it **shall** set the Indicator LED of the specified Channel (1 – 8) to On if the specified Level is above 0%. If no Channel (or a Channel greater than 8) is specified then the WMC8 shall apply the "Goto" Command to all eight of its LED Indicators.

8.3.4. Handling The “Fade Start” Command

When the WMC8 receives and accepts a “Fade Start” Command message (MDID = 0x23) in a UPB Link Packet or a UPB Direct Packet it **shall** set its “linked” Indicator LED to Off if the specified Level is 0% or it shall set its “linked” Indicator LED to On if the specified Level is above 0%.

When the WMC8 receives and accepts a “Fade Start” Command message (MDID = 0x23) in a Direct Packet it **shall** set the Indicator LED of the specified Channel (1 – 8) to Off if the specified Level is 0% or it **shall** set the Indicator LED of the specified Channel (1 – 8) to On if the specified Level is above 0%. If no Channel (or a Channel greater than 8) is specified then the WMC8 shall apply the “Fade Start” Command to all eight of its LED Indicators.

9. Configuring LED Indicator Behaviors

The WMC8 **shall** provide Setup Registers to allow for configuring LED behaviors as described in this section. A UPB Setup Tool can be used to write new values into these registers to change the behavior of the LEDs.

9.1. LED Options Register

The WMC8 **shall** have an 8-bit LED Options Register implemented at address 0x8D of its non-volatile Setup Registers. The LED Options Register has bits and fields that are used to customize the LED operation using a UPB Setup Tool.

Table 13 describes the various bits and fields of the LED Options Register.

Bit	Name	Default	Description
7 & 6	Unused	00	Unused
5	LED Backlighting	1	0 = LED Backlighting is disabled. 1 = LED Backlighting is enabled.
4	Unused	0	Unused
3	LED Tracking Enable	1	0 = LED Tracking is disabled. 1 = LED Tracking is enabled.
2	LED Enable/Disable	1	0 = LED Output is disabled. 1 = LED Output is enabled.
1 & 0	LED Brightness	11	00 = Faint 01 = Low 10 = Medium 11 = High

Table 13: LED Options Register (0x8D)

9.1.1. LED Backlighting

Bit #5 of the LED Options Register **shall** control the LED Backlighting option. When this bit is set to '1' all eight LED **shall** be illuminated to a faint brightness level allowing someone to find the keypad in the dark. When this bit is set to '0' the WMC8 **shall** not illuminate the eight LEDs faintly.

9.1.2. LED Tracking Enable

Bit #3 of the LED Options Register **shall** control the LED Tracking Enable option. When this bit is set to '1' the WMC8 **shall** allow normal led feedback indication as described in Section 5.1 – "LED Visual Feedback". When this bit is set to '0' the WMC8 **shall** not update the LEDs based on received UPB commands.

9.1.3.LED Feedback Enable

Bit #2 of the LED Options Register **shall** control the LED Feedback Enable option. When this bit is set to ‘1’ the WMC8 **shall** allow normal led feedback indication as described in Section 5.1 – “LED Visual Feedback”. When this bit is set to ‘0’ the WMC8 **shall** not allow normal led feedback indication but instead keep the LEDs off.

9.1.4.LED Brightness

Bits #1 and #0 of the LED Options Register **shall** control the LED Brightness option. Four different LED brightness levels (High, Medium, Low, and Faint) **shall** be possible as described in Table 13.

9.2. Mutually Exclusive LED Register

The WMC8 **shall** have an 8-bit Mutually Exclusive LED Register implemented at address 0x8F of its non-volatile Setup Registers. The Mutually Exclusive LED Register has bits that correspond to each of the six LED indicators.

Bit	Name	Default	Description
7	‘L’ Mutex	0	1 = ‘L’ Indicator is mutually exclusive.
6	‘K’ Mutex	0	1 = ‘K’ Indicator is mutually exclusive.
5	‘J’ Mutex	0	1 = ‘J’ Indicator is mutually exclusive.
4	‘I’ Mutex	0	1 = ‘I’ Indicator is mutually exclusive.
3	‘H’ Mutex	0	1 = ‘H’ Indicator is mutually exclusive.
2	‘G’ Mutex	0	1 = ‘G’ Indicator is mutually exclusive.
1	‘F’ Mutex	0	1 = ‘F’ Indicator is mutually exclusive.
0	‘E’ Mutex	0	1 = ‘E’ Indicator is mutually exclusive.

Table 14: Mutually Exclusive LED Register (0x8F)

If a bit in this register is set to ‘1’ the WMC8 **shall** turn off all of the other mutually exclusive LEDs whenever that bit’s corresponding LED is turned on. If a bit is set to ‘0’ the WMC8 **shall** not change the state of the other LEDs whenever that bit’s corresponding LED is turned on.

10. Factory Default Operation

This section describes the operation of the WMC8 with its factory default settings enabled. These settings will be enabled “right out of the box” or whenever Factory Default Mode is enabled as described in section 4.4.3.

10.1. Power-Up Operation

Upon power-up the WMC8 will enter Normal Mode and will display its current firmware version by lighting up its four middle LEDs (G, H, I, and J) as described in section 5.1. After displaying the firmware version the WMC8 will perform a Power-Up Light Show as described in section 5.5. The WMC8 will then set its LED on/off states to the saved Reset LED States value and await further events such a Pushbutton Switch Events or UPB Communication Packet Receptions.

10.2. UPB Communication Packet Transmissions

The WMC8 will transmit UPB Communication Packets onto the powerline in response to various commands from the UPB Core Command Message Set (as described in the [UPB System Description](#) document).

10.3. UPB Communication Packet Receptions

The WMC8 has a factory default Network ID of 255 and a factory default Unit ID of 013. It is capable of handling received UPB Commands from the UPB Core Command Message Set (as described in the [UPB System Description](#) document) for Direct Packets sent to this NID/UID.

Besides handling the UPB Core Commands, the WMC8 also handles the set of UPB Commands described in Table 12 to control its LED Indicators.

10.4. UPB Receive Components

The WMC8 has 8 Receive Components (called Indicators) that are configured for receiving Link Packets addressed to its NID. The factory default Link IDs that the WMC8 will accept are Link IDs #13 through #20 as shown in Table 15.

Receive Component	Link ID	Commands That Turn Indicator ON	Commands That Turn Indicator OFF
'E' Indicator	013	Activate, Goto with a Level > 0, Fade Start with a Level > 0.	Deactivate, Goto with a Level of 0, Fade Start with a Level of 0.
'F' Indicator	014	Activate, Goto with a Level > 0, Fade Start with a Level > 0.	Deactivate, Goto with a Level of 0, Fade Start with a Level of 0.
'G' Indicator	015	Activate, Goto with a Level > 0, Fade Start with a Level > 0.	Deactivate, Goto with a Level of 0, Fade Start with a Level of 0.
'H' Indicator	016	Activate, Goto with a Level > 0, Fade Start with a Level > 0.	Deactivate, Goto with a Level of 0, Fade Start with a Level of 0.
'I' Indicator	017	Activate, Goto with a Level > 0, Fade Start with a Level > 0.	Deactivate, Goto with a Level of 0, Fade Start with a Level of 0.
'J' Indicator	018	Activate, Goto with a Level > 0, Fade Start with a Level > 0.	Deactivate, Goto with a Level of 0, Fade Start with a Level of 0.
'K' Indicator	019	Activate, Goto with a Level > 0, Fade Start with a Level > 0.	Deactivate, Goto with a Level of 0, Fade Start with a Level of 0.
'L' Indicator	020	Activate, Goto with a Level > 0, Fade Start with a Level > 0.	Deactivate, Goto with a Level of 0, Fade Start with a Level of 0.

Table 15: Factory Defaults For Indicators