Simply
Automated
Incorporated

UPB
US1/2 Series
Quad Rocker Wall Switch
with Dimmer
Firmware Specification

V 1.9

1/19/05

Revision History

Spec. Rev.	Date	Firmware Rev.	Description
1.0	4/22/04		Preliminary SWSD
1.1	5/6/04		Preliminary SWSD update
1.2	6/18/04		Preliminary SWSD update
1.3	7/15/04	V2.02	Renamed SWSD 1.2 spec to USQ 1.3, added quad options, modified EE locations,
1.4	8/12/04	V2.04	Added support to program rockers as pushbuttons (toggling feature), added downward compatibility with USW, changed RockerOptions and RockerConfig EE registers, removed ability to select any rocker to control local dimmer
1.5	9/27/04	V2.06	Added variant definitions
1.6	10/13/04	V2.07	US28 fix. Added choice of super toggler to drive local dimmer. Removed Last Level feature for lower rocker.
1.7	12/20/04	V2.07	Table#2 correction, added Variant Switch Map
1.8	1/19/05	V2.10	Added variants US21,US22T

Table Of Contents

1. The Quad Wall Switch Dimmer (USQ)

The Quad Wall Switch Dimmer (USQ) scalable firmware shall be utilized in the US1/US2 series of wall mounted switches containing one dimmer and single, double, triple, or quad rocker switches. The switches maybe configured as pushbuttons with toggling functionality for USQ pushbutton devices. The USQ device shall have three separate ways that can be employed to control its local dimmer: 1) rocker#1, 2) remote slave switch (associated with rocker#1), and 3) Universal Powerline Bus™ (UPB) Commands. Rocker#1 or Pushbutton#1 maybe configured to control the dimmer, or detached from the dimmer allowing independent dimmer control by a remote UPB controller. The USQ device shall contain a single bi-color LED to indicate status, modes, and events.

1.1. Light Dimmer

The USQ device shall have Light Dimmer logic capable of producing 200 different levels of light output as well as off. The Light Dimmer can be configured (or commanded) to change light levels immediately ("Snap") as well as gradually ("Fade").

1.2. Switches

The USQ device may have rocker switches, pushbutton switches, or a combination of both.

1.2.1. Rocker Switches

The USQ device may have decora-style rockers. The USQ firmware shall be configurable such that one to four rockers maybe present. The rockers shall be used to set new light levels, set new operating modes, and to trigger transmission of UPB messages.

1.2.2. Push Button Switches

The USQ device may have decora-style pushbuttons. The USQ firmware shall be configurable such that one to eight push buttons maybe present. The push buttons shall be used to set new light levels, set new operating modes, and to trigger transmission of UPB messages.

1.3. UPB Receiver

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

1.4. UPB Transmitter

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

1.5. UPB Core Logic

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

1.6. LED Indicator

The USQ device shall have a bi-color LED indicator used to indicate its current status and mode of operation.

1.7. Slave Switch

The USQ device shall have a special input (wire) for connecting an optional Slave Switch. The Slave Switch is wired to local rocker #1 and will perform similiarly.

1.8. USQ device Connections

The USQ device **shall** have four wires that are used to connect it to power, load, and an optional slave switch. Figure 1 shows how the USQ devices connect to the lighting system.
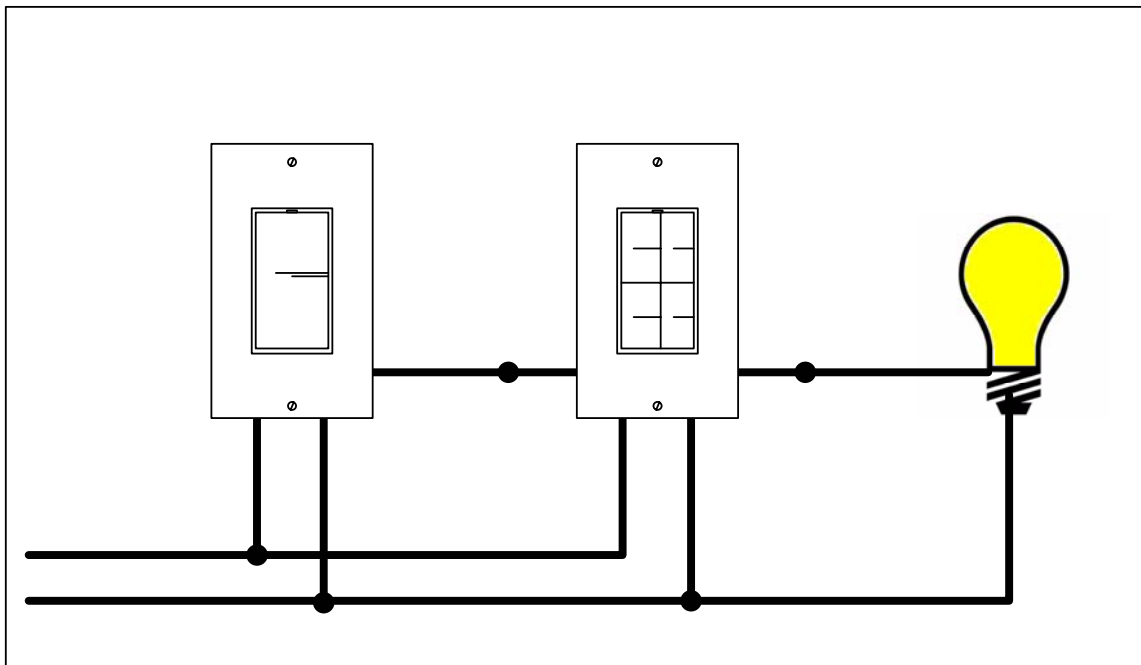
Figure 1 - USQ device connections to a lighting system

2. Modes Of Operation

The USQ device **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 USQ device **shall** be able to operate in the Normal Mode. The Normal Mode is the USQ device's default mode of operation. While in the Normal Mode the USQ device **shall** be able to perform all of its normal operations except that Setup Register Write Protection is enabled. While in the Normal Mode, the LED indicator **shall** indicate this mode of operation as defined in section 7.1.4 " Special Mode LED Indications".

2.2. SETUP Mode

The USQ device **shall** be able to 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 <u>UPB System Description</u> document describes the SETUP Mode in more detail. The USQ device **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 <u>UPB System Description</u> document. The other method is by having its Rocker Switch (or Slave Switch) depressed in a special sequence as described in section 5.7.1 - "Entering SETUP Mode". While in the SETUP Mode, the LED indicator **shall** indicate this mode of operation as defined in section 7.1.4 " Special Mode LED Indications".

2.3. Factory Default Mode

The USQ device **shall** be able to 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 USQ device **shall** be able to enter into the Factory Default Mode as described in section 5.7.3 - "Entering Factory Default Mode". While in the Factory Default Mode, the LED indicator **shall** indicate this mode of operation as defined in section 7.1.4 " Special Mode LED Indications".

3. UPB Setup Registers

Like all UPB devices that conform to the UPB System Model, the USQ device **shall** have a set of non-volatile 8-bit registers known as UPB Setup Registers. The USQ device **shall** have a total of 256 UPB Setup Registers. These registers are used to define and configure how the USQ device will operate as well as to store other important information as described herein. The USQ device **shall** allow read/write access to its UPB Setup Registers via special UPB Messages communicated on the powerline. The USQ device's Setup Registers are partitioned into three main groups (the UPBID, the Configuration Registers, and the Scratch-Pad Registers) as described below.
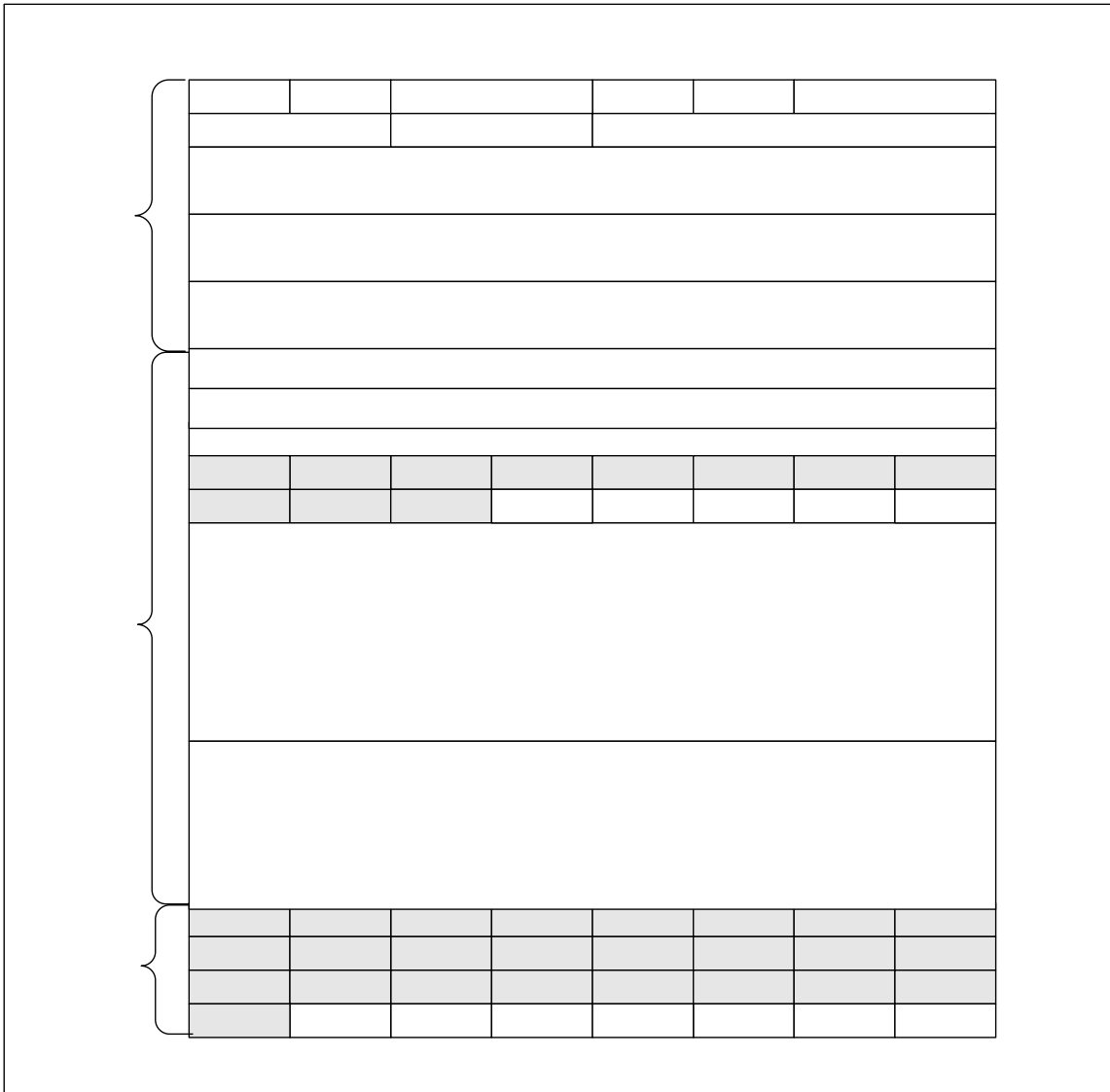
Figure 2 - UPB Setup Registers

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 USQ device **shall** implement the UPBID in the first 64 Setup Registers. Table 1 below describes the Setup Registers that make up the UPBID. The 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	22 (0x16)	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	04 (0x0004) SA	Unique identifier of the manufacturer of this UPB device.
Product ID (PID)	0x08 – 0x09	22 (0x16) USQ device	The manufacturer's unique product identifier for this UPB device.
Firmware Version (FWVER)	0x0A – 0x0B	Depends on the current F/W	Identifies the version of firmware in this device.
Serial Number (SERNUM)	0x0C – 0x0F	Set by the manufacturer	The manufacturer's unique serial number for this UPB device.
Network Name (NNAME)	0x10 – 0x1F	"New Network Name"	A human readable (ASCII) name for the UPB Network that this device communicates on.
Room Name (RNAME)	0x20 – 0x2F	"New Room Name "	A human readable (ASCII) name for the Room that this UPB device is installed in.

Setup Register Field Name	Reg. Num.	Factory Default	Description
Device Name (DNAME)	0x30 – 0x3F	"New USQ"	A human readable (ASCII) name for this UPB device.

Table 1 - The USQ device'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 USQ device **shall** implement the Configuration Registers in the next 128 Setup Registers. The definition of the Configuration Registers is application dependent. Table 2 describes the Configuration Registers for the USQ device 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 – 0x6F	See Table 13 for factory defaults	Configuration table containing 16 Receive Component Records used for receiving UPB Link Packets.
Transmit Component Table for rocker#1	0x70 – 0x79	See Table 15 factory defaults	Configuration table containing Transmit Component Records used for transmitting UPB Link Packets.
Rocker Action Table	0x7A – 0x81	See Table 10 for factory defaults	Configuration table that defines the Dimmer actions to be performed upon single-tap and double-tap events on the Top and Bottom Rocker switches.
Unused	0x82- 0x8A	255 (0xFF)	Unused
LED Options	0x8B	9 (0x09)	Configurable options for the Status LED.
Rocker Config	0x8C	255(0xFF)	Selects 1-8 button inputs
Dimmer Options	0x8D	131 (0x83)	Configurable options for the light dimmer circuit.
UPB Tx Control	0x8E	132 (0x84)	Configurable options for UPB Transmissions.
Rocker Options	0x8F	12(0xC0)	Determines Rocker Action and defines variant type

Setup Register Field Name	Reg. Num.	Factory Default	Description
Transmit Command Table	0x90 – 0xBC	See Table 16 for factory defaults	Table for 16 Command IDs (CmdIds) with the 3-byte UPB Command Messages they represent.
Unused	0xBD – 0xC9	255 (0xFF)	Unused
Transmit Component Table for rockers 2-4	0xCA – 0xE7	See Table 15 for factory defaults	Configuration table containing Transmit Component Records used for transmitting UPB Link Packets.

Table 2 - 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. Table 3 describes the Scratch-Pad Registers for the Wall Switch Dimmer. 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	0xEA – 0xF8	255 (0xFF)
Reset Light Level	0xF9	Location to store the last Light Level 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 - Scratch-Pad Registers

4. Light Dimmer Operations

4.1. Light Levels

The USQ device dimmer output **shall** be capable of creating any of 200 distinct Light Levels (1 – 200) as well as OFF (0). Light Level #0 corresponds to 0% (OFF) and Light Level #200 corresponds to 100% (MAX). When the USQ device sets its Light Level to a new value, it can either do it immediately, called a "Snap", or it can do it gradually over time, called a "Fade". The USQ device can be configured (or commanded) to use one of sixteen possible Fade Rates in setting its new Light Level (see Section 4.1.3).

4.1.1. Pseudo-Logarithmic Dimming Curve

The USQ device **shall** implement a pseudo-logarithmic dimming curve for creating smooth lighting transitions between its 200 Light Levels.

4.1.2. The Reset Light Level

Approximately once every 2 seconds the USQ device **shall** save its current Light Level (in %) into non-volatile memory as the Reset Light Level. When the USQ device first powers up, it **shall** restore its current Light Level (%) to the saved Reset Light Level value.

4.1.3. The Last On Level

Approximately once every 2 seconds the USQ device **shall** save its current non-zero Light Level (in %) into non-volatile memory as the Last On Level. Whenever the USQ device is configured (or commanded) to go to a Light Level above 100% it **shall** use the Last On Level instead. The Last On Level shall be reset to 100% whenever the dimmer is driven to 100%. Refer to section 5.1.2 concerning a similar feature called Last Level.

4.2. Fade Rates

Whenever the USQ device sets its Light Level to a new value, it can either do it immediately, called a Snap, or it can do it a little bit at a time, called a Fade. The USQ device **shall** be able to be configured or commanded to use one of sixteen possible Fade Rates (including Snap) in setting its new Light Level as described in Table 4 below.

Fade Rate	Fade Time (0% – 100%)	Time Per Step
0	Snap!	0
1	0.8 seconds	4.167mS
2	1.6 seconds	8.333 mS
3	3.3 seconds	16.67mS
4	5 seconds	25mS
5	6.6 seconds	33.3 mS
6	10 seconds	50 mS
7	20 seconds	100 mS
8	30 seconds	150 mS
9	1 minute	300 mS
10	2 minutes	600 mS
11	5 minutes	1.5 seconds
12	10 minutes	3 seconds
13	15 minutes	4.5 seconds
14	0.5 hours	9 seconds
15	1.0 hour	18 seconds

Table 4 - Dimmer Fade Rates

4.3. Dimmer Options Register

The USQ device **shall** have an 8-bit Dimmer Options Register implemented at address 0x8D of its non-volatile Setup Registers. The Dimmer Options Register (Figure 3) has bits and fields that are used to customize the dimmer operation using a UPB Setup Tool.

```
        bit7                                                            bit0
        ┌──────────┬──────┬──────┬──────┬──────┬──────┬──────┬──────┐
        │ DIMMABLE │ ---  │ ---  │ TSR  │ DFR3 │ DFR2 │ DFR1 │ DFR0 │
        └──────────┴──────┴──────┴──────┴──────┴──────┴──────┴──────┘

        bit7:       DIMMABLE: Dimming Capable Flag
                    0 = Device is not Dimming Capable
                    1 = Device is Dimming Capable (factory default)

        bit6 - 5:   Unimplemented: for future use

        bit 4:      TSR: Tx State Report
                    0 = Dont transmit a State Report upon Rocker Switch  events
                    1 = Transmit a State Report upon Rocker Switch events

        bit3-0:     DFR<3:0>: Default Fade Rate
                    0000 = Snap
                    0001 = 0.8 seconds
                    0010 = 1.6 seconds
                    0011 = 3.3 seconds
                    0100 = 5.0 seconds
                    0101 = 6.6 seconds
                    0110 = 10 seconds
                    0111 = 20 seconds
                    1000 = 30 seconds
                    1001 = 1 minute
                    1010 = 2 minutes
                    1011 = 5 minutes
                    1100 = 10 minutes
                    1101 = 15 minutes
                    1110 = 30 minutes
                    1111 = 1 hour
```

Figure 3 - Dimmer Options Register

4.3.1. The Dimming Capable Flag

The USQ device **shall** have a 1-bit Dimming Capable Flag implemented as part of its Dimmer Options Setup Register (Figure 3). When this flag is set to 1 (factory default state), the USQ device **shall** allow full 200 level light dimming capabilities. When this flag is cleared to 0, the USQ device **shall** only allow On (100%) and Off (0%) capabilities.

4.3.2. The Default Fade Rate

The USQ device **shall** have a 4-bit Default Fade Rate implemented as part of its Dimmer Options Register (Figure 3). Whenever the USQ device is commanded to use the "default fade rate" it **shall** use the value in the Default Fade Rate field of the Dimmer Options Register. Also, whenever the USQ device is commanded or configured to use a Fade Rate value above 15 it **shall** use the value in the Default Fade Rate field instead.

5. Local Rocker Switch Operations

The USQ device has a decora-style Rocker Switch that is used to control the lighting load, transmit UPB Messages, and to put the USQ device into special modes of operation. The Rocker Switch consists of eight momentary pushbutton switches: two pushbuttons for each of the four rockers.

5.1. Rocker Options Register

The Rocker Options Register is a non-volatile register (location 0x8F) that determines local control of the local dimmer and enables the Last Level feature.

Bit	Name	Description
7	Rocker Connect	0 = Selected local rocker disconnect to local dimmer 1 = Selected local rocker connected to local dimmer
6	Last Level	0 = Last Level disabled 1 = Last Level enabled
5	Tall Rocker	0 = all other variants 1 = single/double tall rockers installed on US2 body
4	Rocker or Pushbutton	0 = local dimmer controlled by rocker#1 1 = local dimmer controlled by pushbutton#1
3 - 0	Variant Selection	Selects US1/US2 model variant

Table 5 – Rocker Options Register

5.1.1. Rocker Connect

This option shall determine if the selected Local Rocker shall control the local dimmer. When set to zero, the Local Rocker shall be disconnected from the local dimmer. When set to one, the Local Rocker shall control the local dimmer.

5.1.2. Last Level

This option will store into non-volatile memory the Last Level the dimmer was driven to by hold-release upper rocker depression. Subsequent single clicks of the upper rocker shall seek to these Last Level value.

5.1.3. Tall Rocker

This option allows single and double tall rockers to reside on the US2 body. When set, this option maps buttons 4 and 8 to buttons 2 and 6, respectively.

5.1.4. Rocker Or Pushbutton

This option is enabled by the Rocker Connect bit. Once activated, this option determines if the local dimmer is controlled by Rocker#1 or Pushbutton#1. Pushbutton#1 shall behave as a "super toggler" when selected.

5.1.5. Variant Selection

The lower nibble of the Rocker Options Register is defines the variant field. The variant field is solely for use of UPB setup tool to identify the configuration of the USQ device. The USQ firmware does not use the variant value to configure the device. When model variant is set to 15, the UPB setup tool declares the device unknown (or new). The Rocker Configuration register and Transmit Component Table values actually configure the device to determine how many rockers/pushbuttons are active and whether they function as pushbuttons (toggle function) or rockers.

Variant (RockerOptions LSB)	Model	Body	Description
0	US24	US2	Half Height Quad Rocker
1	US22S	US2	Half Height Dual Rocker
2	US23	US2	Half Height Tripler Rocker
3	Not used		
4	Not used		
5	Not used		
6	Not used		
7	Not used		
8	US11	US1	Full Height Single Rocker
9	US12	US1	Full Height Dual Rocker
10	US21	US2	Full Height Single Rocker
11	US22T	US2	Full Height Dual Rocker
12	US25	US2	Single Rocker, Four Pushbuttons
13	US26	US2	Dual Rocker, Four Pushbuttons
14	US28	US2	Eight Pushbuttons
15	Model undefined		Default

Table 6 – Rocker Options Variant field definitions

5.1.6. Variant Pushbutton Layout

Variants shall have a variety of rocker and pushbutton layouts. Figure 1 maps switches (as defined in firmware) to rocker and pushbutton numbering of current US1/2 models.
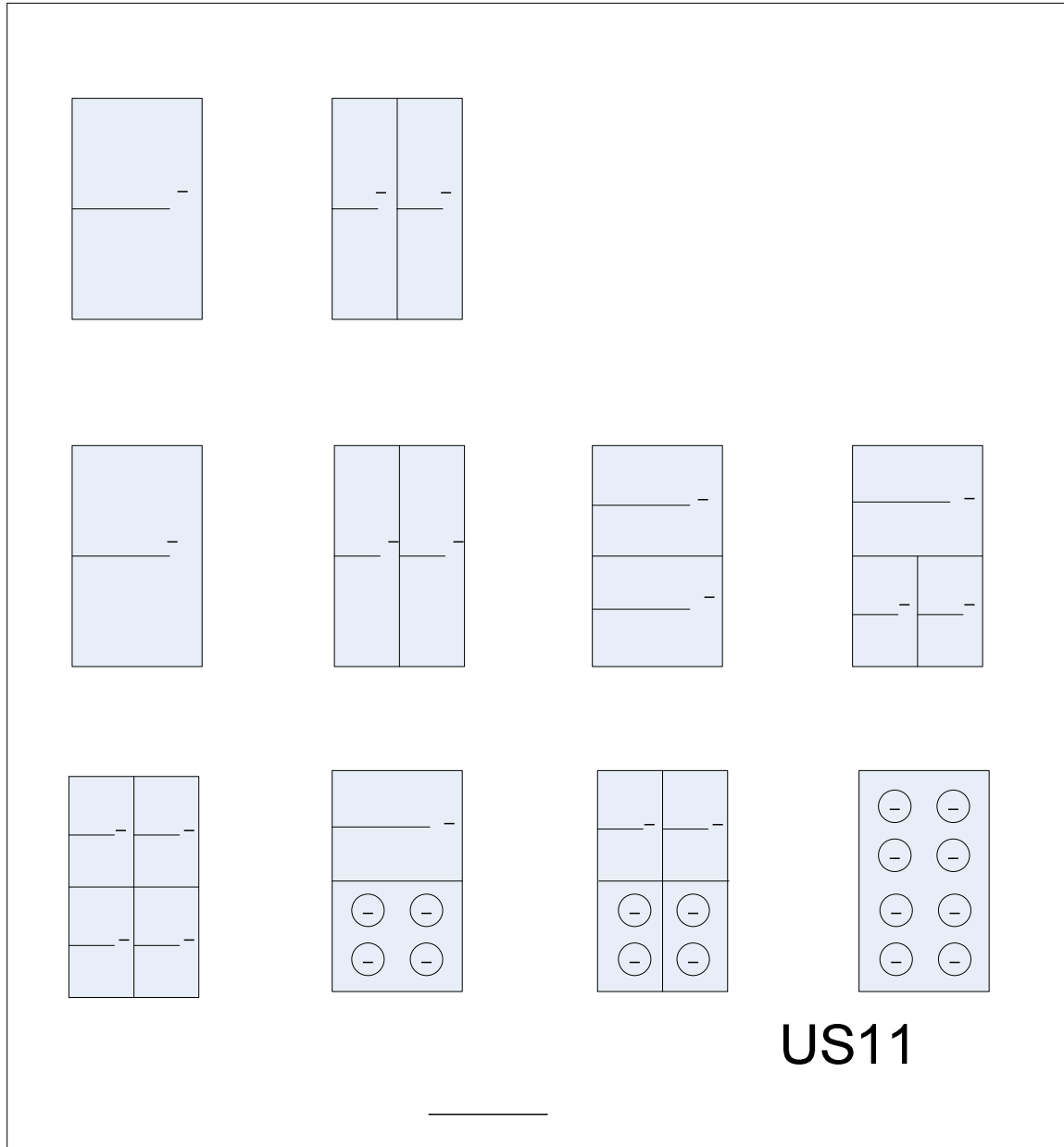

Figure 4 – Variant Switch Mapping

5.2. Rocker Configuration Register

The Rocker Configuration Register is a non-volatile register (location 0x8C) that specifies the number of active rockers as an eight bit mask. The default value of the Rocker Configuration Register shall be 0xFF declaring a four rocker device.

Value	Description
00000001	Rocker #1, upper rocker active
00000010	Rocker #1, lower rocker active
00000011	Rocker #1 active
00001111	Rocker#1,#2 active
00111111	Rocker#1,#2,#3 active
11111111	Rocker#1,#2,#3,#4 active

Table 7 – Rocker Configuration Register Setup Examples

5.3. Rocker Switch Events

The USQ device **shall** be capable of detecting any of the four types of Rocker Switch Events defined in Table 8 below on both of its Rocker Switches.

Rocker 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 was released after a Hold event.

Table 8 - Rocker Switch Events

5.4. Rocker Switch Load Control

A single Rocker Switch **may** be used by the USQ device to control its dimmer's Light Level output as defined in Table 9 below.

Rocker Event	Dimmer Action (Top Rocker)	Dimmer Action (Bottom Rocker)
Single-Tap	Perform the Configured Rocker Switch Dimmer Action as described in section 5.5.	Perform the configured Rocker Switch Dimmer Action as described in section 5.5.
Double-Tap	Perform the Configured Rocker Switch Dimmer Action as described in section 5.5.	Perform the configured Rocker Switch Dimmer Action as described in section 5.5.
Hold	Start fading to 100% at the Default Fade Rate.	Start fading to 0% at the Default Fade Rate.
Release	Stop fading the Light Level.	Stop fading the Light Level.

Table 9 - Rocker Switch Load Control

5.5. Configured Rocker Switch Dimmer Actions

The USQ device treats the Single-Tap and Double-Tap Rocker Switch Events specially, giving the user the freedom to configure the corresponding light dimmer action that they desire. The USQ device **shall** implement a Rocker Switch Action Table in its non-volatile Setup Registers as shown in Table 10 to configure the "Dimmer Action" to be performed on the load upon a Single-Tap and upon a Double-Tap event of the two Rocker Switches.

5.5.1. The Rocker Switch Action Table

The Rocker Switch Action Table **shall** be used to configure the "Dimmer Action" to be performed on the load upon a Single-Tap and/or Double-Tap event. Each "Dimmer Action" **shall** be defined as a Light Level (%) to fade to and an associated Fade Rate to use to get it there. The Rocker Switch Action Table (Table 10) **shall** be 8 bytes long and **shall** be divided into four 2-byte records. There **shall** be one record to correspond to each of the following events: Top Rocker Single-Tap, Top Rocker Double-Tap, Bottom Rocker Single-Tap, and Bottom Rocker Double-Tap. Each 2-byte record consists of one byte to represent the Light Level (%) and the other byte to represent the Fade Rate to use when the corresponding event occurs.

Setup Register Field Name	Reg. Num.	Factory Default		Description
		Level	Rate	
Top Rocker Single-Tap Dimmer Action	0x7A – 0x7B	100	255	Light Level (%) and Fade Rate to go to upon a single-tap event on the Top Rocker switch.
Top Rocker Double-Tap Dimmer Action	0x7C – 0x7D	100	000	Light Level (%) and Fade Rate to go to upon a double-tap event on the Top Rocker switch.
Bottom Rocker Single-Tap Dimmer Action	0x7E – 0x7F	000	255	Light Level (%) and Fade Rate to go to upon a single-tap event on the Bottom Rocker switch.
Bottom Rocker Double-Tap Dimmer Action	0x80 – 0x81	000	000	Light Level (%) and Fade Rate to go to upon a double-tap event on the Bottom Rocker switch.

Table 10 - Rocker Switch Action Table

5.5.2. Default Rocker Switch Dimmer Actions

As an example of using the Rocker Switch Action Table let's explore how the USQ device will behave when set to its factory default values. The factory defaults for the Rocker Switch Action Table are shown in Table 10. With these values set the USQ device should behave as described in Table 11 below.

Rocker Event	Dimmer Action (Top Rocker)	Dimmer Action (Bottom Rocker)
Single-Tap	Fade to 100% at the Default Fade Rate.	Fade to 0% at the Default Fade Rate.
Double-Tap	Snap to 100% at Fade Rate #0.	Snap to 0% at Fade Rate #0.
Hold	Start fading to 100% at the Default Fade Rate.	Start fading to 0% at the Default Fade Rate.
Release	Stop fading the Light Level.	Stop fading the Light Level.

Table 11 - Factory Default Rocker Switch Dimmer Actions

5.6. Rocker Switch Transmit Control

The USQ device can optionally be configured to transmit UPB Messages when any of the Rocker Switch Events listed in Table 8 occurs. Refer to section 5.1 for details on how to configure the USQ device for Rocker Switch Transmissions.

5.7. Rocker Switch Mode Control

The Rocker Switch **shall** be able to be used to put the USQ device into different modes of operation. The USQ device has three different modes of operation (Normal Mode, SETUP Mode, and Factory Default Mode) as defined in section 2.

5.7.1.Entering SETUP Mode

The USQ device **shall** enter SETUP Mode when any Rocker Switch is multi-tapped for exactly 5 times. When the USQ device enters the SETUP Mode it **shall** indicate so by flashing its dimmer's lighting load on and off and by blinking its LED as defined in section 7.1.4.

5.7.2.Exiting SETUP Mode

Once in the SETUP Mode, the USQ device **shall** exit SETUP Mode and enter the Normal Mode when any Rocker Switch is multi-tapped for exactly 2 times. When the USQ device exits the SETUP Mode it will indicate so by flashing its dimmer's lighting load on and off and by stopping the blinking of its LED as defined in section 7.1.4.

5.7.3.Entering Factory Default Mode

Once in the SETUP Mode, the USQ device **shall** exit SETUP Mode and enter the Factory Default Mode when any Rocker Switch is multi-tapped for exactly 10 times. When the USQ device enters the Factory Default Mode it will indicate so by flashing its dimmer's lighting load on and off and by blinking its LED as defined in section 7.1.4.

5.7.4. Exiting Factory Default Mode

Once in the Factory Default Mode, the USQ device **shall** exit Factory Defaults Mode and enter the Normal Mode when any Rocker Switch is multi-tapped for exactly 2 times. When the USQ device exits the SETUP Mode it will indicate so by flashing its dimmer's lighting load on and off and by stopping the blinking of its LED as defined in section 7.1.4.

6. Slave Rocker Switch Operations

The USQ device **shall** be capable of being connected to an optional Slave which can be used to control the USQ device in a similar fashion to the USQ device's own local Rocker Switch.

6.1. Slave Switch Connections

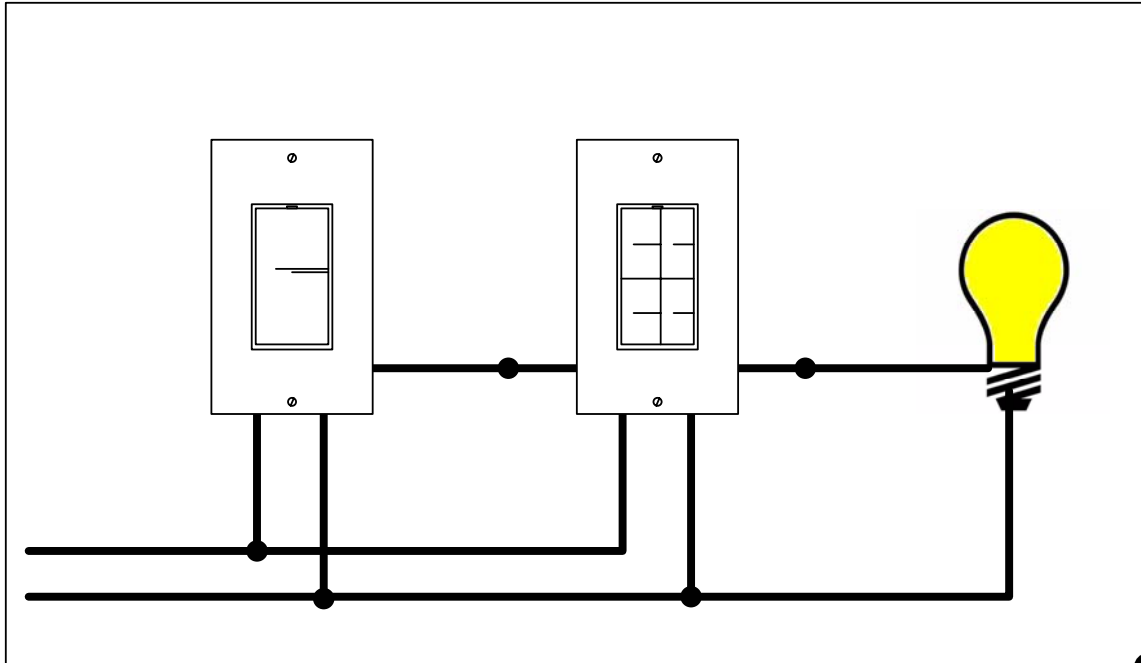Figure 5 shows how the Slave Switch is connected to the USQ device.

Figure 5 - Connecting A Slave Switch

Slave S⋯
(option⋯

6.2. Slave Switch Events

The USQ device **shall** be able to detect the slave switch events as if it were rocker#1. Slave Switch Events will be transmitted as rocker#1 events as defined in Table 8.

6.3. Slave Switch Load Control

The Slave Switch should be considered an extension of rocker#1. When rocker#1 is configured to control the local dimmer so shall the Slave Switch.

6.4. Slave Switch Transmit Control

The Slave Switch should be considered an extension of rocker#1. When rocker#1 is configured to transmit UPB commands, so shall the Slave Switch.

6.5. Slave Switch Mode Control

The Slave Switch is capable of initiating Mode Control operations just as the four local rockers.

7. Status LED Operation

The USQ device has a single bi-color Light Emitting Diode (LED) that it uses to indicate its current status. The Status LED is configured by the settings in the LED Options Register as defined in Table 12.

Black

7.1. The LED Options Register

The USQ device shall have an 8-bit LED Options Register implemented at address 0x8B of its non-volatile Setup Registers. The LED Options Register (Table 12) has bits and fields that are used to customize the Status LED operation using a UPB Setup Tool.

Bit	Name	Description
7	LED Mode	0 = Load Indicator LED enabled 1 = Diagnostic LED enabled
4-6	Unused	Unused
3 - 2	Load On Color	00 = Black (off) 01 = Red 10 = Green 11 = Orange
1 - 0	Load Off Color	00 = Black (off) 01 = Red 10 = Green 11 = Orange

Table 12 - LED Options Register

7.1.1. LED Mode Selection

Bit #7 of the LED Options Register is used to select between two different LED Modes: The Load Indicator LED Mode or the Diagnostic LED Mode. If bit #7 is clear (0) then the USQ device **shall** operate the Status LED in the Load Indicator LED Mode as described in Section 7.1.2. If bit #7 is set (1) then the USQ device **shall** operate the Status LED in the Diagnostic LED Mode as described in Section 7.1.3.

7.1.2. The Load Indicator LED Mode

If the Load Indicator LED Mode is enabled, the USQ device shall turn the Status LED to a color based on the on/off state of the dimmer output. If the dimmer output is set to 0% (off) the USQ device **shall** set the Status LED to the color specified by the Load Off Color bits (1 and 0) of the LED Options Register as defined in Table 12. If the dimmer output is set above 0% the USQ device **shall** set the Status LED to the color specified by the Load On Color bits (3 and 2) of the LED Options Register as defined in Table 12.

7.1.3. The Diagnostic LED Mode

If the Diagnostic LED Mode is enabled, the USQ device **shall** turn the Status LED solid orange. Whenever the USQ device transmits a UPB message, it **shall** indicate so by blinking the status LED red. Whenever the USQ device receives a valid UPB message, it **shall** indicate so by blinking the status LED green.

Whenever the USQ device receives an invalid UPB message, it **shall** indicate so by blinking the status LED black (off).

7.1.4. Special Mode LED Indications

The USQ device has two special modes that it can be put into: SETUP Mode and Factory Default Mode. When the USQ device is in SETUP Mode it **shall** indicate so by blinking its status LED alternately between green and black (off). When the USQ device is in Factory Default Mode it **shall** indicate so by blinking its status LED alternately between red and black (off). When the USQ device is in Normal Mode it **shall** indicate so by stopping the blinking and turning its status LED to solid orange.

7.1.5. Firmware Version LED Indication

When power is first applied, the USQ device **shall** use the status LED to indicate the version of the firmware it is running. It **shall** do this by blinking the LED four times. Each blink will either be red or green. The four blinks **shall** 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 0-1-0-1. The USQ device will therefore blink its LED four times upon power-up: red-green-red-green.

8. UPB Message Reception

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

8.1. Receive Components

The USQ device uses the concept of Receive Components (as described in the UPB System Description document) to configure its UPB Link Packet receiving behavior. The USQ device **shall** have sixteen 3-byte Receive Components implemented in its non-volatile Configuration Registers as shown in Table 13. All sixteen Receive Components (referred to as Presets) are associated with the dimmer's single light dimmer output. Each Receive Component **shall** have an associated Link ID byte that is used when receiving UPB Link Packets. Each Receive Component **shall** also have an associated byte for holding a Light Level and Fade Rate for use in processing the "Activate" and "Deactivate" commands (see section 0 for details).

Setup Register Field Name	Register Numbers	Factory Default Values		
		Link ID	Light Level	Fade Rate
Preset #1	0x40 – 0x42	001	100	255
Preset #2	0x43 – 0x45	002	0	255
Preset #3	0x46 – 0x48	003	80	255
Preset #4	0x49 – 0x4B	004	60	255
Preset #5	0x4C – 0x4E	005	40	255
Preset #6	0x4F – 0x51	006	20	255
Preset #7	0x52 – 0x54	007	100	255
Preset #8	0x55 – 0x57	008	0	255
Preset #9	0x58 – 0x5A	255	255	255
Preset #10	0x5B – 0x5D	255	255	255
Preset #11	0x5E – 0x60	255	255	255
Preset #12	0x61 – 0x63	255	255	255
Preset #13	0x64 – 0x66	255	255	255
Preset #14	0x67 – 0x69	255	255	255
Preset #15	0x6A – 0x6C	255	255	255
Preset #16	0x6D – 0x6F	255	255	255

Table 13 - Receive Component Table

8.1.1. Receiving UPB Link Packets

Whenever the USQ device receives a UPB Link Packet it will attempt to match its Destination ID to one of the valid Link IDs of its sixteen Receive Components. If a match is not found then that Link Packet is not for this USQ device and it **shall** be ignored. If a match is found then the USQ device **shall** accept the Link Packet for further processing. The particular Receive Component that had the Link ID match is "linked" to this Link Packet.

8.1.2. Activating/Deactivating Receive Components

The USQ device **shall** handle the special UPB Link Packet commands of "Activate" and "Deactivate". When the USQ device accepts the "Activate" command it **shall** set its dimmer's output using the Light Level and Fade Rate parameters of the "linked" Receive Component. When the USQ device accepts the "Deactivate" command it **shall** set its dimmer's output to 0% using the Fade Rate parameter of the "linked" Receive Component.

8.1.3. Changing Preset Light Levels and Fade Rates

The Receive Components Light Level and Fade Rate parameters can be changed (configured) with the use of a UPB Setup Tool. In addition, the USQ device **shall** handle the special UPB Link Packet command of "Store Preset". When the USQ device accepts the "Store Preset" command it **shall** store its current Light Level (%) into the "linked" Receive Component (Preset).

8.2. Receiving The Core Command Message Set

The USQ device **shall** be capable of handling received UPB Messages from the UPB Core Command Message Set as described in the UPB System Description document.

8.3. Receiving The Device Control Command Set

Besides handling the UPB Core Commands, the USQ device **shall** also handle the following set of UPB Commands from the UPB Device Control Command Set (see Table 14).

MDID (Hex)	Command Name	Command Description
0x20	Activate	Commands the USQ device to "activate" its linked Receive Component's (Preset) Light Level and Fade Rate.
0x21	Deactivate	Commands the USQ device to "deactivate" its linked Receive Component's (Preset) Light Level and Fade Rate.
0x22	Goto	Commands the USQ device to set its dimmer output to the specified Light Level at the specified Fade Rate.
0x23	Fade Start	Commands the USQ device to set its dimmer output to the specified Light Level at the specified Fade Rate as long as the Dimming Option bit is set to 1 (i.e. Dimming-Capable).
0x24	Fade Stop	Commands the USQ device to stop fading and stay at the current Light Level.
0x25	Blink	Commands the USQ device to blink its dimmer output from 0% to 100% at the specified Blink Rate.
0x30	Report State	Commands the USQ device to send back a Device State Report containing the current dimmer Light Level (%).
0x31	Store Preset	Commands the USQ device to store its current dimmer Light Level (%) value as its linked Receive Component's (Preset) new Light Level.

Table 14 - USQ device UPB Device Control Commands

8.4. The "Activate" Command

When the USQ device receives and accepts an "Activate" Command message (MDID = 0x20) in a UPB Link Packet it **shall** set its Dimmer's light level to the Light Level value of the linked Receive Component (Preset) using the Fade Rate of the linked Receive Component (Preset).

8.5. The "Deactivate" Command

When the USQ device receives and accepts a "Deactivate Link" Command message (MDID = 0x21) in a UPB Link Packet it **shall** set its Dimmer's light level to 0% (OFF) using the Fade Rate of the linked Receive Component (Preset).

8.6. The "Goto" Command

When the USQ device receives and accepts a "Goto" Command message (MDID = 0x22) in a UPB Link Packet or a UPB Direct Packet it **shall** start its Light Dimmer fading its light level towards the specified Light Level using the specified Fade Rate. If no Fade Rate is specified in the command then the USQ device **shall** use its Default Fade Rate instead.

8.7. The "Fade Start" Command

When the USQ device receives and accepts a "Fade Start" Command message (MDID = 0x23) in a UPB Link Packet or a UPB Direct Packet it **shall** start its Light Dimmer fading its light level towards the specified Light Level using the specified Fade Rate. If no Fade Rate is specified in the command then the USQ device **shall** use its Default Fade Rate instead. This command **shall** be ignored if the Dimming Capable Flag in the Dimmer Options Register is set to 0 (not dimming capable).

8.8. The "Fade Stop" Command

When the USQ device receives and accepts a "Fade Stop" Command message (MDID = 0x24) in a UPB Link Packet or a UPB Direct Packet it **shall** stop its Light Dimmer from fading its light level any farther.

8.9. The "Blink" Command

When the USQ device receives and accepts a "Blink" Command message (MDID = 0x25) in a UPB Link Packet or a UPB Direct Packet it **shall** alternate its light level between 100% and 0% at the specified Blink Rate. The USQ device **shall** calculate the time between blinking as:

*Time between blinking = 16.667mS * Blink Rate value*

If no Blink Rate value is specified in the command then the USQ device **shall** use a default Blink Rate value of 30 (0.5 seconds) instead.

8.10. The "Store Preset" Command

When the USQ device receives and accepts a "Store Preset" Command message (MDID = 0x31) in a UPB Link Packet it **shall** store its current Light Level value into the linked Preset Component.

8.11. The "Report Status" Command

When the USQ device receives and accepts a "Report Status" Command message (MDID = 0x30) in a UPB Direct Packet it **shall** build and transmit a Device State Report message.

The "Device State" Report has a Message Data ID of **0x86** and has the following syntax:

MDID	Arg1
0x86	LL

Where LL is the current Light Level % (0x00 – 0x64) of the USQ device dimmer.

9. UPB Message Transmission

The USQ device **shall** be capable of transmitting UPB messages from the powerline.

9.1. Transmit Components

The USQ device uses the concept of Transmit Components (as described in the UPB System Description document) to configure its UPB Link Packet transmission behavior. The USQ device **shall** have eight 5-byte Transmit Components implemented in its non-volatile Configuration Registers as shown in Table 134. The eight Transmit Components are associated with the eight rocker buttons. Each Transmit Component **shall** have an associated Link ID byte that is used when transmitting UPB Link Packets. Each Transmit Component **shall** have associated command bytes for rocker events; one-tap, two-tap, hold, and release.

9.2. Rocker Triggered UPB Transmissions

The rocker switches on the USQ device maybe programmed to trigger transmission of configured UPB Messages to other UPB devices. The USQ device can be configured to transmit UPB Messages whenever any of the defined Rocker Events occur.

9.3. Transmit Components Table

The USQ device uses the concept of Transmit Components (as described in the UPB System Description document) for programming its configurable 1-4 rockers for UPB Transmissions. The USQ device has ten Transmit Components for each rocker pair. See Figure 3.

Figure 3 – Transmit Component Table

Setup Register Field Name	EE Address	Factory Default Values of Rocker Events				
		Link ID	1-Tap	2-Tap	Hold	Release
Upper Rocker#1	0x70 – 0x74	0xFF	ACTIVATE (0x66)	SNAP_ON (0x88)	FADE_UP (0x33)	FADE_STOP (0x44)
Lower Rocker#1	0x75 – 0x79	0xFF	DEACTIVATE (0x55)	SNAP_OFF (0x77)	FADE_DOWN (0x22)	FADE_STOP (0x44)
Upper Rocker#2	0xCA – 0xCE	0x01	ACTIVATE (0x66)	SNAP_ON (0x88)	FADE_UP (0x33)	FADE_STOP (0x44)
Lower Rocker#2	0xCF – 0xD3	0x01	DEACTIVATE (0x55)	SNAP_OFF (0x77)	FADE_DOWN (0x22)	FADE_STOP (0x44)
Upper Rocker#3	0xD4 – 0xD8	0x0A	ACTIVATE (0x66)	SNAP_ON (0x88)	FADE_UP (0x33)	FADE_STOP (0x44)
Lower Rocker#3	0xD9 – 0xDD	0x0A	DEACTIVATE (0x55)	SNAP_OFF (0x77)	FADE_DOWN (0x22)	FADE_STOP (0x44)
Upper Rocker#4	0xDE – 0xE2	0x0B	ACTIVATE (0x66)	SNAP_ON (0x88)	FADE_UP (0x33)	FADE_STOP (0x44)
Lower Rocker#4	0xE3 – 0xE7	0x0B	DEACTIVATE (0x55)	SNAP_OFF (0x77)	FADE_DOWN (0x22)	FADE_STOP (0x44)

Table 15 - Transmit Component Table

The USQ device **shall** implement Transmit Components in its non-volatile EE Configuration Registers as a 40-byte (8 x 5) Transmit Component Tables. The first rocker resides at 70-79 to maintain backward compatibility to the USW single rocker switch.

9.3.1. Transmit Component Table Toggle Feature

The USQ device shall have the ability to support push button toggle feature. The toggle feature is supported by the values in the Transmit Component Table fields; 1-Tap, 2-Tap, Hold, and Release. On each of these actions the USQ firmware shall toggle the upper and lower bit of the respective fields to generate a toggle action. When the upper and lower nibbles of these fields are identical, no toggle action shall be generated.

9.4. 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). If it is assigned an Invalid Link ID then no Rocker 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 Rocker Switch Transmissions.

9.4.1. The Transmit Command IDs

Each Transmit Component record **shall** have four additional bytes that can be assigned a 4-bit Command IDs. There **shall** be a Transmit Command ID byte corresponding to each of the four defined Rocker Events: Single-Tap, Double-Tap, Hold, and Release.

9.5. Using Command IDs

The 4-bit Command ID that gets selected **shall** be used by the USQ device 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 USQ device **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.

9.6. The UPB Transmit Command Table

The USQ device **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 16 shows the UPB Transmit Command Table for the USQ device along with its factory default values. Each three-byte record corresponds to a Command ID value (0 – 14). The USQ device **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 16 - Transmit Command Table

10. Automatic State Report Transmissions

Besides controlling the USQ device's light level and modes of operation, the two Rocker Switches can be configured to trigger transmissions of State Reports whenever they are single-tapped, double-tapped, or released. These Automatic State Reports are perfect for letting home automation controllers know when someone has altered a light level via a rocker switch action.

10.1. Enabling Automatic State Reports

Automatic State Report Transmissions are enabled by setting bit#4 of the Dimmer Options Register (Figure 3). If Automatic State Report Transmissions are enabled the USQ device **shall** build and transmit a State Report message whenever a Rocker Switch is single-tapped, double-tapped, held or released.

10.2. Transmitting Automatic State Reports

The Automatic State Report Transmissions **shall** always be sent in a Link Packet. The Automatic State Report Transmissions **shall** always be directed to the same Network ID as the USQ device is assigned to. The Automatic State Report Transmissions **shall** always be directed to the Broadcast Destination ID (0x00).

The Data field of the Automatic State Report Transmissions **shall** contain a "Device State" Report. The "Device State" Report has a Message Data ID of **0x86** and has the following syntax:

MDID	Arg1
0x86	LL

Where LL is the current Light Level % (0x00 – 0x64) of the USQ device dimmer.

11. Factory Default Operation

This section describes the operation of the USQ device 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 5.7.3.

11.1. Power-Up Operation

Upon power-up the USQ device will enter Normal Mode and will display its current firmware version by blinking its LED four times as described in section 7.1.5. It will then read the saved Reset Light Level from non-volatile memory and set its dimmer's light level to the Reset Light Level at the Default Fade Rate (3.3 seconds). The USQ device will set its LED color to orange and await further events such as Local Rocker Switch Events, Slave Rocker Switch Events, or UPB Communication Packet Receptions.

11.2. Dimmer Operation

The USQ device factory default is for dimming-capable whereby its dimmer can produce 200 different light levels as well as off that it fades between using a pseudo-logarithmic dimming curve. The USQ device factory default value for its Default Fade Rate is 3. With this value, the USQ device will span the lighting range from 0% to 100% in approximately 3.3 seconds. The Default Fade Rate is used whenever the specified Fade Rate is an illegal value (above 15).

11.3. Local Rocker Switch Events

The Local Rocker Switch can be used to change the USQ device dimmer's light level as described in Table 17.

Rocker Event	Dimmer Action (Top Rocker)	Dimmer Action (Bottom Rocker)
Single-Tap	Fade to 100% at the Default Fade Rate.	Fade to 0% at the Default Fade Rate.
Double-Tap	Snap to 100% at Fade Rate #0.	Snap to 0% at Fade Rate #0.
Hold	Start fading to 100% at the Default Fade Rate.	Start fading to 0% at the Default Fade Rate.
Release	Stop fading the Light Level.	Stop fading the Light Level.

Table 17 - Local Rocker Switch Dimmer Actions

The Local Rocker Switch can also be used to put the USQ device into Setup Mode and Factory Default Mode as described in section 5.7

11.4. Slave Rocker Switch Events

The optional Slave Rocker Switch can be used to change the USQ device dimmer's light level as described in Table 18.

Rocker Event	Dimmer Action (Top Rocker)	Dimmer Action (Bottom Rocker)
Single-Tap	Fade to 100% at the Default Fade Rate.	Fade to 0% at the Default Fade Rate.
Double-Tap	Snap to 100% at Fade Rate #0.	Snap to 0% at Fade Rate #0.
Hold	Start fading to 100% at the Default Fade Rate.	Start fading to 0% at the Default Fade Rate.
Release	Stop fading the Light Level.	Stop fading the Light Level.

Table 18 - Slave Rocker Switch Dimmer Actions

The Slave Rocker Switch can also be used to put the USQ device into Setup Mode and Factory Default Mode as described in section 5.7

11.5. UPB Communication Packet Receptions

The USQ device has a factory default Network ID of 255 and a factory default Unit ID of 001. It is capable of handling 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 USQ device also handles the set of UPB Commands described in Table 14.

11.6. UPB Receive Components

The USQ device has 16 Receive Components (called Presets) that are configured for receiving Link Packets addressed to its NID. The factory default Link IDs that the USQ device will accept are Link IDs #1 through #16 as shown in Table 19.

Receive Component	Link ID	Light Level	Fade Rate
Preset #1	001	100%	Default Fade Rate
Preset #2	002	0%	Default Fade Rate
Preset #3	003	80%	Default Fade Rate
Preset #4	004	60%	Default Fade Rate
Preset #5	005	40%	Default Fade Rate
Preset #6	006	20%	Default Fade Rate
Preset #7	007	100%	Default Fade Rate
Preset #8	008	0%	Default Fade Rate
Preset #9	Unused	Unused	Unused
Preset #10	Unused	Unused	Unused
Preset #11	Unused	Unused	Unused
Preset #12	Unused	Unused	Unused
Preset #13	Unused	Unused	Unused
Preset #14	Unused	Unused	Unused
Preset #15	Unused	Unused	Unused
Preset #16	Unused	Unused	Unused

Table 19 - Factory Default Presets

11.7. Activate Link Command Operation

The USQ device has 16 Receive Components (called Presets) that are setup for receiving Link Packets with Link IDs #1 through #16. Each Preset has a Light Level and Fade Rate parameter associated with it that will be "activated" by the Link Activate command. Whenever the USQ device receives a Link Activate command addressed to its NID and one of these Link IDs it will set its dimmer output to the associated Light Level at the associated Fade Rate (see Table 19).

11.8. Deactivate Link Command Operation

The USQ device has 16 Receive Components (called Presets) that are setup for receiving Link Packets with Link IDs #1 through #16. Each Preset has a Light

Level and Fade Rate parameter associated with it that will be "deactivated" by the Link Deactivate command. Whenever the USQ device receives a Link Deactivate command addressed to its NID and one of these Link IDs it will set its dimmer output to 0% (off) at the associated Fade Rate (see Table 19).

11.9. Changing Preset Light Levels

The USQ device has 16 Receive Components (called Presets) that are setup for receiving Link Packets with Link IDs #1 through #16. Each Preset has a Light Level and Fade Rate parameter associated with it. Whenever the USQ device receives a Store State command addressed to its NID and one of these Link IDs it will store its current dimmer Light Level into the associated Light Level parameter of the Preset.

11.10.　　　UPB Communication Packet Transmissions

The USQ device 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). The USQ device factory default setting is for no Rocker Switch Transmissions.