# TABLE OF CONTENTS

1 THE LIGHTGUARD SYSTEM® AND COMPONENTS ........................................................ 2
   1.1 THE LIGHTGUARD SYSTEM® ........................................................................... 2
   1.2 POWER SYSTEM – Flashing Controller Interface .............................................. 2
   1.3 IN-ROADWAY WARNING LIGHT (IRWL) SIGNAL HEAD ................................. 3
   1.4 SYSTEM ACTIVATION; AUTOMATIC/MANUAL/CONTINUOUS/PROGRAM ....... 3
   1.5 LED “ENHANCED” PEDESTRIAN CROSSING SYMBOL SIGN ....................... 3
   1.6 LGS COMPONENTS NEEDED FOR A TYPICAL SMART CROSSWALK™ ......... 4
   1.7 SUGGESTED INSTALLATION EQUIPMENT, MATERI AL S AND TOOLS .......... 5
2 POWER SYSTEM AND COMPONENTS ...................................................................... 6
   2.1 POWER SYSTEM DESCRIPTION ...................................................................... 6
   2.2 TYPICAL LIGHTGUARD SYSTEM® WIRING DIAGRAM .................................... 6
   2.3 AC SYSTEM ....................................................................................................... 7
   2.4 SOLAR SYSTEM ............................................................................................... 9
   2.5 ECP SYSTEM (ECP-1 & ECP-2) ...................................................................... 11
   2.6 ENCLOSURE POLE MOUNT DETAIL ................................................................. 13
   2.7 BACK PANEL ELECTRICAL CONNECTIONS ..................................................... 13
   2.8 POWER CONTROL UNIT (PCU) DESCRIPTION ................................................ 15
3 IN-ROADWAY WARNING LIGHT (IRWL) .............................................................. 21
   3.1 GENERAL DESCRIPTION ................................................................................ 21
   3.2 IRWL SIGNAL AND BASE PLATE INSTALLATION OVERVIEW .................... 21
   3.3 MAJOR CONSIDERATIONS FOR IRWL INSTALLATION ............................... 22
   3.5 CONCRETE INSTALLATION PROCEDURE ....................................................... 30
4 AUTOMATIC ACTIVATION SYSTEM - SMART CROSSWALK™ ................................. 31
   4.1 AUTOMATIC BOLLARD DETECTION SYSTEM DESCRIPTION ......................... 31
   4.2 BOLLARD LAYOUT AND WIRING DIAGRAM (EXAMPLE) ............................. 31
   4.3 BOLLARD INSTALLATION GUIDELINES ........................................................... 32
   4.4 BOLLARD DETECTION ZONE OPERATION VERIFICATION ............................. 34
   4.5 BOLLARD ALIGNMENT ................................................................................... 34
5 PUSHBUTTON ACTIVATION .................................................................................. 37
   5.1 MANUAL PUSHBUTTON ACTIVATION DESCRIPTION ..................................... 37
   5.2 ILLUMINATED PUSHBUTTON ASSEMBLY ..................................................... 37
   5.3 PUSHBUTTON LAYOUT AND WIRING DIAGRAM (EXAMPLE) ...................... 37
   5.4 PUSHBUTTON WIRING TERMINAL BLOCK CONNECTIONS .......................... 38
   5.5 PUSHBUTTON INSTALLATION DETAIL DRAWING ..................................... 38
6 LED “ENHANCED” ILLUMINATED WARNING SIGNS ............................................. 39
   6.1 LED “ENHANCED” SIGN GENERAL DESCRIPTION ........................................ 39
   6.2 LED “ENHANCED” PEDESTRIAN CROSSING SIGN DRAWING .................... 39
7 LIGHTGUARD SYSTEMS SOLAR POWER OPTION ........................................... 40
   7.1 INSTALLATION STEPS ..................................................................................... 40
   7.2 SOLAR MODULE ............................................................................................ 40
   7.3 SOLAR SYSTEM BATTERIES ......................................................................... 42
   7.4 CHARGE CONTROLLER ................................................................................... 43
8 TROUBLE SHOOTING / MAINTENANCE / AFTER INSTALLATION ...................... 44
   8.1 TROUBLE SHOOTING GUIDE ......................................................................... 44
   8.2 FIELD RELATED TOTAL PREVENTATIVE MAINTENANCE ............................ 46
   8.3 FIELD RELATED TOTAL PREVENTATIVE MAINTENANCE ............................ 46
   8.4 EQUIPMENT LIST ............................................................................................ 47
9 ADDENDUMS ........................................................................................................ 48
1 THE LIGHTGUARD SYSTEM AND COMPONENTS

1.1 THE LIGHTGUARD SYSTEM

The LightGuard Systems (the System) is designed for applications at mid-block or uncontrolled intersection crosswalks and other roadway crossings. It is entirely compliant with the MUTCD and in many cases, the MUTCD text was composed with the LightGuard Systems product development and testing in mind.

The System utilizes a series of light emitting diodes (LED’s) in a durable housing embedded in the roadway which flashes, in a unidirectional manner, a warning to approaching motorists that a pedestrian is in or entering the crosswalk. The in-roadway LED warning signals are aimed down the motorist-viewing path of the approaching driver to allow the flashing lights to be easily seen by motorists along the full length of the un-obscured viewing approach path. The lights flash for a set period of time before automatically turning off. The System can be activated by a pedestrian pushing a button, or automatically when a pedestrian passes through an activation zone breaking an optical beam. It can be a stand-alone solar-powered System, or a conventional AC powered System with battery back up.

The LightGuard System™ comprises the following components and all components must work in unison.

1.2 POWER SYSTEM – Flashing Controller Interface

A roadside, or pole mounted, cabinet contains all of the LED drive electronics and field wiring electrical interfaces. Both the AC & the ECP systems operate off a 12 VDC power supply from an AC line. The AC system can be energized from either 115VAC or 230VAC nominal. The ECP can only be energized from 110VAC. The Solar System operates off of 12 VDC nominal battery power and is recharged during daylight hours from a Solar PV panel.

Based on a typical installation, power usage is approximately 18 - 20 watts depending on the type of activation mechanism. Total energy consumed (in KWH) is dependent upon the number of light fixtures, the cross time duration, and the number of activations. Circuit breakers protect internal circuitry and field wiring. The Power Control Unit (PCU) available in the AC & Solar Systems is based on a high speed 8 bit embedded microcontroller utilizing a compiled machine control language. LGS proprietary software program provides effective, reliable operation allowing the user simple operation adjustments with a keypad and display (LCD).
1.3 IN-ROADWAY WARNING LIGHT (IRWL) SIGNAL HEAD

The LightGuard System™ In-Roadway Warning Light signal heads are manufactured of high strength impact resistant materials. They are designed to be mounted onto a metal or composite base plate assembly that is permanently attached to the roadway. This allows for easy replacement of any IRWL that may become damaged, or inoperable, for any reason.

1.4 SYSTEM ACTIVATION; AUTOMATIC/MANUAL/CONTINUOUS/PROGRAM

1.4.1 AUTOMATIC ACTIVATION- Bollards
For AUTOMATIC activation, the System uses state-of-the-art electronic and software driven technology. The Smart Crosswalk™ automatic system is a dual break-beam system utilizing modulated infrared sensors housed in decorative posts, or Bollards, at each side of the crosswalk. Direction of pedestrian travel is detected and allows activation of the System only upon entry, not when exiting. Custom designed Bollards house the drive electronics for automatic activation. They can be positioned up to 50 ft. (15m) apart.

1.4.2 MANUAL ACTIVATION - Pushbutton or optional Key Switch operation
A standard pushbutton assembly may be installed to MANUALLY activate the System. When the pedestrian pushes the button, an “ON” response from the System is immediately visible via flashing LED lights above the words “CROSS WITH CAUTION”. As an added benefit, the PCU automatically monitors frequency and direction of use. Other activation options include pre-set on-off times or Key Switch activation with a set “on” time operation. Keypad functions allow for up to three (3) automatic on-off times for each day of the week.

1.4.3 CONTINUOUS – CONSTANT ON
The Illuminated crosswalk system can be set for continuous flashing 24/7. This is NOT recommended for solar powered systems due to the continuous power drain affecting battery recharge.

1.4.4 PROGRAMMABLE – Pre-set on/off timer
The Illuminated crosswalk system can be programmed to activate for a predetermined duration with 3 different start stop times up to 7 days per week. Refer to section 2.8.4.11 for instructions.

1.5 LED “ENHANCED” PEDESTRIAN CROSSING SYMBOL SIGN

Fluorescent-yellow-green color (FYG), diamond-shaped pedestrian crossing sign (W11-2) with LED warning light modules at the “enhanced” flash rate is recommended with each System (FYG S1-1 type school symbol sign also available). The LED warning light modules are designed to flash in conjunction with activation of the System. This active LED pedestrian crossing sign enhances driver recognition of the System’s presence, especially in adverse weather conditions, and contributes to educating the motorist as to the meaning of the flashing array of in-roadway warning signals. The illuminated W11-2 sign, with the LightGuard embedded LED warning light module is a replacement for the standard W11-2 sign typically placed at the crosswalk site.
## 1.6 LGS COMPONENTS NEEDED FOR A TYPICAL SMART CROSSWALK™

<table>
<thead>
<tr>
<th>Item</th>
<th>Qty</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical Required Equipment</strong> <em>(Quantities based on 4 lane crossing)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td><strong>Flashing Unit Interface Controller</strong> <em>(PCU or ECP)</em> High speed 8 bit embedded microcontroller (PCU has keypad, LCD, &amp; serial port). Both include timer duration mechanism &amp; LGS’s proprietary software program.</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td><strong>Electronics Enclosure</strong> The enclosure is sized to allow mounting of all components necessary to control the System. The enclosure’s water-resistant design is based upon the NEMA specifications.</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td><strong>In-Roadway Warning Lights</strong> The In-roadway Warning Signal assemblies are street-mounted to withstand normal vehicle traffic. The patent protected assemblies, including base plates, are a LGS proprietary design</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td><strong>Automatic Activation Bollards</strong> Pedestrian detection Bollards are located at each crosswalk entrance. Optical beam interruption sensors are designed to automatically activate the Smart Crosswalk™ System</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td><strong>LED Enhanced Pedestrian Symbol Warning Sign</strong> The fluorescent-yellow-green (FYG) color, diamond shaped pedestrian warning sign (W11A-2) contains LED warning light modules designed to flash at the same flash rate &amp; in conjunction with activation of the LightGuard System™.</td>
</tr>
<tr>
<td>6</td>
<td>LOT</td>
<td><strong>Mount Assemblies</strong> LGS approved standard mount assemblies are sized and configured appropriately to allow mounting of the enclosure, automatic activation sensors, LED enhanced signs, Tamper resistant hardware is recommended but not included</td>
</tr>
<tr>
<td>7</td>
<td>LOT</td>
<td><strong>Signal Head Spare Parts</strong> Gel-plugs and O-ring.</td>
</tr>
<tr>
<td>8</td>
<td>LOT</td>
<td><strong>Cable/wiring</strong> LGS approved multi-strand 8 conductor wiring *(BELDEN 28601A), 18 AWG, to connect the activation assemblies to the System PCU. Stranded wire, 14 AWG, type RHW-2/USE-2/XLP *(3 individual conductor colors – BLK, YEL, &amp; RED), maximum OD 0.17” <em>(4.3 mm) can be provided to connect the IRWL to the PCU.</em></td>
</tr>
<tr>
<td>9</td>
<td>LOT</td>
<td><strong>Epoxy</strong> LGS approved 2 part Epoxy <em>(either BONDO 7084 or DSB)</em>. Epoxy mixing &amp; dispensing equipment not provided - refer to section 3.2.7.</td>
</tr>
<tr>
<td>10</td>
<td>LOT</td>
<td><strong>Loop sealant</strong> LGS approved loop sealant <em>(DSB 900)</em> mixing &amp; dispensing equipment not provided.</td>
</tr>
<tr>
<td>11</td>
<td>LOT</td>
<td><strong>Backer Rod</strong> LGS approved Backer Rod</td>
</tr>
</tbody>
</table>

### Optional or Alternate Equipment

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td><strong>Solar Power Assembly and Enclosure</strong> Includes crosswalk flashing controller, Solar Panel with pole mount, battery charge controller <em>(amp/load)</em>, sealed solar cell batteries, battery &amp; solar panel cables, branch circuit protection.</td>
</tr>
<tr>
<td>13</td>
<td><strong>ECP Assembly and Enclosure</strong> ECP Assembly includes flashing unit controller</td>
</tr>
<tr>
<td>14</td>
<td><strong>AC Beacon Interface</strong> Modified PCU &amp; DIN Rail connections for 2 separate 115VAC relays operating in either wig-wag or continuous mode</td>
</tr>
<tr>
<td>15</td>
<td><strong>DC Beacon Interface</strong> Modified PCU &amp; DIN rail connections for 2 separate 12VDC relays operating in either wig-wag or continuous mode</td>
</tr>
<tr>
<td>16</td>
<td><strong>Audible crosswalk Interface</strong> Modified PCU and DIN rail connections for various audible systems <em>(voice, chirp, tweet, etc.)</em></td>
</tr>
<tr>
<td>17</td>
<td><strong>Dual Zone Upgrade Kit</strong> Modified PCU &amp; DIN rail connections for 2 independent cross walk zones <em>(activates flashing at 2 separate crosswalks)</em></td>
</tr>
<tr>
<td>18</td>
<td><strong>RRFB</strong> Rectangular Rapidly Flashing Beacons</td>
</tr>
<tr>
<td>19</td>
<td><strong>RAD</strong> Remote Activation Device <em>(compact form Automatic Directional Detectors)</em></td>
</tr>
</tbody>
</table>
1.7 SUGGESTED INSTALLATION EQUIPMENT, MATERIALS AND TOOLS

The general list below may include all equipment, materials, or tools required for installation.

Typical electrical tools used in street lighting and signal work

<table>
<thead>
<tr>
<th>Tool Description</th>
<th>Tool Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inch pound torque wrench</td>
<td>2 Putty knives x 4” (100mm) wide</td>
</tr>
<tr>
<td>End wrenches &amp; sockets</td>
<td>Cordless drill with assorted bits 0.250” (6.3mm) to 1” &amp; hole saws 1” &amp; 1½” (25mm &amp; 38mm)</td>
</tr>
<tr>
<td>Crescent wrenches</td>
<td>Rotor hammer – 1” bit &amp; 1½” bit</td>
</tr>
<tr>
<td>Allen wrenches</td>
<td>Skill saw &amp; blades</td>
</tr>
<tr>
<td>Hammers - 3 lb. (1.5kg) &amp; claw</td>
<td>Small hand held grinder</td>
</tr>
<tr>
<td>Hack saw, File, &amp; Knife</td>
<td>Latex gloves – disposable</td>
</tr>
<tr>
<td>Wire strippers</td>
<td>AC DC meter</td>
</tr>
<tr>
<td>Slip Joint Channel Lock Pliers</td>
<td>Container for mixing two part epoxy</td>
</tr>
<tr>
<td>Chisel</td>
<td>24” long drum mixer for viscous material</td>
</tr>
<tr>
<td>1/8” hex socket</td>
<td>Variable speed high torque drill (AC powered) for mixing. Battery powered NOT recommended</td>
</tr>
<tr>
<td>Taps &amp; Dies</td>
<td></td>
</tr>
</tbody>
</table>

- 100 ft (30m) measuring tape - Duct Seal
- Black & red electrical tape - Fish tape
- Core Drill: Standard Core Drill or Custom “Flat Bottom” Core Drill. Contact LightGuard Systems for more information about availability.

- Air-blower (compressor) - Wheelbarrow
- Broom & dust pan - Shovel – square point & round point
- 1 Hose - garden type & fire hydrant adaptor - Rope

- Cut-off saw, mixed fuel, & spare blades - 6 sack mortar mix (base of poles & boxes)
- Conduit sealer - 90lb (40kg) sack of sand
- 5-gallon (20L) pail of ¾” (19mm) rock for under traffic valve boxes
- Generator, with extension cord, for auxiliary power
- Power driven asphalt (saw) cutter capable of cutting ½” (12mm) wide x 2” (50mm) deep
- 1¼” (32mm) minimum conduit as required by local agency (sizes can be determined by site engineer)
- Reel wire holder ½” (12mm) diameter x 36” (1m) long on stand (optional)

- ALL NECESSARY EQUIPMENT FOR IMPLEMENTING AN APPROVED TRAFFIC CONTROL PLAN
2 POWER SYSTEM AND COMPONENTS

2.1 POWER SYSTEM DESCRIPTION

An AC powered system uses either 115VAC nominal or optional 230VAC nominal as an energy source. A DPST 5A circuit breaker protects both the Line and Neutral for single line OR both Lines for line-line input. The AC power is transformed to 12VDC nominal via a 150W power supply. The 5A DPST circuit breaker is marked by the factory for both Line & Neutral, with one pole of the 5A DPST circuit breaker labeled “hot black” and the other labeled “neutral white”. For line-line operation, the label marked “neutral white” must be removed or otherwise placard over & the power supply switch must be reset to 230V prior to energizing the main 5A DPST circuit breaker on the back panel. The switch setting is normally factory configured for 115VAC & MUST BE RESET at time of installation for 230VAC source. Refer to section 2.3.3 for switch location.

A Solar powered system uses a minimum 75W Photovoltaic array providing DC power to the internal batteries. All branch circuits have their own independent circuit protection in the Electronics Enclosure.

An ECP system uses 115VAC as an energy source. A DPST 5A circuit breaker protects both the Line and Neutral. The AC power is transformed to 12VDC nominal via a 150W power supply.

2.2 TYPICAL LIGHTGUARD SYSTEM® WIRING DIAGRAM

NOTE: This is a reference diagram only, connections shown are not applicable to all installations.
2.3 AC SYSTEM

2.3.1 AC ENCLOSURE DESCRIPTION

The hasp latch locking enclosure is included with the LightGuard System®. The Aluminum enclosure (UL 50 standards and NEMA 3R) & Fiberglass Enclosure (NEMA 6) contains the control panel components and can be mounted to a pole or wall. Adjustable mounting brackets are provided with enclosure (mounting hardware not included, specific hardware to be supplied by installer). The all aluminum enclosure (*no longer stock item – special request only*) comes standard with a white powder coat finish & contain knock-outs on the rear for ½” NPT connectors (refer to sections 2.3.2 & 2.4.2).

2.3.2 AC ENCLOSURE OUTLINE DRAWING

2.3.3 AC BACK PANEL LAYOUT
2.3.4 AC BACK PANEL SCHEMATIC
2.4 SOLAR SYSTEM

2.4.1 SOLAR ENCLOSURE
Solar powered Systems are free-standing pedestal mount or pole mount enclosures. Aluminum cabinets contain knock-outs on the rear for ½” NPT connectors (refer to sections 2.3.2 & 2.4.2).

2.4.2 SOLAR BACK PANEL LAYOUT

[Diagram of solar panel layout with labels for BATTERY CHARGE CONTROLLER, PCU (Power Control Unit), TERMINAL BLOCKS, and CIRCUIT BREAKERS]
2.4.3 SOLAR BACK PANEL SCHEMATIC
2.5 ECP SYSTEM (ECP-1 & ECP-2)
The ECP system differs from the AC & SOLAR systems in several ways. All user INPUT connections are made directly to the Flashing Unit Controller Subassembly. This system is NOT field programmable, only cross time is user selectable. Refer to section 2.5.4 for additional information.

2.5.1 ECP ENCLOSURE
The enclosure is a NEMA4X Fiberglass structure designed for wall or pole mounting only. Uni-strut brackets are provided with enclosure (mounting hardware not included, specific hardware to be supplied by installer). Electrical connections can be made by drilling access holes either on the bottom or the lower region on the rear of the enclosure. The enclosure has sufficient clearance to support up to one 1½” NPT connector on the rear, and several 1½” NPT connectors on the bottom. The standard enclosure color is white.

2.5.2 ECP BACK PANEL LAYOUT
2.5.3 ECP BACK PANEL SCHEMATIC

2.5.4 ECP FLASH UNIT PARAMETER ADJUSTMENTS

The ECP-1 has only one field adjustment, setting the cross time flash duration. This is set by rotating the selector knob to the number of seconds required for the system to flash once activated. Cross time can be set from 5 seconds to 100 seconds. The ECP will operate with Bollards &/or Pushbuttons. Status indicator lights on the Flashing Unit Controller Subassembly show an input activation & the output flashing activation. There is also an LED to indicate that the system is energized. Lastly, there is a test button which can be used for in-cabinet testing of the ECP System.

The ECP-2 can be factory configured for 2 independent outputs each triggered from any of the activation inputs. This system is customizable but with limitations. Contact LightGuard Systems for specific custom configurations (ie: dual color IRWL and/or DC beacons with alternating flash patterns).
2.6 ENCLOSURE POLE MOUNT DETAIL

All enclosures can be pole mounted using supplied Uni-strut brackets and appropriate hardware. The ECP, AC, & SOLAR Systems use the identical brackets.

2.7 BACK PANEL ELECTRICAL CONNECTIONS

AC & SOLAR SYSTEMS
The AC & Solar back panels incorporate the system Power Control Unit (PCU), circuit breakers, and backup battery charge controller. The PCU is field programmable & controls both signaling and timing functions. The battery charge controller sequences battery charging and low voltage load disconnect.

ECP SYSTEM
The ECP back panel incorporates the ECP flash unit, circuit breakers, and DC power supply.
2.7.1 TERMINAL BLOCK CONNECTION DEFINITIONS (DC ONLY +12VDC & 0VDC)

**SYSTEM INPUTS (DC ONLY)**
- 1A: Bollard Sensor 1st call signal side 1 (Bollards closest to enclosure)
- 1B: Bollard Sensor 2nd call signal side 1
- 2A: Bollard Sensor 1st call signal side 2 (Bollards farthest from enclosure)
- 2B: Bollard Sensor 2nd call signal side 2
- PA: Normally open line from Pushbutton assembly closest to enclosure
- PB: Normally open line from Pushbutton assembly farthest from enclosure

**SWITCHED 12VDC OUTPUT (Enlighten1 pulse rate)**
- S+: In-roadway Warning Signal YEL &/or RED wire depending on IRWL color. (minimum 2 terminals provided)

**CONSTANT CURRENT SOURCE (12VDC Output For Use With Bollards Only)**
- B+: Bollard area LED courtesy lights & Sensor Power (minimum 2 terminals provided)

**DC GROUNDS (0 VDC)**
- GND: In-roadway Warning Signals DC Ground/Common
- Pushbutton DC Ground/Common
- Bollard Power DC Ground/Common
- LED Pushbutton Placard DC Ground/Common
- LED “Enhanced” Illuminated Pedestrian Symbol Crossing sign DC Ground/Common

2.7.2 TYPICAL CONTROL PANEL TERMINAL BLOCK CONNECTION DIAGRAM

**ENCLOSURE TERMINAL BLOCK CONNECTIONS FOR IN-ROADWAY WARNING LIGHT SIGNALS:**

```
1 1 2 2 P P S S B B G G G G
A B A B A B + + + + N N N N
D D D D
```

*NOTE: ALWAYS USE 14 AWG WIRING, TYPE RHW-2/USE-2/XLP MAX OD .17" (4.3mm) APPROVED BY LOCAL AGENCY FOR IN-ROADWAY WARNING SIGNAL ARRAY HOME RUN CONNECTION. S+ POSITIVE CONDUCTOR COLOR IS DEPENDANT ON IRWL COLOR – RED IS USED FOR RED IRWL, YEL IS USED FOR YEL IRWL. FOR ACTIVATION MECHANISM, ALWAYS USE 8 CONDUCTOR 18 AWG STRANDED SIGNAL CABLE TO RUN FROM ENCLOSURE TO OPPOSITE SIDE OF STREET.*
2.8 POWER CONTROL UNIT (PCU) DESCRIPTION

The PCU is based on a high-speed 8 bit embedded microcontroller utilizing compiled machine control language. A LightGuard proprietary software program provides effective, reliable operation allowing the user to make simple adjustments to the System parameters with a keypad and liquid crystal display (LCD).

2.8.1 TYPICAL POWER CONTROL UNIT (PCU) DRAWING

2.8.2 POWER CONTROL UNIT (PCU) PARAMETER ADJUSTMENTS

The PCU is pre-programmed with easily adjustable parameters. To operate the System manually flip all circuit breaker switches up to “ON” position. All functions are accessible from the keypad. A high-contrast liquid crystal display (LCD) indicates the settings. Pressing a key will display data or a parameter on the LCD. Some keys will access a list of parameters. If no change is desired, press the “#” key to escape or advance to the next parameter in that list. Pressing the “#” key can also escape from a partially entered value. Each parameter has a required number of digits. The required number must be entered or the number will default back to existing number.

The POWER CONTROL UNIT (PCU) KEYPAD FUNCTIONS TABLE describes programming the PCU using the keypad and display. Generally when a menu is accessed using one of the numeric keys, the user must complete all entries within that menu before the PCU will accept other menu parameter inputs. In many cases, the # key will act as a “next” function advancing the menu without changing the existing parameter in program memory. There is no “escape” key to undo keypad entries. If a keypad error is made, the user must complete that function menu & then repeat that function menu with correct keypad entries.
Additional notes

**INITIATING THE SYSTEM** – When the PCU is energized for the first time, a message should display on the LCD with instructions to contact LightGuard Systems Inc. for an ACTIVATION CODE. This code is used for both system installation tracking & warranty tracking purposes.

**CROSS TIME** - **Refer to local governing agency for System activation / crossing time.** Cross time is set in seconds (PCU is pre-programmed with 20 seconds as a factory default). Cross time is entered in 2 digit increments using the numeric keypad. Typical cross time duration is based on pedestrians walking speed being 2 feet to 3 feet per second. Slower pedestrians require more time than faster pedestrians. A generic formula to compute a typical cross time is to divide the length of the crosswalk (width of the street) by either 2 or 3. Cross time should be set by the installer after observing pedestrian patterns.

An example of a 60 foot long crosswalk: 60’ ÷ 2’ per second = 30 seconds

**FACTORY SETTINGS** - The system is preset with a cross time of 20 seconds, the activation counts are set to Zero, & the date/time are set for PST, system default is Single Zone Mode.

**ACTIVATION COUNT DISPLAY** - When the system is in Activation Count Display Mode (LCD shows the number of activations for either Bollards or pushbuttons), the system is in “a sleep state”. System activation WILL NOT occur (IRWL will not operate) until the activation count display mode is toggled off by pressing either 1 or 3 on the keypad respectively (software version 1.4 & earlier). When using software version 1.5 & later, activation count display mode will end after 1 minute to allow normal operation.

**DOWNLOADING PCU MEMORY** – PCU memory contains a limited number (approximately 65,000) of “date/time stamped” activation counts, diagnostics, & “power-up” events. The data is accessible using a computer connected to the appropriate port via RS232. Refer to addendum procedure for correct steps. This feature is available in software version 1.5 & higher.

**SYSTEM ACTIVATION DISPLAY** – When the system has been activated, the LCD will indicate a countdown of the remaining cross time until the Enlighten1™ flashing sequence ends. This feature is compatible with software version 1.6.7 and higher.

**REMOTE COMMUNICATIONS** – The PCU is designed for remote communication via the RS232 port. When operated in Terminal Mode, the remote terminal will echo many of the PCU LCD commands and text as well as some system diagnostics. Also while in Terminal Mode, the remote terminal keyboard will operate all of the PCU keypad functions. Refer to addendum procedure for remote connections. This feature is compatible with software version 1.7 and higher.

**SINGLE/DUAL ZONE MODE** – The PCU is capable of supporting both Single & Dual Zone Modes (whether or not the peripheral hardware for the Dual Zone Mode is physically connected to the PCU). The system default on “power up” is Single Zone Mode. Each time power is recycled to the PCU, the system will revert to Single Zone Mode operation. If Dual Zone Mode is required, pressing the keypad 2 will toggle into Dual Zone Mode. Single zone can be re-selected either by pressing keypad 2 again or by cycling power to the PCU. The mode can be verified (displayed on the LCD) using the keypad *. Refer to Dual Zone Installation Manual Addendum for further information. This feature is available in software version 1.7 & higher.

**Custom functions available only on request**
### 2.8.3 POWER CONTROL UNIT (PCU) KEYPAD FUNCTIONS TABLE (software v 1.7.X)

<table>
<thead>
<tr>
<th>Function</th>
<th>Keypad Press</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear all the Counters (Note: manually record counters prior to resetting to zero)</td>
<td>0 → 555</td>
</tr>
<tr>
<td>Display number of BOLLARD system activations (for Bollard pairs 1, 2, 3, &amp; 4)</td>
<td>1 → # to close</td>
</tr>
<tr>
<td>Display number of PUSHBUTTON system activations (for PB’s: A, B, C, &amp; D)</td>
<td>3 → # to close</td>
</tr>
<tr>
<td><strong>Set Cross Time</strong> Enter cross time in 2 digit increments up to 99 seconds. <strong>ZONE 1 - Bollards 1&amp;2 Pushbuttons A&amp;B</strong></td>
<td></td>
</tr>
<tr>
<td><strong>ZONE 2 - Bollards 3&amp;4 Pushbuttons C&amp;D</strong> (requires custom PCU and software setting for Single/Dual Zone mode operation)</td>
<td></td>
</tr>
<tr>
<td>Set Calendar &amp; 3 Scheduled Activations (Auto Time 1, 2, &amp; 3)</td>
<td>5</td>
</tr>
<tr>
<td>1st Scheduled Activation</td>
<td></td>
</tr>
<tr>
<td>Set Auto Time 1 ON Use 4 digits, i.e. 09:30 (24 HOUR CLOCK)</td>
<td>4 → 2 DIGITS</td>
</tr>
<tr>
<td>Set Auto Time 1 OFF Use 4 digits, i.e. 09:40 (24 HOUR CLOCK)</td>
<td>7 → 2 DIGITS</td>
</tr>
<tr>
<td>Set Days Active press combination of 0 &amp; 1 for each day of the week SMTWTFS - 0 for inactive day or 1 for active day</td>
<td>7 DIGITS (0 or 1)</td>
</tr>
<tr>
<td>2nd Scheduled Activation</td>
<td></td>
</tr>
<tr>
<td>Set Auto Time 2 ON Use 4 digits, i.e. 12:30 (24 HOUR CLOCK)</td>
<td>4 DIGITS</td>
</tr>
<tr>
<td>Set Auto Time 2 OFF Use 4 digits, i.e. 12:40 (24 HOUR CLOCK)</td>
<td>4 DIGITS</td>
</tr>
<tr>
<td>Set Days Active press combination of 0 &amp; 1 for each day of the week SMTWTFS - 0 for inactive day or 1 for active day</td>
<td>7 DIGITS (0 or 1)</td>
</tr>
<tr>
<td>3rd Scheduled Activation</td>
<td></td>
</tr>
<tr>
<td>Set Auto Time 3 ON Use 4 digits, i.e. 15:30 (24 HOUR CLOCK)</td>
<td>4 DIGITS</td>
</tr>
<tr>
<td>Set Auto Time 3 OFF Use 4 digits, i.e. 15:40 (24 HOUR CLOCK)</td>
<td>4 DIGITS</td>
</tr>
<tr>
<td>Set Days Active press combination of 0 &amp; 1 for each day of the week SMTWTFS - 0 for inactive day or 1 for active day</td>
<td>7 DIGITS (0 or 1)</td>
</tr>
<tr>
<td>Pedestrian Detectors in/out Service</td>
<td>turn power on or off to all Bollards using keypad 6 to alternate between on &amp; off</td>
</tr>
<tr>
<td>Single/Dual Zone mode</td>
<td>toggles software between single zone and dual zone modes. The software MUST be in Single Zone mode for all inputs to activate ZONE ONE.</td>
</tr>
<tr>
<td>All Outputs on Constant Blink</td>
<td>using keypad 9 to alternate between on &amp; off</td>
</tr>
<tr>
<td>Display <strong>Software Version</strong></td>
<td>*</td>
</tr>
</tbody>
</table>
2.8.4 POWER CONTROL UNIT (PCU) DETAILED KEYPAD INSTRUCTIONS (software v 1.7)

The following detailed instructions for using the keypad and display is organized by function. The text on the left describes the key-presses and programming process step, and the text on the right is what is actually shown on the PCU display.

2.8.4.1 1ST TIME START UP

To activate the system for the 1st time, a start code is required. This start code can be obtained by contacting LightGuard Systems using the phone number shown in the display.

<table>
<thead>
<tr>
<th>1st time start up Display</th>
<th>Call 1-888-247-2974 or Enter Start Code:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key-in the correct 3 digit start code. Keying in the 1st digit will overwrite the existing display. Each successive digit will overwrite the previous digit. Example shown is typing in Start Code 123</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

2.8.4.2 DEFAULT DISPLAY

The Default Display will be visible at all times unless another menu is currently activated. After a short period of inactivity, the system will generally revert back to the Default Display (exceptions are constant flash mode & fault conditions) to accept keypad inputs.

| The example shown is April 1 2009 @ 9:51A | LightGuard Systems 04/01/09 09:51:05 |

2.8.4.3 SOFTWARE VERSION

The system will show the software version & zone mode from the internal micro controller.

| To display the software version Press *. The example shown is version 1.7.4 in Single Zone Mode | SW version 1.7.4 Single Zone Mode |

2.8.4.4 CHANGE CROSS TIME

The Factory Default Cross Time is set to 20 seconds.

| To Set Cross Time for Zone 1, Press 4 to open the menu & then 2 digits to set new time (example 15 sec) | Zone 1 Cross Time=20 New Time is 15 |
| To Set Cross Time for Zone 2, Press 7 to open the menu & then 2 digits to set new time (example 25 sec) | Zone 2 Cross Time=20 New Time is 25 |

2.8.4.5 CLEAR ALL THE COUNTERS

| To Clear all the counters: Press 0 to open the menu | Press 555 to Zero Counters & Log: |
| Then press 555 | Press 555 to Zero Counters & Log: 555 |
| Clear counters Message will briefly display | Counters are Set to Zero |
2.8.4.6 **DISPLAY BOLLARD ACTIVATION COUNTS**

To Display the number of Bollard system activations (Bollard pairs 1, 2, 3, 4), press 1 to open the menu. The example shows 12,345 call signals received from each of the Bollard pairs.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>12345</td>
</tr>
<tr>
<td>#2</td>
<td>12345</td>
</tr>
<tr>
<td>#3</td>
<td>12345</td>
</tr>
<tr>
<td>#4</td>
<td>12345</td>
</tr>
</tbody>
</table>

2.8.4.7 **DISPLAY PUSHBUTTON ACTIVATION COUNTS**

To Display the number of pushbutton system activations (buttons A,B,C,D), press 3 to open the menu. The example shows 12,345 call signals received from each of the Bollard pairs.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>#A</td>
<td>12345</td>
</tr>
<tr>
<td>#B</td>
<td>12345</td>
</tr>
<tr>
<td>#C</td>
<td>12345</td>
</tr>
<tr>
<td>#D</td>
<td>12345</td>
</tr>
</tbody>
</table>

2.8.4.8 **BOLLARD POWER ON/OFF**

The power to the Bollards can be toggled off/on using the keypad.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ped Detectors</td>
<td>OUT OF SERVICE</td>
</tr>
<tr>
<td>Ped Detectors</td>
<td>IN SERVICE</td>
</tr>
</tbody>
</table>

2.8.4.9 **CONSTANT FLASH**

The flashing outputs can be set to activate continuously.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant Flash Mode</td>
<td>Press 9 to End</td>
</tr>
</tbody>
</table>

2.8.4.10 **CALENDAR SETTING**

The calendar menu is linked / integrated into the auto-time activation feature menu. Once this menu is initiated, there is no “back” capability. If a mistake is made in keying, either finish the menu sequence & then repeat the entire process with correct keying or turn the power off/on for system reset. In general, press * to advance the menu without having to input prompted data.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Set Time?</td>
<td>☐</td>
</tr>
<tr>
<td>Enter Time using 24 hour clock. Example showing current time 13:11 (1:11 PM)</td>
<td>Time: 13:11</td>
</tr>
<tr>
<td>Example showing current time 13:11 (1:11 PM) changing to 0953 (9:53AM)</td>
<td>Time: 13:11</td>
</tr>
<tr>
<td>New Time Message will briefly display</td>
<td>TIME: 09:53</td>
</tr>
<tr>
<td>Press # to enter the date</td>
<td>☐</td>
</tr>
<tr>
<td>Enter date using 6 digits MMDDYY format</td>
<td>Date: 04/01/09</td>
</tr>
<tr>
<td>Example showing current date April 1 2009 changing to January 1, 2010</td>
<td>Date: 04/01/09</td>
</tr>
</tbody>
</table>
New Date Message will briefly display  
Date: 01/01/10

Press # to enter the day of the week
# = yes / * = no
Set Day? □

Enter a number to represent the day of the week using a single digit 1 through 7
Day # is: 6
NEW # (SUN=1) □

Example showing current day of the week is Friday changing to Wednesday
Day # is: 6
NEW # (SUN=1) 4

New Day Message will briefly display
Day: 4

The AutoTime setting prompt will display. Press * to advance the menu without setting AutoTime. Press # to set AutoTime.
# = yes / * = no
Set Zone 1 AutoTimes

2.8.4.11 AUTO TIME

After the calendar has been set, the menu will continue for setting up automatic activations at specific times. This feature is referred to as Auto Time. There are 3 different Auto Time settings available. To bypass this part of the menu, pressing * will advance thru the successive prompts until the Default Display is shown. To program the controller for Auto Time, follow the steps below.

Press # to set up Automatic Activations based on schedule. This example shows how to program the system for Zone 1 activations from 7:00A-8:30A on Monday Wednesday & Friday. Note that the same sequence is used for programming Zone 2.

Auto Times Setting Message will briefly display
Zone 1
AutoTime Settings

Then the prompt to Enter a Start Time will display
Time 1 ON: 00:00
NEW Time 1 ON: □

Set a Start time for 1st Auto activation to 7:00A
Time 1 ON: 00:00
NEW Time 1 ON: 0700

New Start Time Message will briefly display
Time 1 ON: 0700

Then the prompt to Enter a Stop Time will display
Time 1 OFF: 00:00
NEW Time 1 OFF: □

Set a Start time for 1st Auto activation to 8:30A
Time 1 OFF: 00:00
NEW Time 1 OFF: 0830

New On Time Message will briefly display
Time 1 OFF: 0830

Then a prompt will appear to program the days this scheduled activation will occur.

Days Active#1:0000000
NEW SMTWTFS: □

Keying in a 1 means that auto time is set for that day, a 0 means no auto time that day. The example shows auto times for Monday Wednesday & Friday only.

Days Active#1:0000000
NEW SMTWTFS: 0101010

Then a message briefly displays showing the days that have been set to activate.

Days Active#1:0101010

The menu process steps for Auto Time will repeat for EACH of the other 2 auto time activations. These process steps can also be repeated for Zone 2 as required / if applicable.
3 IN-ROADWAY WARNING LIGHT (IRWL)

3.1 GENERAL DESCRIPTION

The LightGuard System® In-Roadway Warning Light (IRWL) LED light fixture is made of a high strength plastic composite. It is designed for mounting into a base plate assembly that is permanently attached to the roadway. This allows for any in-roadway warning light fixture that may become damaged, or inoperable for any reason, to be easily repaired with a plug-in replacement.

IN-ROADWAY WARNING LIGHT (IRWL) TYPE-9X ASSEMBLY

General Performance Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Typical Mounting</th>
<th>Base Plate Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility</td>
<td>± 22.5° Horiz</td>
<td>SD-10C (composite)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+10° Vert</td>
<td>CHS-14 (steel)</td>
<td></td>
</tr>
<tr>
<td>Operating Temp</td>
<td>-20° to +80°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Voltage</td>
<td>9VDC to 15VDC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC Current @ 12VDC</td>
<td>0.1 Amps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg Power Dissipation</td>
<td>1.5 watts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luminous Intensity</td>
<td>252,000 mcd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>Polyurethane/Nylon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Housing Color</td>
<td>Black</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.2 IRWL SIGNAL AND BASE PLATE INSTALLATION OVERVIEW

**NOTE:** Correct Placement of Bases is CRITICAL to System Performance

**Step 1** - Determine placement and site angles of in-roadway warning signals to intersect at optimum driver viewing zone as specified by Signal Alignment Drawing (refer to sections 3.3.1 & 3.3.2 & 3.3.3 & 3.3.4). Signal assemblies can be manually aimed, but laser site method is optimal.

**Step 2** - Perform saw cuts using pavement cutting device in accordance with predetermined layout to facilitate hook-ups through bottom of base plate to terminal connection points. Cuts should be ½” (12mm) wide in accordance with the CA Standard Plan ES-5A, or local standards, with a depth of 2” to 2½” (50mm to 63mm) for direct burial of wire (see section 3.3.6).

**Step 3** - Provide depression cut-out for base plates approximately 1 3/8” (35mm) ± 1/8” (3mm) deep on concrete or asphalt. Depression cut-out should be ¼“ to ½” (6mm to 12mm), slightly larger than base plate. Depression cut-outs should be level, or even, to conform to the existing approach grade of the roadway. see section 3.3.5

**Step 4** - If required, dig out for traffic electric hand hole boxes and install boxes for wiring access points at predetermined locations in accordance with the CA Standard Plan ES-5E, or local standards.

**Step 5** - Install all necessary wire to predetermined connection points and lay in cleared roadway cuts. Using duct seal or equivalent, create a temporary "epoxy dam" at the interface where the saw cuts enter/exit the depression cut area. The epoxy dam will temporarily hold down the wires & simultaneously dam the core drill area to prevent flow of epoxy back into the saw cut.
Step 6 - Check for proper site distance angles and level depth of base plate. Mark alignment on roadway for base plate focus direction. Top of base plate (circumferential edge shown in section 3.3.6) should be flush or slightly below (less than .10” = 2.5mm) roadway surface AND free from excess adhesive (See section 3.3.6).

Step 7 - Using an AC powered drum mixer, mix only enough 2-part epoxy (see section 1.6) for 2 to 3 base plates, since Epoxy working life is approximately 10 minutes. Surfaces should be cleaned of dirt or debris, and dry before applying adhesive. Ensure that wires are vertical in the center of the depression cut. Pour epoxy into depression cut approximately ¼” (6mm) depth. Pull wire through center hole in base plate. Secure base plates to roadway surface by pressing the base plate into the epoxy in the depression cut. Ensure that epoxy flows around the outside diameter of the base plate and slightly around the wires emerging from the center hole of the base plate, but DOES NOT fill the base plate. Ensure that epoxy fills outside diameter of base plate up to grade level. Ensure that the base plate is aligned with the mark made in step 6 above and is aimed vertically toward the zone of convergence prior to epoxy curing. Allow minimum of 30 minutes of epoxy cure time prior to moving wires for connecting pigtail gel plugs (section 3.3.7).

Step 8 - Allow minimum of 1 hour cure time (above 70°F & 2 hours if colder temperatures) before opening traffic lanes to vehicles travelling over recently epoxied base plates. Signal heads can be secured to base plates as soon as epoxy has sufficiently hardened. NOTE: Temperature is critical.

Step 9 - Secure IRWL to base plates using socket head cap screws using Allen Wrench or equivalent. Socket head cap screws are to be coated with anti-seize compound for maintenance purposes to ensure that screws can be removed after exposure to the environment & additionally contain an embedded nylon thread-lock bead to prevent the screws from backing out while exposed to the roadway environment.

Step 10 - Complete “dress-up” saw cuts with Loop Sealant etc. DO NOT use Loop Sealant to “dress up” outside diameter of base plate to level epoxy surface with grade. Only use recommended 2 part epoxy for the outside diameter of the base plate.

3.3 MAJOR CONSIDERATIONS FOR IRWL INSTALLATION
There are a number of basic considerations when determining the location and alignment direction of each in-roadway module for any given installation site. These items should be considered during the installation procedure for the LightGuard in-roadway warning system. Be sure to have enough specified wire/cable, 2-part epoxy, and saw cut filler (loop detector type filler) ON SITE BEFORE BEGINNING INSTALLATION.
3.3.1 IRWL DISTANCE FROM CROSSWALK LINES
The installer should ensure that the IRWL are located approximately 18” (1.5m) from the outward edge of the crosswalk. In general, greater distances can be used without any noticeable difference to the motorist. However, MUTCD standards indicate IRWL should be within less than 10 feet (3m) of the crosswalk lines. If required by a specific circumstance, (i.e., grade or advance curve warning layout) placement may necessitate an authorized deviation, using sound engineering judgment (thereby not conforming to MUTCD standards).

3.3.2 IRWL POSITIONING CONCERNS
Each IRWL should be located in a position that will be directionally visible to the approaching motorist from their viewing position at the wheel usually 200’ to 400’ (61m to 122m) in advance of the crosswalk, allowing sufficient time to recognize and react to the warning lights upon activation.

When locating IRWL in the path of street sweeping equipment, caution should be taken to consider the proper location for minimizing possible cosmetic damage to the IRWL at the “curb and gutter” locations (on the approach sides) by avoiding the “skid paths” associated with this type of equipment.

3.3.3 IRWL LAYOUT PATTERN
The pattern or layout should follow the recommended configurations that have been tested and proven effective for the type of crosswalk for which the system is being used. The MUTCD - Manual for Uniform Traffic Control Devices 2009 chapter 4N (http://mutcd.fhwa.dot.gov/htm/2009/part4/part4n.htm) defines the authorized use & application of IRWL. For best practice; one module on the outside travel lane edge of each parking lane or bike lane (stay out of bike/parking lanes), one module on the center divider lane or line, and one module in each travel lane approximately under the location of each vehicle’s license plate, (or centered between the tire paths of the travel lane). The “geographic” center of the lane may not be the appropriate location as vehicular traffic tends to travel “off center” of any given marked lane. The idea is to minimize the frequency of tire impact to the in-roadway modules by placing them outside of the predominant vehicle tire wear pattern. With a raised median strip, the module that is usually placed on the centerline or lane should be installed on the far left of the approach lanes next to the raised median curb or barrier. For maximum or higher level needs, an optional addition of one module on each lane delineation line may be considered. Placement should be in accordance with MUTCD. Examples showing optional & required placement for California MUTCD can be found via http://www.dot.ca.gov/hq/traffops/engineering/mutcd/pdf/CA-Chap4E-Chap4L.pdf.

3.3.4 IRWL AIMING POINTS & ORIENTATION
The light beam view path of the modules should be determined by the local traffic engineer or responsible agency for the purposes of reaching the motorists viewing point 200’ to 400’ (61m to 122m) in advance of the crossing. Generally, the layout provides for the modules in the approach travel lanes to be aimed straight down the approaching motorist’s viewing path. The parking lane units (from the left and right sides) should also be aimed or aligned toward a “control point” approximately 200’ to 400’ (61m to 122m) in advance of the crossing, and should also converge at the approaching motorist view path. This would have the outside units canted slightly inward toward the center of the lanes to that point. The units on the center line and opposing travel lanes will be canted slightly toward the approaching motorist travel lanes to those “control points” that will allow the approaching motorist the best view of the light source generally from 200’ to 400’ (61m to 122m) away depending upon the approach speeds at the particular location. Curved approaches will require a greater degree of analysis to provide the maximum benefit.
3.3.4.1 CONVERGENCE ZONES

The “Zone of Convergence” refers to the area in the lanes of travel where the beams from the in-roadway LED lights merge. This “zone” gives the driver adequate time to react to the presence of a pedestrian by drawing his/her attention to the crosswalk. When aligning signal heads, great care must be taken to position them correctly to achieve this desired distance.

If the speed limit on the roadway is 25 mph (40Kmh), the “zone” should be approximately 250’ (76m) out from the signal heads. If the speed limit is 45 mph (72Kmh), signal heads should be aligned to make the zone 350’ (106m) to 400’ (121m) away from the signal heads. See chart for additional stopping distances based on road conditions and vehicle speed.

Note: Alignment of in-roadway warning signals to be site specific - city engineer or roadway authority to establish “control points” for each actual location. Control points may vary depending upon terrain, slope, vehicle approach speed, or regulation etc.

3.3.4.2 TYPICAL IRWL SIGNAL ALIGNMENT - STRAIGHT ROADWAY

Example: Typical Four Lane Midblock Crosswalk with 14 IRWL (Drawing Not to Scale)

3.3.4.3 TYPICAL IRWL SIGNAL ALIGNMENT - CURVED ROADWAY

Determining the location of the “Zone of Convergence” on a curved roadway is similar to a straight roadway. Using the chart showing the Minimum Stopping Distance on Dry Pavement, determine the total stopping distance based upon the speed limit of the roadway. The minimum starting point of the convergence zone is determined by the minimum stopping distance on dry pavement for the posted speed limit. This minimum stopping distance includes a motorist decision distance, based on a one-second reaction time, plus the necessary speed deceleration distance required to come to a complete stop under optimum conditions.

As an example, the minimum stopping distance on dry pavement for a roadway with a 35 mph (56Kmh) speed limit is approximately 161 ft. (49m). This minimum distance would allow a motorist to visually...
recognize the flashing amber LED lights, slow down, and if necessary, bring his/her vehicle to a complete, safe stop.

Signal heads should be aligned to make the LED lights and therefore the zone appear as soon as possible as the driver approaches. On curved or winding roads, the entrance to the zone isn’t always at the optimal distance to provide the earliest possible notification to approaching vehicles. Optional LED signal heads may also be installed down the center line of the road to give even more advance warning, giving the driver the time to brake and stop for the pedestrian.

3.3.5 DEPRESSION CUTS FOR LIGHT MODULE (IRWL / SIGNAL HEAD) BASE PLATES
The depression cuts for the base plate assemblies can be accomplished in a number of ways. Most contractors prefer core drilling or a chip hammer. Alternatively a flat bottom “Grinding Core Drill Bit” can be used. Also, making “cross cuts” in the pavement at the IRWL location will considerably expedite the core drilling process (refer to section 3.2). After determining the location and aiming direction of a particular light module, then core or chip out hole approximately 1¾” ± ¼” (35mm ± 3mm) deep refer to reference dimension table. A clean “corner” is desired at the bottom (flat bottom, vertical edges). Trim interior surface to proper depth, clean and prepare for epoxy. The size of the depression cut is VERY important. If the depression cut is too deep or the OD is too large, then excess epoxy will be required for securing to the roadway. If the depression cut is too shallow, the base plate will protrude above grade. If the depression cut OD is too small, insufficient epoxy will prevent the base plate from being permanently affixed to the roadbed.

3.3.5.1 REFERENCE DIMENSIONS FOR BASE PLATE MOUNTING TO ROADWAY

<table>
<thead>
<tr>
<th>Base Plate Model</th>
<th>Base Plate Material</th>
<th>Base Plate OD - Outside Diameter</th>
<th>Base Plate Height</th>
<th>Recommended Depression Cut Hole Diameter</th>
<th>Recommended Depression Cut Hole Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHS-14 revH min</td>
<td>Steel</td>
<td>13¾” (350mm)</td>
<td>1⅝” (35mm)</td>
<td>14” (356mm)</td>
<td>1½” max (38mm)</td>
</tr>
<tr>
<td>SD-10C</td>
<td>Composite</td>
<td>9 ⅞” (251mm)</td>
<td>1⅝” (35mm)</td>
<td>10” (254mm) min</td>
<td>1½” max (38mm)</td>
</tr>
</tbody>
</table>

3.3.6 SAW CUT FOR WIRING AND IRWL MODULES
The saw cut for wiring should follow the manual for depth and width to accommodate the necessary wiring and tray cable for the installation. As a general rule this averages ¾” - ½” (9.5mm – 12mm) wide cut approximately 2 ½” (63mm) deep (should be below core drill depth). Operational component connections from PCU to across the street can be pulled to terminal boxes for easy access connecting
activation mechanisms and other active LED components using standard type wire. Ensure that the saw cut makes a complete loop through all IRWL locations (refer to sections 2.2 & 3.3.8).

3.3.6.1 IRWL SAW CUT CROSS SECTION FRONT VIEW - (SD10-C BASE PLATE SHOWN)

IN-ROADWAY WARNING SIGNAL

FINISHED GRADE OF PAVEMENT

PAVEMENT

3.3.6.2 IRWL SAW CUT CROSS SECTION SIDE VIEW

FINISHED GRADE OF PAVEMENT

IN-ROADWAY WARNING LIGHT WIRING

Example Backer Rod Option

3.3.6.3 IRWL SAW CUT TOP VIEW (SD-10C BASE PLATE SHOWN)

DRAWING NOT TO SCALE

NOTE: USE 14 AWG WIRING, (see section 1.6) APPROVED BY LOCAL AGENCY FOR IN-ROADWAY WARNING SIGNAL ARRAY HOME RUN CONNECTION. FOR BOLLARD AND PUSHBUTTON'S, ALWAYS USE 8 CONDUCTOR 18 AWG MINIMUM DIRECT BURIAL CABLE TO ROUTE FROM ENCLOSURE TO OPPOSITE SIDE OF STREET FOR BOLLARD AND PUSHBUTTON'S.
3.3.7 EPOXY
Be sure to have enough wire/cable, SPECIFIED 2 part epoxy (Bondo 7084 Piezo/Traffic Sensor Sealant or DSB epoxy available from LGS upon request), and saw cut filler (loop detector type filler specified by local regulations) ON SITE BEFORE BEGINNING INSTALLATION. AFTER ALL WIRES ARE IN PLACE IN THE WIRE CUTS. Using duct seal or equivalent, create a temporary “epoxy dam” section 3.3.6.3 at the interface where the saw cuts enter/exit the depression cut area. The temporary epoxy dam prevents epoxy from flowing from the depression cut into the saw cut.

Remove plastic thread protectors from topside threaded holes in base plate. Temporarily install socket head cap screws into threaded holes (approximately 3-4 turns) in order to use the screws for base plate leveling. Slip the wire through the center hole and “stand” the base plate on end “ready” to place into the depression. Thoroughly mix the appropriate type of epoxy for use in the base plate depression cut. Place an appropriate amount of 2 part epoxy in the depression (sufficient to completely seal bottom and rise around outside edges of the base plate when pushed into place). To insure a proper moisture seal, place the initial “glob” of epoxy in the center of the depression, move (or wiggle) wires around in the epoxy to attain wire seal, then push material to the outside edges and set the base assembly in place. The base plate should be aimed and level (use the temporarily installed screws to elevate the base plate if required during leveling) before epoxy is allowed to completely cure. Note: If the depression is for some reason cut too deep, a “few” small rocks, pebbles or BB’s can be used to maintain a proper height. It is best to have the epoxy surround the base plate edges approximately level with the surface. NOTE: Epoxy working life is approximately 10 minutes depending upon ambient temperature. After this duration, the base plate can’t be moved. Allow epoxy time to fully set, generally 20 to 30 minutes, prior to installing IRWL.

3.3.8 LIGHTGUARD SYSTEM IRWL WIRING DIAGRAM (EXAMPLE)

Refer to section 3.3.4 for IRWL Aiming and Alignment
3.3.9 IRWL CONDUCTORS/WIRES

ENCLOSURE TERMINAL BLOCK CONNECTIONS FOR IRWL (RED/YEL DEPENDANT ON IRWL COLOR):

<table>
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Be certain that wire (ref section 1.6) type RHW-2/USE-2/XLP MAX OD 0.17” (4.3mm) is the correct size and type for in-roadway modules, and activation mechanisms (Bollards &/or Pushbuttons) for single run across street as recommended. Pull and cut 14 AWG wires to appropriate length. DO NOT STRIP INSULATION from IRWL wire. Connect to molded plug connector (pigtail cable assembly) provided in base plate assembly using provided Scotchlok Self-Stripping Pigtail Connectors-crimp to seal (see section 3.3.11).

Activation mechanism conductors for pushbuttons or Bollards (should be Belden cable 28601A as referenced in section 1.6) can be collocated in the same saw cut with the IRWL conductors (see section 3.3.6.2). Trim the IRWL conductors to a suitable length to work with for wiring the base plates.

3.3.10 TYPICAL IRWL SIGNAL BASE PLATE WIRING DRAWING

Figure 3.6A – Base Plate Wiring (SD-10C shown)
3.3.11 GEL PLUG TERMINATION INSTRUCTIONS

The Scotchlok 314 Self-Stripping Electrical Pigtail Connectors are moisture resistant and do not require wire stripping. *This can only be done in baseplates that have enough wire extending from the roadway to allow the IRWL pigtail to set into the underside of the IRWL connector cavity when assembled. The GEL PLUG connector requires 3/4” (19mm) of wire to be fully inserted into it.*

1) Outer Diameter of type RHW-2/USE-2/XLP wire should be **MAX OD 0.17” (4.3mm).** This will allow the insulated wire to be inserted into the Scotchlok 314 connector. Any exposed bare wire should be clipped off from the wires when connected to ensure that no part of the conductor is exposed.

2) Insert all three wires to be connected into the three open holes in the connector, until they all reach the back end of the connector.

3) With a standard pair of slip joint pliers, pinch down on the blue cap of the connector until the outer edge of the blue cap is flush with the rim of the white connector housing. It may be necessary to wipe off the expelled gel after crimping.

4) Place the connector in the bottom (lowest part) of the base cavity and route the wires so no pinches will occur when the head is tightened. Double-sided adhesive tape can be used to hold connector in place until head is re-installed.

5) Plug IRWL into connector and fit IRWL into base. *Adjust wires so NO PINCHES occur.*

3.3.12 IRWL INSTALLATION

Using compressed air, remove dirt and all debris from base plate cavity. Ensure that mounting screw threads are clear. For extremely harsh environments, consider placing duct seal or plumbers putty onto the base plate in the region under the signal head around the outside edge perimeter to minimize the potential for moisture entering the base plate. Plug pig-tailed base plate cable electrical connector (RECEPTACLE) into IRWL cable electrical connector (PLUG). Note appropriate alignment for 3 pin connector. Ensure that mated molded plug connectors are PROPERLY SEATED. Check for proper “O” ring placement and attach IRWL to base using **SOCKET HEAD CAP SCREWS** with **LOCK WASHERS** and **FLAT WASHERS.** Tighten using an **INCH POUND TORQUE WRENCH.**
Composite Base plate: Recommended torque value is not to exceed 4 ft lbs 48 in lbs (5N m) – NO TIGHTER. Hand tightening with a standard Allen wrench is also acceptable. WARNING – the composite base plate is very sensitive to this procedure, as damage to the threads may occur if tightened over 4 ft lbs (5N m).

Check for even contact and snug fit with base plate top surface. Consider placing additional duct seal or plumbers putty into the gap between the base plate and the signal head and into the counter bore holes for the socket head cap screws to minimize the potential for moisture or debris from entering the base plate. Check for LED light module operation and move on to next unit.

NOTE: It is IMPERATIVE that these steps be followed when installing the signal heads. Failure to do so voids the manufacturer’s warranty. It is highly recommended that within 30-45 days after initial installation, that the heads be re-checked to verify that the 4 ft lbs (5N m) of torque has been maintained.

3.4 NEW ROAD SURFACE CONSTRUCTION INSTALLATIONS
If site is new construction, conduit under the roadway surface and knockout templates (to achieve base plate depression excavation for installation) is an option for the installer/contractor. This will avoid or minimize saw cutting into new roadway surfaces. Plywood cutouts or similar knockouts to match the base plate assembly size may be utilized in preparation for the installation of the base plates upon completion of the roadway surface. Precise engineering must to be exercised to insure proper placement and alignment of the in-roadway modules on the lane lines and travel lanes once the work is completed. A separate conduit is recommended for the single run of tray cable across the street.

3.5 CONCRETE INSTALLATION PROCEDURE
The following information is a basic guideline for installing LightGuard Systems In-Roadway Warning Lights at locations where new concrete is to be poured.

Conduit must be installed. It should be placed at least 3" to 4" (76mm to 101mm) below the surface of the roadway (or as required by local regulations). The single ¾” (19mm) hole in the center of the base plate can be enlarged to approx. 2½” (63mm) dia in order to insert two ¾” PVC conduits connected to 90° elbows up into the base plate wiring cavity. Alternatively, a single 1½” to 2” diameter metal or PVC conduit can be used with a TEE connection stub that extends at least 1" (25mm) above the surface (after concrete is poured) for pulling wire loops through TEE’s. This is installed at each location where an In-Roadway Warning Light Base plate will be placed. Minimum recommended conduit is ¾” PVC to comply with NEC 14AWG type RHW-2/USE-2/XLP conductors.

Use a circular wooden plug or equivalent 1½” (38mm) thick by approx 10⅛” (257mm) dia for SD-10 Base plate or 14” (355mm) dia for CHS-14 Base plate) with a center hole having a diameter just larger than the conduit stub(s) protruding up from the road bed as a concrete forming tool. The plug center hole diameter should be minimum 1/8” (3mm) smaller than center hole in base plate to ensure subsequent base plate seating. The plug is placed over the conduit stub (or elbows) during the concrete pour to create a depression form for installing the base plate when concrete is dry.

After the concrete is dry, the wooden plug is removed & the base plate is affixed into the road. Excess concrete around the conduit should be removed to allow epoxy to bond the conduit to the base plate at the center hole. The extended conduit can then be cut flush to the inside surface of the base plate. Remove any excess epoxy &/or concrete from the base plate. After conductors are terminated, the exposed portion of the conduit opening should be filled with duct seal to minimize the potential of moisture or contaminants from entering the conduit.
4 AUTOMATIC ACTIVATION SYSTEM - SMART CROSSWALK™

4.1 AUTOMATIC BOLLARD DETECTION SYSTEM DESCRIPTION

Automatic Activation System consists of “gateways” comprised of Bollards or posts. Each Bollard contains sensor circuitry, and they are placed so pedestrians entering a crosswalk must pass between them automatically activating the Smart Crosswalk™. The built-in sensors detect pedestrians using the crosswalk and detect their direction of travel. The built-in sensor module projects infrared beams of modulated light to the respective receiver module. Each module incorporates a high gain detector. This allows the System to activate for Crosswalk entry, and not for exit. THE FRONT OF EACH BOLLARD PAIR SHOULD BE FACING EACH OTHER.

Bollards are used in pairs. Each Bollard sends its own signal back to the controller. When one of the input status LED indicators is illuminated, then the controller has received a signal that an object has entered the activation zone. Once sensor A is triggered, followed by sensor B, the system is activated for the desired cross time. If an input status indicator LED is illuminated but no object has entered the activation zone, then the receiver is not receiving the emitter’s beam.

4.2 BOLLARD LAYOUT AND WIRING DIAGRAM (EXAMPLE)
4.3. **BOLLARD INSTALLATION GUIDELINES**

4.3.1. **INSTALLATION STEPS**

**Step 1**  Prior to installing Bollards, the proposed site should be inspected several times to observe the everyday habits of local citizens who utilize the crosswalk. Particular attention should be paid to how far back pedestrians may "cut the corner" when entering the crosswalk. Bollards, as positioned, may not detect every pedestrian using the crosswalk. For example, a 12 ft. (3.6m) wide crosswalk (dimension from outside crosswalk stripe to outside crosswalk stripe), Bollards would be positioned approximately 5 to 6 ft. (1.5m to 1.8m) outside of the outer edge of the crosswalk stripe and about 18" to 24" (46cm to 61cm) behind the face of curb. Once Bollard locations have been determined, wiring, or conduit, may be run prior to installation of the hold down bolts.

**Step 2**  The preferred method of securing Bollards into position is to remove an 8" (20cm) square section of sidewalk then dig approximately 18" (46cm) and set anchor bolts in 6 sack concrete mix (Refer to Bollard Mounting Detail section 4.3.2). Other methods are acceptable, such as drilled anchor bolts, however, the bolts may become loose as a result of the Bollard being bumped. A loose Bollard will cause the calibrated internal sensors to become misaligned (reference section 4.4 for Bollard Alignment). J-Bolt alignment template is provided. Snap a "chalk line" between Bollard pair locations to ensure that j-bolt templates are directly facing each other (not skewed) FRONT facing FRONT.

**Step 3**  After Bollard anchor bolts have been set, and the concrete has cured, the Bollards can be secured to the anchor bolts. Position the base of the Bollard approximately 1/8" to ¼" (3mm to 6mm) above the finished sidewalk grade, level, and secure. All hardware MUST be tightly secured. If installed on a sloping sidewalk, ensure that Bollard is vertical using leveling nuts.

**Step 4**  Run wires and make final wiring connections to each Bollard (See section 4.3.3 & 4.3.4). Make wiring connections to terminal blocks in enclosure. Once wiring connections have been completed the Bollard light sensors are ready to be aligned (See section 4.4).

4.3.2 **BOLLARD MOUNTING DETAIL**

**NOTE:** To alleviate wire access or electrical connection difficulties, conduit height should not exceed 1" above grade – unless required by local regulations.
4.3.3 BOLLARD WIRING - CONTROL PANEL TERMINAL BLOCK CONNECTIONS

ENCLOSURE TERMINAL BLOCK CONNECTIONS FOR BOLLARDS:

1 1 2 2 P P S S B B G G G G
A B A B A B + + + + N N N N
D D D D

4.3.4 BOLLARD WIRING – BOLLARD TERMINAL BLOCKS CONNECTIONS

1. Route all cable (Belden 28601A) conductors entering from the bottom of the bollard up thorough the housing into the Light Dome Assembly for connections to the wiring terminal block.
2. Ensure adequate length of conductor cable (recommend 8’ each) such that the Light Dome Assembly can be easily removed and placed on the ground without stressing the conductors.
3. Ensure that cable routing up into the Light Dome incorporates strain relief such that the weight of the wires does not stress the terminal block connections after installation.
4.4. BOLLARD DETECTION ZONE OPERATION VERIFICATION

Each bollard receiver sends its own call signal to the controller. Since each bollard pair has its own A-B separate input to the controller, the controller will only activate the flashing sequence when the “A” bollard is detected prior to the “B” Bollard. Refer to section 4.3.4 BOLLARD TERMINAL BLOCK WIRE COLOR TABLE for recommended connection designations.

**Step 1** Ensure zones are correctly connected to the flashing controller by observing the input status indicator LED on the controller (see Section 2.8.1) or alternatively on the left side on the ECP.

**Step 2** Observe pedestrian entering the crosswalk between the Bollards. The first LED that lights should be yellow (PCU upper row is A zone), the second should be green (PCU lower row is B-zone - upper rows are green in some older model PCUs). If the LED’s illuminate in the reverse order, then the wires are reversed. To correct, reverse wires 1A and 1B at the PCU terminal block connections.

**Step 3** Observe pedestrian exiting the crosswalk. The activation LED indicators should light in order of Bollard B then Bollard A. In this condition, the PCU will ignore the call signal and not initiate the flashing sequence.

**Step 4** Observe pedestrian returning from other side of street entering the crosswalk between Bollards 2A and 2B. Ensure that when pedestrian enters the crosswalk between Bollards that the 2A input status indicator LED (yellow) comes on, then the 2B input status indicator LED (green) comes on.

4.5 BOLLARD ALIGNMENT

If after connecting & energizing the system, any LED input status indicators in the controller (PCU or ECP) are illuminated, this indicates Bollard detection sensors are probably out of alignment. Generic steps for initial installation & alignment are included below.

**Step 1** Determine that Bollards 1A and 1B are plumb, secure, and aimed directly at each other (FRONT facing FRONT). If the Bollards are not aimed directly at each other, then align sensors following steps in section 4.5.1 to compensate for Bollard misalignment.

**Step 2** Make sure Bollard piezo-electric buzzer switch is engaged (rotated fully counterclockwise) = If the sensor is *not aligned* the buzzer will sound.

**Step 3** Ensure there is power to emitting sensor in each Bollard. If there appears to be a power problem, correct then continue.

**Step 4** Adjust a Bollard’s receiver and emitter sensors (refer to sections 4.5.1 & 4.5.2).

**Step 5** With controller enclosure door open, observe the input status indicator LED (see section 2.8.1 for location of input status indicator LED).

**Step 6** Repeat above procedure for each Bollard 1A, 1B, 2A, & 2B. Note that standing behind each Bollard, the emitter is always on left side & the receiver is always on right side. Once all Bollards are aligned and reassembled, ensure that all input status indicator LED are *not* illuminated (ref step 5 above). Reassemble the Bollards.
4.5.1 BOLLARD SENSOR ADJUSTMENT STEPS

Each Bollard is equipped with detection sensors 1 transmitter/emitter and 1 receiver. To adjust the detection sensors follow the procedure below;

**Step 1** Remove 4 socket head hex drive screws from the upper portion (Acrylic light diffuser) of the Bollard (see Figure 4-5)

**Step 2** Slide rounded top of Bollard (Light Dome Assy) upward and out.

**Step 3** Standing behind the Bollard, look down 18" (45cm) into the top portion of Bollard. There are 2 black colored sensor modules. The sensor on the right is the Zone receiver and the sensor on the left is the Zone emitter (see Figure 4-5).

**Step 4** SLIGHTLY loosen screws on each side of sensor and move sensor until buzzer silences. When properly aligned, each input status indicator LED in the controller will NOT be illuminated and the buzzer will NOT sound which means that both detection zones are clear and ready for operation.

**Step 5** Tighten sensor screws when properly aligned and disconnect buzzer. If Buzzers are not disconnected after alignment, then the buzzer will sound each time the Bollard Beam is momentarily “broken.” The LightGuard System is supplied with a portable mirror (located in electrical cabinet) that can be used to view the LED status Indicators located on the back side of each of the Bollard sensors (see Figure 4-5 to interpret the LED status indicators).

4.5.2 BOLLARD SENSOR ADJUSTMENT DETAIL

- **WHEN ENTERING THE CROSSWALK, “A” BOLLARD IS ALWAYS ON THE LEFT, “B” BOLLARD IS ALWAYS ON THE RIGHT**
- **ENSURE THAT BOLLARDS ARE DIRECTLY FACING EACH OTHER – FRONT FACING FRONT**
- **MINIMIZE ELEVATION DIFFERENCES BETWEEN BOLLARDS TO PREVENT HAVING TO ALIGN SENSORS VERTICALLY**
- **WHEN BOLLARDS ARE INSTALLED FACING EACH OTHER & LEVEL, SENSORS SHOULD NOT REQUIRE ADDITIONAL ALIGNMENT**
- **ACCESS SENSORS BY REMOVING LIGHT/DOME ASSEMBLY**
- **ENGAGE BUZZER SWITCH DURING ALIGNMENT PROCESS**
- **SLIGHTLY LOOSEN SWIVEL MOUNT SCREWS TO ENABLE SENSOR ROTATION**
- **STARTING WITH RECEIVER, ROTATE SENSORS SIDE/SIDE & UP/DOWN TOWARD CENTER UNTIL BUZZING CEASES.**
- **VERIFY OPTIMAL ALIGNMENT USING MIRROR TO VIEW RECEIVER LED STATUS INDICATORS**
- **ONCE SENSORS ARE ALIGNED, TIGHTEN LOCKING SCREWS TO SECURE IN PLACE**
- **DISENGAGE BUZZER SWITCH AFTER ALIGNMENT**

- **AE** = EMITTER INSIDE THE “A” BOLLARD LOCATED ON LEFT SIDE AS THE CROSSWALK IS ENTERED
- **AR** = RECEIVER INSIDE “A” BOLLARD LOCATED ON LEFT SIDE AS THE CROSSWALK IS ENTERED
- **BE** = EMITTER INSIDE “B” BOLLARD LOCATED ON RIGHT SIDE AS THE CROSSWALK IS ENTERED
- **BR** = RECEIVER INSIDE “B” BOLLARD LOCATED ON RIGHT SIDE AS THE CROSSWALK IS ENTERED
Interpreting the Receiver LED Status Indicators

**Receiver Sensor LED Status Indicator legend**
- Optimaly aligned = GREEN + ORANGE
- Non-Optimaly aligned = GREEN ONLY
- Not aligned or blocked beam = YELLOW ONLY
- Shorted/failed = ORANGE ONLY
- Not powered or failed = NO LED

**Transmitter Sensor LED status indicator legend**
- Transmitting = green only
- Not powered or failed = no LED

<table>
<thead>
<tr>
<th>OPTIMALLY ALIGNED</th>
<th>NON-OPTIMALLY ALIGNED</th>
<th>NOT ALIGNED or BEAM BLOCKED</th>
<th>SHORTED/FAILED</th>
</tr>
</thead>
</table>

Remove Diffuser, Wires, & Light Dome Assembly

Standing behind Bollard & looking Down, Emitter is on the Left, Receiver is on the Right

To adjust sensor orientation/alignment, LOOSEN these screws only, DO NOT REMOVE SCREWS.

**Figure 4-5**
5  PUSHBUTTON ACTIVATION

5.1  MANUAL PUSHBUTTON ACTIVATION DESCRIPTION

Manually activated smart crosswalk installations utilize an ADA compliant standard pedestrian operated pushbutton assembly to activate the system. In these installations, a pole mounted pushbutton station, (typically incorporating a small sign with the words “CROSS WITH CAUTION” and a row of flashing amber LEDs see section 5.5), is placed near the entrance to crosswalk (see section 5.3). The row of flashing amber LEDs indicates to the pedestrian the warning system is activated. The words “CROSS WITH CAUTION” remind the pedestrian to maintain vigilance for their own safety by paying attention to traffic conditions while crossing the street. The ADA compliant standard pedestrian activation pushbutton device should be installed as recommended in the Manual on Uniform Traffic Control Devices (MUTCD) or other local agency approved specifications.

5.2  ILLUMINATED PUSHBUTTON ASSEMBLY

GENERAL SPECIFICATIONS

| ASSEMBLY SIZE: | Height: 11¾” (300mm) - Width: 5” (127mm) |
| COLOR:         | Green housing, yellow/black faceplate, silver tone 2 inch pushbutton |
| FACEPLATE LIGHTS: | Amber Light Emitting Diodes (LEDs) which flash with system activation |
| MATERIAL:      | Cast Aluminum |
| VOLTAGE:       | 12 VDC nominal (not to exceed 15 V) |
| MOUNTING:      | See local agency approved standard specifications for location and height |

5.3  PUSHBUTTON LAYOUT AND WIRING DIAGRAM (EXAMPLE)
5.4 PUSHBUTTON WIRING TERMINAL BLOCK CONNECTIONS

ENCLOSURE TERMINAL BLOCK CONNECTIONS FOR PUSH BUTTONS:

```
1 1 2 3 P P S S B B G G G G
2 A A B B + + + + N N N N
D D D D
C C R R
O O E E
L L D D
O O C C
R R K K
```

5.5 PUSHBUTTON INSTALLATION DETAIL DRAWING

Follow instructions noted on drawing for pole mounting & wiring detail. Mounting bolt holes must be tapped in pole. Wire access holes should be de-burred to prevent wire insulation damage. **Conductors between LED sign/placard cavity & Pushbutton cavity MUST be routed INSIDE the pole to ensure weather tight integrity.**
6 LED “ENHANCED” ILLUMINATED WARNING SIGNS

6.1 LED “ENHANCED” SIGN GENERAL DESCRIPTION

LightGuard System® installations may, as an option, utilize high retro-reflectivity MUTCD approved diamond shaped pedestrian crossing symbol signs (e.g. W11-2) or equivalent, equipped with flashing amber LED modules located at the sign border (see below) or under the walking pedestrian symbol. These signs are placed at, or before, the crosswalk to assist in warning approaching motorists that a pedestrian is in, or about to enter the crosswalk. The embedded LED modules flash at the LightGuard System® enhanced flash rate. This LED “enhanced” pedestrian crossing symbol sign should be installed at the crosswalk location as recommended in the Manual on Uniform Traffic Control Devices (MUTCD). For school crossings, a pentagon school symbol sign (e.g. S1-1) is also available. NOTE: Any advance warning signs should be consistent with color of other signs (Yellow or Fluorescent Yellow/Green).

6.2 LED “ENHANCED” PEDESTRIAN CROSSING SIGN DRAWING

![Diagram of LED enhanced pedestrian crossing sign]

ACTIVE PEDESTRIAN CROSSING SYMBOL SIGN WITH LED MODULES

GENERAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>SIZE</th>
<th>MUTCD compliant Chapter 2 (custom upon request)</th>
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<tbody>
<tr>
<td>TYPE</td>
<td>MUTCD compliant Chapter 2 (custom upon request)</td>
</tr>
<tr>
<td>LED</td>
<td>MUTCD compliant (Typical 8 LED module border enhanced)</td>
</tr>
<tr>
<td>INPUT</td>
<td>Nominal 12VDC</td>
</tr>
<tr>
<td>COLOR</td>
<td>MUTCD compliant (FYG, YEL, ORG, etc.)</td>
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<tr>
<td>MOUNTING</td>
<td>Bracket provided (tamper resistant fasten hardware to be supplied by installer). See local agency approved standard specifications for location and height</td>
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7 LIGHTGUARD SYSTEMS SOLAR POWER OPTION

7.1 INSTALLATION STEPS

1. Using the drawing, assemble the Solar Panel mount with the hardware supplied.
2. Use the ¼” hardware to attach the module to the Module Rails.
3. Use the 5/16” hardware to bolt the Module Rails to the SPM-1 Pole Bracket.
4. Adjust the mount to the proper tilt angle for your site latitude.
5. Face the solar module due South (NOT MAGNETIC SOUTH) for Northern Latitudes and due North for Southern Latitudes.
6. ENSURE that the Batteries are fully charged prior to installation.

7.2 SOLAR MODULE

Use the 14 / 2 TC tray cable supplied to wire the solar module into the charge control panel inside the enclosure. It is recommended that ½” flexible metal conduit be run between the solar module junction box and the mast to protect the tray cable. An opening in the mast to accept the conduit will need to be provided.

Remove the cover of the black junction box on the back of the module and note the 6 screws. Also, note a positive (+) sign and a negative (-) sign which show the 2 positive and negative terminals. Connect 1 wire to either of the 2 positive (+) and negative (-) terminals. Use the red conductor for positive and the black for negative. Many Solar Modules are “configurable” in that depending on which terminals are used for electrical connections, different voltage levels are available. The open circuit voltage (OCV = voltage when not connected to charging circuit) should be 19 to 21 VDC. Verify that OCV = 19 to 21 volts across the Solar Module terminals when connecting to the Solar Module Terminal Blocks. Do not use any of the screws designed to secure the Terminal Block to the panel for electrical connections.

Route the tray cable down the mast into the enclosure. Make sure the solar module is covered, or not connected to the tray cable, when routing the cable through the enclosure. Even in low sunlight the module can produce 18 to 20 volts.

7.2.1 SOLAR MODULE DESCRIPTION

The solar array consists of a minimum 75 watt solar power module which is to be pole mounted. This solar module is designed to charge the two 12 volt batteries in the system. In full sun, this module can produce a maximum on 4.25 amps when charging the battery. During the day, the amount of charging current will vary with the intensity of the sunlight hitting the module. The open circuit voltage (voltage when not connected to charging circuit) can be up to 21 volts.

7.2.2 SOLAR MODULE MOUNTING

The solar module is to be mounted to the side of a 4” galvanized mast using the aluminum side-of-pole mount and hardware supplied. The solar module must be oriented facing TRUE South & unobstructed to sunlight. Attach the mounting rails to the pole bracket and adjust the tilt angle to create an angle setting for your local latitude from horizontal facing South. Refer to sections 7.2.3 & 7.2.4 for orientation details. Use U-bolts to secure the mount to the mast.
7.2.3 ORIENTING THE SOLAR MODULE

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It is important for proper system operation that the array be oriented true South (if you are located in the northern hemisphere) & unobstructed to sunlight. The directions of magnetic South and true South differ from one another depending on geographic location. This variance is called declination. Check the deviation for your region in order to extrapolate true South from a compass heading of magnetic South. The map in this section shows the magnetic declination for the US. For example, central Oklahoma falls between the 8° E and the 10° E lines. This means that the north point of a compass points about 9° E of true north. So true north is actually 9° to the WEST of where the compass points.

7.2.4 DECLINATION ANGLE FOR SOLAR PANELS

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When installing photovoltaic modules, be aware that they generate maximum power when facing the sun directly. The fixed position which approximates this ideal over the course of the year, thus maximizing annual energy production, is facing due South (in the Northern Hemisphere) or due North (in the Southern Hemisphere) at the angle listed in the table in the next column. Note that these cardinal directions are true NOT magnetic orientations. The table below shows the fixed angle above horizontal at which modules should be installed in order to maximize annual energy output.

At some installations, it may be cost-effective to adjust the tilt seasonally. At most latitudes, performance can be improved during the summer by using an angle flatter than the chart’s recommendation; conversely, a steeper angle can improve winter performance.

If modules are not cleaned regularly, it is recommended that they not be mounted at an angle flatter than 15°. Flatter angles cannot take full advantage of the cleansing action of rainfall.
7.2.5 MODULE TILT ANGLE

Solar modules produce the most power when they are pointed directly at the sun. For installations where the solar modules are mounted to a permanent structure, the solar modules should be tilted for optimum winter performance. As a rule, if the system power production is adequate in the winter, it will be satisfactory during the rest of the year. The module tilt angle is measured between the solar modules and the ground.

Example: A module mounted in Miami, Florida (latitude 26° should be tilted at approximately 31° from horizontal, and should be faced due South.

<table>
<thead>
<tr>
<th>Latitude Site</th>
<th>Tilt Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15°</td>
<td>15°</td>
</tr>
<tr>
<td>15-25°</td>
<td>SAME AS Latitude</td>
</tr>
<tr>
<td>25-30°</td>
<td>add 5° to local latitude</td>
</tr>
<tr>
<td>30-35°</td>
<td>add 10° to local latitude</td>
</tr>
<tr>
<td>35-40°</td>
<td>add 15° to local latitude</td>
</tr>
<tr>
<td>40° +</td>
<td>add 20° to local latitude</td>
</tr>
</tbody>
</table>

7.3 SOLAR SYSTEM BATTERIES

The enclosure contains 2 SLA batteries, the PCU (power control unit) and the charge controller. Two 12 volt deep cycle sealed gel-cell batteries are supplied. Each battery is rated at approximately 100 amp hours. The batteries are to be wired in parallel (positive-to-positive and negative-to-negative) to give 12 volts nominal at 200 amp hours of storage. Use the red and black battery cables supplied to parallel the batteries. Install the wiring into the terminal blocks & circuit breaker before installing the batteries.
Use the red and black cables, supplied with the ring terminals, to make the battery connections. Connect the red cable to the positive post on 1 battery and the black cable to the negative post on the other battery. This will ensure even charging between the 2 batteries (note figure below).

![Battery Connections Diagram]

Connect the red and black #14 tray cable wires, from the solar module, to the labeled circuit breaker and negative buss block (refer to Section 2.4.3).

### 7.4 CHARGE CONTROLLER

#### 7.4.1 CHARGE CONTROLLER WIRING

The charge controller, located inside the enclosure, provides all wiring connections for the solar module, batteries, and power to the PCU. The PCU controls power to the in-roadway warning signals, signs, and pushbuttons.

Ensure all circuit breakers are OFF before making any connections. There are three 15 amp circuit breakers:

1) Solar Module circuit breaker: controls solar module power to the system.
2) Load circuit breaker: controls load power to the PCU, in-roadway warning signals, and signs.
3) Battery Main circuit breaker: controls battery power to the system.

#### 7.4.2 SOLAR CONTROLLER

A charge / load controller is located on the charge control panel (for further information / specs, contact your LGS representative). This controller is being used to regulate the battery charging and protect the batteries from being over discharged. The charge controller is pre-wired and factory adjusted. Do not make any adjustments to the charge controller without contacting LightGuard Systems, Inc. first. Indicator(s) on the face of the controller indicates the battery state of charge. Note the legend on the face of the charge controller.

During normal operation, the charge controller will allow the battery voltage to rise up approximately 14.1 volts while charging. This end-of-charge voltage will vary with temperature. The charge controller might employ a supplemental temperature probe attached to the side of one of the batteries in the enclosure. If supplied, attach the probe approximately three quarters of the way up the side of the battery case using the adhesive pad on the probe. This will ensure proper charging of the batteries throughout the year.

At night, the battery voltage should register between 12.0 and 12.8 volts depending upon how well the batteries were charge during the day. In times of exceptionally bad weather, and / or exceptionally heavy crosswalk usage, the battery voltage may drop below 12.0 volts. When the voltage drops to below approximately 11.8 volts, the charge controller will shut off power to the PCU and in-roadway warning signals ensuring protection of the batteries from damage as a result of over discharge. The charge controller will not allow power back to the PCU until the voltage rises back up to approximately 12.8 volts after several hours of charging. This solar power system is designed to operate in all weather conditions throughout the year.
# 8 TROUBLE SHOOTING / MAINTENANCE / AFTER INSTALLATION

## 8.1 TROUBLE SHOOTING GUIDE & TIPS

<table>
<thead>
<tr>
<th>SYMPTOM</th>
<th>CHECK</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM WILL NOT ACTIVATE</td>
<td>Check PCU for proper System operation by &quot;PUSH TO TEST&quot; Button on right side of PCU</td>
<td>If LED Activation Indicator flashes, check Bollards for proper alignment and sensors for obstruction. Check pushbuttons connections. If LED Indicator does not flash, check PCU components.</td>
</tr>
<tr>
<td>IN-ROADWAY WARNING SIGNALS FLASHING DIMLY, OR NOT AT ALL</td>
<td>Check all in-roadway warning signals for damage</td>
<td>Remove &amp; Replace (R &amp; R) with spare warning signal as needed.</td>
</tr>
<tr>
<td></td>
<td>Check all in-roadway warning signal window ramps for blockage or debris.</td>
<td>Broom any debris from pavement around in-roadway warning signals to allow for unobstructed motorist view.</td>
</tr>
<tr>
<td></td>
<td>Check all in-roadway warning signal light modules for proper flash operation</td>
<td>View in-roadway warning signals from 150' to 200' away for the approaching motorists' perspective. R &amp; R with spare warning signal as needed.</td>
</tr>
<tr>
<td>GRAFFITI OR PAINT ON EQUIPMENT</td>
<td>Check for proper activation operation</td>
<td>Remove graffiti or paint. Tagster Graffiti Emulsifier from Rhomar Industries is recommended. Call (800) 688-6221 to order.</td>
</tr>
<tr>
<td>SYSTEM ON CONSTANT BLINK 50/50</td>
<td>Check for stuck PB or mis-Aligned Bollards ref section 4.4</td>
<td>Inspect PCU display for diagnostic information. System enters “Default Flash Pattern” to alert maintenance crews that attention is required. If the LCD does not indicate which input is “stuck”, then press “D” on the keypad to display input diagnostics.</td>
</tr>
<tr>
<td>PUSHBUTTON INPUTS DO NOT ACTIVATE FLASHING OUTPUT</td>
<td>Verify that button(s) is/are operational Verify conductor integrity from pushbuttons to flashing controller</td>
<td>Inputs can be simulated at the flashing controller. Temporarily remove the button input field wires from the Din Rail locations PA/PB &amp; affix a jumper wire (12” stripped ½” at both ends) into the DC GROUND on the Din Rail. Then use the “free end” of the jumper to make contact with the PA/PB inputs on the flashing controller. If an LED indicator illuminates, then the PCU can receive signals &amp; the problem is with the field wiring or the Pushbutton(s)</td>
</tr>
<tr>
<td>STUCK BOLLARD SIGNAL</td>
<td>Check 1) bollard sensor alignment, 2) bollard sensor operation, 3) bollard conductors for shorts</td>
<td>Verify bollard sensor alignment using either buzzer or LED status indicators to ensure sensor switches when beams are blocked. Verify that call signal conductor from bollard to control panel is not shorted/compromised</td>
</tr>
</tbody>
</table>
TROUBLE SHOOTING TIPS

- Routine maintenance should include periodic on-site inspections (twice annually is recommended) of the System for proper operation.
- Check activation system for proper operation and tighten fastening hardware as needed.
- Clean Bollards and sensor shield if needed and check for proper Bollard alignment and activation.
- In-roadway warning signals should be visually checked for sufficient light output with window ramps swiped clean as needed. Should window ramp become obscured over time, remove and replace with spare warning signal.
- Check for proper adhesion of all warning signals to the roadway surface. Fill any gaps around in-roadway signal assemblies with bituminous hot stick to prevent debris or moisture intrusion.
- Inspect wire trench cuts for sufficient loop sealant and fill where needed with filler or bituminous hot stick material.
- Check enclosure and sign mounts for secure attachment and tighten fastening hardware as needed.
- Note/Record activation counts using PCU keypad functions 1, 2, or 3, then reset to clear by pressing 0, then 555 (NOT MANDITORY)
- Note and clean any graffiti from enclosure equipment. (We recommend Tagster™ Graffiti Emulsifier from Rhomar Industries - Springfield, Missouri - (800) 688-6221 - Email: rhomarind@aol.com)
8.2 FIELD RELATED TOTAL PREVENTATIVE MAINTENANCE

After initial installation, the following steps should be followed to test/validate correct operation and to ensure proper operation in the future. Installation should consist of all components secured appropriately and all electrical connections terminated as required.

Step 1 Energize all circuit breakers
Step 2 Contact LightGuard Systems to obtain a 3 digit ACTIVATION CODE for warranty & maintenance tracking purposes. (888) 247-2974
Step 3 Verify that no LED fault/activation indicators are ON in the PCU. These indicators are 2 rows of LED (Yellow & Green) directly below the PCU housing in the enclosure. If any fault/activation indicators are on, check Bollard alignment, pushbuttons, and field wiring connections.
Step 4 Press keypad 9 to initiate constant blink. Verify that all IRWL & optional illuminated LED signs & Pushbuttons are active
Step 5 Press keypad 9 to toggle constant blink off
Step 6 Test/verify that activation mechanisms operate (PB &/or Bollards) and activate flashing output for the cross time duration. If any Bollards activate the system when exiting the crosswalk instead of entering the crosswalk, swap A & B wires in control panel for that Bollard pair.
Step 7 Set cross time as required (refer to section 2.8.3)

8.3 FIELD RELATED TOTAL PREVENTATIVE MAINTENANCE

8.3.1 SCOPE
This procedure describes the recommended process for inspecting & maintaining LGS equipment after installation. This section applies to Illuminated signs, electrical interface cabinets, In Roadway Warning Lights (IRWL), and activation mechanisms (Bollards & Pushbuttons).

8.3.2 MAINTENANCE PERIOD
Perform Preventative Maintenance/Inspection approximately every 6 months.

8.3.3 MATERIAL REQUIRED
A. Battery tester
B. Non-metallic whisk broom
C. Soapy water and cloth

8.3.4 RECOMMENDED SPARES
A. IRWL

8.3.5 ELECTRICAL INTERFACE CABINET (AC, SOLAR, ECP)
1. Open Electrical Interface Cabinet
2. Clean any foreign matter that might have accumulated inside cabinet, (spider webs etc.)
3. Test battery voltage, if value is less than 12VDC refer to trouble shooting guide (section 8.1)
4. Optional activation data, (consider posting on inside cabinet door for recordation review).
   a. use keypad 1 & 3 to display activation history, record activation data (date & number of activations) on paper and store in LGS enclosure
   b. reset activation counters using keypad 0, then 555 to clear activation history
5. Press keypad 9 to verify that all light outputs activate, press 9 again to toggle outputs back to ready mode
6. SOLAR powered systems
   a. If solar panel has foreign matter on it, clean solar panel using water
   b. Verify that the charge controller indicates that the batteries are being charged & warranty period (date) on batteries is valid

8.3.6 ILLUMINATED SIGNS
1. Verify that light windows in illuminated signs are clear of debris, and properly aligned to target path, and all LED modules operate fully.
8.3.7 ACTIVATION MECHANISMS
1. Pushbuttons
   a. verify that LED lenses on pushbutton placards are clear of debris
   b. verify that pushbuttons activate flash sequence (Four LED indicators each sign)
2. Bollards
   c. Verify that Bollards are aligned (indicated by Electrical Interface Panel LED’s LD1 through LD12 are all NOT illuminated)
   d. Verify that Bollard courtesy lights are illuminated (refer to section 4.3)
   e. Ensure that Bollard sensors are clean with no obstructions inhibiting sensor performance
   f. Ensure that Bollards are SOLIDLY secure to mounting pads by attempting to “rock them”

8.3.8 IRWL
1. Verify that all IRWL illuminate when system is activated
   a. if any IRWL do not activate, refer to troubleshooting guide in LGS Installation Manual
2. Verify “self clearing” design is keeping debris build-up clear from front of units, (If needed wipe window with wet cloth).
3. Within 60-90 days of Initial installation, verify that each IRWL is secure/seated in base plate. If loose, then remove IRWL, clean mating surfaces, and reinstall in accordance with LGS Installation Manual. Repeat at 6 month intervals.
4. If any IRWL are broken, then replace units
5. Inspect IRWL for signs of condensation. If from approximately 200 feet this presents a noticeable decrease in performance or signal head visibility, it should be replaced. If condition does not appear to affect the light visible to the motorist, it may not need replacement (review warranty in T’s & C’s).

8.4 EQUIPMENT LIST
This section describes standard components of the LightGuard family of products applicable to this Installation Manual.

8.4.1 SPARES & REPLACEMENTS EQUIPMENT LIST
The following list contains LGS model names/numbers for items typically sold as spares or replacements.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGS-SN-LED</td>
<td>Amber LED module for illuminated signs</td>
</tr>
<tr>
<td>LGS-BOL SENS ASSY T3A</td>
<td>T3A Bollard sensor assembly -- RCVR, XMTR, swivel mount, bracket, courtesy light</td>
</tr>
<tr>
<td>LGS-GEL-PLUGS</td>
<td>IRWL electrical splice connection inside base plate</td>
</tr>
<tr>
<td>LGS-ORING</td>
<td>IRWL sealing oring</td>
</tr>
<tr>
<td>LGS-PB ONLY</td>
<td>Pushbutton mechanism</td>
</tr>
<tr>
<td>LGS-GRAYHILL RELAY</td>
<td>Magnecraft relay for obsolete back panel</td>
</tr>
<tr>
<td>LGS-CDMRLY</td>
<td>Crydom relay for obsolete back panel</td>
</tr>
<tr>
<td>LGS-9X-1</td>
<td>Signal head only - red LED</td>
</tr>
<tr>
<td>LGS-9X-2</td>
<td>Signal head only - bi-color red/amber LED</td>
</tr>
<tr>
<td>LGS-9X-3</td>
<td>Signal head only - amber LED</td>
</tr>
<tr>
<td>LGS-9X-4</td>
<td>Signal head only - white LED</td>
</tr>
<tr>
<td>LGS-CHS 14</td>
<td>Base plate only - 14” snowplow resistant</td>
</tr>
<tr>
<td>LGS-PCU-MICRO</td>
<td>LGS-micro controller module for PCU</td>
</tr>
<tr>
<td>LGS-SD10-C-FG</td>
<td>Base plate only - 10” composite</td>
</tr>
<tr>
<td>LGS-SOL-PANEL-ONLY</td>
<td>Solar panel for LGS 2’ x 4’ (80 watts)</td>
</tr>
<tr>
<td>LGS-REC-ONLY</td>
<td>Receiver sensor for LGS-T3</td>
</tr>
<tr>
<td>LGS-TRANS-ONLY</td>
<td>Transmitter sensor for LGS-T3</td>
</tr>
</tbody>
</table>
### 8.4.2 STANDARD EQUIPMENT LIST

The following list contains LGS model names/numbers for Standard items applicable to this Manual.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGS-SOLAR SYSTEM</td>
<td>Solar Powered PCU w/Programmable Interface, Batteries, Cabinet &amp; Panel</td>
</tr>
<tr>
<td>LGS-SOLAR SYS-DUAL ZONE</td>
<td>Solar System with Dual Independent Zone Upgrade</td>
</tr>
<tr>
<td>LGS-ECP-1</td>
<td>Entry Level LGS Control Panel and Cabinet</td>
</tr>
<tr>
<td>LGS-ECP-2</td>
<td>Entry Level LGS Control Panel - custom applications only</td>
</tr>
<tr>
<td>LGS-PCU/A DUAL</td>
<td>Dual Zone A/C PCU w/ Battery Backup &amp; Programmable Interface, Cabinet</td>
</tr>
<tr>
<td>LGS-PCU/BKPN-AC</td>
<td>AC Power Control Unit w/Backpan, Battery Backup &amp; Programmable Interface Only</td>
</tr>
<tr>
<td>LGS-PCU-AC</td>
<td>Standard A/C PCU w/Programmable Interface, Battery, Backup, Backpan &amp; Cabinet</td>
</tr>
<tr>
<td>LGS-9X-3/CHS-14</td>
<td>Amber LED Signal Head w/ Snow Plow Resistant 14&quot;Base Plate</td>
</tr>
<tr>
<td>LGS-9X-3/SD10-C</td>
<td>Amber LED Signal Head w/ 10&quot; Composite Base Plate</td>
</tr>
<tr>
<td>LGS-9X-1/CHS-14</td>
<td>Red LED Signal Head w/ Snow Plow Resistant 14&quot;Base Plate</td>
</tr>
<tr>
<td>LGS-9X-1/SD10-C</td>
<td>Red LED Signal Head w/ 10&quot; Composite Base Plate</td>
</tr>
<tr>
<td>LGS-9X-2/CHS-14</td>
<td>Bi-Color LED Signal Head w/ Snow Plow Resistant 14&quot;Base Plate</td>
</tr>
<tr>
<td>LGS-9X-2/SD10-C</td>
<td>Bi-Color LED Signal Head w/ 10&quot; Composite Base Plate</td>
</tr>
<tr>
<td>LGS-PBA-BRAILLE</td>
<td>ADA 2&quot; Pushbutton Assembly w/ Braille Placard- Pair</td>
</tr>
<tr>
<td>LGS-PBA-PAIR</td>
<td>ADA 2&quot; Pushbutton Assembly w/LED Placard - Pair (L &amp; R)</td>
</tr>
<tr>
<td>LGS-PBA-POL-PAIR</td>
<td>ADA 2&quot; Pushbutton Assembly w/LED Placard &amp; Audible Message-Pair</td>
</tr>
<tr>
<td>LGS-RAD</td>
<td>Remote Activation Detector</td>
</tr>
<tr>
<td>LGS-T3A</td>
<td>Automatic Pedestrian Detection Bollard</td>
</tr>
<tr>
<td>LGS- W11-2-B-30-FYG</td>
<td>Ped Sign w/o Crosswalk &amp; LED Enhanced Border</td>
</tr>
<tr>
<td>LGS-S1-1/B-30-FYG</td>
<td>School Sign w/o Crosswalk &amp; LED Enhanced Border</td>
</tr>
<tr>
<td>LGS-W79/W-11-1</td>
<td>Bicycle Crossing Sign &amp; LED Enhanced Symbol</td>
</tr>
<tr>
<td>LGS-BONDO</td>
<td>Two Part Epoxy for Securing Base Plate Into Roadway (pass thru item)</td>
</tr>
<tr>
<td>LGS-CAB-SOL</td>
<td>Pad Mount Enclosure for Solar or AC Systems</td>
</tr>
<tr>
<td>LGS-PCU-ASSEMBLY</td>
<td>A/C Power Control Unit Only - No Enclosure or Backpan</td>
</tr>
<tr>
<td>LGS-AC BEACON-KIT</td>
<td>Separate 110VAC Wig-Wag Output Simultaneous w/ Signal Head Flashing</td>
</tr>
<tr>
<td>LGS-AC-OUT-UPGRD</td>
<td>Separate 110VAC Output Simultaneous w/ Signal Head Flashing</td>
</tr>
<tr>
<td>LGS-DC BEACON-KIT</td>
<td>Separate 12VDC Wig-Wag Output Simultaneous w/ Signal Head Flashing</td>
</tr>
<tr>
<td>LGS-DC-OUT-UPGD</td>
<td>Separate 12VDC Output Simultaneous w/ Signal Head Flashing</td>
</tr>
<tr>
<td>LGS-NOVAX-UPGD</td>
<td>Upgrade LGS Controller for Novax Audible Alert</td>
</tr>
</tbody>
</table>

### 9 ADDENDUMS

This section is reserved for addendums typically applicable to various upgrade kits noted as optional equipment in Section 1.6. Each addendum is supplied separately with appropriate upgrade kit.