PAPI
Style B
Type L-880, Type L-881
Instruction Manual
Rev 2.0

Precision Approach Path Indicator

In accordance with:
FAA
Advisory Circular AC-150/5345-28G

Manufactured by:
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THIS MANUAL COVERS STYLE B, CURRENT POWERED, SERIES LIGHTING CIRCUIT, PAPI SYSTEMS ONLY

GUARANTEE

Airport Lighting Company guarantees that the equipment manufactured by Airport Lighting Company and covered by this manual has been manufactured and will perform in accordance with applicable specifications. Any defect in design, materials (excluding lamps,) or workmanship which may occur during proper and normal use during a period of 1 year from date of installation or a maximum of 2 years from date of shipment will be corrected by repair or replacement by Airport Lighting Company, with transportation costs borne by the purchaser. This guarantee covers PAPI systems, 880-4-C-2 series, 881-4-C-2 series, consisting of light units 88-3C01.

Table of Contents

Note:

All shaded text items are direct quotes from FAA Advisory Circulars

List of Figures

Figures in section 3 are from AC 150/5340-30C with original figure numbers and captions.

List of Tables

Tables in section 3 have been copied from AC 150/5340-30C and use the original figure numbers and captions.

1.0 General Information

1.1 Scope

This instruction manual is provided for use with FAA type L-880 and L-881, Style B Precision Path Approach Indicator (PAPI) as covered by FAA AC-150/5345-28G and manufactured by Airport Lighting Co., Manlius, NY, USA. It is for use with PAPI systems, 880-4-C-2 series, 881-4-C-2 series, consisting of light units 88-3A00.

1.2 Equipment Description

1.2.1 Type

a. L-880 system consists of 4 light units
b. L-881 system consists of 2 light units

1.2.2 Style B, current powered

All Style B light units are identical and contain tilt switch sensing and control as well as additional circuitry which, upon failure of any lamp(s) in a light unit, allows the remaining lamp(s) to continue operation and to operate at proper power levels. Style B light units have their intensity controlled solely by the constant current regulator, either 3 step or 5 step, and incorporate no automatic control based on meteorological light levels.

1.2.3 Class

All PAPI systems of the above referenced catalog number 880-4-C-2 series, 881-4-C-2 series, consisting of light units 88-3A00 are Class II, and operate at a lower limit of minus 67 degrees F (-55 degrees C) and upper limit of 131 degrees F (55 degrees C). By virtue of this fact, they are automatically qualified to Class I which operate at a lower limit of minus 31 degree F (-35 degrees C) and an upper limit of 131 degrees F (55 degrees C).

1.2.4 Lamps

All PAPI light units contain 3 type MR16 lamps with integral reflectors, 105 watts each, at 6.6 amps. The replacement lamp part number is 106.

2.0 Theory of Operation

The Precision Approach Path Indicator (PAPI) system is a system made up of either two or four light units. The light units are placed at the left side of the runway at the touchdown location. The light units have a split beam which is viewed as red when viewed from below the center of the beam and white when viewed above the center of the beam. When used in conjunction with each other, the light units provide the pilot with a light signal letting him know if he is above or below the correct glide path.

2.1 FAA PAPI Description

Note: Please check www.faa.gov for the latest update of any advisory circulars that are referenced in this manual.

The FAA describes the PAPI system as;

> (From FAA Advisory Circular 150/5340-30C, 7.3.f (4))
> PAPI
> This system provides visual approach slope guidance. On runways not provided with electronic guidance, the light signals are beneficial in aiding the pilot of an aircraft to determine the correct glide slope. The presence of objects in the approach area may present a serious hazard if an aircraft descends below the normal path. This is especially true where sources of visual reference information are lacking or deceptive: i.e., hilltops, valleys, terrain grades, and remote airports. The PAPI assists the pilot in maintaining a safe distance above hazardous objects. The visual aiming point obtained with the PAPI reduces the probability of undershoots or overshoots. The 2-box PAPI system is normally installed on runways that are not provided with electronic guidance, on non-Part 139 airports, or when there is a serious hazard where the aircraft descends below the normal approach path angle. The system can be expanded to a 4-box system when jet aircraft operations are introduced at a future time.

> (From FAA Advisory Circular 150/5340-30C, 7.4.d)
> **Configurations**
> PAPI
> Provide light units that project the visual signal towards an approaching aircraft with the innermost light unit located 50 feet (15 m) from the left runway edge. The light units are installed in a line perpendicular to the runway edge. Each light unit emits a two-color (red and white) light beam. When the light units are properly aimed, the optical system provides visual approach slope information. Where terrain, intersecting runways, or taxiways make an installation on the left side of the runway impractical, the light housing units may be located on the right side of the runway. See 7.5c(5) for aiming criteria. See Figure 1 for PAPI signal presentation as seen from the approaching aircraft.

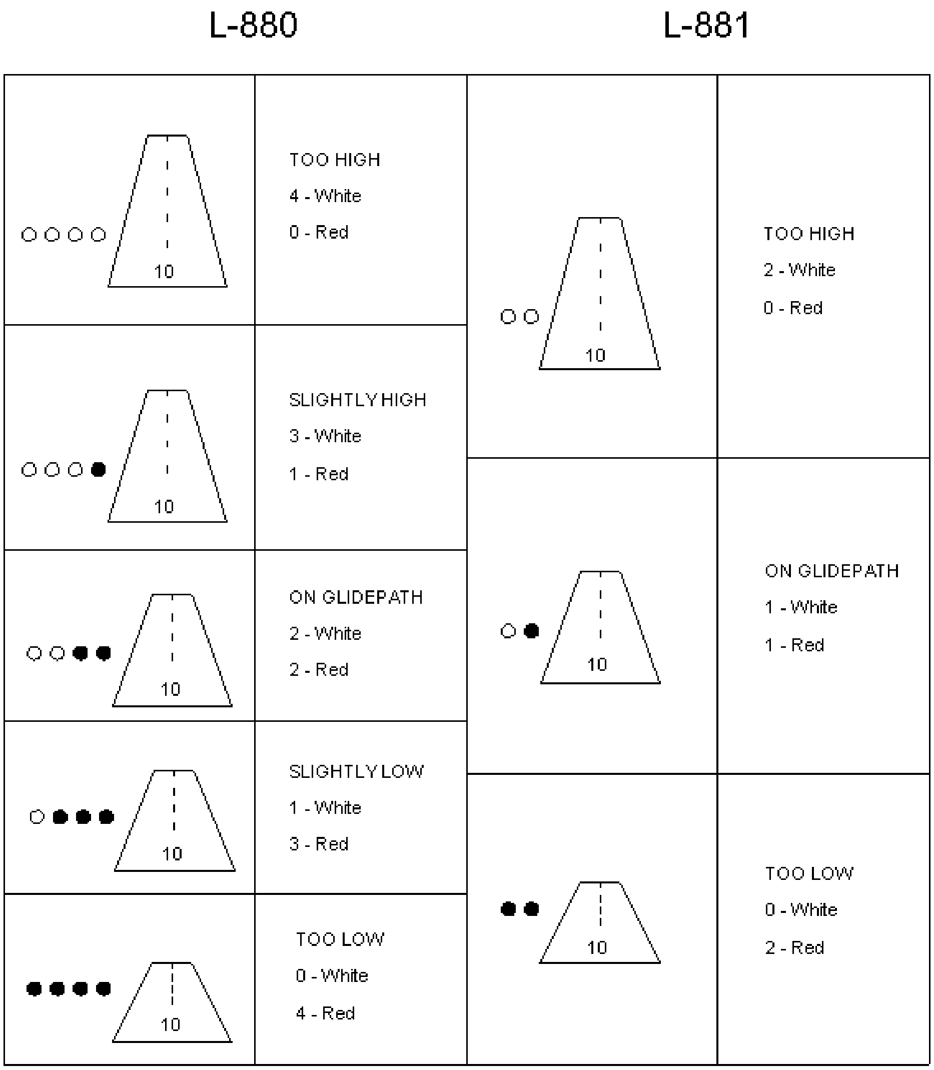


Figure 1: Signal Presentation

2.2 Light Unit

The PAPI system is comprised of either 2 or 4 Light Units. Each Light Unit projects a split beam of light with white on the top and red on the bottom. The transition between the colors in the split beam is sharp due to the properties of the lens and filter combination. The line that designates the change from red to white is parallel to the bottom plate of the Light Unit. The Light Unit is aimed by tilting the Light Unit upward. Each Light Unit consists of three lamps in order to help ensure against a light unit out situation and to meet FAA photometric requirements. If one of the lamps in a light unit goes out, the other two lamps will continue to function. From a distance, each light unit appears as a single light source. The two or four light pattern is created by using two or four light units.

2.3 Aiming Angle

The Aiming Angle is the angle above the horizontal bar at which the light unit is aimed. The unit closest to the runway will have the largest Aiming Angle, the Aiming Angles will then recede in value with the unit farthest from the runway having the smallest value.

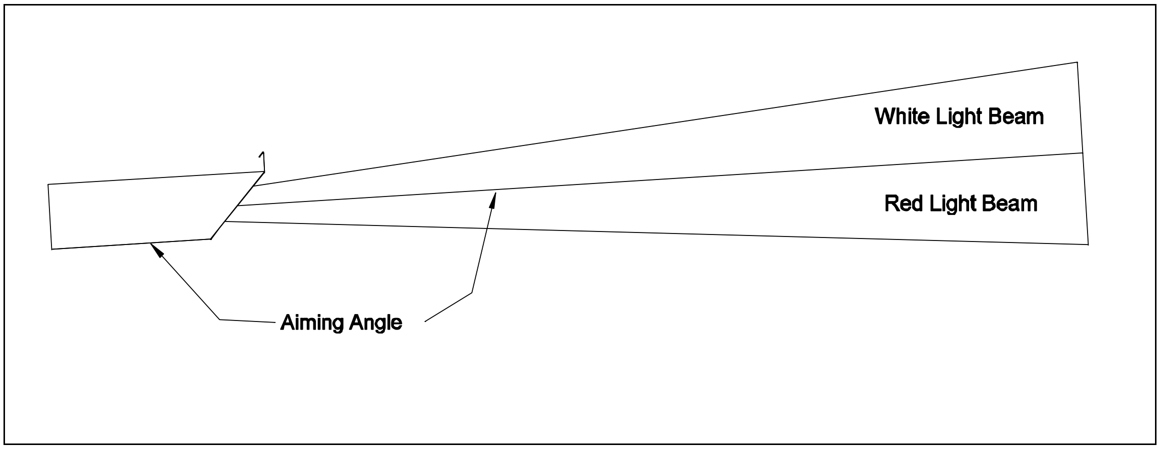


Figure 2: Aiming Angle

In order to guide the pilot in to a safe landing, the Aiming Angles of the Light Units are set to values which are a function of the runway glide slope.

2.4 Digital Aiming Tilt Sensor

A Digital Aiming Tilt Sensor, DATS, is present in each light unit, and is designed to display the aiming angle and provide a signal to trigger the shutdown of the PAPI system should any of the light units be displaced from its aimed position. It is set after the light unit has been aimed. The tilt switch is designed to allow operation when the light unit is properly aligned. The DATS relay switch will open when the light unit is tilted down. The switching will occur when the light unit is tilted between ¼ and ½ a degree down and the switch will remain open in all tilt switch positions beyond this range. The DATS relay switch will open when the light unit is tilted up. The switching will occur when the light unit is tilted between ½ and 1 degree up and the switch will remain open in all tilt switch positions beyond this range. Shutdown will occur after a 10 second but before a 30 second period of continuous tilt out signal in accordance with FAA requirements.

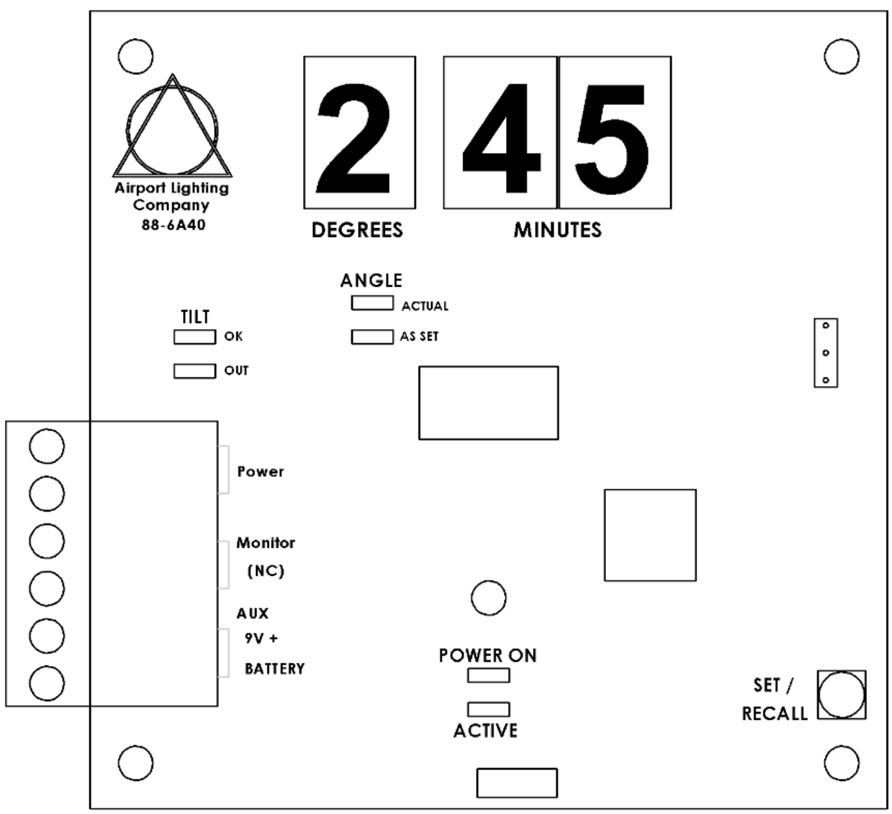


Figure 3: Digital Aiming Tilt Sensor, DATS

3.0 FAA Siting Considerations

The FAA provides the following siting considerations;

Note: Please check www.faa.gov for the latest update of any advisory circulars that are referenced in this manual.

(From FAA Advisory Circular 150/5340-30C, 7.5.d)

7.5. Design.

d. <u>PAPI</u>

(1) <u>Siting Considerations</u>

(a) The PAPI system should be located at the approach end of the runway on the left side.

(b) The PAPI must be sited and aimed so it defines an approach path with sufficient clearance over obstacles and a minimum threshold crossing heights per Table 7.1.

(c) See the manufacturer's installation manual for a light housing assembly aiming procedure.

(d) Other PAPI alignment tolerances and considerations common to installations are in paragraph 7.5h.

(2) <u>Siting PAPI on a Runway With an ILS Glide Path</u>. When siting PAPI on a runway with an ILS system, the PAPI visual approach path must coincide with the ILS glide path. The PAPI must be placed at the same distance from the threshold as the touchdown point of the ILS glide path with a tolerance of ±30 feet (±10 m). If the PAPI is installed on an ILS runway primarily used by aircraft in height group 4 (see Table 7.1), the PAPI distance from the threshold must equal the distance to the ILS glide path touchdown point plus an additional 300 feet +50, -0 (90 m +15, -0) from the runway threshold.

(3) <u>Siting PAPI on a Runway Without an ILS Glide Path</u>. When a runway is not ILS equipped, the position and aiming for the PAPI must be aligned to produce the required threshold crossing height and obstacle clearance for the runway approach path per the following:

NOTE: The following method can be used to determine the PAPI distance from the runway threshold provided there are no obstacles in the area from which the PAPI signals can be observed, no differences in elevation between the threshold and the installation zone of the PAPI or between the units, or reduced length of runway.

(a) The distance of the PAPI units from the runway threshold can be calculated from the equation:

D1 = TCH x cotangent (angle of lowest on-course signal)
D1 = calculated distance of the PAPI unit from the runway threshold
TCH = threshold crossing height

(b) The TCH is determined by the height group of aircraft that primarily use the runway. Refer to Table 7-1 and determine the recommended TCH.

(c) Refer to Table 7-2 and determine the lowest on course signal for the third light unit from the runway edge - 10 minutes (') below glidepath.

(d) The standard visual glideslope for PAPI is 3°. For non-jet runways, the glideslope may be increased to 4° to provide obstacle clearance.

(e) The aiming angle of the third light unit is:

3° - 10' = 2° 50'

(f) Determine the distance of the PAPI from the runway threshold (TCH = 45 feet, Height Group 2):

D1 = 45 x cotangent 2° 50’ (2° 50’ = 2.833°) (cotangent = 1/tan)
D1 = 45 x 20.20579
D1 = 909.26 feet from the runway threshold

e. PAPI Obstacle Clearance Surface (OCS).

(a) Reference 0. The PAPI obstacle clearance surface is established to provide the pilot with a minimum clearance over obstacles during approach. The PAPI must be positioned and aimed so that no obstacles penetrate this surface. The surface begins 300 feet (90 m) in front of (closer to the runway threshold) the PAPI system and proceeds outward into the approach zone at an angle 1 degree less than the aiming angle of the third LHA (lowest on course signal, L-880) from the runway. For an L-881 PAPI, the lowest on course signal is for the unit farthest from the runway. The OCS extends 10° on either side of the runway centerline to a distance of 4 miles (6.44 km) from the point of origin.

(b) Position and aim the PAPI so that there is no risk of an obstruction penetrating the OCS. Perform a site survey and verify that an obstacle will not penetrate the OCS.

(c) If an obstruction penetrates the obstacle clearance surface and cannot be removed, increase the PAPI glideslope angle or move the PAPI farther from the threshold to provide an increased TCH equal to the obstacle penetration height. Use the following formula:

D1 = TCH + H x cotangent θ

where:

D1 = calculated distance of the PAPI from the runway threshold
TCH = threshold crossing height
H = the height of the object above the OCS
θ = PAPI lowest on course signal

(5) Threshold Crossing Height (TCH). The TCH is the height of the lowest on-course signal at a point directly above the intersection of the runway centerline and the threshold.

(a) The minimum TCH varies with the height group of aircraft that primarily use the runway.

(b) The PAPI approach path must provide the proper TCH for the most demanding height group using the runway per Table 7.1.

(6) PAPI AIMING. The standard aiming angles for Type L-880 and Type L-881 systems are shown in Tables 7.2 and 7.3.

Table 7-1. Threshold Crossing Heights.

Representative aircraft type	Approximate Cockpit-to-wheel height	Visual Threshold Crossing Height	Remarks
Height Group 1 General aviation Small commuters Corporate turbo jets	10 feet (3 m) or less	40 feet (+5, -20) 12 m (+2, -6)	Many runways less than 6,000 feet (1829 m) long with reduced widths and/or restricted weight bearing that would normally prohibit landings by larger aircraft.
Height Group 2 F-28, CV-340/44O/580 A-737, DC-9, DC-8	15 feet (4.5 m)	45 feet (+5, -20) 14 m (+2, -6)	Regional airport with limited air carrier service
Height Group 3 B-727/707/720/757	20 feet (6 m)	50 feet (+5,-15) 15 m (+2, -6)	Primary runways not normally used by aircraft with ILS glide-path-to-wheel heights exceeding 20 feet (6 m).
Height group 4 B-747/767, L-1011, DC-10 A-300	Over 25 feet (7.6 m)	75 feet (+5, -15) 23 m (+2, -4)	Most primary runways at major airports.

Table 7-2. Aiming of Type L-880 (4 Box) PAPI Relative to Pre-selected Glide Path.

Light Unit	Aiming Angle (in minutes of arc)	Ht group 4 aircraft. on runway with ILS
	Standard installation	
Unit nearest runway	30’ above glide path	35’ above glide path
Next adjacent unit	10’ above glide path	15’ above glide path
Next adjacent unit	10’ below glide path	15’ below glide path
Next adjacent Unit	30’ below glide path	35’ below glide path

Table 7-3. Aiming of Type L-881 (2 Box) PAPI Relative to Pre-selected Glide Path.

Light Unit	Aiming angle (in minutes of arc)
Unit nearest runway	15’ above glide path
Unit farthest from runway	15’ below glide path

(7) OTHER SITING DIMENSIONS AND TOLERANCES.

(a) Distance from Runway Edge:

1. The inboard light unit must be not be less than 50 feet, +10, -0, (15 m, +3, -0) from the runway edge (see Figure 79) or to other runways or taxiways.

2. The distance from the runway edge may be reduced to 30 feet (10 m) for small general aviation runways used by non-jet aircraft.

(b) Separation Between Light Units:

1. The PAPI light units must have a lateral separation of:

a. Between 20 and 30 feet (6 to 9 m) for L-880 systems.

NOTE: *the distance between light units is measured center to center*.

b. For the L-880, the distance between light units may not vary by more than ± 1 foot (0.3 m).

(c) Azimuth Aiming. Each light unit must be aimed outward into the approach zone on a line parallel to the runway centerline within a tolerance of ±1/2 degree.

(d) Mounting Height Tolerances.

1. The beam centers of all light units must be within ±1 inch of a horizontal plane.

2. The PAPI horizontal plane must be within 1 foot (0.3 m) of the elevation of the runway centerline at the intercept point of the visual glide path with the runway (except for the siting conditions in subparagraph g below).

(e) Tolerance Along Line Perpendicular to Runway. The front face of each light unit in a bar must be located on a line perpendicular to the runway centerline within +6 inches (+152 mm).

(f) Correction for Runway Longitudinal Gradient.

1. On runways where there is a difference in elevation between the runway threshold and the PAPI, it may be necessary to adjust the location of the light units with respect to the threshold to meet the required obstacle clearance and TCH.

2. When an elevation difference exists, the following steps (reference 0) must be used to compute the change in the distance from the threshold required and preserve the proper geometry.

   a. Obtain the runway longitudinal gradient (RWY) from "as-built" drawings or airport obstruction charts.

   NOTE: *If the information cannot be obtained from the above sources, a survey must be performed to obtain RWY.*

   b. Determine the ideal (D1, zero gradient) PAPI distance from the runway threshold (T).

   c. Assume a level reference plane at the runway threshold elevation. Plot the location determined in (2) above.

   d. Plot the runway longitudinal gradient (RWY).

   e. Project the visual glide path angle (θ) to its intersection with the runway longitudinal gradient (RWY).

   f. Solve for the adjusted distance from threshold (d) either mathematically or graphically.

   g. Double-check to see that the calculated location gives the desired TCH.

(g) Additional Siting Considerations.

1. If the terrain drops off rapidly near the approach threshold and severe turbulence is experienced, then PAPI must be located farther from the threshold to keep the aircraft at the maximum possible threshold crossing height.

2. For short runways, the PAPI must be as near the threshold as possible to provide the maximum amount of runway for braking after landing.

3. At locations where snow is likely to obscure the light beams, the light units may be installed so the top of the unit is a maximum of 6 feet (2 m) above ground level.

4. PAPI LHAs must not be located closer than 50 feet from a crossing runway, taxiway, or warm-up apron or within the ILS critical area.

5. The inboard light housing may be located up to 75 feet (23 m) from the runway edge where damage may occur arising from jet blast and wing vortices. This is a deviation from standard and must be submitted to the local Airport District Office for approval prior to installation.

NOTES:

- *Increasing the height of the PAPI light units will also raise the threshold crossing height for the glide path.*

- *This may also require locating the light units farther from the runway edge to ensure adequate clearance for aircraft.*

- *The location for the light units (closer to the runway threshold) must be recalculated to maintain the correct TCH and Obstacle Clear Surface (OCS).*

(8) Electrical Systems. Select equipment and connect the light units for continuous operation, series operation. See Figure 88 for typical wiring diagrams.

(a) Continuous Operation. Provide a continuous power source to permit the PAPI to be energized at all times.

(b) Series Operation. Use isolation transformers (not supplied with PAPI equipment) in conjunction with the light unit to connect them into the series lighting circuit. The CCR will control the brightness of the system. Select a series circuit capable of accepting an additional load for each installation. Provide a selector switch to permit independent control of the PAPI. At an existing runway lighting installation, the 2-box PAPI may be connected into the series runway lighting circuit; however, it would be necessary to burn the runway edge lights at top brightness if approach slope information is needed during daytime conditions.

(c) Multiple Operation. . (Does not Apply to Style B)

(d) Wire. Use No. 8 AWG wires to connect light units in series circuits. Make connections to multiple circuits with wire insulated for 600 volts minimum.

(9) Foundation. See 90 for design details for the light unit's foundation.

(10) Feeder Circuit. The PAPI may be specified to operate from a ~~standard utility voltage (Style A) or from a~~ constant current power supply (Style B). (Strike through does not Apply to Style B)

(a) The power cable must be per FAA Type L-824 per AC 150/5345-7, *Specification for L-624 Underground Electrical Cable for Airport Lighting Circuit*, or equivalent.

(b) Lightning arresters for both power and control lines must be provided per AC/150-5345-28, *Precision Approach Path Indicator (PAPI) Systems*.

NOTE: *The output power lines for an L-828 regulator used for Style B systems already have integral lightning protection).*

(c) All fuses or circuit breakers must be within the equipment ratings.

(12) Style B PAPI System.

(a) PAPI systems that operate from a constant current source must use several types of FAA equipment:

1. The system power source is an L-828 CCR (AC 150/5345-10, *Specification for Constant Current Regulators and Regulator Monitors)*, with an output current of 6.6 amps. The CCR automatically compensates for up to –5 percent to +10 percent deviations from its nominal input voltage, and may be ordered with three or five brightness steps.

2. The five-step regulator is recommended, since the lowest brightness step on a three-step regulator may be too bright for some rural PAPI installations.

(b) The output of the CCR powers L-830 isolation transformers (per AC 150/5345-47, *Isolation Transformers for Airport Lighting Systems).* The isolation transformer wattage must be chosen for PAPI maximum load.

(13) Wiring the PAPI Light Units.

(a) For Style A systems, (Not applicable to Style B systems.)

(b) Ensure all PAPI light boxes are properly grounded to the connection point provided by the manufacturer.

(c) All wiring entering the PAPI light unit must be through plugs and receptacles that will separate if the box is struck by an aircraft. The receptacles are located and secured at the frangible couplings.

(d) A length of flexible watertight conduit conveys the PAPI wiring between the frangible coupling and the PAPI light box. The flexible conduit is required so the PAPI box has sufficient movement for proper aiming.

(e) All underground connections must be made with either splices or plugs and receptacles per AC 150/5345-26, *Specification for L-823, Plug and Receptacle, Cable Connectors.*

(14) PAPI Lamp Brightness Control.

(a) Style A Systems. (not applicable to Style B systems)

(15) Style B Systems. The lamp intensity of style B systems is controlled by the tap settings on an L-828 regulator. See AC 150/5345-10.

1. We recommend that the PAPI not be powered from a runway edge lighting circuit, as this will require the edge lights to be at full intensity during day operations.

2. A dedicated L-828 CCR with five current steps (2.8 to 6.6A) is the preferred method of powering the PAPI. The regulator current steps may be controlled either manually or automatically via a photocell.

(16) PAPI Power Control. The PAPI may be turned on and off by a number of different methods.

(a) For Style A systems, (not applicable to Style B systems)

(b) For Style B systems, the PAPI is turned on and off by the L-828 regulator control circuitry.

(c) The remote control that activates either Style A or B systems may be located in the control tower, flight service station, or other attended facility.

(d) Alternatively, the PAPI power control lines may be activated by an L-854 radio control receiver (AC 150/5345-49, *Specification L-854, Radio Control Equipment)*. The L-854 allows the PAPI to be energized by either a pilot on approach, or by an airport ground control station.

(17) Other PAPI Power Control Configurations.

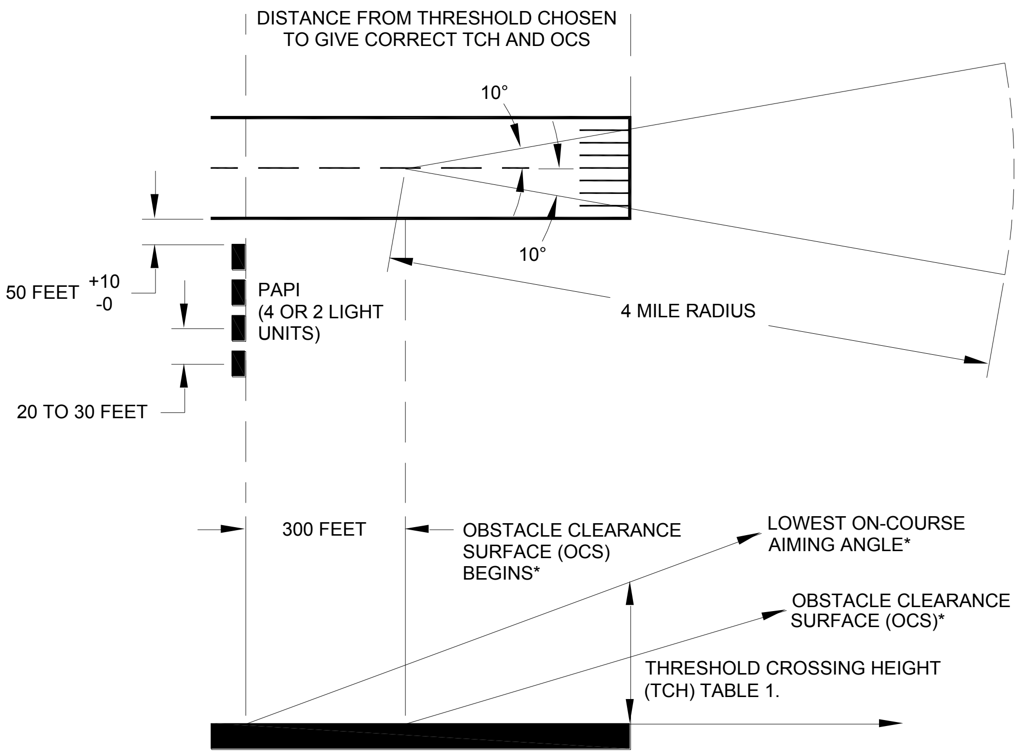
(a) PAPIs On Both Runway Ends.

1. It is desirable to independently control PAPIs for each runway end, energizing only the PAPI that serves the active runway end.

2. Turning off both systems when the runway is inactive will conserve energy.

(b) [Omitted does not apply to Style B sytem)

(18) Style B PAPI Lamp Bypass. CCRs will increase the output current as the number of isolation transformers with an open secondary (caused by burned-out lamps) increases. The increased current will cause more lamp failures, increasing the regulator current. This situation is particularly critical when the connected load is small (less than 50 percent) compared to the regulator rating. A lamp bypass device prevents the runaway effect by shorting the secondary of the isolating transformer and simulating the resistance of a lamp. Lamp bypass devices are an optional feature, and are recommenced for all Style B PAPIs powered by resonant-type CCRs.



PAPI OCS ANGLE = LOWEST ON-COURSE AIMING ANGLE - 1 DEGREE

NOTES:

1. THE VISUAL GLIDE PATH ANGLE IS THE CENTER OF THE ON-COURSE ZONE, AND IS A NOMINAL 3 DEGREES WHEN MEASURED FROM THE HORIZONTAL SURFACE OF THE RUNWAY.

   A. FOR NON-JET RUNWAYS, THE GLIDE PATH MAY BE RAISED TO 4 DEGREES MAXIMUM TO PROVIDE OBSTACLE CLEARANCE.

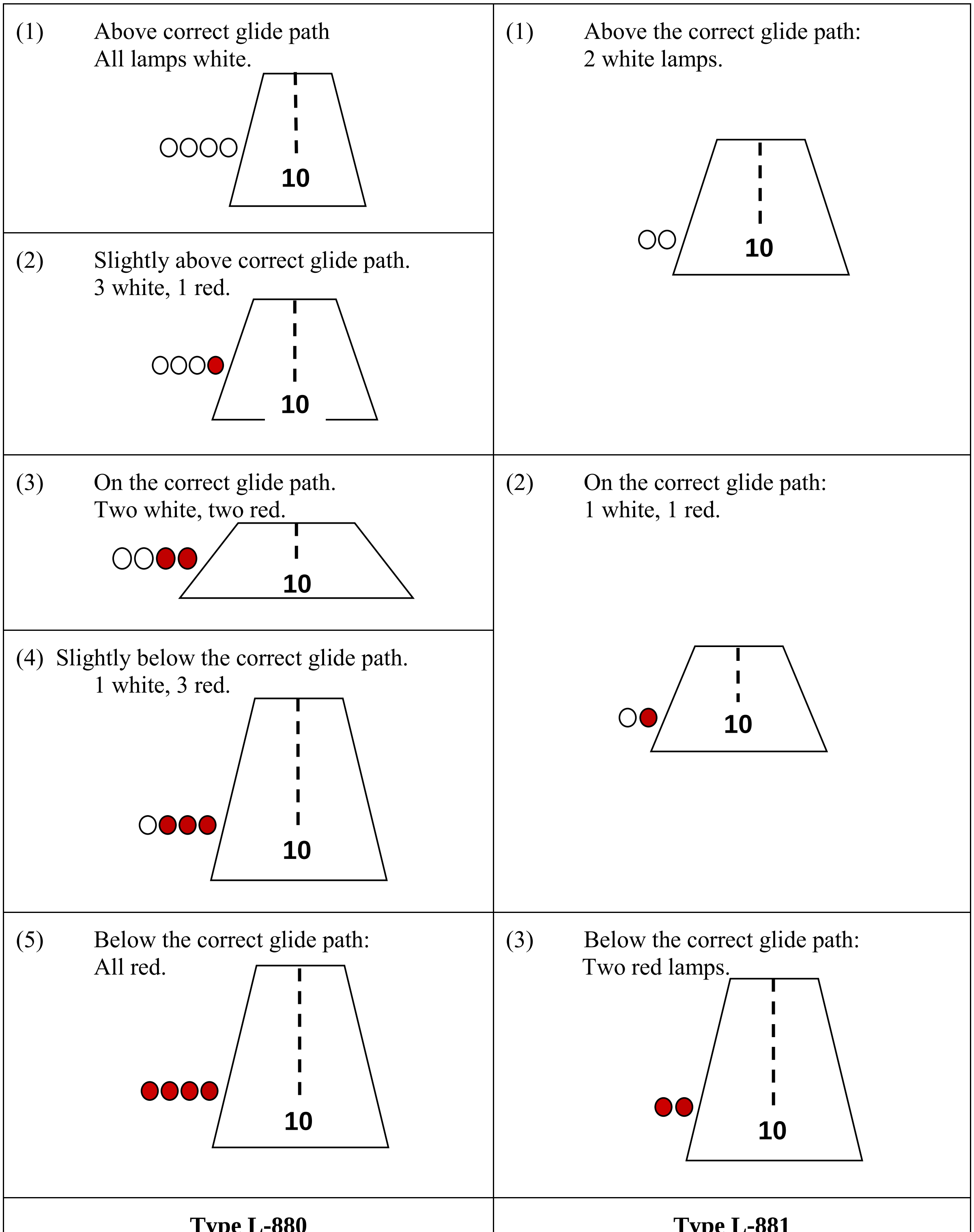
   B. IF THE PAPI GLIDE PATH IS CHANGED TO A HIGHER ANGLE FROM THE NOMINAL 3 DEGREES, IT MUST BE COMMUNICATED IN A NOTICE TO AIRMAN (NOTAM) AND PUBLISHED IN THE AIRPORT FACILITY DIRECTORY.

2. PAPI OBSTACLE CLEARANCE SURFACE (OCS).

   A. THE PAPI OCS PROVIDES THE PILOT WITH A MINIMUM APPROACH CLEARANCE.

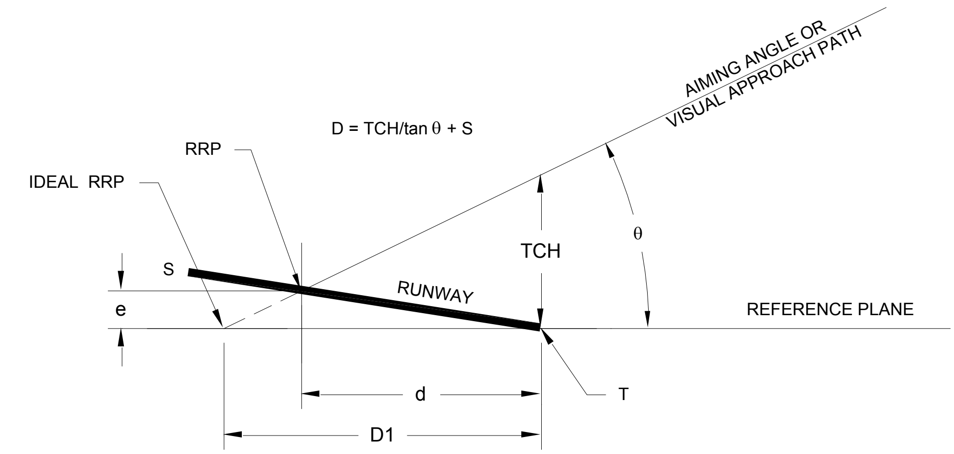
   B. THE PAPI MUST BE POSITIONED AND AIMED SO NO OBSTACLES PENETRATE ITS SURFACE.
      (1) THE OCS BEGINS 300 FEET [90M] IN FRONT OF THE PAPI SYSTEM.
      (2) THE OCS IS PROJECTED INTO THE APPROACH ZONE DEGREE LESS THEN AIMING ANGLE OF THE THIRD LIGHT UNIT FROM THE RUNWAY FOR AN L-880 SYSTEM, OR THE OUTSIDE LIGHT UNIT FOR AN L-881 SYSTEM.

Figure 79: PAPI Obstacle Clearance Surface.

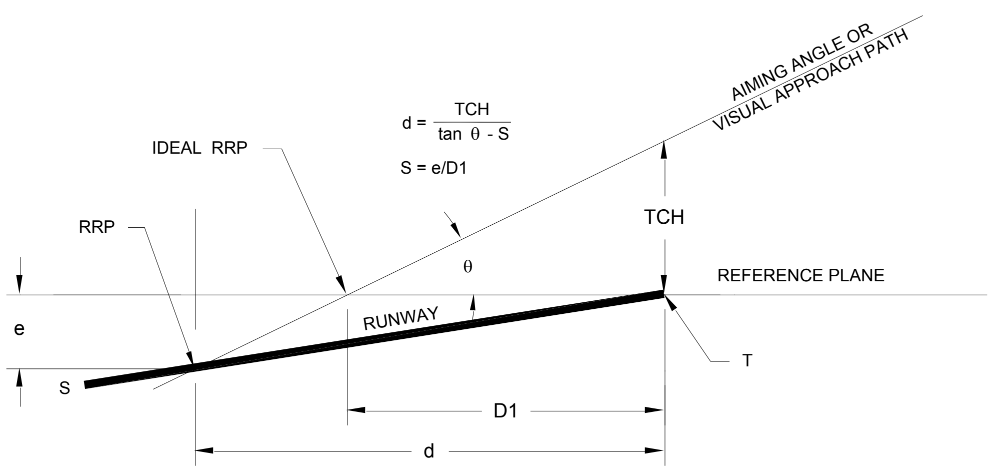


NOTE: *The PAPI is a system of either four or two identical light units placed on the left of the runway in a line perpendicular to the centerline. The boxes are positioned and aimed to produce the visual signal shown above.*

Figure 80: PAPI Signal Presentation.



Siting station displaced toward threshold



Siting station displaced from threshold

SYMBOLS:

D1 = ideal (zero gradient) distance from threshold

RWY = runway longitudinal gradient

TCH = threshold crossing height

T = threshold

e = elevation difference between threshold and RRP

RRP = runway reference point (where aiming angle or visual approach path intersects runway profile)

d = adjusted distance form threshold

θ = aiming angle

S = percent slope of runway = e/d
(S is used in decimal form in the equations)

Figure 81: Correction for Runway Longitudinal Gradient.

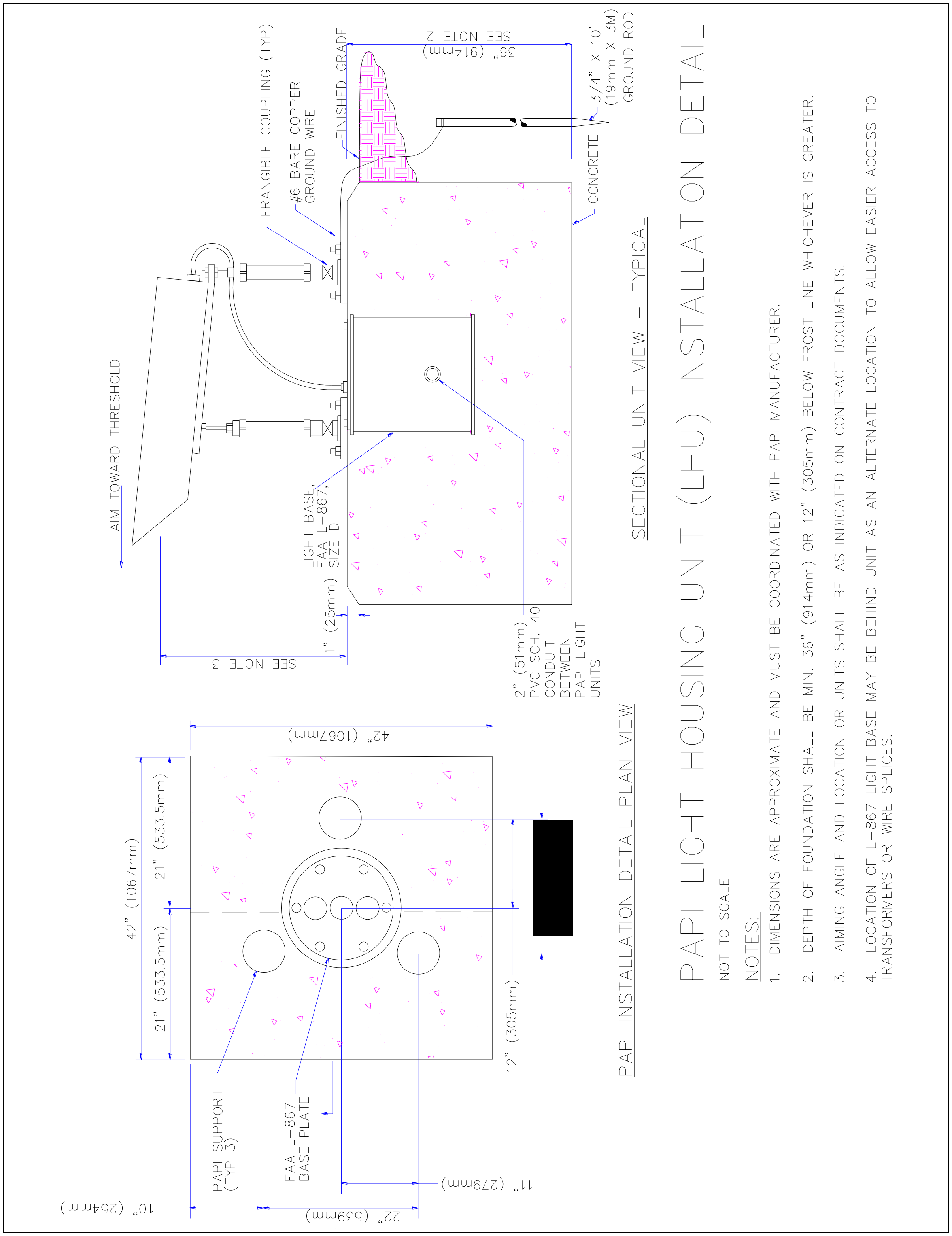


Figure 90: PAPI Light Housing Unit (LHU) Installation Detail.

(Dimensions don't match Airport Lighting Company's PAPI Light Units)

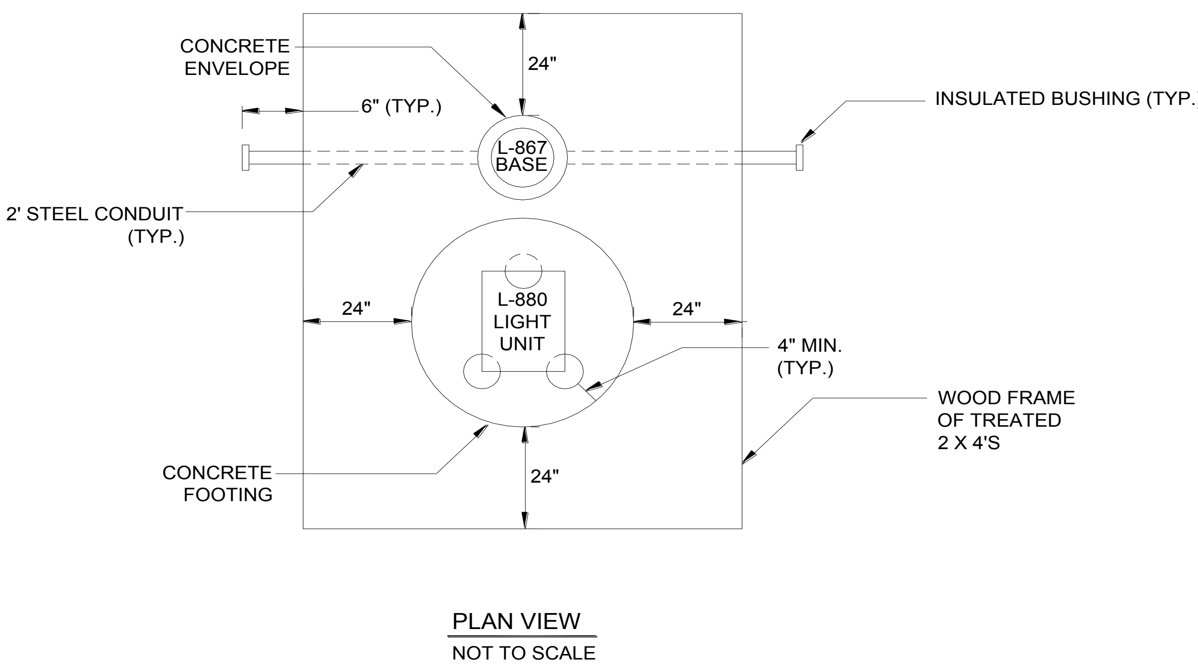


Figure 133: Standard Details for Precision Approach Path Indicators (PAPIs) – PAPI Light Unit Locations.

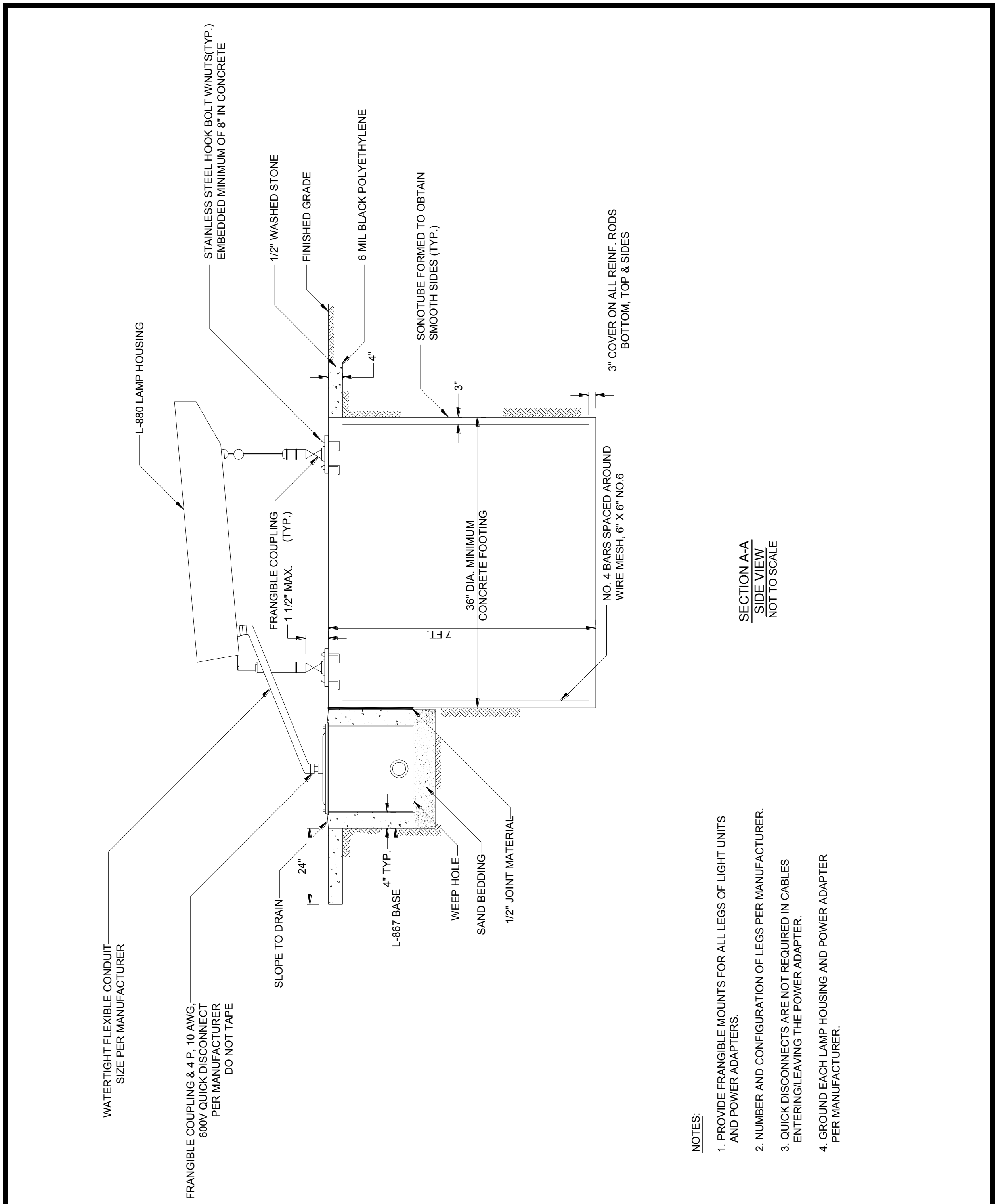


Figure 135: Standard Details for Precision Approach Path Indicators (PAPIs) – Section A-A.

4.0 Installation

4.1 Placement of the Light Units

The FAA has very specific regulations regarding the placement of the Light Units. The distance from the threshold of the runway to the PAPI light bar is a distance that requires some calculations. The calculations are a function of the Threshold Crossing Height (TCH), the Obstacle Clearance Surface (OCS), the runway longitudinal gradient, the runway glideslope, and what size aircraft will use the runway. If the site plans do not list the distance to threshold, the information to calculate this distance can be found in section 3 of this manual.

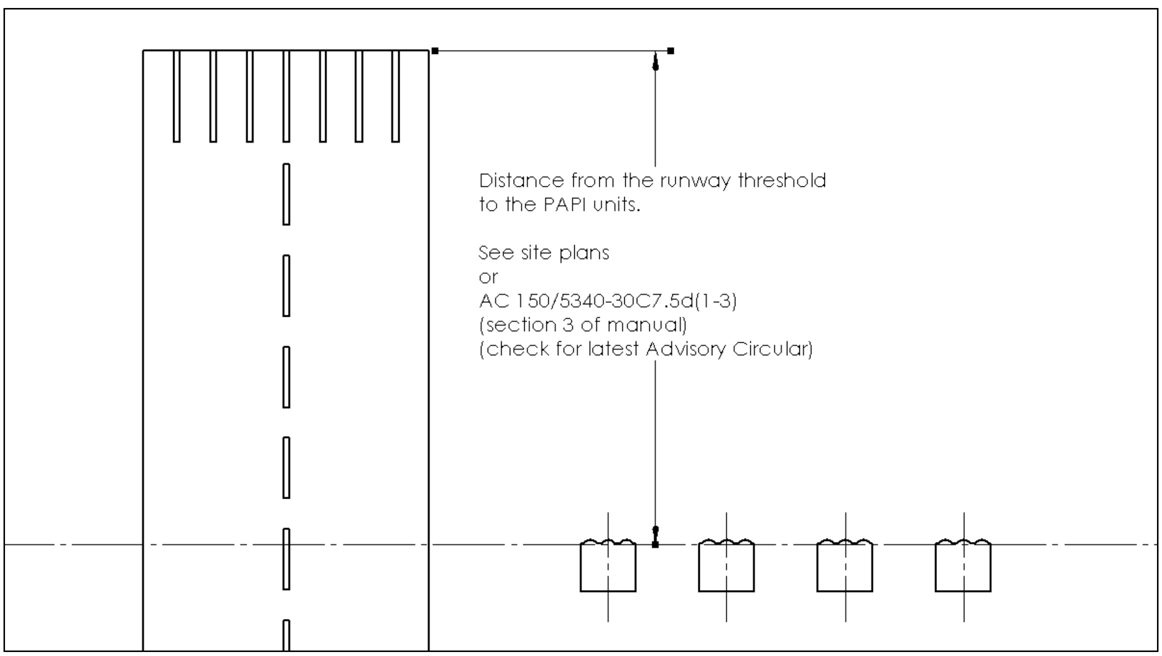


Figure 4: Distance to Threshold

The FAA specifies the placement of the light units as follows;

(From FAA Advisory Circular 150/5340-30C, 7.5.e (7) a, b and c)

(a) <u>Distance from Runway Edge</u>:

<u>1</u>. The inboard light unit must be not be less than 50 feet, +10, -0, (15 m, +3, -0) from the runway edge (see Figure 79) or to other runways or taxiways.

2. The distance from the runway edge may be reduced to 30 feet (10 m) for small general aviation runways used by non-jet aircraft.

(b) Separation between Light Units:

3. The PAPI light units must have a lateral separation of:

a. Between 20 and 30 feet (6 to 9 m) for L-880 systems.

NOTE: *the distance between light units is measured center to center*.

b. For the L-880, the distance between light units may not vary by more than ± 1 foot (0.3 m).

(c) Azimuth Aiming. Each light unit must be aimed outward into the approach zone on a line parallel to the runway centerline within a tolerance of ±1/2 degree.

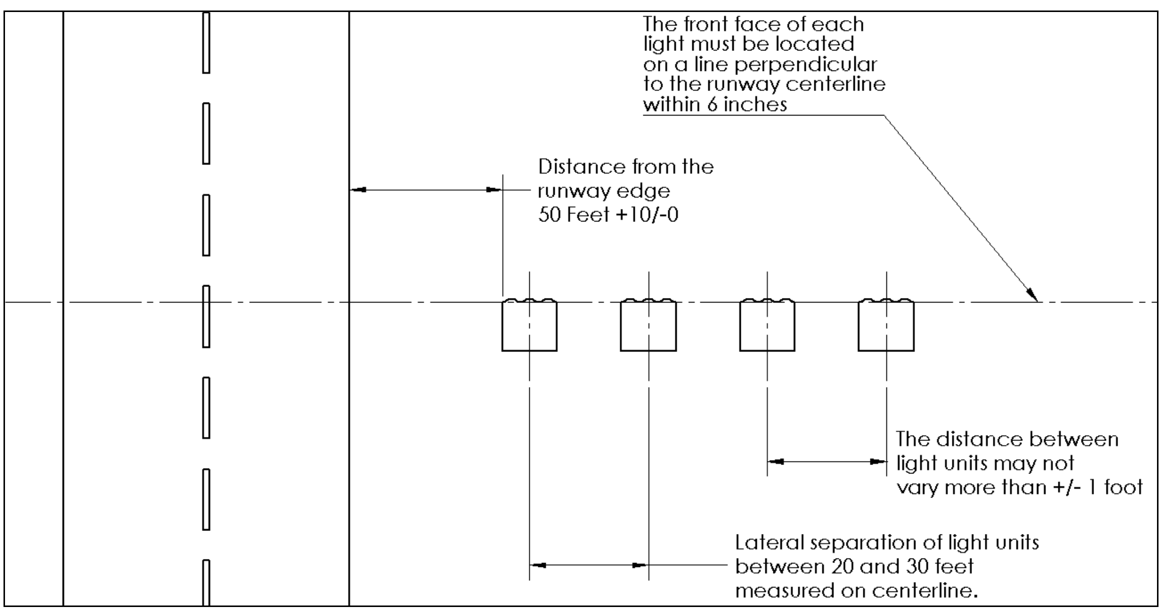


Figure 5: Field Placement

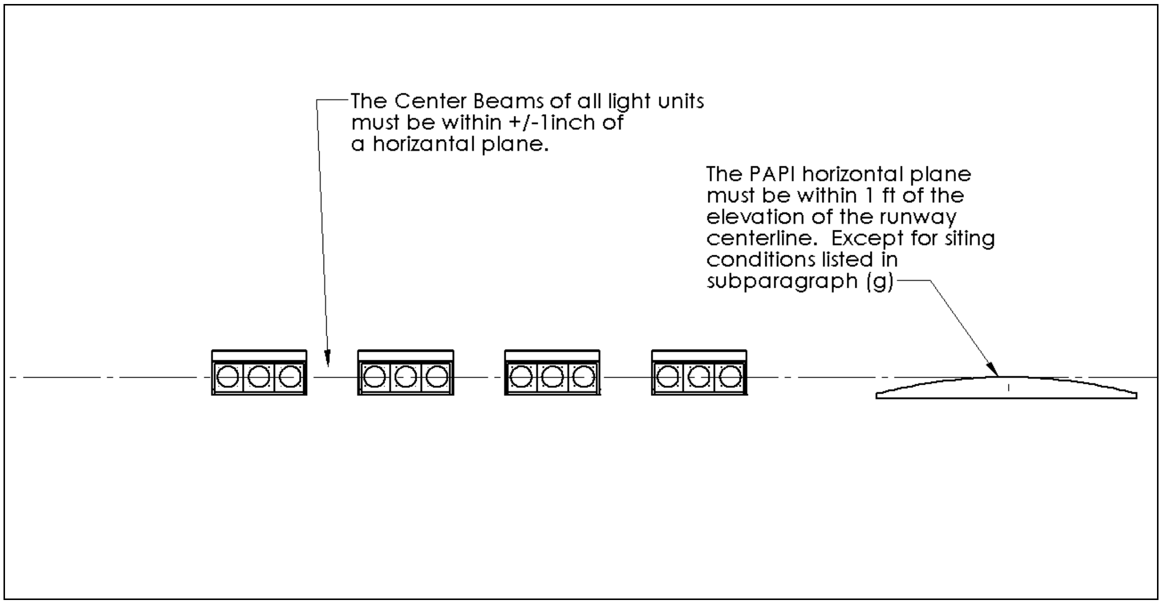


Figure 6: Placement of Light Unit

(From FAA Advisory Circular 150/5340-30C, 7.5.e (7) d and e)

(d) Mounting Height Tolerances.

1. The beam centers of all light units must be within ±1 inch of a horizontal plane.

2. The PAPI horizontal plane must be within 1 foot (0.3 m) of the elevation of the runway centerline at the intercept point of the visual glide path with the runway (except for the siting conditions in subparagraph g below)

(e) Tolerance Along Line Perpendicular to Runway. The front face of each light unit in a bar must be located on a line perpendicular to the runway centerline within +6 inches (+152 mm).

Shaded text is a direct quote from FAA Advisory Circulars.

4.2 Electrical Requirements

Each light unit requires a 300-watt isolation transformer. There is a series loop through all of the light units that is used to signal light unit tilt status. If any one of the light units becomes out of tilt, it will shut off all the light units.

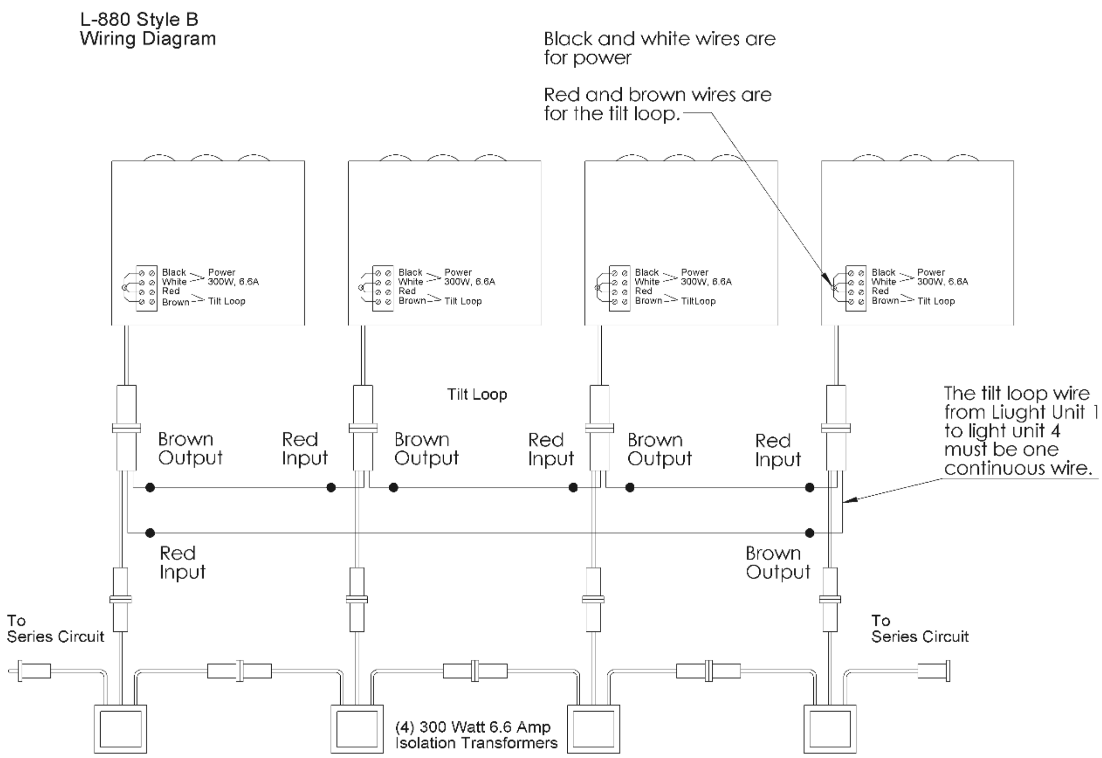


Figure 7: L-880, Style B Wiring Diagram

Note: The tilt loop is wired in series such that the brown wire from Light Unit1 connects to the red wire of Light Unit 2, the brown wire from Light Unit 2 connects to the red wire of Light Unit 3, the brown wire from Light Unit 3 connects to the red wire of Light Unit 4, and the brown wire from Light Unit 4 connects to the red wire of Light Unit 1.

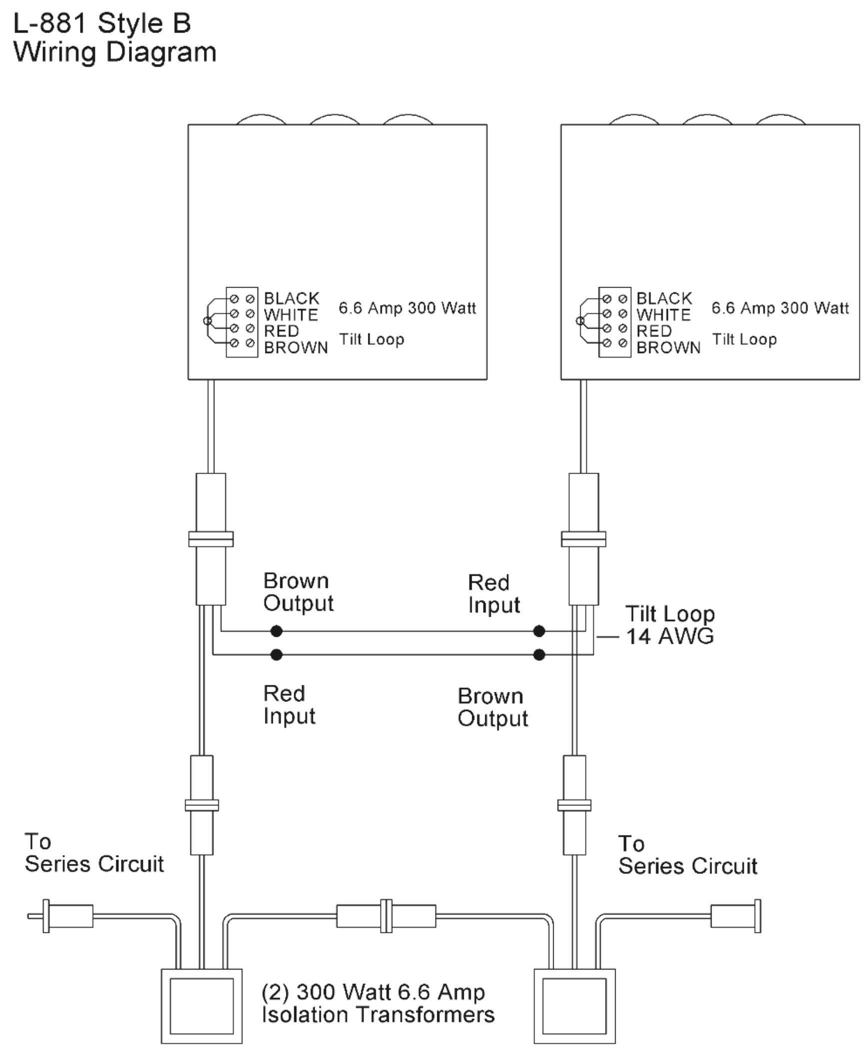


Figure 8: L-881, Style B Wiring Diagram

Note: The tilt loop is wired in series such that the brown wire from Light Unit1 connects to the red wire of Light Unit 2, and the brown wire from Light Unit 2 connects to the red wire of Light Unit 1.

4.3 Foundation Requirements

The FAA requirements for the PAPI Light Unit can be found in:

Figure 90. PAPI Light Unit (LU) Installation Details

Figure 133. Standard Details for the Precision Approach Path Indicators (PAPIs)
PAPI Light Unit Locations
Figure 135. Standard Details for the Precision Approach Path Indicators (PAPIs)

4.4 Assembly of the Light Unit

Mount three floor flanges to the foundation. The proper locations are:

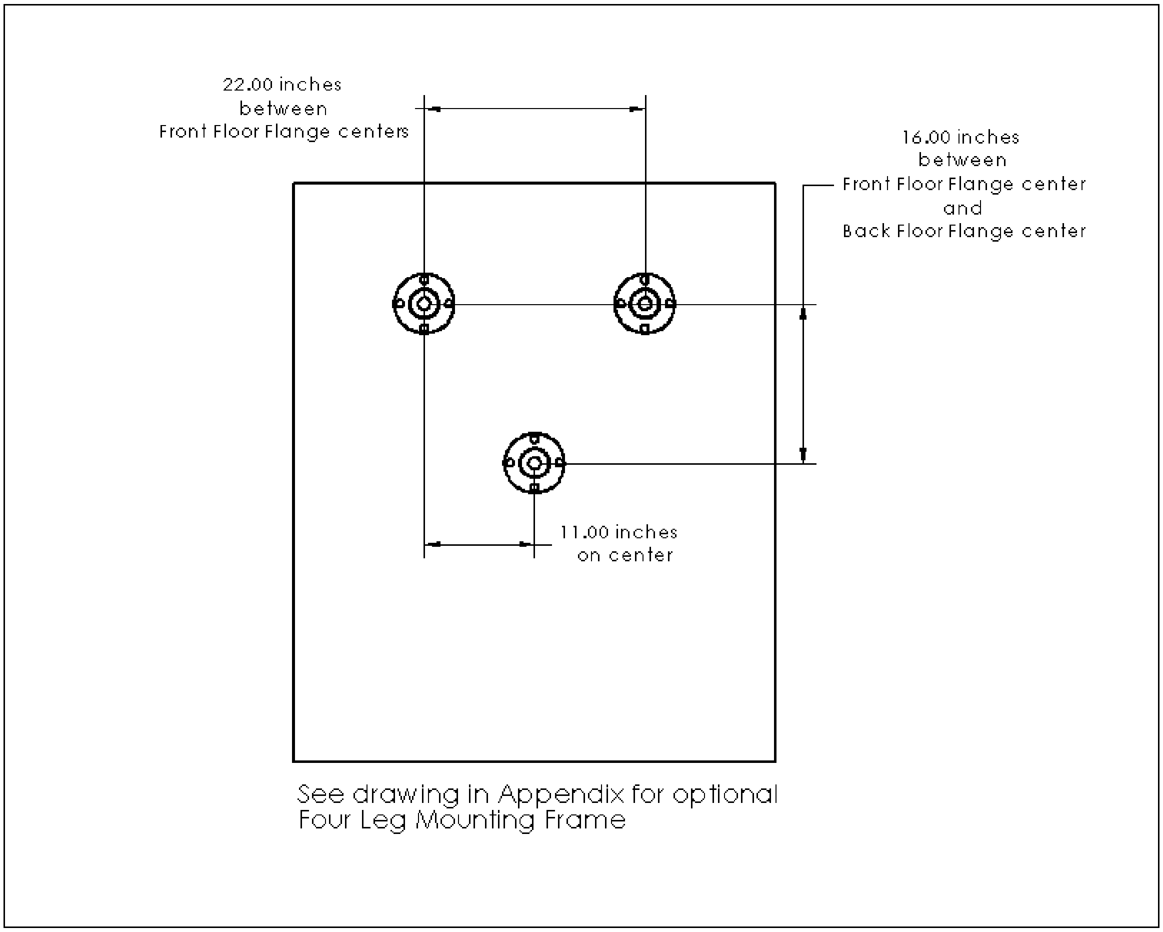


Figure 9: Floor Flange Placement

The contractor can mount the floor flanges to the foundation using either cast 3/8” stainless steel threaded anchors into the foundation or use 3/8” stainless steel expansion bolts.

The contractor is to supply 2 inch EMT to be used in the Leg Assembly. The correct cut dimension for the EMT is;

2 Front Legs:

EMT Cut Dimension = Light Beam Center – 16 inches

Or
EMT Cut Dimension = Light Unit Top Surface Height – 19 inches

1 Rear Leg:

EMT Cut Dimension = Light Beam Center – 17 inches
Or
EMT Cut Dimension = Light Unit Top Surface Height – 20 inches

The center of the light beam is 3 inches below the top flat surface of the light unit.

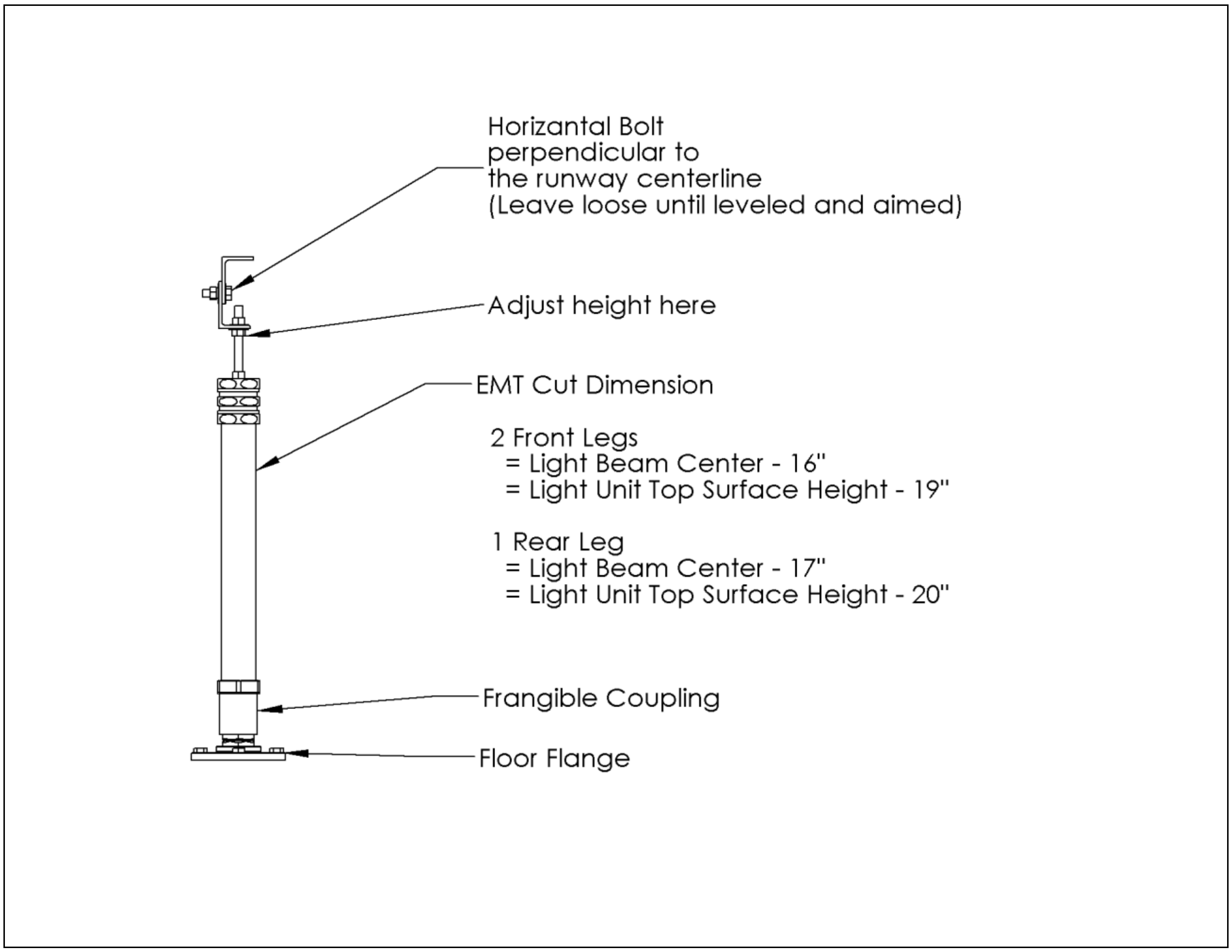


Figure 10: EMT Cut Dimension

When assembling the legs, keep the top horizontal bolt perpendicular to the runway to allow the light unit to rotate during the aiming process. Remove the light unit cover. Bolt the light unit to the leg assemblies.

4.5 Wiring the Light Unit

- Cut the Flex tubing that goes from the light unit to the can cover to the proper length. It should be long enough to make the connection easily. This will make it easy to service in the future.

- Fasten the top liquid-tight straight fitting to the PVC Coupling on the bottom of the Light Unit (LU).

- Attach the flex tubing to the bottom liquid-tight straight fitting that is preassembled to the aluminum disk.

- Pass the Light Unit Wire Harness up from the bottom liquid-tight straight fitting.

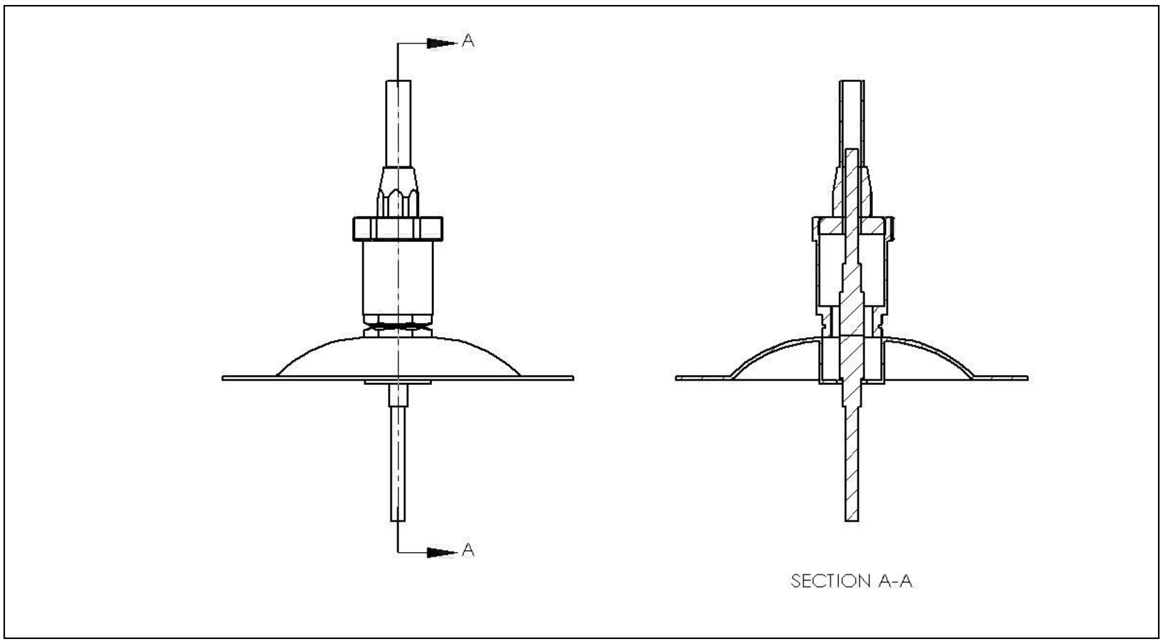


Figure 11: Breakaway Plug Connection

- Remove the lid from the can.

- Pass the (4pin female//2 pin male/2 wire ends) cable through can lid so that the 4 pin female connector is on top of the lid.

- Attach a 59B frangible coupling to the can lid.

- Connect the 4 pin connectors together.

- Pass the Light Unit Wire Harness up through the light unit and secure the liquid-tight straight fitting to the bottom of the light unit.

- Fasten the straight fitting connector disk to the frangible coupling.

- Check that all connections are secure and no extra wire is needed.

- Tighten the strain relief on the inside of the light unit

- Measure the wire coming out of the strain relief and cut it at 7”.

- Remove the outer jacket off the wire, back 6”.

- Strip each of the four wires 3/8” and crimp on the blue fork terminals.

- Attach the fork terminal to the terminal block as per the figure 12

- Fasten the tilt loop leads on the Isolation Transformer Wire Harness to the tilts series loop per figures 7 and 8. On the L-880, 4 light unit systems, the tilt loop wire from light unit 1 to light unit 4 must be one continuous wire per figure 7.

- Attach 300 Watt isolation transformer per the figures 7 and 8.

- Once all wiring is complete secure the cans and secure the LU cover.

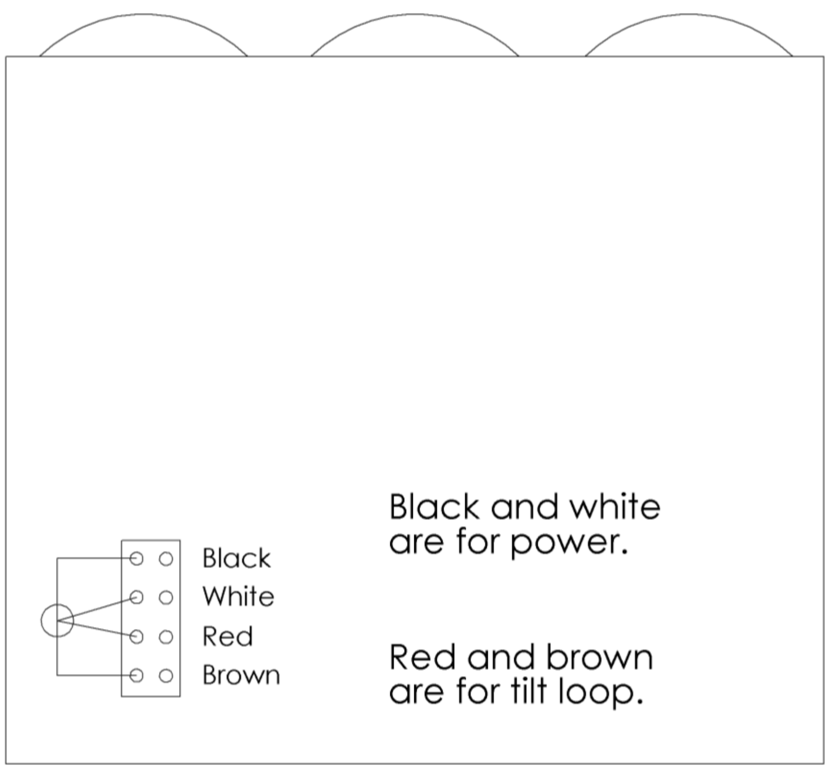


Figure 12: Light Unit Wiring

5.0 Aiming

The light units are pre-focused at the factory. The beam of light produced by each light unit comes straight out and is parallel to the bottom surface of the light unit. In order to create the light pattern that provides a signal for the pilot, the light unit is leveled side to side by adjusting the height of the front legs, and aimed at a precise angle, by changing the height of the rear leg(s),

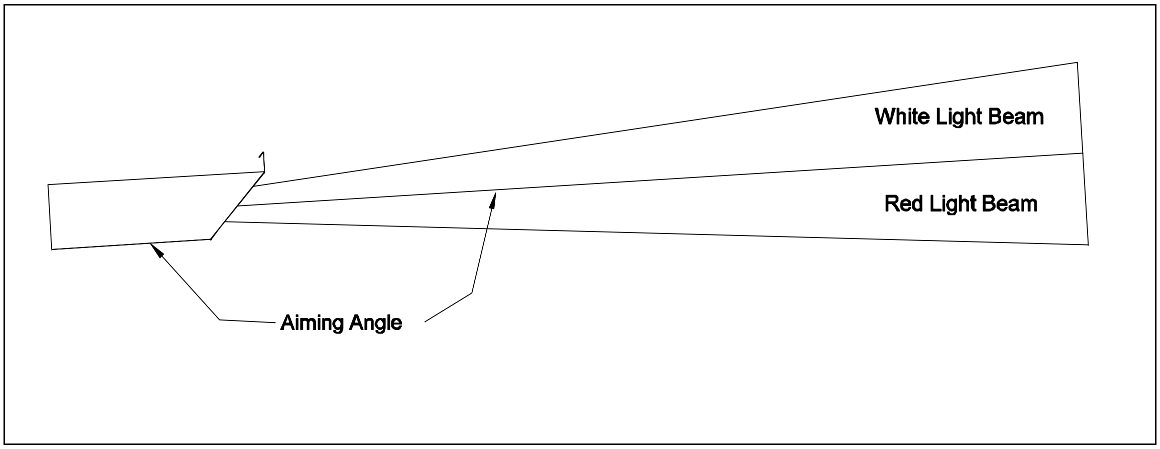


Figure 13: Aiming Angle

5.1 Digital Aiming Tilt Sensor

The Digital Aiming Tilt Sensor, DATS, is an electronic angle indicator tool used to set each light unit at the correct aiming angle and to switch the PAPI off if the light unit is out of tilt. The digital readout on the DATS is in degrees and minutes. The DATS is powered by the PAPI electrical system or by a 9-volt battery if power is not available at the time of installation. The DATS works by displaying the aiming angle of the light unit. The light unit's aiming angle is adjusted at the threaded rod until the display on the DATS matches the desired aiming angle. Once the aiming angle is reached the tilt function needs to be set so that it will determine if the light unit is out of tilt (see 5.2). Once the aiming angle is electronically recorded the DATS will monitor the aiming angle and determine if the light unit is within range or out of tilt.

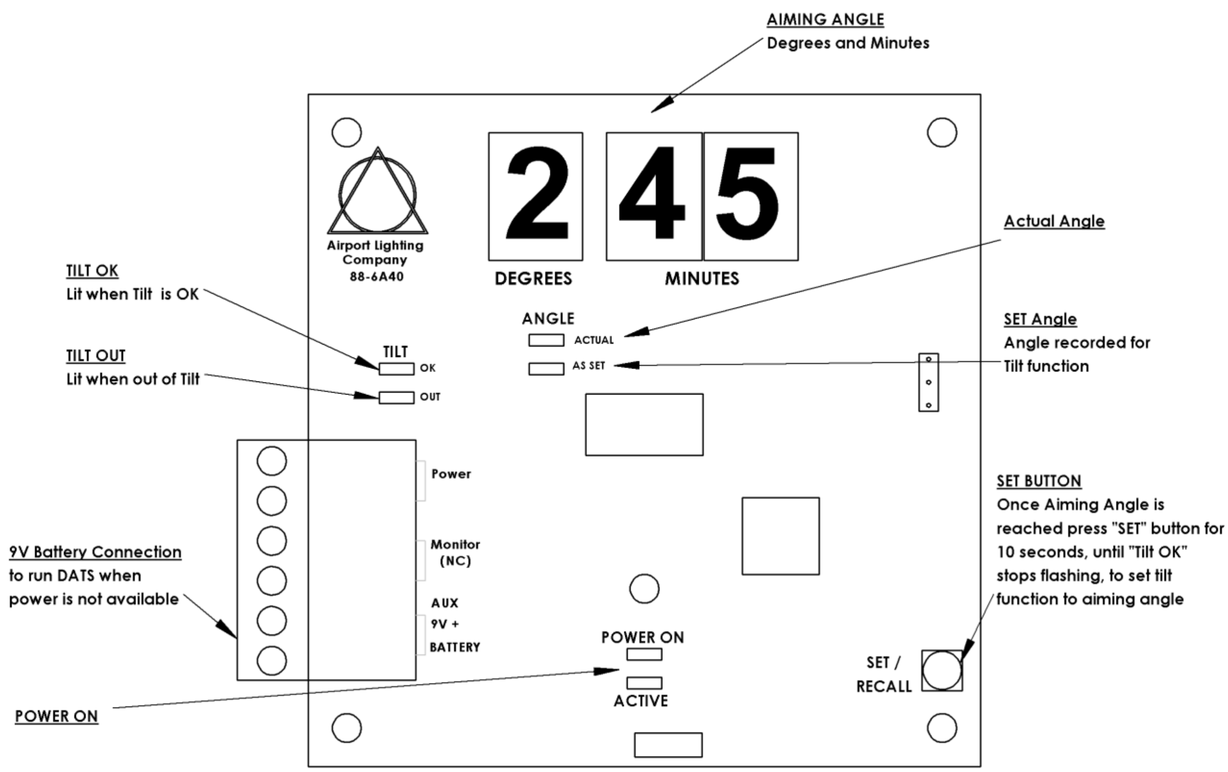


Figure 14: Digital Aiming Tilt Sensor, DATS

5.2 Aiming Angle

The Aiming Angle is the angle above the horizontal plane at which the light unit is aimed. The unit closest to the runway will have the largest Aiming Angle, the Aiming Angles will then recede in value with the unit farthest from the runway having the smallest value. The Aiming Angles will be listed on the PAPI site drawings.

Aiming Angles are referred to in degree and minutes. One degree of arc is equal to 60 minutes of arc. Note that the symbol for minutes is the same as the symbol for feet. When working with the PAPI system whenever you see the ’ symbol always check to see if it is a reference to a distance in feet or an angle in minutes. This manual will always write out degrees and minutes to eliminate any confusion.

Two degrees 50 minutes is written: 2^0 50’ (2 degrees 50 minutes)

If you need to convert from degrees in decimal to degrees and minutes use the formula below.

To convert from decimal to minutes multiply the decimal value by 60;

$$0.5\ \cancel{\text{degree}} * \frac{60\ \text{minutes}}{1\ \cancel{\text{degree}}} = 30\ \text{minutes}$$

$$2.83\ \text{degrees} = 2\ \text{degrees} + \left(0.83\ \cancel{\text{degree}} * \frac{60\ \text{minutes}}{1\ \cancel{\text{degree}}}\right) = 2\ \text{degrees}\ 50\ \text{minutes}$$

5.3 Aiming the Light Unit

Once the light units are fully assembled and mounted on the foundations, they need to be carefully aimed.

- Disconnect power to the light units
- Remove the light unit covers
- Loosen the horizontal bolts at the angle brackets just enough to allow the brackets to rotate freely.
- Level all the light units to the same horizontal plane (see Figure 6, pg. 26 for initial installation)
- Once all the light units are on the same horizontal plane each light unit can be aimed.
- Set the light unit level side to side by adjusting the leg heights until it is level.

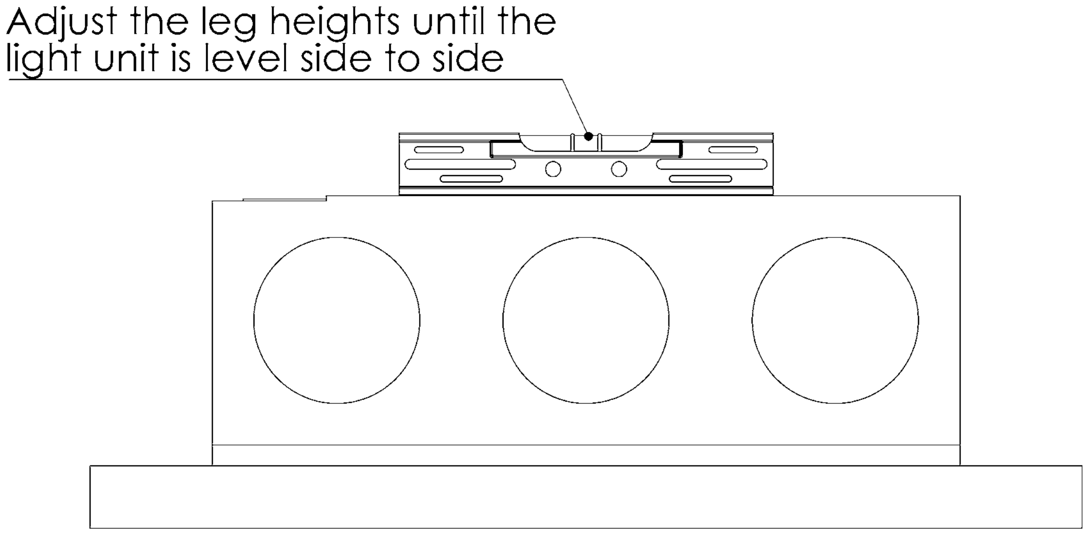


Figure 15: Front View, Leveling

- Adjust the height of the nuts on the two front threaded rods at the angle brackets to adjust the side to side leveling.

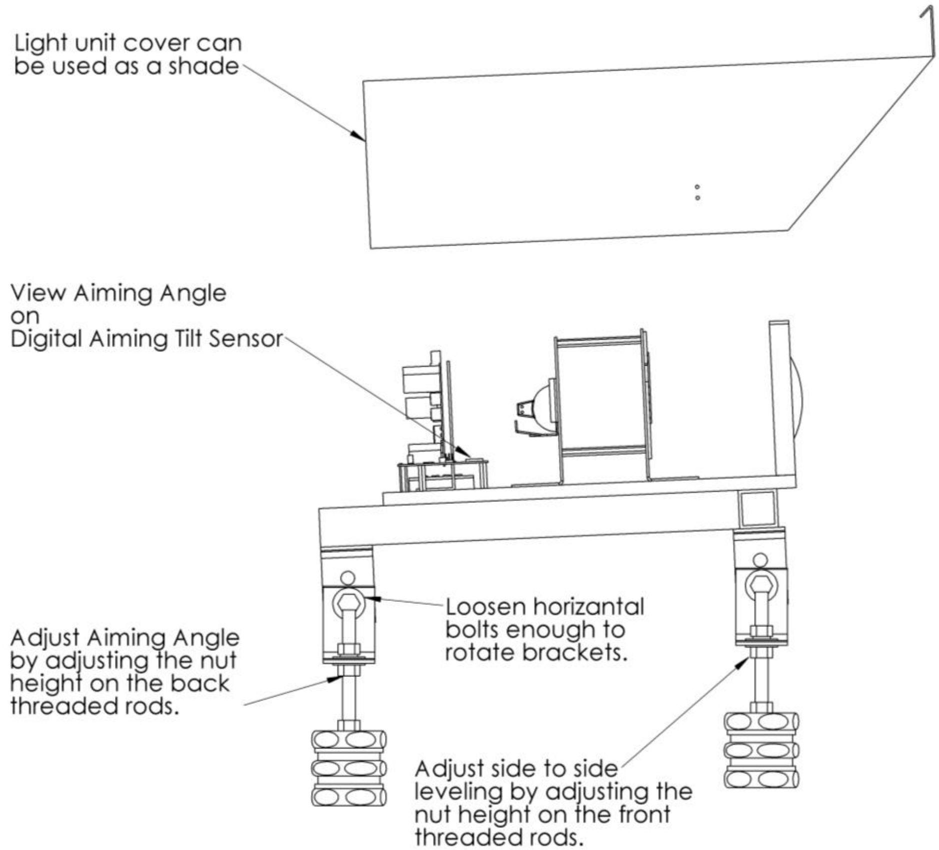


Figure 16: Side View Aiming Adjustment

- Note: Each light unit has a different aiming angle.
- Turn on power thru a 300 Watt isolation transformer on an airfield circuit. Any current setting from 2.8 to 6.6 will work. A 9-volt battery can be used to power the Digital Aiming Tilt Sensor, DATS, if power is not available during initial installation.
- The lamps might go out during the aiming process but the DATS will be fully operational. Disregard the lamps during the aiming procedure.
- Adjust the back nuts on the threaded rod to adjust the aiming angle. If you adjust the front nuts, you risk throwing off the side to side leveling and falling off the horizontal plane that all the light units lie on.
- Once the aiming angle is set recheck the side to side leveling.
- Secure all bolts and double check the aiming angle and side to side leveling.
- Once aiming is complete, press and hold the "Set" button on the DATS to record the correct aiming angle. Press and hold for 10 seconds. When the Tilt OK LED stops flashing the unit will display the "As Set" aiming angle being used by the tilt function. The "As Set" angle can later be displayed by a momentary press of the SET button. Releasing the set button will display the current position of the light

unit.

- Once all the DATS are set the PAPI should automatically reset and begin operating normally.
- Turn the power off. If a 9 Volt battery was used, remove it.

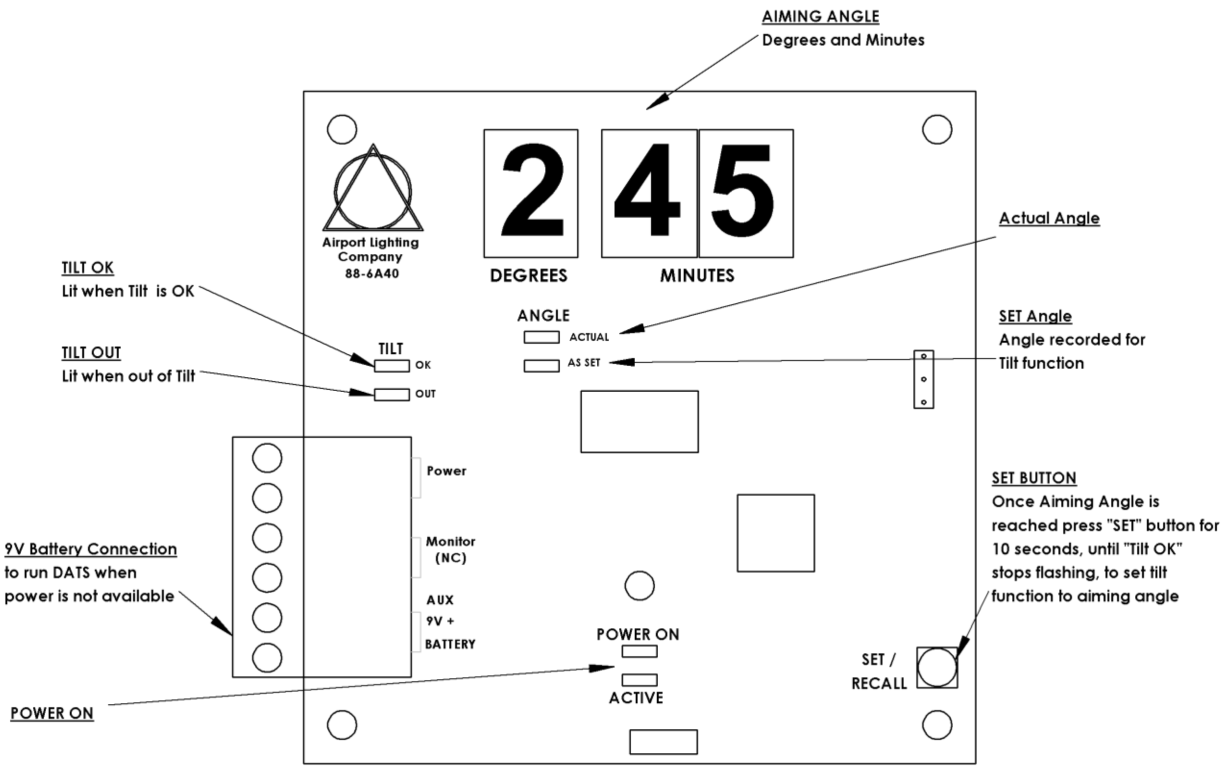


Figure 17: Digital Aiming Tilt Sensor

- Replace the light unit cover and secure the four hold down clips.
- Once all light units have been aimed and their covers are on and secured, restore power to the PAPI system.
- Check that all lights come on.

6.0 Operating Instructions

The Style B PAPI system gets power from the regulator. After turning on the regulator, look to see if the lamps come on. The PAPI system has Digital Aiming Tilt Sensors which will shut all of the lamps off, if one light unit is out of tilt. A visual check is required to determine that the lamps are on. The intensity of the lamps is controlled by the regulator brightness setting.

6.1 Basic Maintenance

A regular inspection should be made to ensure that all lamps are working. Maintenance that can be performed in the field includes:

- Lamp replacement
- PAPI alignment inspection
- Digital Aiming Tilt Sensor inspection
- Lens and filter cleaning
- Electrical wiring inspection

For any other maintenance issues please contact the Airport Lighting Company for further instructions.

External Maintenance

The basic external maintenance includes checking that all three lamps in each unit are working properly, cleaning the lenses with a window cleaner, checking all electrical junctions are secure, and checking that each leg assembly is firm and secure.

Internal Maintenance

Internal maintenance should be done when it is required to change a lamp or reset a tilt switch. Use a window cleaner to clean the inside surfaces of the clear lenses and red filters. Wiring and the fasteners that connect the light unit base plate to the mounting frame should also be inspected.

6.2 Replacing a Lamp

Replacement lamps can be ordered from the factory at any time but it is recommended to stock a few PAPI lamps for quick replacement. The Airport Lighting Company PAPI replacement lamp is part number 106.

- Note which lamp needs to be replaced, (you may decide to mark below lens with the piece of tape so you can identify the correct lamp when power has been removed).
- Disconnect power to the PAPI
- Remove the Light Unit cover.
- Disconnect the lamp terminals
- Use the lever on the side of the lamp-holder to push the lamp up
- Remove the old lamp
- Push the lever back before installing a new lamp
- Slide the new lamp into the lamp-holder until it touches the bottom.
- Reconnect the lamp terminals.
- Lenses and filters can be cleaned at this time with a glass cleaner.
- Reinstall the PAPI Cover and secure the four latches
- Return power to the PAPI.
- Check that all lamps are working

6.3 Troubleshooting: System Out of Tilt

The PAPI system is designed to shut down if any of the light units becomes out of tilt, to ensure that the pilot does not receive an incorrect signal.

On the Style B PAPI systems, there are red LED indicators on the main control (larger) board in each light unit which go out if any of the units become out of tilt.

First, check all units for the flashing of the “Active” green LED, which will indicate that all of the main power boards have incoming power and are functioning properly. If any is not on, there is a problem with that board. If all are not on, there is an overall system incoming power problem somewhere upstream.

Next, check any unit to see that the green LED labeled “Tilt Loop OK” on the main board is on. If “Tilt Loop OK” is not on, and the red “Tilt Loop Fault” is lighted, a tilt switch is indicating tilt out of limits. All main boards will show the green “Tilt Loop OK” light on when all units are in tilt. All main boards will show the red “Tilt Loop Fault” regardless of which light unit is out of tilt. If any red “Tilt Loop Fault” is on, check the tilt sensor board (the smaller board) in each unit to find any light unit which is out of tilt. See Figure 18 for details.

Re-Aim the light unit shown out of tilt, recheck side to side aiming, and reset the tilt function in the Digital Aiming Tilt Sensor (see Aiming in Section 5.3)

Restore power to the system and check that all “Tilt Loop OK” LEDs are illuminated.

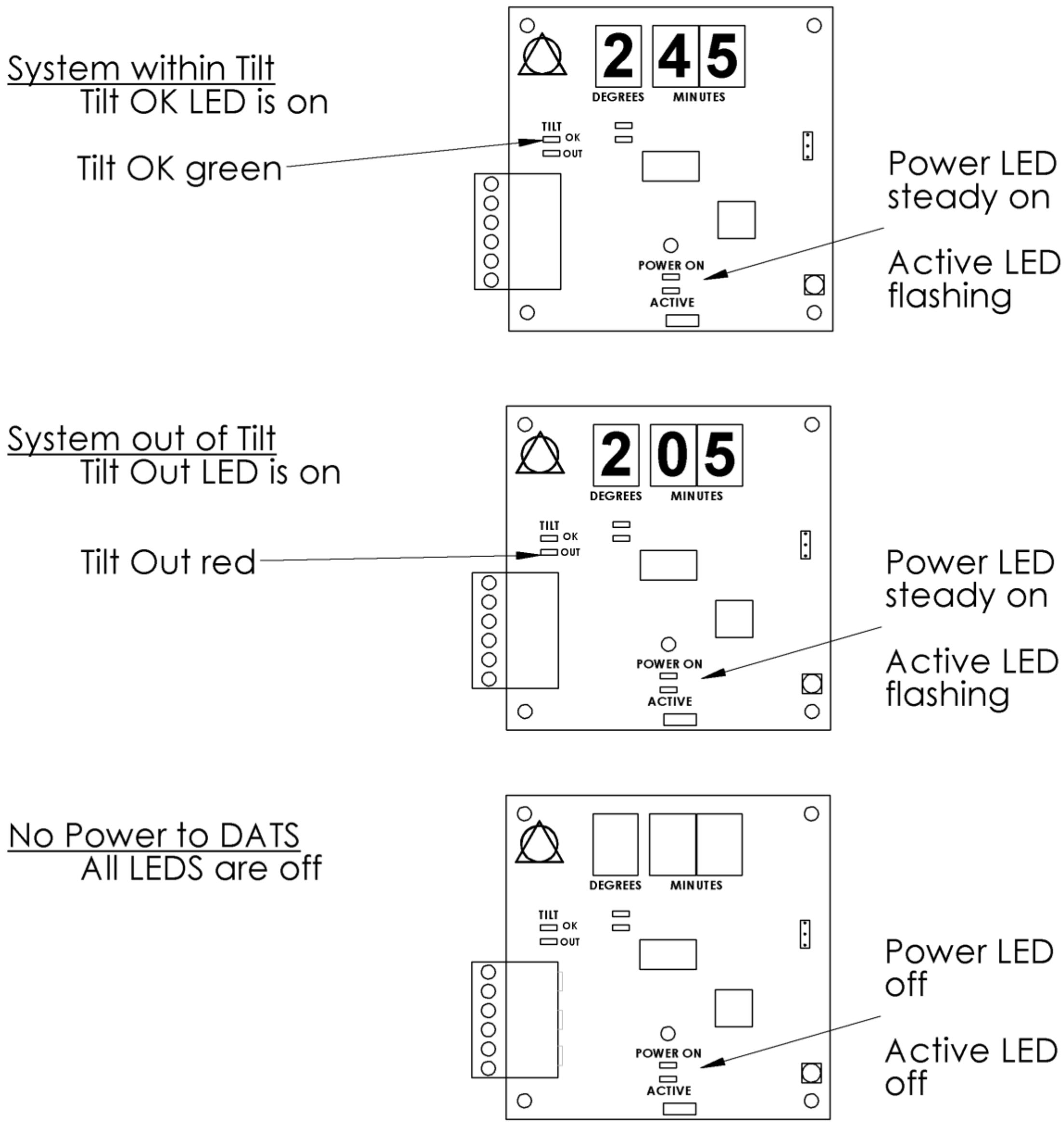


Figure 18: Digital Aiming Tilt Sensor LED Indicators

6.4 Troubleshooting: CPAPI Controller Circuit Board

The CPAPI Controller circuit board has three LED indicators. ACTIVE, TILT LOOP OK and TILT LOOP FAULT. When the printed circuit board has power, and is operating, the ACTIVE LED indicator will flash. If the printed circuit board recognizes that the Digital Aiming Tilt Sensor, DATS, is at the proper angle, the TILT LOOP OK LED indicator will come on.

If the DATS is out of tilt, the TILT LOOP FAULT LED will come on. Once the DATS is realigned one of two things will happen. If power was shut down the correct LED settings will return when the system is re-powered. If the DATS was realigned or reset without removing power, the system will delay approximately 15 seconds before it restores power to the PAPI lamps.

If a lamp goes out, the printed circuit board will recognize which lamp has gone out and will de-energize the relay switch that sends power to the lamp and at the same time will provide an alternate path for power to the remaining lamps. The SERVICE INDICATOR connection will be activated. The de-energized relay will allow the lamp to be replaced. Once a new lamp has been put in place the maintenance personnel can press the Reset Button and the printed circuit will re-energize the lamp. The other option for replacing a lamp is to turn power off to the PAPI system, replace the lamp and restore power to the system. The reset button is only necessary to restore power to a lamp if the system cannot be shut down. If the PAPI system can be shut down, the printed circuit board will return to normal operation when it is re-powered.

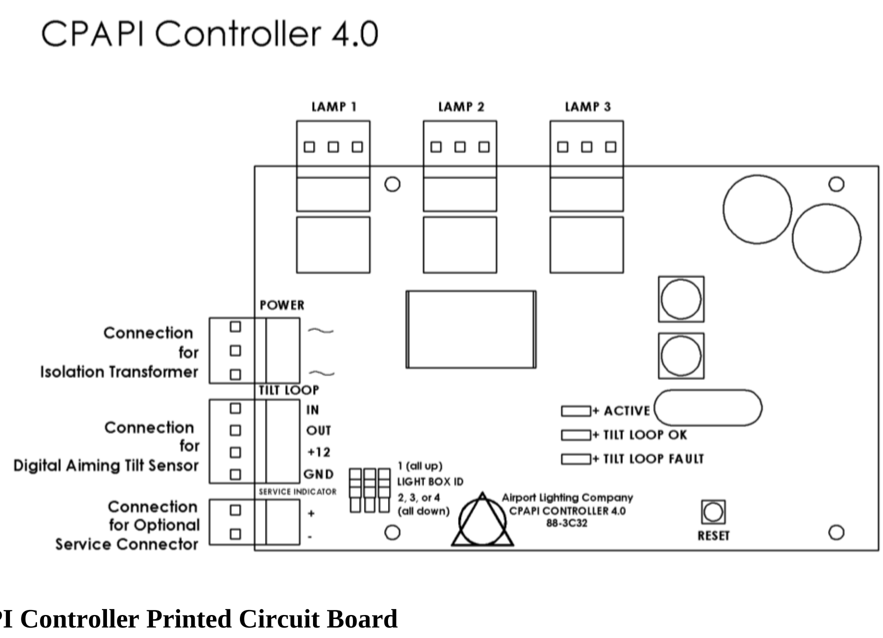


Figure 19: CPAPI Controller Printed Circuit Board

The CPAPI Controller printed circuit board in each light unit is identical. But there are 3 switches that cause the CPAPI Controller in one light unit to be the Master and the remaining CPAPI Controller in the remaining light units to be Normal. These switches are installed and tested when the CPAPI is manufactured and need not be addressed in the field. The only time it needs to be addressed is if a circuit board is being replaced. The replacement circuit board will need to have the switches in the same position as the board it is replacing.

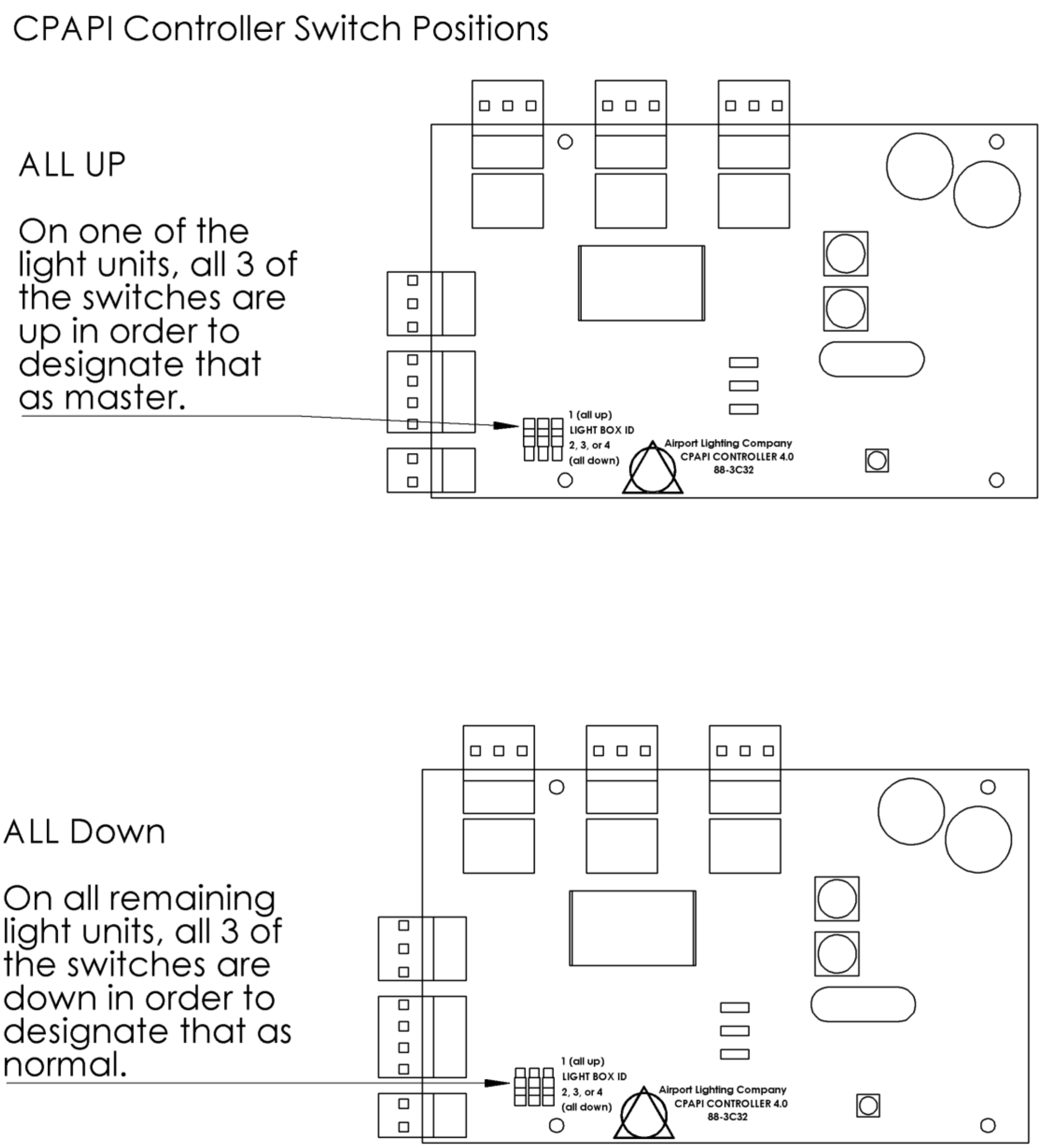


Figure 20: CPAPI Controller Switch Positions

Table 1: Trouble Shooting Chart

<table>
<tr><th>Problem</th><th>Cause</th><th colspan="2">Check</th><th>Corrective Action</th></tr>
<tr><td rowspan="7">All Lamps Out</td><td rowspan="3">No Power</td><td colspan="2" rowspan="2">Check “ACTIVE” LED indicator on CPAPI CONTROLLER printed circuit board</td><td>Restore power to the light unit</td></tr>
<tr><td>Restore power to the printed circuit board</td></tr>
<tr><td colspan="2">Check voltage at terminal block, across white and black</td><td>Restore power to the light unit</td></tr>
<tr><td rowspan="3">Out of Tilt</td><td colspan="2">Check “TILT LOOP OK” indicator on light unit CPAPI CONTROLLER circuit board</td><td>Check all Digital Aiming Tilt Sensors</td></tr>
<tr><td rowspan="2">Check LED indicators on Digital Aiming Tilt Sensor</td><td>ACTIVE is off</td><td>Restore power to tilt switch</td></tr>
<tr><td>Tilt OK is off</td><td>Re-Aim light unit</td></tr>
<tr><td>Lamps out</td><td colspan="2">Check lamps</td><td>Turn power off, replace lamps, and turn power on.</td></tr>
<tr><td rowspan="2">Single Lamp Out</td><td rowspan="2">Lamp out</td><td colspan="2" rowspan="2">Check lamp</td><td>Turn power off, replace lamp, and turn power on.</td></tr>
<tr><td>Replace lamp, press “Reset” button on CPAPI CONTROLLER circuit board</td></tr>
<tr><td>Premature Lamp Failure</td><td>Too much current</td><td colspan="2">Check current going into light unit. (Maximum expected value 6.6 amps)</td><td>Check current at constant current regulator.</td></tr>
</table>

CPAPI Troubleshooting

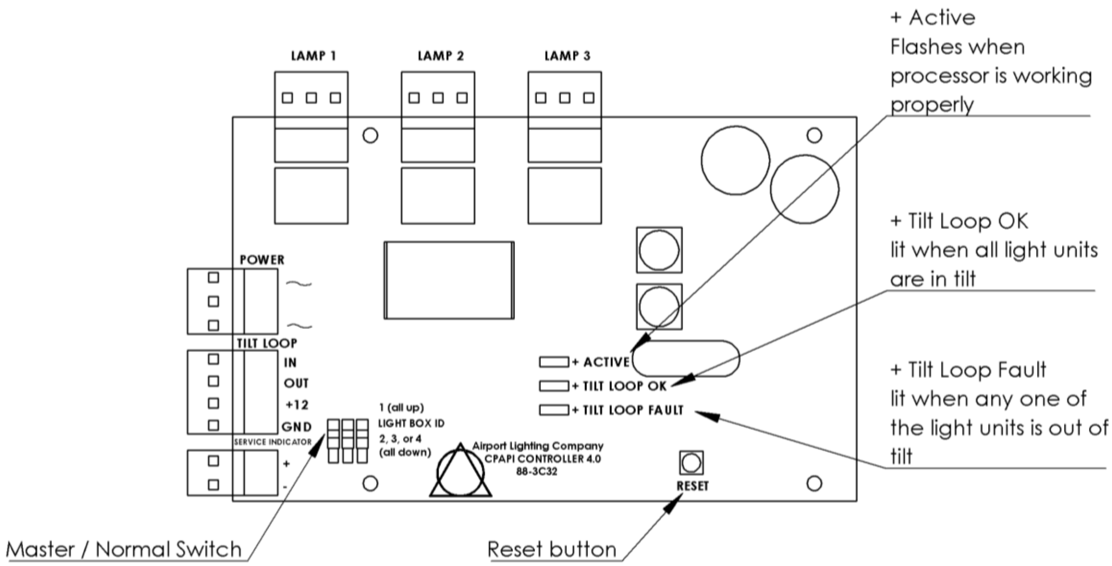


Figure 21: CPAPI Controller Trouble Shooting

6.5 Replacement Parts

Table 2: Replacement Parts List

Part Number	Name	Manufacturer	MFG Part #	Rating / Physical Characteristics
59E	Frangible Coupling	ALC		
88-2A51	Strain Relief	Common Part		½ inch EGS
88-2A55	½" PVC Coupling	Common Part		Schedule 80 / PVC
106	PAPI Lamp	Osram	64339-A	105 Watt 6.6 Amp
88-3A15	4 Pos Terminal Block	Marathon	671GP04	300V @ 20Amps
88-3A35	Light Unit Cover	ALC		Aluminum
88-3A43	3 Leg Mounting Frame	ALC		Aluminum
88-3A44	4 Leg Mounting Frame	ALC		Aluminum
88-3C26	CPAPI PCB Mount	ALC		Aluminum
88-3C32	CPAPI Printed Circuit Board Rev 4.0	ALC		
88-4V61	2 Pos PCB Plug Out	ASI	CPF5.08/2VE	
88-4V64	3 Pos PCB Plug Out, Power	ASI	MRT3P5.08/3V01VE	300v @ 12 amps
88-4C62	3 Pos PCB Plug Up, Lamp	ASI	MRT3P5.08/3VE	300v @ 12 amps
88-4C64	4 Pos PCB Plug Out, DATS	ASI	MRT3P5.08/4V01VE	300v @ 12 amps
88-6A40	Digital Aiming Tilt Sensor, DATS	ALC		
88-8A02	Leg Kit	ALC		
88-9A25	Liquid-tight Straight Fitting ½"	Common Part		
88-9A31	Straight Fitting Connector Disk	ALC		Aluminum
88-9A34	Liquid-tight Flexible Metallic Conduit	Common Part		
88-9A37	Light Unit Upper Cable	ALC		
~~88-9C38~~	CPAPI Isolation Transformer Wire Harness	ALC		

	Part Number	Part Name
1	88-3A15	4 Pos Terminal Block
2	88-3C32	CPAPI Controller Printed Circuit Board
3	88-3C26	CPAPI PCB Mount
4	88-6A40	Digital Aiming Tilt Sensor
5	106	PAPI Lamp
6	88-4V61	2 Pos PCB Plug, Out
7	88-4V64	3 Pos PCB Plug, Out
8	88-4C64	4 Pos PCB Plug, Out
9	88-4C62	3 Pos PCB Plug, Up

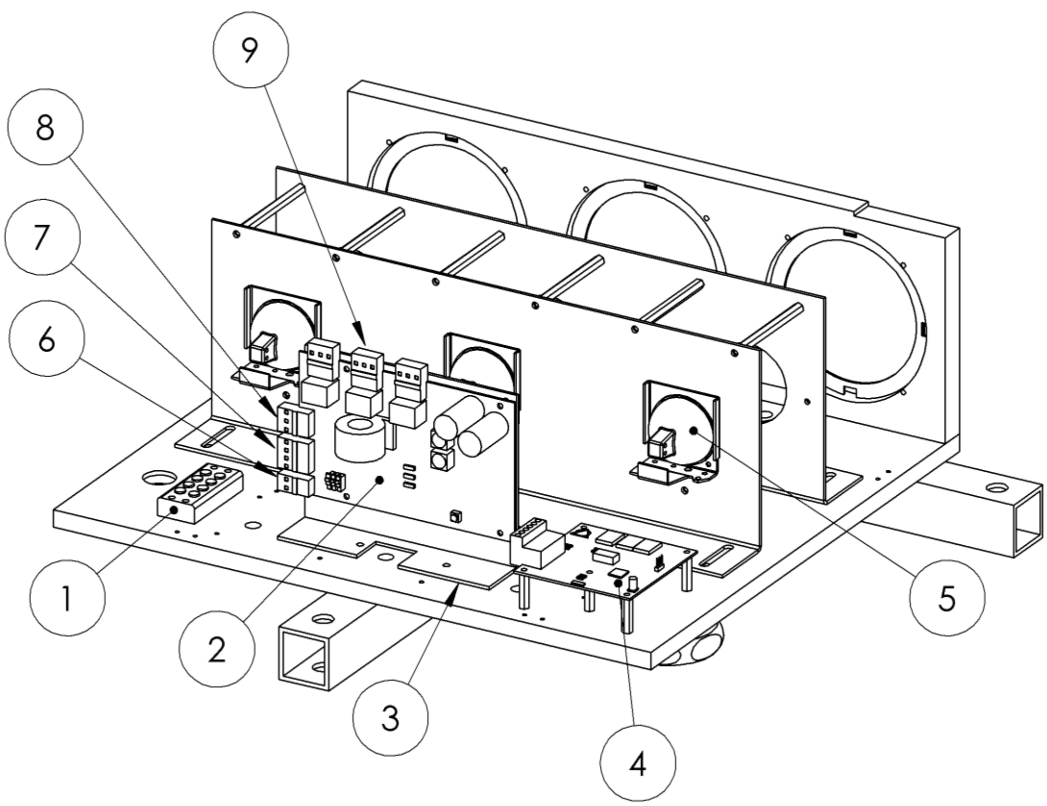


Figure 22: Parts Light Unit

	Part Number	Part Name
1	88-3A10	Light Unit Cover Assembly
2	88-2A51	Strain Relief
3	88-2A55	½" PVC Coupling
4	88-9A25	Liquid-tight Straight Fitting ½"
5	88-9A34	½" Liquid-tight Metallic Conduit
6	88-9A31	Straight Fitting Connector Disk
7	59E	Frangible Coupling
8	72	Base Plate (purchased separately)

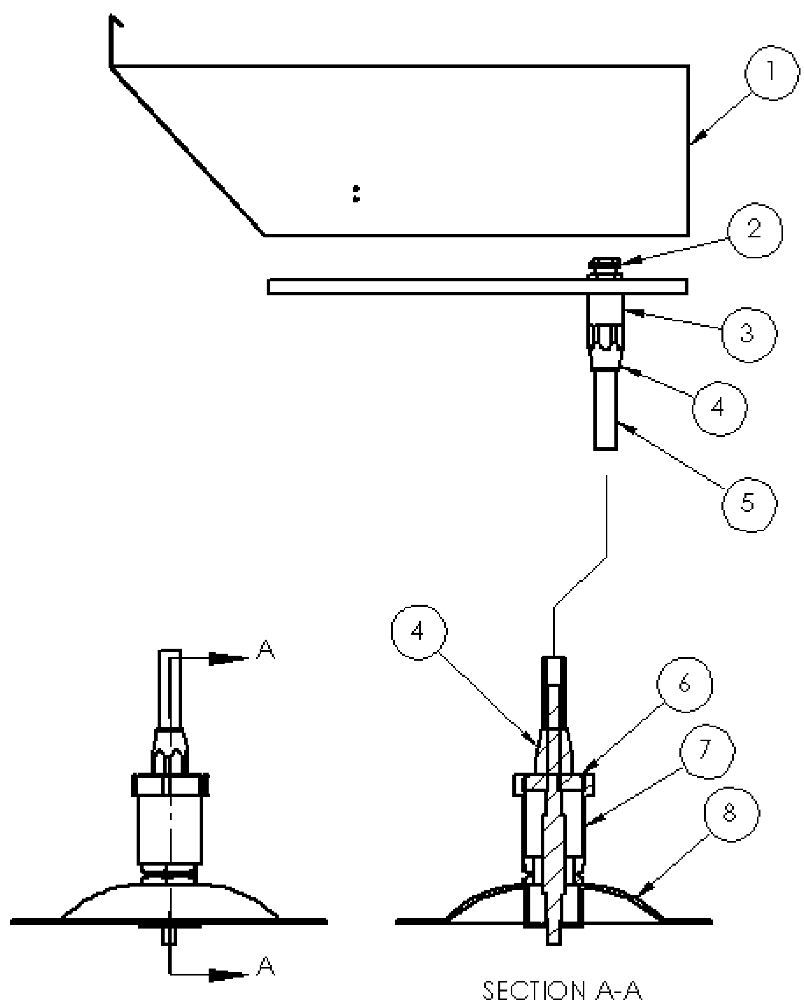


Figure 23: Parts External Fittings

	Part Number	Part Name
1	88-9A37	Light Unit Upper Cable
2	88-9C38	CPAPI Isolation Transformer Harness
3	34-10	300 Watt Isolation Transformer (purchased separately)

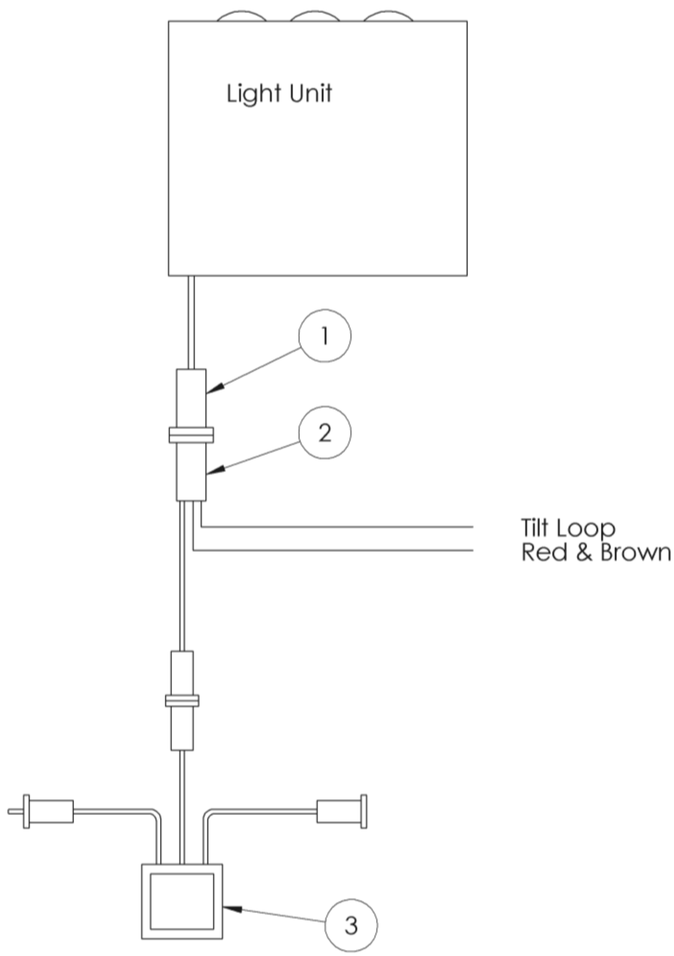


Figure 24: Parts, Wiring Harnesses

	Part Number	Part Name
1	88-8A02	Leg Kit Assembly
2	88-3A43	3 Leg Mounting Frame (standard)
3	88-3A44	4 Leg Mounting Frame (optional)

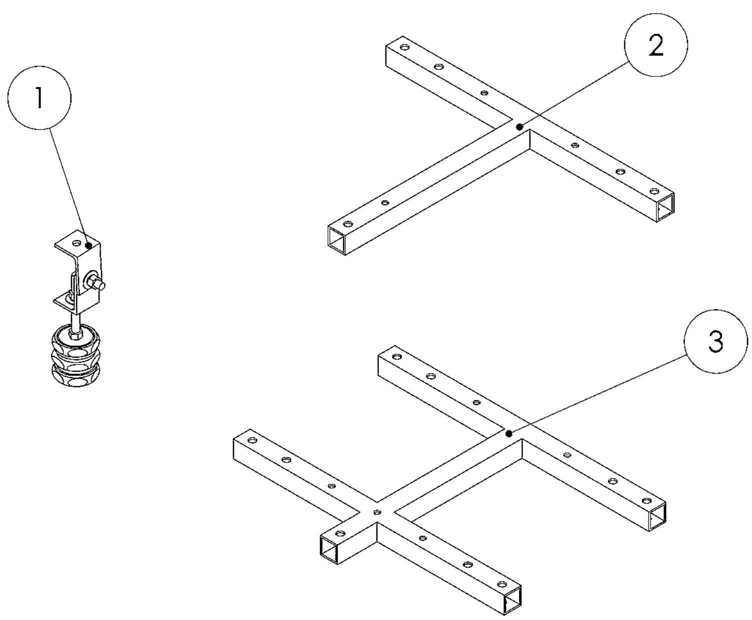


Figure 25: Mounting Hardware

Appendix

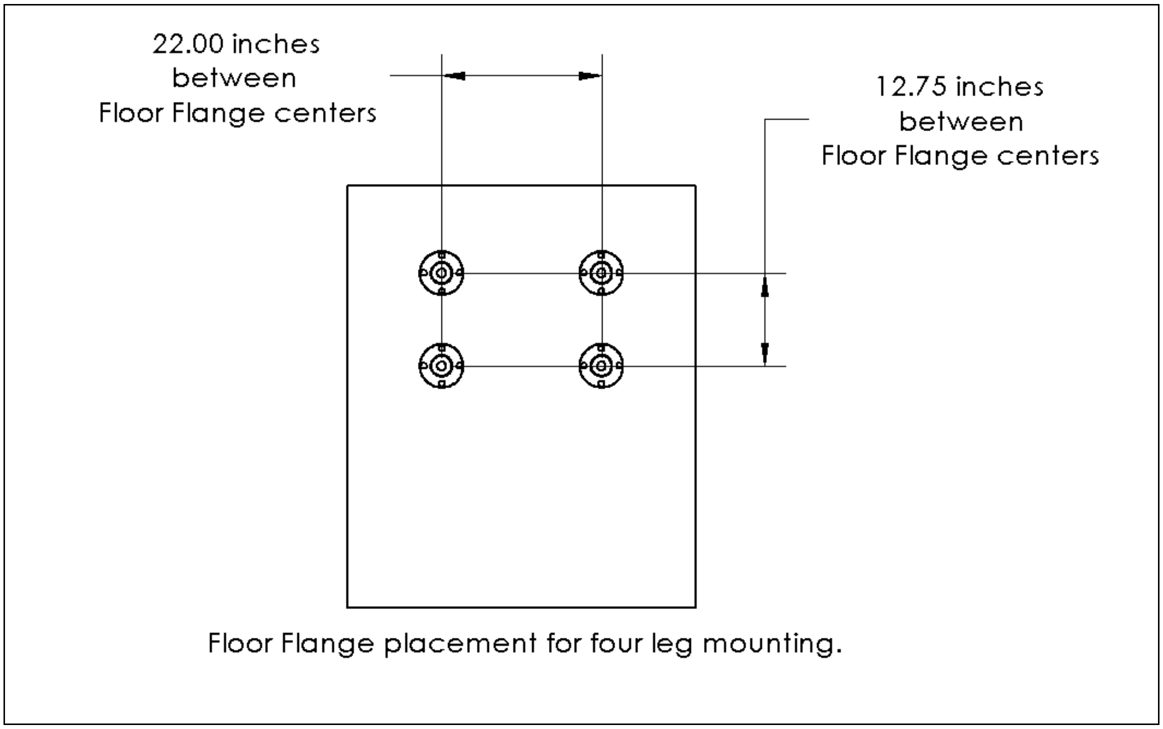


Figure 26: 4 Leg Floor Flange Placements

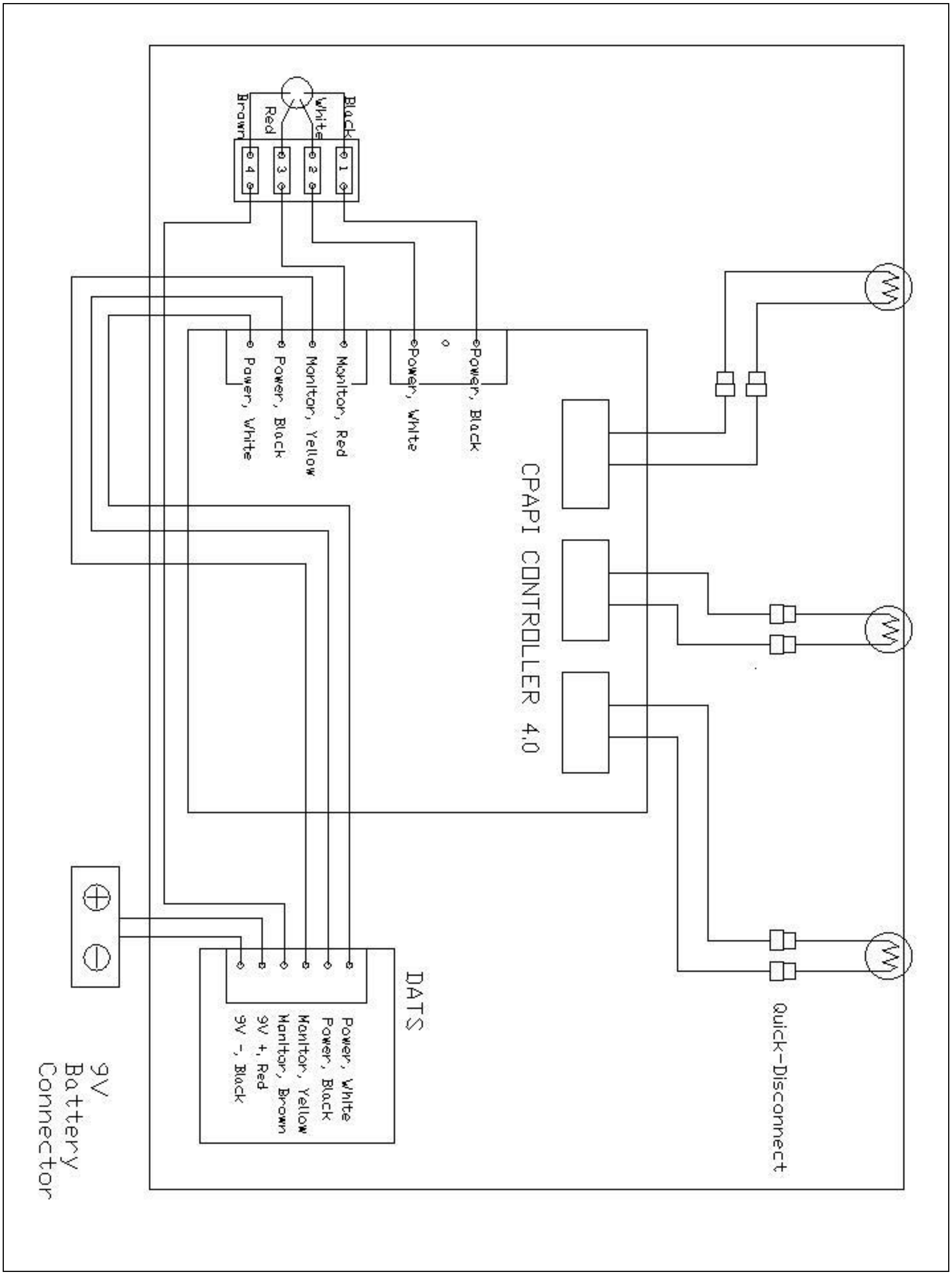


Figure 27: Light Unit Wiring