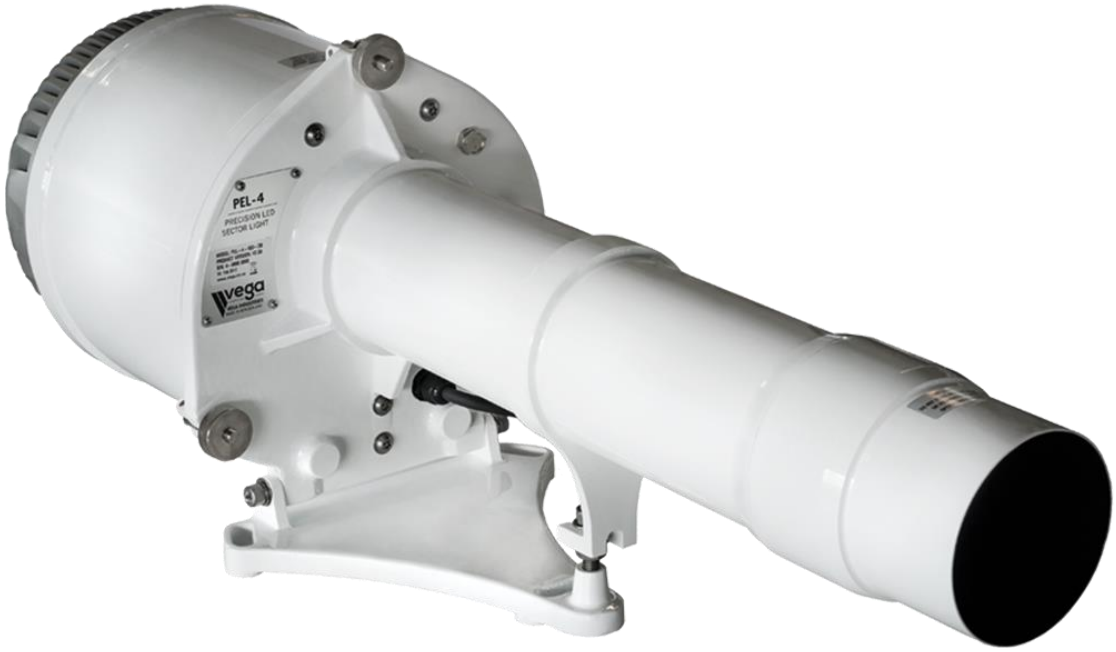
PEL-4 LED Precision Sector Light
All Horizontal Divergence Models

Installation, Operation and Programming Manual



PEL-4 Product Manual	
Available colour range	Red, Green or White
Available models	3.5D, 5D, 10D, 20D
Sector number & sub tenses	Custom
Software version:	3.0.3
Product version:	3.00
Manual version:	1.1
Date released:	January 2023

IMPORTANT: If oscillating boundary has been installed, remove temporary packers from inside of PEL-4 before first use.

CAUTION: The PEL-4 is a source of bright light. Do not stare directly into the beam from close range. Observe all warnings and guidelines in this instruction manual.

Manual quick reference

Manual Revision	Description of Change	Date manual released	Software version	PEL-4 Serial number
1.00	Initial release.	December 2016	2.2.0	405-00000010
1.01	Updated Dataport I/O levels	December 2016	2.2.0	405-00000010
1.02	Updated performance figures, maintenance recommendations and other minor corrections for product version 2.0. Monitoring tags adjusted for interfacing to AIS & VegaWeb. Error logging feature added. Improved current logging data.	March 2017	2.2.3+	405-00000100
1.03	Updated specification table	Nov 2017	2.2.7+	400-00000140
1.04	Added 3.5D specification table	June 2018	2.2.8+	400-00000160
1.05	Added 3.5D mounting information and factory default reset codes.	June 2018	2.2.8+	400-00000160
1.06	Updated monitoring data units for better VegaAIS compatibility. Updated flash compensation mode to support latest IALA E-200-4 2017 Rec by default. Incomplete emergency mode deprecated. Corrected programming instructions to describe colour intensity programming.	August 2018	2.2.9+	
1.07	Manufacturer contact information changed	January 2019	2.2.9+	400-00000310
1.08	Emergency mode; Calendar function; Error codes	March 2020	2.3.4+	400-00000380
1.1	20D version added; +Uout added to Data Port	January 2023	3.0.3+	4-0000-0690

PEL-4 LED Versions by release date and serial number

WHITE LED		
LED Version	Release Date	Serial Number
480	December 2016	405-00000010

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Product Warranty

Sabik OY warrants that all products supplied are free from labour and material defects, and will repair or replace (at its option) the whole or any part of the products found to be faulty. Sabik OY is not liable for any charge beyond the point of delivery, including installation, alignment or testing. To claim under warranty the product must be returned to the manufacturer.

Table of contents

1.0 INTRODUCTION TO THE PEL-4 PRECISION LED SECTOR LIGHT.

1.1 Overview

The Vega PEL-4 Precision LED Sector Light (PEL-4) is a highly energy-efficient marine sector light projector. The PEL-4 is available in a range of horizontal divergences to cover many applications. The sectors of the PEL-4 can be customised in number and sub-tense for a specific application.

The PEL-4 typically projects up to three colours in a custom arrangement from one to seven sectors, using high intensity LED technology to produce white light. The red and green sectors are generated through coloured filters. On request, the white sector(s) can be reduced in intensity to match the intensity of the red and green sectors.

The PEL-4 complies with the IALA Recommendations E-200-1 Marine Signal Lights (Colours), E-200-2 Marine Signal Lights (Luminous Range), E-200-3 Marine Signal Lights (Measurement), and E-200-4 Marine Signal Lights (Determination & Calculation of Effective Intensity).

The power supply has been designed to operate using a nominal 12 VDC or 24 VDC power supply. The full input voltage operating range is 10V to 30V.

Introducing LED technology also means regular maintenance such as the need to change lamps on a six-monthly basis has been eliminated.. The LED has been mounted onto a specially-designed cassette so that if the LED is replaced or upgraded at a future date, the replacement cassette will guarantee precise optical alignment with no special effort.

If an oscillating boundary is fitted, it is operated by a stepper motor and controller. The motor is sealed and self-lubricating and there is no gearbox, thereby eliminating any need for regular maintenance of these parts.

The rear cover is sealed with silicone o-rings for maximum security in harsh environments. It is not recommended that the rear cover be opened on a regular basis. If it is opened, then the silicone o-rings should be replaced to ensure a quality seal.

The PEL-4 has been designed with many features to allow the user to set up the operation for a specific site. These features are programmable using the Vega Remote infrared programmer (TVIR programmer). A TVIR programmer is provided with each PEL-4. The unit will be delivered with the operator's specified settings. Details on how to re-program the PEL-4 are available in a later section of this manual.

The flash character and range required from the PEL-4 must be supported by the power supply it is connected to. Increasing the range or the duty cycle of the PEL-4 might require provision of a larger power-supply, solar panel or battery capacity. Information is provided in this manual to enable operator power consumption calculations. Vega's solution engineers or the local Vega distributor can assist in calculating these figures with respect to the flash character and range. As a result of specifying a power supply too small for the load of the PEL-4, intermittent operation will occur due to low battery voltage setting.

Additional options available include an external GPS module (VSU-29) to allow the PEL-4 to synchronise (sync) with other lights, and an interface to the VegaAIS and VegaWeb monitoring products. The PEL-4 has a hardwire sync option as standard and this can be

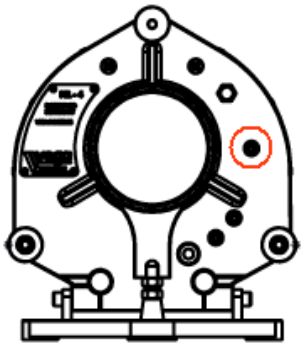
connected to any Vega-compatible sync source operating from the same power supply voltage as the PEL-4.

To begin using the PEL-4, the power will need to be connected. The PEL-4 has been pre-programmed for the flash character, effective intensity, and any other features required at the time of sale.

1.2 Quick-start Guide

This guide provides simple steps to begin operation of the PEL-4.

- Open the rear cover and remove all protective packers which are used for shipping
- Connect power to the PEL-4: nominal 12V or 24V supplies are suitable. Brown or red is positive, blue or black is negative.
- The PEL-4 will have been shipped from the factory with the operator's required settings. Therefore, 30 seconds after power-up, the PEL-4 should be operating as required
- If the operator required remote control settings, then the PEL-4 might not activate until external wiring and correct voltages have been completed for the dataport. Remote control settings can be disabled if necessary for bench testing – refer to Appendix A.2.
- The PEL-4 will start in night mode and will begin monitoring the level of daylight. The detection of night or day can be controlled by gently covering or exposing the infrared and daylight sensor with a cloth. The location of the sensor is shown by the red circle in the following diagram:



- After power-up, the PEL-4 will begin to monitor for the low battery threshold (factory setting 11 Volts or 22 Volts, for 12V and 24V systems, respectively). If the input voltage falls below the threshold, then the PEL-4 will turn off. The PEL-4 will not return to normal operation again until the battery charges to above 13.0 Volts or 26.0 Volts (for 12V or 24V systems, respectively).
- Light output can be reviewed by placing a screen (such as a piece of cardboard) in front of the lens. At close range (less than 50m) this image will be out of focus, however it will be useful for indicating significant intensity changes and verifying the oscillating boundary function.

1.3 Automatic Flash Compensation

The PEL-4 is programmed for effective intensity. The effective intensity is automatically compensated according to IALA E-200-4 to maintain a constant visible range regardless of the flash character selected.

For rectangular flash characters the E-200-4 2017 Modified Allard algorithm resolves to the Schmidt-Clausen algorithm shown here. Where each flash on period (*f*) within a total flash character is compensated by a factor (*SC*) according to its individual duration, as per:

$$SC = (f + a)/f$$

For the default compensation compliant with E-200-4 2017, during night, the applied flash compensation formula uses the Schmidt-Clausen constant of *a*=0.1s. During the day *a*=0.1s is always used.

For the alternative E-200-4 2008 algorithm, during night, the applied flash compensation formula uses the Schmidt-Clausen constant of *a*=0.2s. During the day *a*=0.1s is always used.

When flash compensation is disabled, a = 0, in the above formula, meaning that SC = 1.0.

The PEL-4 has the full range of Vega flash characters available, plus a custom character that can be defined by the operator. If oscillating boundaries are required, then it is recommended to usea fixed character, or a character with a long-duration flash-on (such as an occulting character) to avoid confusing the observer.

1.4 PEL-4 Intensity Specification

The PEL-4 is programmed for the required colour (red/green) effective intensity in Candela. The white intensity will depend on the model of PEL-4. If the PEL-4 is a Uniform White model then the white intensity will be approximately the same as (but never less than) the programmed colour intensity. If the PEL-4 is an Intense White model then the white intensity will be considerably greater than the programmed colour intensity (typically 3 times to 4 times brighter). The precise colour to white intensity relationships are described in the tables in Appendix B and current consumption data is provided for each intensity setting shown.

The PEL-4 is capable of operating in fixed character up to and including its maximum intensity setting shown in the table.

Example 1: How to calculate the PEL-4 fixed character intensity setting and to calculate the current consumption.

A PEL-4 is set to fixed character and a colour intensity setting of 200,000 candela is required. Identify the appropriate value in the white intensity column, and read the corresponding (colour intensity) value from the Prog Code column. This Prog Code should be used in the intensity programming sequence for the PEL-4, using the TVIR Remote02. Similarly, the continuous PEL-4 optical current drawn at this intensity will be read from the Current column. The PEL-4 overhead currents shown at the bottom of the table can be added to the optical value to obtain a final consumption figure. The red and green intensities in candela can also be read from their respective columns.

Note that the table only contains examples taken from the very wide range of intensity values available from the PEL-4. Any intensity can be programmed in 1 candela steps

between the minimum value shown in the table (the lowest value above zero) and the maximum value in the table.

Example 2: How to calculate the PEL-4 flashing character intensity setting and to calculate the current consumption.

For a PEL-4 set with an ISO 4s flash character and a desired white effective intensity of 100,000 candela, the table in Appendix B should be consulted twice:

- Read off the nearest intensity to the desired effective intensity and consult the Prog Code column. Use this value as a guide for how to program the effective intensity. For example, the nearest intensity to 100,000 is 120,400. The Prog Code for this value is **120 400**, so the Prog Code for 100,000 candela will be **100 000**. Program the PEL-4 with this intensity using the instructions in Appendix A.
- Calculate the peak intensity for the above settings: The E-200-4 2017 flash compensation at night will be 1.05, meaning that the white peak intensity required from the PEL-4 will be 100,000 * 1.05 = 105,000 candela. Comparing this white peak intensity figure with the white maximum intensity figure in the table shows that the PEL-4 is capable of generating this character+intensity specification. The peak current consumption for this white peak intensity figure can be read off from the table using the nearest intensity value or by linearly interpolating between two adjacent values. The average current consumption can then be calculated by applying the flash character duty cycle to the peak current and adding the PEL-4 overhead currents from the bottom of the table.

The PEL-4 will not output intensity above its maximum candela capability shown in the table.

The PEL-4 LED is protected from over-temperature which could be caused by excessive environmental conditions or covering of the heatsink. The internal LED temperature is monitored to automatically compensate for the effects of heat on the output intensity and to also protect the LED in the case of an over-temperature condition.

The PEL-4 will output the intensity it has been programmed in ambient temperatures between -30°C and +50°C at fixed character and maximum intensity.

At ambient temperatures exceeding +50°C (including the effects of solar heating of the PEL-4), the PEL-4 will reduce its output intensity to protect the LED. The PEL-4 will not abruptly turn off if over-temperature conditions are encountered but will gradually turn down the intensity until, and if, a severe over-temperature condition occurs.

Therefore, the PEL-4 will continue to operate up to an equivalent ambient temperature of +85°C, at which the LED will be extinguished. At this point an over-temperature alarm condition will be signaled by the PEL-4.

Once the LED temperature has reduced below a safe threshold, the LED will be turned on again.

2.0 ELECTRICAL CONNECTION

2.1 Power Connection

The PEL-4 is designed to work from a nominal supply voltage of 12VDC or 24VDC.

If the supply is connected in reverse, the PEL-4 will not operate. However, the PEL-4 will not be damaged as it is protected from reverse polarity.

Power connection details are shown below:

Wire Colour	Function	Comment
Brown or Red	Vin +	+10VDC to +30VDC
Blue or Black	Vin –	0V

2.2 Hardwire Sync Connection

The hardwire sync (green wire from the Dataport) operates as a positive to negative transition. The hardwire sync and a common ground pair can be connected between several Vega beacons that operate from the same power supply voltage. This inter-connection will result in the beacons and PEL-4 flash characters being synchronised.

The start of the PEL-4 flash character can be delayed between 0 and 9.9 seconds from the sync edge should it be desirable to have a different start time to that of other beacons connected to the synchronising wire.

Other beacon manufacturers may not use a negative transition signal and in such cases the third-party sync signal will not be able to synchronise the PEL-4. If there is a requirement for the PEL-4 to synchronise to another manufacturer's beacon that uses positive synchronisation, then enquire with Vega whether a sync converter option might be available.

2.3 DataPort

The dataport option provides the following interface connections:

- Serial interface (RS232 levels by default, RS485 on request);
- Remote Control/Traffic Light hardwired inputs;
- PEL-4 status hardwired outputs.
- Sync (bidirectional signal).

The dataport pin-out and cable colour-code are described in the following table.

Pin	Colour	Signal	Direction	Description
1	Cyan	Signal Ground	Ground	A polyfuse-protected common signal ground.
2	Pink	Beacon OK	Output	Grounded (positive sink) when PEL-4 is operating normally with no alarm condition. Open-circuit when an alarm is present or when power is removed.
3	Grey	AIS Beacon Fail	Output	Grounded (positive sink) when PEL-4 has an alarm condition or when power is removed. Electrically separate but logically identical to Beacon Fail signal.
4	Green	Sync	Bidi	Vega hard-wired sync.
5	White	Beacon Fail	Output	Grounded (positive sink) when PEL-4 has an alarm condition or when power is removed. Electrically separate but logically identical to AIS Beacon Fail signal.
6	Blue	Beacon On	Output	Grounded (positive sink) when PEL-4 is active. Open-circuit otherwise, or when power is removed.
7	Yellow	Transmit	Output	Serial transmit output from the PEL-4.
8	Brown	+Uout	Output	Power supply feed to the external monitoring module. Electrically equal to positive input supply voltage through internal overvoltage protection board (Not supported with standard Data Cable).
9	Violet	Receive	Input	Serial receive input to the PEL-4.
10	Red	On/Off	Input	Remote Control or Traffic Light input. Its behaviour and polarity is user-programmable.
11	Black	Signal Ground	Ground	A polyfuse-protected common signal ground.
12	Orange	Day/Night	Input	Remote Control or Traffic Light input. Its behaviour and polarity is user-programmable.

The Beacon Fail and AIS Beacon Fail outputs are polyfuse-protected to 300mA maximum current.

+Uout output is polyfuse-protected to 1000 mA maximum current.

All other outputs, excluding the serial connections, are polyfuse-protected to 750mA maximum current.

All hardwired inputs, excluding sync, have a 4V threshold with respect to signal ground. An internal pull-up is permanently enabled. Do not attempt to use the internal input pull-up to control external devices.

With the exception of the serial connections, all inputs and outputs should be limited to 30V operation with respect to signal ground.

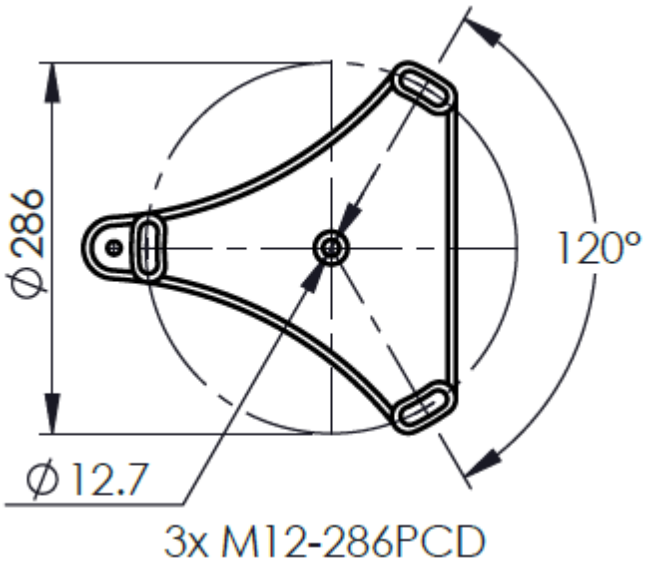
The serial interface connections should be limited to ±7V with respect to signal ground and are polyfuse-protected to 100mA.

The serial interface defaults to 115.2kbaud, 8 bits, no parity, 1 stop bit (8N1).

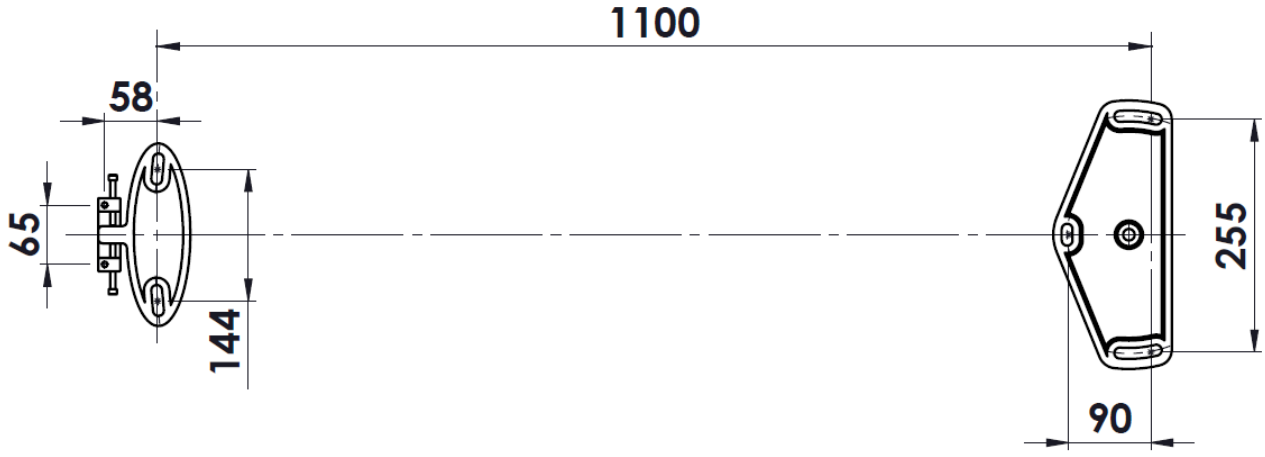
3.0 MOUNTING AND ALIGNMENT

3.1 Mounting

A typical PEL-4 mounting plate is shown in the following figure. The mounting holes are designed for M12 or half-inch bolts at 120 degree-spacing on a 286mm Pitch Circle Diameter (PCD).



PEL-4 5D, 10D & 20D Models' Mounting Pattren – Plan View

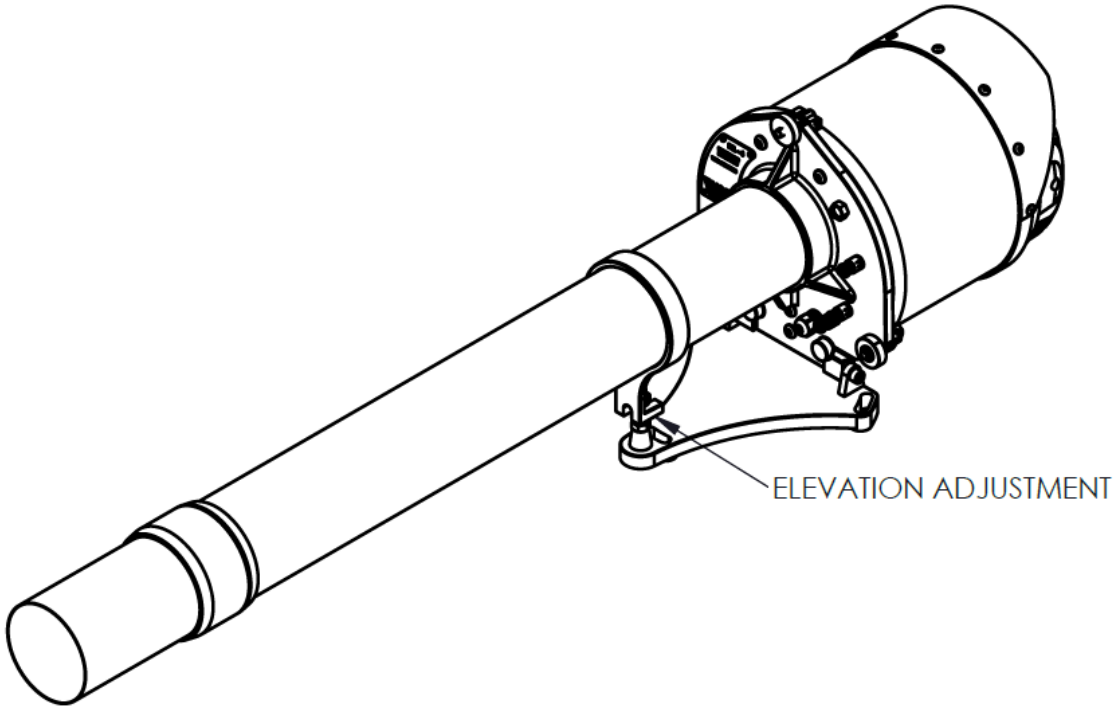


PEL-4 3.5D Model's Mounting Brackets – Plan View

3.2 Alignment

The PEL-4 mounting bracket provides a few degrees of horizontal angle adjustment prior to tightening the M12 bolts through it.

The PEL-4 includes an M12 elevation adjustment screw beneath the barrel, as shown in the following diagrams.



4.0 PROGRAMMING

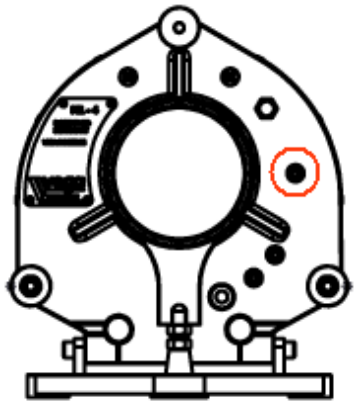
The PEL-4 can be programmed using the TVIR programmer (shown below).

IMPORTANT
Before attempting to use the TVIR programmer for the first time, please pull the plastic insulating strip out of the battery holder – you do not need to remove the battery holder to do this.
The TVIR programmer will not work if the plastic strip is left in place.

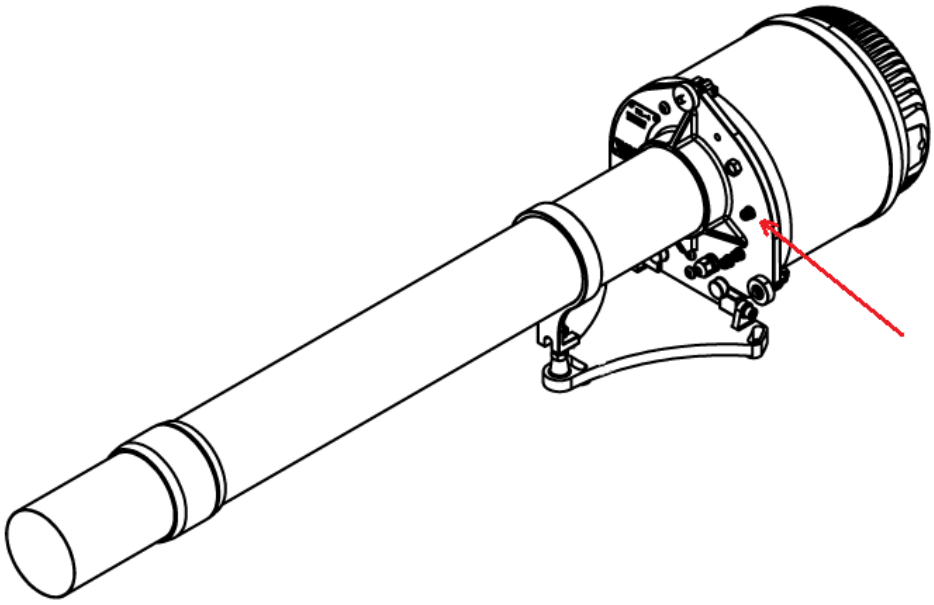
Red standby key, used to enter

Numeric keypad, used to configure the programmable features of the

The infrared receiver for programming the PEL-4 is located in the programming and daylight sensor projecting from the connector face of the PEL-4 mainframe (indicated by the red markings in the following diagrams). For best results when programming, direct the TVIR programmer at this part of the PEL-4. Refer to Appendix A for operating the TVIR Programmer.



Location of the PEL-4 Programming Infrared Receiver and Daylight Detector



Location of the PEL-4 Programming Infrared Receiver and Daylight Detector

4.1 Programming Syntax

Reading or writing parameters with the TVIR programmer involves entering a sequence of numbers on the keypad. The programming syntax is: OPERATION FEATURE [VALUE]

Note: - the VALUE parameter is only required when writing data to the PEL-4.

There are four OPERATIONs:

Programming	Operation 1
System Information	Operation 3
Special & PIN codes	Operation 7
Read settings	Operation 9

The FEATURE parameter represents the feature of the PEL-4 to be read or written such as flash character or intensity.

The VALUE parameter is the new value to set the selected FEATURE to.

For example, the sequence 9 8 reads the low battery threshold (operation 9 = read setting, feature 8 = low battery threshold).

Appendix A of this manual provides a Table for the programming features of the PEL-4. Please take the time to become familiar with the table before continuing.

4.2 Visual Feedback when Using the TVIR Programmer

The PEL-4 will provide visual feedback of the programming instructions it receives from the TVIR programmer. This feedback is provided to confirm that TVIR commands have been received correctly and therefore ensures the PEL-4 is programmed correctly. The visual feedback is provided by a green LED inside the infrared/daylight sensor projecting from the PEL-4 mainframe connector surface. During programming, the main LED is extinguished.

The programming visual feedback is summarized below:

Programmer Keys	PEL-4 response
Enter Programming Mode (by pressing red standby key for 5 seconds)	4 quick flashes (0.1sec on 0.1sec off).
Numeric key when programming	1 flash for each key pressed
When programming sequence recognized	The 3 or 4 digit value code is output using a series of flashes of 0.1sec on and 0.1sec off with a gap of 0.5sec between each number of the code. A zero is represented by a 2 second on flash.
When programming sequence **is not** recognized	3 quick flashes (0.1sec on 0.1sec off) The PEL-4 will remain in programming mode waiting for a new programming instruction.

Programmer Keys	PEL-4 response
Exiting Programming mode No programming activity for 10 Seconds	The PEL-4 will give two quick flashes followed by a short pause followed by another two quick flashes. After this the PEL-4 will resume normal operation.

4.3 If the PEL-4 will not enter Programming Mode

If you find the PEL-4 will not enter the programming mode, it could be caused by several reasons such as:

- The battery in the TVIR Programmer is missing, or the plastic battery insulator has not been removed, or the battery has low voltage.
- There is no 12VDC or 24VDC supply connected to the PEL-4.
- The beacon could be in low power sleep mode (due to calendar hibernation, storage mode or low battery mode), in which case the TVIR red standby button should be held down for a longer period, typically up to 30 seconds, before the beacon will respond.

If the PEL-4 enters programming mode but rejects all commands that would change its settings, then it requires a security PIN to be entered by the operator to allow programming. Refer to Section 7 and Appendix A.

4.4 Becoming Familiar with the Programming Syntax and Flash Feedback

If you have not used the TVIR Programmer before, spend some time learning how the PEL-4 will respond to the various programming actions. Make sure the PEL-4 is connected to a power supply and experiment with the following.

Enter and Exit Program mode:

1. Enter program mode Press the red standby button for 5 seconds	The PEL-4 will give 4 quick flashes to indicate it has entered programming mode
2. Exit program mode Leave the programmer idle for 10 seconds	The PEL-4 will give two quick flashes followed by a short pause followed by another two quick flashes. After this the PEL-4 will resume normal operation.

Program the Low Battery Threshold:

Referring to Appendix A it can be seen that the low battery threshold is feature 8. The three digit value that is read or written is the threshold voltage * 10.

Operation	= Programming	= 1	
Feature	= Low Battery Threshold	= 8	
Value	= New Value	= 105	(i.e. 10.5 Volts)

The sequence to program this threshold is therefore 1 8 105

1 Enter programming mode Press the red standby button for 5 seconds	The PEL-4 will give 4 quick flashes to indicate it has entered programming mode

2. Enter the programming sequence for writing the low battery threshold (1 8 105)	The PEL-4 will flash once each time a key on the programmer is operated. When the sequence is completed and accepted the PEL-4 will repeat the value 105 in a series of flashes. One quick flash followed by a 0.5sec gap followed by a 2 second flash (for zero) followed by a 0.5 second gap followed by five quick flashes
3 Exit programming mode Leave the programmer idle for 10 seconds	The PEL-4 will give two quick flashes followed by a short pause followed by another two quick flashes. After this it will resume normal operation.

After completing this exercise, be sure to set the low battery threshold back to your desired value (the default is 11.0V, i.e. 110). All configuration settings are stored in EEPROM so switching the power on or off will not reset these values.

Create a programming error by attempting to program an out of range value:
This time try to program the high battery threshold to an invalid value. Referring to Appendix A it can be seen that the high battery threshold is feature 8, and the valid range is 12.0 to 18.0VDC.

Operation	= Programming	= 1	
Feature	= High Battery Threshold	= 9	
Value	= New Value	= 100	(i.e. 10.0 Volts)

The sequence to program this threshold is therefore 1 9 100

1. Enter programming mode Press the red standby button for 5 seconds	The PEL-4 will give 4 quick flashes to indicate it has entered programming mode
2. Enter the programming sequence for the Operation Mode (15003)	The PEL-4 will flash once each time a key on the programmer is operated. When the sequence is completed the command will be rejected and an error indicated by 3 quick flashes. The PEL-4 will then return to programming mode and is ready for a new instruction.
3. Exit programming mode Leave the programmer idle for 10 seconds	The PEL-4 will give two quick flashes followed by a short pause followed by another two quick flashes. After this the PEL-4 will resume normal operation.

Reading System Information
Referring to Appendix A it can be seen that the battery voltage can be read from the System Checks (feature 3), feature 1. The value that is returned is the battery voltage * 10 (three digits):

Operation	= System Checks	= 3

Feature = Battery Voltage = 1
The sequence to read the battery voltage is therefore 3 1

1. Enter programming mode Press the red standby button for 5 seconds	The PEL-4 will give 4 quick flashes to indicate it has entered programming mode
2. Enter the programming sequence for the information (31)	The PEL-4 will flash once each time a key on the programmer is operated. When the sequence is completed and accepted the PEL-4 will provide the voltage level in a series of flashes (12.3VDC). One quick flash followed by a 0.5sec gap followed by 2 quick flashes followed by a 0.5 second gap followed by two quick flashes.
3. Exit programming mode Leave the programmer idle for 10 seconds	The PEL-4 will give two quick flashes followed by a short pause followed by another two quick flashes. After this the PEL-4 will resume normal operation.

4.5 Deciding which Settings are required

Since the PEL-4 is delivered from the factory with operator-specified settings, it is unlikely to be necessary to reprogram any settings. The “Read Settings” feature can be used to note the values already programmed.

4.6 Programming or Reading Multiple Settings

In the examples above, the PEL-4 was allowed to time-out of programming mode after reading or writing each parameter. This is not necessary as multiple parameters can be read and written in one programming sequence.

5.0 NORMAL, AUTOMATIC OPERATING MODE

The operation mode setting is the master mode setting of the PEL-4. It controls whether the PEL-4 is operational or in storage mode and how the PEL-4 responds to detected fault conditions.

There are two normal, automatic operation modes:

- Fail-safe, in which the PEL-4 will operate automatically and will turn off if it detects an internal fault, or;
- Best-effort (this is the default), in which the PEL-4 will operate automatically and will attempt to continue operating if it detects an internal fault.

When the PEL-4 detects an internal fault, it will always set the alarm output, irrespective of whether it is set to fail-safe or best-effort modes. In best-effort mode, in some fault cases it will not be possible for the PEL-4 to continue operating. (For example, if the input voltage drops below the low battery threshold then the PEL-4 will turn off and signal an alarm, even if its operation mode was Best-effort mode.)

To set the Operation Mode, follow this sequence:

Operation	=Program (or read)	= 1 (or 9)
Feature	=Operation Mode	= 5
Value		=XXX

The normal operation mode values are shown in bold in the following table:

Normal, Automatic Operation Modes		
Value	**Name**	**Description**
001	**Normal Mode – fail-safe**	PEL-4 shuts down on fault condition.
002	**Normal Mode – best-effort (default)**	PEL-4 attempts to continue on fault condition.

Other operation modes are available, for example, for remote control via hardwire input or serial command. These are described in the more advanced sections of this manual and listed in Appendix A.

The PEL-4 can be programmed over the serial interface of the Dataport. Appendix A includes references to the serial interface commands that are equivalent to, or associated with, the TVIR programmer commands. A detailed description of the serial interface commands is provided in Appendix H.

The following sections describe programmable features and parameters that are supported in normal, automatic mode.

5.1 Flash Character

Vega PEL-4s are pre-programmed with 246 standard characters, each represented by a three digit code (XYY). The first digit of the code represents a flash type – such as 1YY for Isophase characters. If additional flash characters are required that are not included in the standard set, these can be included if advised at time of order. These would then be available for programming under User Character Type 9YY.

Operation	=Program (or read)	=1 (or 9)
Feature	=Flash Character	=0
Value	=Select from Appendix A	=XYY

5.2 Custom Flash Character

A single 'custom' character can be programmed in raw time-counts for occasions when the desired character is not included in the PEL-4 pre-programmed set of standard characters.

To program the custom character, the details of the on and off periods of the flash character has to be recorded in the PEL-4 and then the flash character '999' has to be programmed (see the previous section for this last step).

The programming of a custom character has its own syntax and this needs to be followed correctly to be able to program the character successfully:

Operation	=Custom Character	=2
Value	=Code sequence for the character	(Pairs of 3-digit On/Off values & END code)

The code sequence is entered in a series of 3 digit value-pairs representing an on period and an off period. Each 3-digit value is a multiple of 0.05 seconds. The 3-digit code for a 1 second on or off period would be 020 (20 multiplied by 0.05 seconds is 1 second).

The following restrictions apply:

- The minimum period that can be programmed is 0.1 second or the code of 002.
- The maximum period that can be programmed is 12.75 seconds or the code of 255. For longer periods than 12.75 seconds an ADD code can be entered

There are two special codes used as part of the custom character programming

- The ADD code to get on or off periods greater than 12.75 seconds = 001
- The END code when the programming of the custom character is finished = 000

If an error occurs when entering a custom character, the PEL-4 will flash the error code of 3 quick flashes.
Programming a custom character creates a flash character with code 999. To get the PEL-4 to use the custom character the value of 999 must be entered as the flash character.

Some examples:
e.g.
Q 1s (0.3s) is programmed as:
2 – 006 014 000

Fl(5) 30s 4 x (1s, 1s), 1s, 21s is programmed as:
2 – 020 020 020 020 020 020 020 020 020 255 001 165 000

5.3 Day/Night Automatic Operation of the PEL-4

By default the PEL-4 is fitted with a photocell day/night detector. The PEL-4 automatically detects day and night and can be configured to operate in any of the following ways:

- Night-only (set night intensity to the desired value and day intensity to zero)
- Day-only (set night intensity to zero and day intensity to the desired value)
- Night and Day (set night and day intensities to the desired values)

The PEL-4 is capable of outputting its full intensity range from minimum to maximum in each of night and day operation. Additionally, one of night or day intensities can be set to zero. There is no relationship user-programmed between the night and day intensity values and any combination of valid values is programmable.

In normal automatic day/night mode, the PEL-4 is continually sampling the daylight level. The default construction of the PEL-4 places the photocell inside the rear cover, obscuring it from the intense light output of the PEL-4. It is important to ensure that the rear cover is not obscured from daylight if automatic day/night operation is required. The PEL-4 will transition from night to day operation, or vice versa, after three consecutive, filtered daylight samples agree that the user-programmed Lux threshold has been reached. The PEL-4 will nominally respond to a light level change in thirty seconds, and will take slightly longer if fixed character is selected.

There are 12 different day/night transition light levels allowing for a shorter or longer night.

Operation	=Program (or read)	= 1 (or 9)
Feature	=Day/Night Control	= 4
Value	=Select from Appendix A	=0YY

The first digit (0) of the Day/Night Control value should always be zero.
The YY digits of the Day/Night Control Value determine when the Day/Night transition occurs. The lux levels of the twelve settings are detailed in Appendix A. The accuracy of the light sensor is ±10%.

5.4 Night & Day Intensity Settings

The PEL-4 allows separate programming of night and day intensities. The intensity range offered by the PEL-4 makes it practical to set the day intensity higher than the night intensity in order to achieve similar day and night ranges in nautical miles. Zero is a valid intensity setting. The programmable effective intensity settings are provided in Appendix B.

The PEL-4 is programmable in effective intensity or in peak intensity during the flash. When an effective intensity is programmed into the PEL-4, the peak intensity is controlled automatically for the selected flash character, using the default IALA E-200-4 2017 flash compensation algorithm, to maintain the required effective intensity. The operator needs to confirm from Appendix B that for any combination of programmed effective intensity and flash character that the PEL-4's maximum intensity specification is not exceeded.

An alternative flash compensation algorithm is available: IALA E-200-4 2008. Refer to Appendix A for how to program this alternative mode.

When a 'peak intensity during the flash' value is programmed into the PEL-4 then no flash compensation is calculated and the programmed intensity is used directly during the flash on period. Refer to Appendix A for how to program this mode (i.e. no flash compensation).

To program night or day intensity using the TVIR Remote02:

Operation	=Program (or read)	=1 (or 9)
Feature	=Intensity	=1 for night intensity, 2 for day intensity
Value	=Select from Appendix B	=XXX XXX (6 digits)

(The 3-space-3 formatting of the six intensity digits in the example above and also in the Appendix B tables is merely to aid in clarity).

5.5 Synchronising Options

Three options are available for synchronisation on the PEL-4:

- Hard wired synchronisation;
- External GPS synchronisation using Vega VSU-29 module. A monitoring or AIS product can also be used.

Hard wired synchronisation can be used where the other beacons to be synchronised are within practical wiring distance. Otherwise, external GPS-based synchronisation can be used.

For Vega LED products, the sync pulse has a unique format including a positive to negative transition and day/night information. Each PEL-4 can be set to be a sync master or sync slave. As a sync slave, the PEL-4 will not generate sync pulses and will only turn on if sync pulses are received. A PEL-4 set to be a sync master (the default) will generate a sync pulse at the start of the flash character. Where a set of hardwired beacon have inter-connected syncs and are all masters the first light to send a sync pulse will control the other lights.

In slave mode a PEL-4 will operate on the basis of the sync pulses received and will stop operating after a programmed number of flash cycles after the sync pulse is lost. To program a slave PEL-4 to keep running for a number of flash cycles after the loss of the master sync pulse:

Operation	=Program (or read)	=1 (or 9)
Feature	=Additional Sync Options	=7
Value		=0YY

Where YY is the number of flashes after loss of sync (a minimum of 2 is recommended).

Programming a flash count of 998 will put the PEL-4 into Sync low off mode – where the PEL-4 will turn off if the sync line is grounded. Obviously normal sync will not work if this option is selected. Programming a flash count of 999 will turn off the Sync low off mode.

A master-sync or slave-sync PEL-4 can have its flash character offset in time from another beacon using the Sync Delay feature. The Sync Delay setting causes the PEL-4 to delays its flash character with respect to the flash character of connected beacons by the delay period. This function also works with GPS synchronisation.

Operation	=Program (or read)	=1 (or 9)
Feature	=Synchronisation	=3
Value		=XYY (999 disables synchronisation)

X determines if the PEL-4 is a master or slave unit.

- 0YY Sync Master (with GPS enabled if detected)
- 1YY Sync Slave
- 2YY Sync Master with GPS disabled

YY allows for the start of the flash character to be delayed from 0.0 seconds to 9.9 seconds in 0.1 second increments. For example YY=25 would provide a delay of 2.5 seconds.

5.6 Battery Thresholds

The PEL-4 has programmable battery threshold settings designed to protect a battery from damage by being over-discharged.

The PEL-4 protects the battery from low voltage damage and will switch off when the programmed low threshold is reached. This feature also protects the PEL-4 from over-current damage (since the current drain will increase as the battery voltage reduces to maintain constant power input). This feature can be disabled if not required.

If the low battery threshold is set to any value other than zero, then if the PEL-4 detects three consecutive voltage readings less than the programmed low voltage threshold, it will turn off. The PEL-4 will turn off under this condition in both fail-safe and best-effort operational modes. While the PEL-4 is off, it will generate an alarm output condition. Normal operation of the PEL-4 will be resumed once the battery voltage exceeds the battery high threshold value.

For a nominal 12V battery supply, the default threshold values are 11.0V for the low voltage threshold (110), and 12.8V for the high voltage threshold (128). For a nominal 24V battery supply, the default values are 22.0V for the low voltage threshold (220), and 25.6V for the high voltage threshold (256). A dual-voltage product will be shipped with 12V settings and these can be adjusted anywhere in the combined 12 and 24V ranges. Setting the low voltage value to 999 will disable this function of protecting the battery. Note, however that the PEL-4 will always turn off when the input voltage is either too low for it to function correctly, or below the input current demand of the PEL-4's design specification. Setting the high voltage threshold to 999 will reset it back to the default value.

5.7 Calendar

The PEL-4 allows the programming of 5 pairs of calendar dates where the beacon will turn off at the first date, hibernate, and then return to "Normal" operation on the second date.

The default setting for the calendar is "disabled" and the feature must be turned "on" and the current local date and time set in order to enable the function. The PEL-4 obeys the programmed on and off dates in a sequential manner and care needs to be taken that the off periods are not overlapped. Overlapped off periods may result in operation that is not as expected. A setting of 0000 will disable the ON or OFF date and all ON/OFF dates can be disabled by using Feature 50 and entering 0000.

Enter TVIR programming mode by operating the standby button for 5 seconds.

Operation =4 =Calendar

Feature =See table below

Value =See table below

Program and reading of settings are done using a different feature code.

The calendar does not support daylight saving time. All date settings are referenced to the real time that is entered.

The day of the month is a number between 01 and 31. The beacon does not check the days entered against a particular month.

Feature	**Value**	**Flash response from beacon**
00 Calendar Enable/Disable	000 Disable 001 Enable	000 Disable 001 Enable 011 Enabled and Hibernating
01 Read Enable/Disable		000 Disable 001 Enable 011 Enabled and Hibernating
10 Set Year	YYYY (i.e. 2010)	YYYY (i.e. 2010)
11 Read Year		YYYY (i.e. 2010)
20 Set Month/Day/Hour/Minute	MMDDHHMM MM is month (01 to 12) DD is day (01 to 31) HH is hour (00 to 23) MM is minute (00 to 59)	MMDDHHMM MM is month (01 to 12) DD is day (01 to 31) HH is hour (00 to 23) MM is minute (00 to 59)
21 Read Month/Day/Hour/Minute		MMDDHHMM MM is month (01 to 12) DD is day (01 to 31) HH is hour (00 to 23) MM is minute (00 to 59)
30 Set 1st OFF date	MMDD (0000 Disables) MM is month (01 to 12) DD is day (01 to 31)	MMDD MM is month (01 to 12) DD is day (01 to 31)
40 Read 1st OFF date		MMDD MM is month (01 to 12) DD is day (01 to 31)
31 Set 1st ON date	MMDD (0000 Disables) MM is month (01 to 12) DD is day (01 to 31)	MMDD MM is month (01 to 12) DD is day (01 to 31)
41 Read 1st ON date		MMDD MM is month (01 to 12) DD is day (01 to 31)
32 Set 2nd OFF date		
42 Read 2nd OFF date		
33 Set 2nd ON date		
43 Read 2nd ON date		
34 Set 3rd OFF date		
44 Read 3rd OFF date		
35 Set 3rd ON date		
45 Read 3rd ON date		
36 Set 4th OFF date		
46 Read 4th OFF date		
37 Set 4th ON date		
47 Read 4th ON date		
38 Set 5th OFF date		
48 Read 5th OFF date		
39 Set 5th ON date		
49 Read 5th ON date		
50 Clear All ON/OFF dates	0000 Disable	0000

6.0 PERFORMING SYSTEM CHECKS

The PEL-4 firmware contains both manufacturing and real-time information that the user can retrieve for identification or diagnostic purposes.

Information that can be requested includes:

- Software version (3 digits);
- Battery/supply voltage
- Temperature reading (3 digits, °Kelvin, subtract 273 to obtain °Celsius.);
- Current adjustment (always reads '100', which means 100%, or no adjustment);
- Serial number (8 digits);
- Characterisation number (4 digits, refers to the LED+optical calibration. Consult Vega if more information is required);
- GPS detected ('001' if daughterboard detected and GPS lock obtained).

See the System Checks portion of the generic programming commands described in Appendix A.1 for the full list of data available.

For example the PEL-4 provides a reading of the supply voltage as a quick means of checking battery voltage.

Operation	=Read Only	=3
Feature	=Input Voltage	=1 (see Appendix A for others)
Value		=Series of flashes providing the requested value.

The input voltage value is provided in tenths of a volt. For example, a read-back of '120' means 12.0V was detected. An error of +/-2% in this reading is typical.

Similar system and real-time information can be obtained using the serial interface features. A monitoring data stream is available through the serial interface if the dataport option is fitted.

7.0 SETTING A SECURITY PIN NUMBER

The PEL-4s are shipped from the factory with security protection enabled. If there is concern about unauthorised TVIR programming, then a 3-digit PIN number can be set.

When a PIN number is set, that PIN number must be entered first, before programming any parameters. If the PIN is not entered first, an error message will be generated and the programming attempt will be ignored.

Entering a PIN number is only necessary when changing settings; it is possible to read settings without using the PIN number.

Setting a PIN number of 000 will cause security to be disabled. i.e. a PIN is no longer required prior to changing settings. This is the factory default state.

For setting a Security PIN
Enter TVIR programming mode by operating the standby button for 5 seconds.

Operation	=7	=Special
Feature	=1	=Set PIN
Value	=XXX	=PIN number (Value 000 means there is no security)

The PEL-4 will then flash back the PIN number in a series of flashes.

To change settings when a Security PIN is used:
Enter TVIR programming mode by operating the standby button for 5 seconds.

Operation	=7	=Special
Feature	=7	=Check PIN
Value	=XXX	=PIN number

If the entered PIN number is correct, the PEL-4 will flash back the PIN number using a series of flashes and, during the current TVIR programming session (only), subsequent programming commands will be accepted.

Entering an incorrect PIN will cause the PEL-4 to return an error flash code. Multiple attempts can be made without penalty to enter the correct PIN.

If the PIN number is lost, please contact Vega for further instructions.

8.0 AUXILIARY AND SPECIAL CHARACTER OPERATIONS

In addition to the standard single flash character mode of operation, which is the default operation mode of the beacon, several special flash character modes are supported, as follows:

- Dual Character Mode, in which the standard flash character is used for night and the auxiliary flash character for day;
- Flash/Fixed remote control, in which hardwired or serial interface control can be used to switch between the programmed character and a fixed character. This function is enabled through programming the remote control operation of the beacon. Refer to the Remote Control section for a description.
- Emergency Mode, in which the character is changed from the normal character (operating day and/or night), to an emergency character when the battery voltage drops below a preset threshold.

8.1 Accessing the Auxiliary Flash Character

The Auxiliary character is separately programmable. To program the auxiliary flash character, enter TVIR programming mode and follow these steps in this order:

Operation	=Program (or read)	=1
Feature	=Operation Mode	=5
Value	=Access Auxiliary Character	=005

Operation	=Program (or read)	=1 (or 9)
Feature	=Flash Character	=0
Value	=Select from Appendix A	=XYY

To return to accessing the normal flash character, either exit and re-enter TVIR programming mode, or enter the following sequence of steps:

Operation	=Program (or read)	=1
Feature	=Operation Mode	=5
Value	=Access Normal Character	=000

Operation	=Program (or read)	=1 (or 9)
Feature	=Flash Character	=0
Value	=Select from Appendix A	=XYY

8.2 Flash Character Modes

As well as the default single character mode, dual character mode is supported. These modes are accessible using the special flash mode TVIR command.
In dual character mode the standard (or normal) flash character only operates when the beacon detects night. During day, the beacon uses the auxiliary flash character.

All of these modes are compatible with remote control and traffic light control modes. E.g. for dual character mode, the beacon switches between flash characters at day/night transitions, regardless of which mechanism is used to identify day and night to the beacon.

8.2.1 Dual Character Mode

Dual character mode can be set and read using the following command sequence:

Operation	=Special	=7
Feature	=Set Flash Mode	=2
Value	=Select from Appendix A	=X1Z (X & Z are independent of this mode)

Digit X is presently always zero. Digit Z defines the flash compensation mode and is described in the next section.

The current character mode can be read back using the sequence:

Operation	=Special	=7
Feature	=Read Flash Mode	=3

The second digit of the returned 3-digit value will indicate the character mode, as follows:

- 0: Normal, single character mode;
- 1: Dual character mode;
- 2: Emergency mode.

As indicated in Section 5.6, there is a factory default reset mode for dual character operation. Use the following command sequence to set up a beacon into dual character mode:

Operation	=Program (or read)	= 1
Feature	=Operation Mode	= 5
Value		= 997

This programming sequence also modifies a number of settings. Refer to Appendix A.2 for detailed information of which settings are modified.

8.2.2 Single Flash Character Mode (Default)

Single Flash Character mode (the default mode) can be set and read using the following command sequence:

Operation	=Special	=7
Feature	=Set Flash Mode	=2
Value	=Select from Appendix A	=X0Z (X & Z are independent of this mode)

Digit X is presently always zero. Digit Z defines the flash compensation mode and is described in the next section.

The current character mode can be read back using the sequence:

Operation	=Special	=7
Feature	=Read Flash Mode	=3

The second digit of the returned 3-digit value will indicate the character mode, as follows:

- 0: Normal, single character mode;
- 1: Dual character mode;
- 2: Emergency mode.

8.2.3 Emergency Mode

Emergency flash mode can be set and read using the following command sequence:

Operation	=Special	=7
Feature	=Set Flash Mode	=2
Value	=Select from Appendix A	=X2Z (X & Z are independent of this mode)

Digit X is presently always zero. Digit Z defines the flash compensation mode and is described in the next section.

The current character mode can be read back using the sequence:

Operation	=Special	=7
Feature	=Read Flash Mode	=3

The second digit of the returned 3-digit value will indicate the character mode, as follows:

- 0: Normal, single character mode;
- 1: Dual character mode;
- 2: Emergency mode.

Emergency mode activates the auxiliary character if the input voltage falls between the user-programmable low (exclusive) and high (inclusive) battery thresholds. In emergency mode the programmed intensity is halved in day and night operation. If the battery voltage rises 1.0V above the high battery threshold then the beacon returns to normal operation. If the battery voltage falls below (inclusive) the low battery threshold then the beacon enters low battery mode (low power sleep) until the battery voltage returns to >=1.0V above the low battery threshold, which initiates a reset and return to appropriate operation (normal or emergency, depending on the current battery voltage).

When the beacon is in emergency mode the alarm output is activated and a unique emergency error code is output via serial monitoring for tag <MER>. When the beacon is in low battery mode, the alarm is activated and the low battery error code is output via serial monitoring for tag <MER>.

As indicated in Section 5.6, there is a factory default reset mode for a particular custom setup of emergency mode operation. Use the following command sequence to set up this custom emergency mode:

Operation	=Program (or read)	= 1
Feature	=Operation Mode	= 5
Value		= 996

This programming sequence also modifies a number of settings. Refer to Appendix A.2 for detailed information of which settings are modified.

8.3 Flash Compensation Modes

The PEL-4 is capable of generating several different flash characteristics. The IALA E-200-4 2017 flash compensation algorithm is enabled by default. Additionally, a peak intensity during flash mode is available in which no flash compensation is applied. Lastly, an historic IALA E-200-4 2008 flash compensation algorithm can also be programmed.

These modes are selectable using the third digit of the special set flash mode command:

Operation	=Special	=7

Feature	=Set Flash Mode	=2
Value	=Select from Appendix A	=XYZ (X & Y are independent of this mode)

X is presently always 0. Where the third digit, Z, is the value controlling the flash compensation mode.

These flash compensation modes are compatible with all other PEL-4 modes.

8.3.1 IALA E-200-4 2017 Effective Intensity Mode (Default)

The IALA-recommended Modified Allard or Schmidt-Clausen flash compensation algorithm is implemented when the effective intensity flash compensation mode is enabled. For rectangular flash characters the Modified Allard algorithm resolves to the Schmidt-Clausen algorithm shown here. Where each flash on period (*f*) within a total flash character is compensated by a factor (*SC*) according to its individual duration, as per:

$$SC = (f + a)/f$$

For the default compensation compliant with E-200-4 2017, during night, the applied flash compensation formula uses the Schmidt-Clausen constant of *a*=0.1s. During the day *a*=0.1s is always used.

For the alternative E-200-4 2008 algorithm, during night, the applied flash compensation formula uses the Schmidt-Clausen constant of *a*=0.2s. During the day *a*=0.1s is always used.

When flash compensation is disabled, a = 0, in the above formula, meaning that SC = 1.0.

The default, E-200-4 2017 effective intensity mode can be selected as follows:

Operation	=Special	=7
Feature	=Set Flash Mode	=2
Value	=Select from Appendix A	=XY0 (X & Y are independent of this mode)

X is presently always zero. Y is independent and defines the auxiliary and special flashing mode as described in the previous section.

The alternative IALA E-200-4 2008 can be selected as follows:

Operation	=Special	=7
Feature	=Set Flash Mode	=2
Value	=Select from Appendix A	=XY2 (X & Y are independent of this mode)

X is presently always zero. Y is independent and defines the auxiliary and special flashing mode as described in the previous section.

8.3.2 Peak Intensity During the Flash Mode

No flash compensation is applied in this mode. The programmed day or night intensity is directly output from the PEL-4 during the flash on (a.k.a. peak) period of the flash character.

Peak intensity during flash mode can be selected as follows:

Operation	=Special	=7
Feature	=Set Flash Mode	=2
Value	=Select from Appendix A	=XY1 (X & Y are independent of this mode)

X is presently always zero. Y is independent and defines the auxiliary and special flashing mode as described in the previous section.

9. REMOTE CONTROL OPERATION

The PEL-4 includes an extensive set of remote control features. These features are compatible with many other advanced PEL-4 functions.

9.1 Enabling Remote Control Operation

The remote control features must be enabled using the master operation mode programming sequence. The precise remote control operation settings can be programmed with separate commands before or after programming the master operation mode to enable them. To enable remote control mode, program the following sequence, as per Appendix A.1:

Operation	=Program (or read)	= 1 (or 9)
Feature	=Operation Mode	= 5
Value		= 003 (fail-safe) or 004 (best-effort)

To disable remote control mode, send the following command:

Operation	=Program (or read)	= 1 (or 9)
Feature	=Operation Mode	= 5
Value		= 001 (fail-safe) or 002 (best-effort)

To define a particular remote control behaviour, use the following command:

Operation	=Special	= 7
Feature	=Set Remote Control Mode	= 4
Value	=Select from Appendix A	= XYZ (see Appendices A.3, A.4 & A.5)

To read back:

Operation	=Special	= 7
Feature	=Read Remote Control Mode	= 5

Value XYZ is returned (see Appendices A.3, A.4 & A.5).

Digits X and Y set the electrical behaviour and polarity sensitivity of the control inputs. Digit Z defines the combination of inputs that are active in remote control mode. The details of how to program this advanced feature set are given in Appendices A.1, A.3, A.4 and A.5. In the following sections some examples are provided to assist with the operator's understanding of how to select features suitable for his/her application.

9.2 Remote Control Inputs

In remote control mode, the two hardwired inputs, On/Off and Day/Night, operate independently of each other. These inputs, and associated signal grounds, are listed in the table below.

There are serial interface commands available in remote control mode that correspond to each of the hardwired inputs. Refer to the later section describing the use of serial interface remote control and how it interacts with the hardwired remote control inputs.

9.2.1 Hard-wired Input Control Programming

The user has complete control to enable or disable any combination of these two remote control inputs. A disabled input means that the PEL-4's normal automatic behaviour applies to that function. An enabled input means that the PEL-4's behaviour for that function is controlled by the state of the relevant hardwired input. Later in this section, there follow some examples of user-programming of remote control inputs and corresponding PEL-4 behaviour. All options are listed in Appendix A.2.

Remote Control Mode Input Behaviour					
Pin	**Colour**	**Signal**	**Direction**	**'Z' parameter (Add values)**	**PEL-4 behaviour when input is enabled**
1	Cyan	Signal Ground	Ground	-	A polyfuse-protected common signal ground.
10	Red	On/Off	Input	4	Active: PEL-4 turns on. Inactive: PEL-4 turns off.
11	Black	Signal Ground	Ground	-	A polyfuse-protected common signal ground.
12	Orange	Day/Night	Input	2	Active: PEL-4 switches to day intensity. Inactive: PEL-4 switches to night intensity.

The 'Z' parameter value column shows the value required to be added into the 'Z' parameter to enable the relevant input when programming the remote control settings.
i.e. the 7-4-XYZ remote control mode command contains three separate digits controlling separate parts of the remote control setup:

- Digit X defines the input active polarity (the PEL-4 only supports 1 = high active);
- Digit Y defines whether an internal pull-up/down is enabled (the PEL-4 only supports 1 = pull-down enabled);
- Digit Z defines which combination of the two inputs is enabled. Each input is allocated a value of 2, or 4. Values of Z of 0, 2, 4, or 6 allow all combinations of the two inputs to be enabled (including none and all).

The details of the remote control mode programming are given in Appendix A.

9.2.2 Hard-wired Input Level Settings Programming

The remote control inputs are set as active-high with a pull-down. All programming options are provided in Appendix A.2. All inputs are always programmed with the same level and pull-up settings.

9.3 Serial Remote Control Interface

The serial remote control interface is enabled when the hardwired remote control inputs are enabled (i.e. when either 1-5-003 or 1-5-004 TVIR commands are sent, or the equivalent <OPM>3/ or <OPM>4/ are sent followed by a restart, <RST>1/).

The serial interface defaults to 115.2kbaud, 8 bits, no parity, 1 stop bit (8N1).

If the hardwired remote control inputs remain in a constant state then they will be ignored and the remote control serial interface commands will be in total control. See the next section if it is desirable to use both hardwired and serial remote controls simultaneously.

The serial commands applicable to the remote control interface are as follows:

Control Feature	Serial Command	'B' parameter value	PEL-4 behaviour when corresponding input is enabled (see 7-4-XYZ or <RCM>XYZ/ commands)
On/Off	<RON>B/	1	Active: PEL-4 turns on.
		0	Inactive: PEL-4 turns off.
		?	Returns current PEL-4 state. (Should be regularly polled due to internal states being updated each second).
Day/Night	<RDN>B/	1	Active: PEL-4 switches to day intensity.
		0	Inactive: PEL-4 switches to night intensity.
		?	Returns current PEL-4 state. (Should be regularly polled due to internal states being updated each second).

The serial interface commands work in a differential mode to the current PEL-4 state. If a new serial command is received that requires a change in state compared to the existing PEL-4 state, then a change of state is scheduled and will occur in the next one to two seconds.

The new state can be identified by polling with the same command and a '?' parameter. Note that the read-back state will not instantly change after the new command is sent, so polling is necessary to detect the new state.

For example, if the PEL-4 is in night state and an '<RDN>1/' command is sent to change to day state, this change will occur within 1 to two seconds of receipt of the command. Read-back command '<RDN>?/' can be sent repeatedly until the new state is internally recognised.

The two serial remote control interface commands work independently of each other.

Other PEL-4 modes are compatible with the operation of the remote controls serial interface, including dual character, effective or peak intensity modes, etc.

9.4 Serial Remote Control Mode Changes

The serial remote control interface is very versatile because the actual remote control mode can be modified in real time through the serial interface.

The remote control mode commands described in sections 9.2.1 and 9.2.2 are all available with the '<RCM>' remote control mode serial command. This command uses the same parameters as does the '7-4-'XYZ' command. The <RCM> command operates immediately without requiring a PEL-4 restart. The <RCM> command is shown in Appendices A.1, A.3 and A.4 alongside the equivalent TVIR commands.

The capability to reprogram a PEL-4's mode allows greater control of the PEL-4. For example, the <RCM> command allows a single PEL-4 to be remotely configured into any of the PEL-4 remote control applications described in section 9.2.3. In fact, the same PEL-4 can have its remote control mode changed repeatedly without ever being physically accessed. In addition, all PEL-4 parameters such as day and night intensity, flash characters, etc can also be modified via the serial interface.

9.5 Simultaneous Use of Remote Control Hardwired Inputs and Serial Interface

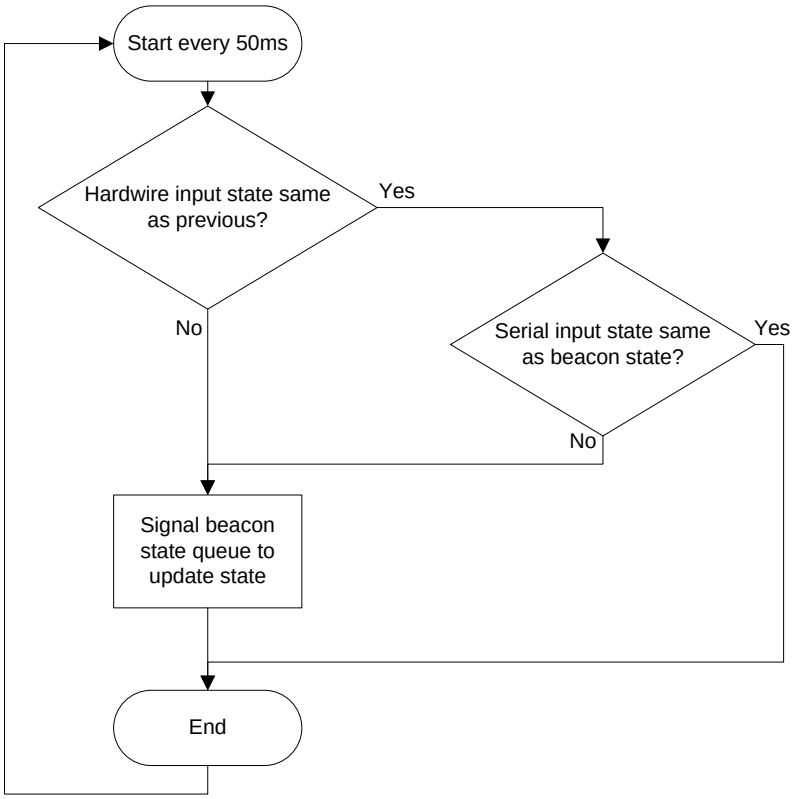
Both the serial remote control interface and the hardwired remote control inputs, operate in a differential mode. That is, a new control state is detected and implemented only when a change occurs. The hardwired and serial control interfaces are designed to work together to support remote serial control of a PEL-4 with a local hardwired manual override. The following flow diagram gives an overview of the interaction of the two control systems.

An example of how the serial and hardwire controls interact is as follows:

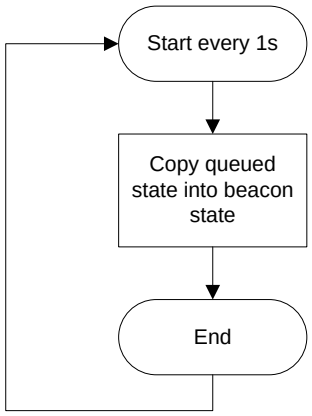
- After commissioning, a PEL-4 is remotely turned on and off every 24 hours using the serial interface command <RON>.
- If a fault occurs with the serial communications system, a site-visit can be made to manually set the PEL-4 into the correct state. A manual override can be activated on-site by toggling the On/Off hardwired input to the desired state (see next step).
- The hardwired input recognises a change in its own state, so if its state does not match the current PEL-4 state, it will need to be toggled. This 'toggling' approach will always work with the hardwired inputs. (e.g. if the PEL-4 was off and the hardwire On/Off input switch was found to be in the on position then toggling the switch on->off->on will always turn on the PEL-4).
- If necessary, repeated site visits to manually change the PEL-4 state can be made until the serial communications system is repaired.
- Until new serial <RON> commands are received by the PEL-4, it will remain in the state manually set by the On/Off input switch.
- Once the serial communication system is operational again, sending a new <RON> command(s) will override whatever state the hardwire On/Off switch was manually set to – normal service is resumed.

The same behaviour occurs with the Day/Night (<RDN>) input (command).

Hardwire Input and Serial Remote Control Input Processing



Beacon State Queue Processing



10.0 ROUTINE MAINTENANCE

10.1 Maintenance Cleaning

Vega PEL-4 requires no internal maintenance.

The exterior of the PEL-4 should be inspected and cleaned occasionally to ensure maximum intensity and that no foreign material is trapped in the heat sink on the rear of each unit.

Use warm soapy water to wash the exposed front lens surface and the outside of the PEL-4. Rinse off with clean water.

Do not use any form of abrasive cloth or cleaner on any part of the PEL.

Regular opening of the PEL-4's rear cover is not recommended. There are no user-serviceable parts inside.

Do not touch, rub or clean the LED. The LED can be hot and extremely bright.

Do not touch, rub or clean the filters.

It is not recommended to clean the acrylic condenser lens. If necessary, a lint-free cloth, preferably an anti-static type could be used to gently clean both surfaces of the acrylic condenser lens. Be careful not to touch the LED or the filters while cleaning the acrylic condenser lens. Do not use any form of abrasive cloth or cleaner on the lens.

Keep the inside of the PEL-4 dry at all times.

There is no requirement for replacement of lubricant.

10.2 Inspection check

Periodically check that the PEL-4 remains firmly secured and level, and that the mounting fasteners are still in good condition. Investigate any corrosion of the mounting structure and take appropriate preventive action.

APPENDIX A PROGRAMMING TABLE

Appendix A.1 Generic TVIR Programming Commands

PEL-4s are shipped in Normal, Automatic and Single Character Mode unless specifically requested otherwise. The operating mode and other settings are indicated on the associated PEL-4 test sheet.

The operator has full control of the PEL-4's operational mode and all settings can be altered as described in the following tables.

For most TVIR commands in the following table, the corresponding serial interface command or related serial commands are shown in `Courier New` font. All serial interface commands can accept a question mark, '?' as a parameter and will return the current settings after the receipt of the trailing forward slash '/'. (Parameter '`B`' in various commands represents a binary value, '0' or '1'.) Most commands require a PEL-4 restart ('`<RST>1/`') before they will affect PEL-4 operation.

Generic TVIR Programming Commands		
Operation	**Feature**	**Value**
1 = Program Mode 9 = Read Settings	0 = Flash Character <FID>XYY/ for default character. <AID>XYY/ for auxiliary character.	Flash Character: In single character mode the default character is accessed here and is used for both night and day operation. In dual character & emergency modes both the default/normal character and the auxiliary/emergency character can be accessed by this command. Precede this command with either 1-5-000 (for default/night/normal character) or with 1-5-005 (for auxiliary/day/emergency character). Characters are listed in Appendix G: 000 – Fixed character 1YY – Iso phase (ISO) 2YY – Occulting (OC) 3YY – Flash (Fl) 4YY - Multiple Flash (Fl(x)) 5YY - Very Quick (VQ) 6YY - Quick (Q) 7YY – Long (LF) 8YY – Morse (MO) 9YY – Custom (Codes)
	1 = Night Intensity <NRG>XXXXXX/	Four-digit value Refer to Appendix B for a table of available settings. Automatic, default flash compensation is applied unless the Flash Mode is changed from the default.
	2 = Day Intensity <DRG>XXXXXX/	Four-digit value Refer to Appendix B for a table of available settings. Automatic, default flash compensation is applied unless the Flash Mode is changed from the default.
1 = Program Mode 9 = Read Settings	3 = Synchronisation <OSO>B/ <SYD>YY/ <SDA>B/ <GPE>B/ Factory settings: 000	0YY PEL-4 in master mode 1YY PEL-4 in slave mode YY=sync delay seconds (0.0 to 9.9 seconds) 999 – Disable Sync (Hardwire & GPS). 998 – On When Sync is Low. (Send any 0YY, 1YY setting to cancel all 998 through 999 modes).

Generic TVIR Programming Commands		
Operation	**Feature**	**Value**
	4 = Day/Night Control <DNT>0YY/ Factory setting: 005	0YY Format: YY= Day/Night transition Lux Level Night Lux. Day Lux YY=01 40 100 YY=02 50 150 YY=03 75 100 CCG YY=04 75 150 YY=05 75 175 IALA suggested YY=06 100 175 YY=07 100 200 YY=08 150 250 YY=09 250 320 longest night USCG YY=10 15 40 shortest night YY=11 30 50 YY=12 15 60
1 = Program Mode 9 = Read Settings	5 = Operation Mode <OPM>XXX/ <TST>B/ Factory setting: 002	**Normal, Automatic Operation Modes** 001 – Normal Failsafe 002 – Normal Best Effort (Default) **Remote Control Modes** 003 – Remote Failsafe Mode 004 – Remote Best Effort Mode (see options in Appendix A.2) **Access to program Auxiliary Flash Char.** 005 – Auxiliary flash character can be temporarily set with 1-0-XXX command. Does not modify other operation modes. 000 – Cancels auxiliary flash character and allows setting of normal flash character. Does not modify other operation modes **Transient Test Modes** 007 – Alarm Test – Sets alarm until TVIR programming mode exit. **Storage Mode** 009 – Turns off beacon (intended for beacons with integral battery) **Other Operations** 99X – Factory Default Reset (see corresponding table in Appendix A.3)

Generic TVIR Programming Commands		
Operation	**Feature**	**Value**
1 = Program Mode	6 = Interface Mode & Bus Address <MON>b/ <MFR>b/ b = 0 or 1 <R2B>x/ x = baud rate <TYR>b/ b=10, 20, 21, etc.	**Interface Mode (Master Projector):** **00X, where X is:** 0 – Disable IRDA and RS232, No Monitoring 1 – Enable IRDA, No Monitoring 2 – Enable IRDA, Monitoring on Demand 3 – Enable IRDA, Monitoring Free Running 4 – Enable RS232, Monitoring on Demand 5 – Enable RS232, Monitoring Free Running (suitable for VegaWeb monitoring) 6 – Enable RS232, No Monitoring (default setting) 7 –Enable RS232, Monitoring, 60s Free Running 8 – Enable RS232, Monitoring, 60s Free running (suitable for AIS monitoring), 38400 baud (i.e. includes command 8-7-005) **Projector Bus Addressing:** **Warning: ADJUSTING THIS SETTING COULD DISABLE THE BEACON.** **This information is provided for service purposes.** **9TA** – Set projector address to A within a set of T projectors. Where T = 1 to 9; A = 0 (master address) to 8 (1-8 are slave addresses); T>A . Only legal value for PEL-4: Single projector system: 910 – Standalone projector (Total = 1, projector is master = address 0).
9 = Read Settings	6 = Interface Mode & Bus Address	**TA0X** where TA holds the **Bus Addressing** code and X is the **Interface Mode code** (see definitions above).

Generic TVIR Programming Commands		
Operation	**Feature**	**Value**
	7 = Additional Sync Options <SSF>YY/ <ODS>B/ Factory setting: 002	0YY– Continue number of cycles (002-099) after loss of sync (disables 'Off on sync low' mode). 999 – PEL-4 never stops flashing (even on loss of external sync) 998 – PEL-4 disabled by holding sync low ('Off on sync low')
	8 = Low battery threshold <BLW>YYY/ Recommended settings: 12V operation: 110 (Default). 24V operation: 220	YYY – Battery low threshold (00.0 to 24.0V) 999 – Disabled, No battery low cut off.Units are shipped with the operator's requested voltage setting. User can set to any value in the range. In emergency mode this value sets the beacon off/emergency boundary threshold for a discharging battery. (A charging battery will trigger a restart and resumption of operation at 1.0V above this value.)
	9 = High battery threshold <BHI>YYY/ Recommended settings: 12V operation: 128 (12.8V) 24V operation: 256 (25.6V)	YYY – Battery high threshold (8V to 27.6V) 999 - reset to default setting (12.8V)Units are shipped with the operator's requested voltage setting. User can set to any value in the range. In emergency mode this threshold sets the emergency mode boundary voltage for a discharging battery. (At 1.0V above this value emergency mode will change to normal operation.)
2 – Custom Character Setting	Custom flash character segments <SPC>.../	**Set a custom character which can be selected as character code 999 with the Flash Character command.** Up to 9 on/off (flash/eclipse) time-period pairs can be programmed. Time periods are programmed in 50 millisecond units (i.e. a 1s period is programmed as a count of 20). Numbers 002 to 255 are permitted in the on/off pairs, meaning that a precision of 0.1s is possible. Code 001 is a special case indicating continuation (it connects the two values on either side of it). The sequence must be terminated with the 000 End command. e.g. Q 1s (0.3s) is programmed as: 2 – 006 014 000 Fl(5) 30s 4 x (1s, 1s), 1s, 21s is programmed as: 2 – 020 020 020 020 020 020 020 020 020 255 001 165 000

Generic TVIR Programming Commands		
Operation	**Feature**	**Value**
3 – System Checks	0 = Software version <VER>?/	Version Y.Y.Y (e.g. 2.1.0)
	1 – Battery voltage <BAT>?/	YY.Y Volts (e.g. 11.7 volts) Last voltage prior to entering programming mode
	2 – Temperature Reading <TMP> ?/	Temperature of the electronics in degrees Kelvin (C+273)
	3 – Current adjustment	Percentage output adjust (100% only)
	4 – Serial Number <SER>?/	Displays beacon serial number as a series of flashes (8 digits).
	5 – LED version number <LED>?/	Displays LED version number identifier (4 digits)
	6 – Characterisation number <CAR>?/	Displays LED characterisation identifier (4 digits)
	7 – GPS option detected <GPS>?/	000 – if GPS not detected 001 – if GPS detected
	9 – Testing & Error Logging <ERR>Error, Qty, Before, Between, After, Restart count, Flag/ Flag: 0 for decimal, not monitored; 1 for hex, not monitored; 10 for decimal, monitored; 11 for hex, monitored; <CLE>/ <HIC>?/	000 – 001 – 002 – Display Battery Voltage in volts x 10 003 – Display Solar Voltage in volts x 10 004 – Temperature in Kelvin from default sensor 005 – Display raw light level reading in ADC counts 006 – 0 100 – Display master error code (0 = Good) 101 – Display logged error code (0 = none) 102 – Display logged error count 103 – Reset logged error code & error count, night counts & restart count 104 – Display night count before error 105 – Display night count between first & last errors 106 – Display night count after last error 107 – Display restart count 998 – Display hibernation Count value (seconds) 999 – Reserved for factory use.

Generic TVIR Programming Commands		
Operation	**Feature**	**Value**
7 - Special	1-Set PIN <PIN>XXX/	XXX (000 clears the PIN) If the new PIN code is non-zero then it must be entered using the 7-7-XXX command before any settings can be programmed. Commands for reading settings can be entered without previously entering the PIN.
	2 – Set Flash Mode <FOM>XYZ/ <FCM>Z/	**Special operational modes:** The default setting is 000 (effective intensity and single character modes). Programming pattern: **XYZ –** where X is 0; Y is the auxiliary flash character mode setting, and; Z is the rectangular flash character mode setting. **Y. Auxiliary and Special Flashing Operation** **00Z – (Default) Single Character Mode:** A single flash character is enabled for normal ATON operation. Auxiliary flash character disabled. **01Z – Dual Character Mode:** Auxiliary flash character enabled as day character, with normal flash character enabled as night character. **02Z - Emergency Flash Mode**: Auxiliary flash character enabled as emergency mode character, which is executed when the input voltage drops below the battery high threshold. In emergency mode the programmed intensity is halved in day and night. **Z. Flash Compensation Mode** **0Y0 – (Default) Effective Intensity Mode:** The beacon is programmed in effective intensity, compliant with IALA E-200-4 2017. (SC constant c = MA constant a = 0.1s for night, except for blue beacons. During the day beacons of all colours use a = 0.1s). **0Y1 – Peak Intensity During Flash Mode:** The beacon is programmed in peak intensity during the flash. i.e. there is no flash compensation for the programmed intensity value. **0Y2 – Historic Effective Intensity Mode:** The beacon is programmed in effective intensity, compliant with IALA E-200-4 2008. (SC constant c = 0.2s at night. During the day beacons of all colours use c = 0.1s).

Generic TVIR Programming Commands		
Operation	**Feature**	**Value**
7 - Special	3 – Read Flash Mode <FOM>?/ <FCM>?/	XYZ – defined as above in command 7-2-XYZ
	4 – Set Remote Controls <RCM>XYZ/ <OPM>3/ or <OPM>4/ <RON>B/ <RDN>B/ <RFF>B/	**Sets remote control mode functions and pull-up/pull-down state and polarity sensitivity of the dataport inputs.** Only affects operation if Remote Control is enabled with 1-5-003 or 1-5-004 command. Otherwise, the settings are retained but ignored. The default setting is 000. (Refer to the Remote Control table in Appendix A.2 for a detailed description.)
	5 – Read Remote Controls <RCM>?/ <RON>?/ <RDN>?/ <RFF>?/	**Reads back remote control mode function of the dataport I/O lines.** Describes PEL-4 functionality when Remote Control Mode is enabled (1-5-003 or 1-5-004). (Refer to the following Remote Control table in Appendix A.2 for a detailed description.)
	7 – Enter PIN <PIN>XXX/	XXX
	8 – Set RPM <RPM>XXX/	ABCD – Revolutions Per Minute * 100. Correct settings are: 0000 – Fixed-sector PEL & disables RPM alarm monitoring; 2000 – Oscillating Boundary PEL (i.e. equivalent to 20RPM) & enables RPM alarm monitoring.
	9 – Read RPM <RPM>?/	ABCD – Revolutions Per Minute * 100
8 – Special Options	7 – Set RS232 Baud Rate <R2B>x/ x = baud rate	000 – Default 115200 Baud (suitable for VegaWeb monitoring) 001 – 4800 Baud 002 – 9600 Baud 003 – 14400 Baud 004 – 19200 Baud 005 – 38400 Baud (suitable for AIS monitoring) 006 – 57600 Baud

Appendix A.2 Remote Control Input Level Settings

The following table describes the four combinatorial options for remote control of the PEL-4. There are two separate remote control inputs: On/Off and Day/Night. Each control input is either enabled (shown with a ☑ symbol) or disabled (shown with 'Auto'). When a control input is enabled then its equivalent serial interface command is also enabled.

PEL-4 Remote Control I/O Settings					
Programming Code / Serial Command	**Input's Active Level (X=1)**	**Internal Pull-up or Pull-down (Y=1)**	**Enabled Inputs (Z)**		**Type of Inputs and Operational State (Active states are On & Day)**
			On/ Off (val 4)	**Day/ Night** (val 2)	
7-4-110 <RCM>110/	High Active (>4V) (Open circuit is inactive)	Pull-down	Auto	Auto	Normal Automatic (Best Effort) operation. All inputs inactive. All serial control commands inactive.
7-4-112 <RCM>112/			Auto	☑	PEL-4 automatically On. Day/Night input is operational. <RDN> serial command is operational.
7-4-114 <RCM>114/			☑	Auto	On/Off input is operational. <RON> serial command is operational. Day/Night operations are automatic.
7-4-116 <RCM>116/			☑	☑	On/Off and Day/Night inputs operational. <RON> and <RDN> serial commands are operational.

Appendix A.3 Factory Default Reset Commands

The following commands reset multiple beacon settings to nominal values. Several alternative commands are provided for convenience, allowing a beacon to be set to one of several nominal operational types. For a particular factory reset programming code, the beacon is programmed with the settings in the same row as the code.

Factory Default Reset Commands		
Programming Code	Reset Variant	Reset Effects
1-5-999 <FDF>999/	Oscillating Boundary + 12V Battery Thresholds	• Default (Night & Day) Fixed Character (1-0-000) • Night intensity is set to maximum intensity • Day intensity is set to maximum intensity • Master sync & zero sync delay set (1-3-000) • IALA day/night thresholds (1-4-005) • Normal, Automatic Best Effort Mode (1-5-002) • Standard sync behaviour (1-7-999, 1-7-002) • Low and high battery thresholds reset to 12V nominal. These should be reviewed by the user and adjusted for the supply voltage if necessary. • Default Effective Intensity Flash Mode & Single Flash Character Modes (7-2-000) • Auto-storage and calendar modes are disabled. • Oscillating boundary detection and alarm function are enabled. • Remote control and traffic light modes are disabled.
1-5-998 <FDF>998/	Fixed Boundary + 24V Battery Thresholds	• Default (Night & Day) Fixed Character (1-0-000) • Night intensity is set to maximum intensity • Day intensity is set to maximum intensity • Master sync & zero sync delay set (1-3-000) • IALA day/night thresholds (1-4-005) • Normal, Automatic Best Effort Mode (1-5-002) • Standard sync behaviour (1-7-999, 1-7-002) • Low and high battery thresholds reset to 24V nominal. These should be reviewed by the user and adjusted for the supply voltage if necessary. • Default Effective Intensity Flash Mode & Single Flash Character Modes (7-2-000) • Auto-storage and calendar modes are disabled. • Oscillating boundary detection and alarm function are disabled. • Remote control and traffic light modes are disabled.

Factory Default Reset Commands (continued)		
Programming Code	Reset Variant	Reset Effects
1-5-997 <FDF>997/	Oscillating Boundary + On/Off Remote Control + 24V Battery Thresholds	• Default (Night & Day) Fixed Character (1-0-000) • Night intensity is set to maximum intensity • Day intensity is set to maximum intensity • Master sync & zero sync delay set (1-3-000) • IALA day/night thresholds (1-4-005) • Normal, Automatic Best Effort Mode (1-5-002) • Standard sync behaviour (1-7-999, 1-7-002) • Low and high battery thresholds reset to 24V nominal. These should be reviewed by the user and adjusted for the supply voltage if necessary. • Default Effective Intensity Flash Mode & Single Flash Character Modes (7-2-000) • Auto-storage and calendar modes are disabled. • Oscillating boundary detection and alarm function are enabled. • Remote control On/Off function is enabled.
1-5-996 <FDF>996/	Fixed Boundary + On/Off Remote Control + 24V Battery Thresholds	• Default (Night & Day) Fixed Character (1-0-000) • Night intensity is set to maximum intensity • Day intensity is set to maximum intensity • Master sync & zero sync delay set (1-3-000) • IALA day/night thresholds (1-4-005) • Normal, Automatic Best Effort Mode (1-5-002) • Standard sync behaviour (1-7-999, 1-7-002) • Low and high battery thresholds reset to 24V nominal. These should be reviewed by the user and adjusted for the supply voltage if necessary. • Default Effective Intensity Flash Mode & Single Flash Character Modes (7-2-000) • Auto-storage and calendar modes are disabled. • Oscillating boundary detection and alarm function are disabled. • Remote control On/Off function is enabled.

APPENDIX B INTENSITY SETTINGS AND CURRENTS

Refer to the end of this appendix for the table legend and notes.

Appendix B.1 3.5D Models

PEL-4 3D5 Uniform White						
Build 435CV2ND30UW480				Characterisation 3520		
WHITE, RED, GREEN				Jun-18		Prog Code (six digits) **
10,000 Cd/m2 Bkgnd (Nm) @ 0.74T	5,000 Cd/m2 Bkgnd (Nm) @ 0.74T	Night Range (Nm) @ 0.74T	Intensity (Cd)	Current (A) @25C, 24V	Current (A) @25C, 12V	
3.0	3.8	19.1	**77,770**	**1.90**	**3.90**	**077 770**
2.8	3.5	18.5	**61,650**	**1.49**	**3.12**	**061 650**
2.6	3.3	18.0	**51,000**	**1.22**	**1.96**	**051 000**
2.4	3.1	17.5	**40,600**	**0.95**	**1.32**	**040 600**
2.1	2.6	16.5	**26,700**	**0.59**	**1.13**	**026 700**
1.8	2.3	15.7	**19,100**	**0.42**	**0.67**	**019 100**
1.7	2.2	15.4	**16,800**	**0.37**	**0.36**	**016 800**
1.4	1.8	14.2	**10,100**	**0.22**	**0.17**	**010 100**
1.1	1.4	12.8	**5,500**	**0.12**	**0.07**	**005 500**
0.5	0.7	9.3	**1,000**	**0.022**	**0.04**	**001 000**
0.3	0.4	6.7	**230**	**0.000**	**0.000**	**000 230**
0	0	0	**0**	**0**	**0**	**000 000**
Max Candela (kCD) -30C to +50C			**77.778**			
Max LED Current (A@25C)				**1.9**	**3.9**	
Beacon On Controller current (A)*				0.008	0.01	
Beacon Off Controller current (A)				0.008	0.01	
Beacon On Motor current (A)***				0.085	0.15	
Beacon Off Motor current (A)				0.085	0.15	

PEL-4 3D5 Intense White										
Build 435CV2ND00UW480								Characterisation 3520		
INTENSE WHITE				RED & GREEN				Jun-18		Prog Code (six digits) **
10,000 Cd/m2 Bkgnd (Nm) @ 0.74T	5,000 Cd/m2 Bkgnd (Nm) @ 0.74T	Night Range (Nm) @ 0.74T	White Intensity (Cd)	10,000 Cd/m2 Bkgnd (Nm) @ 0.74T	5,000 Cd/m2 Bkgnd (Nm) @ 0.74T	Night Range (Nm) @ 0.74T	Intensity (Cd)	Current (A) @25C, 24V	Current (A) @25C, 12V	
4.9	5.9	22.9	**350,000**	3.0	3.8	19.1	**77,778**	**1.90**	**3.90**	**077 778**
4.5	5.5	22.2	**268,950**	2.8	3.5	18.4	**59,700**	**1.44**	**3.12**	**059 700**
4.0	4.9	21.2	**182,800**	2.4	3.1	17.5	**40,600**	**0.95**	**1.96**	**040 600**
3.5	4.3	20.2	**120,400**	2.1	2.6	16.5	**26,700**	**0.60**	**1.14**	**026 700**
3.0	3.8	19.0	**76,000**	1.7	2.2	15.4	**16,800**	**0.37**	**0.67**	**016 800**
2.5	3.2	17.8	**45,457**	1.4	1.8	14.2	**10,100**	**0.22**	**0.37**	**010 100**
2.0	2.6	16.3	**25,026**	1.1	1.4	12.9	**5,500**	**0.12**	**0.18**	**005 500**
1.5	2.0	14.6	**12,110**	0.8	1.0	11.3	**2,600**	**0.06**	**0.07**	**002 600**
1.0	1.3	12.5	**4,630**	0.5	0.7	9.3	**1,000**	**0.023**	**0.04**	**001 000**
0.5	0.7	9.5	**1,055**	0.3	0.4	6.7	**230**	**0.000**	**0.00**	**000 230**
0	0	0	**0**	0	0	0	**0**	**0**	**0.00**	**000 000**
Max Candela (kCD) -30C to +50C			**350**				**78**			
Max LED Current (A @ 25C)								**1.9**	**3.9**	
Beacon On Controller continuous current (A)*								0.008	0.01	
Beacon Off Controller continuous current (A)								0.008	0.01	
Beacon On Motor continuous current (A)***								0.085	0.15	
Beacon Off Motor continuous current (A)								0.085	0.15	

Appendix B.2 5D Models

PEL-4 5D Uniform White						
Build 405CV2ND30UW480				Characterisation 0520		
		WHITE, RED, GREEN		Mar-17		Prog Code (six digits) **
10,000 Cd/m2 Bkgnd (Nm) @ 0.74T	5,000 Cd/m2 Bkgnd (Nm) @ 0.74T	Night Range (Nm) @ 0.74T	Intensity (Cd)	Current (A) @25C, 24V	Current (A) @25C, 12V	
2.6	3.3	17.9	**50,000**	**1.90**	**3.90**	**050 000**
2.4	3.1	17.5	**40,600**	**1.53**	**3.12**	**040 600**
2.1	2.6	16.5	**26,700**	**0.97**	**1.96**	**026 700**
1.8	2.3	15.7	**19,100**	**0.67**	**1.32**	**019 100**
1.7	2.2	15.4	**16,800**	**0.58**	**1.13**	**016 800**
1.4	1.8	14.2	**10,100**	**0.34**	**0.67**	**010 100**
1.1	1.4	12.8	**5,500**	**0.19**	**0.36**	**005 500**
0.8	1.0	11.3	**2,600**	**0.09**	**0.17**	**002 600**
0.5	0.7	9.3	**1,000**	**0.03**	**0.07**	**001 000**
0.4	0.5	8.4	**600**	**0.020**	**0.04**	**000 600**
0.2	0.3	6.0	**150**	**0.000**	**0.000**	**000 150**
0	0	0	**0**	**0**	**0**	**000 000**
Max Candela (kCD) -30C to +50C			**50**			
Max LED Current (A@25C)				**1.9**	**3.9**	
Beacon On Controller current (A)*				0.008	0.01	
Beacon Off Controller current (A)				0.008	0.01	
Beacon On Motor current (A)***				0.085	0.15	
Beacon Off Motor current (A)				0.085	0.15	

PEL-4 5D Intense White										
Build 405CV2ND00UW480								Characterisation 0520		
INTENSE WHITE				RED & GREEN				Mar-17		Prog Code (six digits) **
10,000 Cd/m2 Bkgnd (Nm) @ 0.74T	5,000 Cd/m2 Bkgnd (Nm) @ 0.74T	Night Range (Nm) @ 0.74T	White Intensity (Cd)	10,000 Cd/m2 Bkgnd (Nm) @ 0.74T	5,000 Cd/m2 Bkgnd (Nm) @ 0.74T	Night Range (Nm) @ 0.74T	Intensity (Cd)	Current (A) @25C, 24V	Current (A) @25C, 12V	
4.3	5.2	21.7	**225,000**	2.6	3.3	17.9	**50,000**	**1.90**	**3.90**	**050 000**
4.0	4.9	21.2	**182,800**	2.4	3.1	17.5	**40,600**	**1.53**	**3.12**	**040 600**
3.5	4.3	20.2	**120,400**	2.1	2.6	16.5	**26,700**	**0.98**	**1.96**	**026 700**
3.0	3.8	19.0	**76,000**	1.7	2.2	15.4	**16,800**	**0.58**	**1.14**	**016 800**
2.5	3.2	17.8	**45,457**	1.4	1.8	14.2	**10,100**	**0.34**	**0.67**	**010 100**
2.0	2.6	16.3	**25,026**	1.1	1.4	12.8	**5,500**	**0.19**	**0.37**	**005 500**
1.5	2.0	14.6	**12,110**	0.8	1.0	11.3	**2,600**	**0.09**	**0.18**	**002 600**
1.0	1.3	12.5	**4,630**	0.5	0.7	9.3	**1,000**	**0.04**	**0.07**	**001 000**
0.8	1.1	11.4	**2,790**	0.4	0.5	8.4	**600**	**0.021**	**0.04**	**000 600**
0.4	0.5	8.4	**678**	0.2	0.3	6.0	**150**	**0.000**	**0.00**	**000 150**
0	0	0	**0**	0	0	0	**0**	**0**	**0.00**	**000 000**
Max Candela (kCD) -30C to +50C			**225**				**50**			
Max LED Current (A @ 25C)								**1.9**	**3.9**	
Beacon On Controller continuous current (A)*								0.008	0.01	
Beacon Off Controller continuous current (A)								0.008	0.01	
Beacon On Motor continuous current (A)***								0.085	0.15	
Beacon Off Motor continuous current (A)								0.085	0.15	

Appendix B.3 10D Models

PEL-4 10D Uniform White						
Build 410CV2ND30UW480				Characterisation 1020		
		WHITE, RED, GREEN		Mar-17		Prog Code (six digits) **
10,000 Cd/m2 Bkgnd (Nm) @ 0.74T	5,000 Cd/m2 Bkgnd (Nm) @ 0.74T	Night Range (Nm) @ 0.74T	Intensity (Cd)	Current (A) @25C, 24V	Current (A) @25C, 12V	
1.8	2.4	15.8	**20,200**	**1.90**	**3.90**	**020 200**
1.7	2.2	15.4	**16,800**	**1.57**	**3.20**	**016 800**
1.5	2.0	14.6	**12,095**	**1.10**	**2.23**	**012 095**
1.4	1.8	14.2	**10,100**	**0.91**	**1.81**	**010 100**
1.1	1.4	12.8	**5,500**	**0.46**	**0.90**	**005 500**
0.9	1.2	12.0	**3,638**	**0.31**	**0.59**	**003 638**
0.8	1.0	11.3	**2,600**	**0.22**	**0.42**	**002 600**
0.5	0.7	9.3	**1,000**	**0.08**	**0.16**	**001 000**
0.4	0.5	8.4	**600**	**0.05**	**0.10**	**000 600**
0.3	0.4	7.1	**300**	**0.03**	**0.05**	**000 300**
0.2	0.3	6.0	**150**	**0.01**	**0.02**	**000 150**
0.1	0.2	4.7	**61**	**0.01**	**0.01**	**000 061**
0	0	0	**0**	**0**	**0.00**	**000 000**
Max Candela (kCD) -30C to +50C			**20.2**			
Max LED Current (A@25C)				**1.9**	**3.9**	
Beacon On Controller current (A)*				0.008	0.01	
Beacon Off Controller current (A)				0.008	0.01	
Beacon On Motor current (A)***				0.085	0.15	
Beacon Off Motor current (A)				0.085	0.15	

PEL-4 10D Intense White										
Build 410CV2ND00UW480								Characterisation 1020		
INTENSE WHITE				RED & GREEN				Mar-17		Prog Code (six digits) **
10,000 Cd/m2 Bkgnd (Nm) @ 0.74T	5,000 Cd/m2 Bkgnd (Nm) @ 0.74T	Night Range (Nm) @ 0.74T	White Intensity (Cd)	10,000 Cd/m2 Bkgnd (Nm) @ 0.74T	5,000 Cd/m2 Bkgnd (Nm) @ 0.74T	Night Range (Nm) @ 0.74T	Intensity (Cd)	Current (A) @25C, 24V	Current (A) @25C, 12V	
3.2	4.0	19.5	**91,000**	1.8	2.4	15.8	**20,220**	**1.90**	**3.90**	**020 220**
3.0	3.8	19.0	**76,000**	1.7	2.2	15.4	**16,888**	**1.57**	**3.21**	**016 888**
2.7	3.4	18.2	**54,430**	1.5	2.0	14.6	**12,000**	**1.10**	**2.22**	**012 000**
2.5	3.2	17.8	**45,457**	1.4	1.8	14.2	**10,100**	**0.91**	**1.81**	**010 100**
2.0	2.6	16.3	**25,026**	1.1	1.4	12.8	**5,500**	**0.47**	**0.91**	**005 500**
1.5	2.0	14.6	**12,110**	0.9	1.2	12.0	**2,600**	**0.23**	**0.44**	**002 600**
1.0	1.3	12.5	**4,630**	0.8	1.0	11.3	**1,000**	**0.09**	**0.17**	**001 000**
0.8	1.1	11.4	**2,790**	0.5	0.7	9.3	**600**	**0.05**	**0.10**	**000 600**
0.6	0.8	9.9	**1,350**	0.3	0.4	7.1	**300**	**0.03**	**0.05**	**000 300**
0.4	0.5	8.4	**678**	0.2	0.3	6.0	**100**	**0.013**	**0.025**	**000 100**
0.3	0.4	7.0	**274**	0.1	0.2	4.7	**60**	**0.000**	**0.000**	**000 060**
0	0	0	**0**	0	0	0	**0**	**0**	**0**	**000 000**
Max Candela (kCD) -30C to +50C			**91**				**20.2**			
Max LED Current (A @ 25C)								**1.9**	**3.9**	
Beacon On Controller continuous current (A)*								0.008	0.01	
Beacon Off Controller continuous current (A)								0.008	0.01	
Beacon On Motor continuous current (A)***								0.085	0.15	
Beacon Off Motor continuous current (A)								0.085	0.15	

Appendix B.4 20D Models

PEL-4-20D Uniform White						
GREEN, WHITE, RED				January 23		
10,000 cd/m2 Bkgnd (Nm) @0.74T	5,000 cd/m2 Bkgnd (Nm) @0.74T	Night Range (Nm) @0.74T	Intensity (cd)	Current (A) @25C, 24V	Current (A) @25C, 12V	Prog Code (six digits) **
1,0	1,3	12,4	4400	1,89	3,92	004 400
0,9	1,2	12,0	3640	1,55	3,19	003 640
0,8	1,0	11,4	2790	1,18	2,42	002 790
0,7	0,9	10,8	2075	0,88	1,80	002 075
0,6	0,8	10,1	1480	0,63	1,29	001 480
0,5	0,7	9,3	1000	0,38	0,78	001 000
0,4	0,5	8,4	620	0,23	0,49	000 620
0,3	0,4	7,3	340	0,13	0,27	000 340
0,2	0,3	6,0	150	0,06	0,12	000 150
0,1	0,1	4,1	40	0,02	0,04	000 040
0,0	0,0	0,0	0	0,00	0,00	000 000
Max Candela (kcd) -30C to +50C			4,4			
Max Current Consumption (A @25C)				1,90	3,90	
Beacon On Controller contiuous current (A) *				0,008	0,01	
Beacon Off Controller contiuous current (A)				0,008	0,01	
Beacon Off Motor contiuous current (A) ***				0,085	0,15	
Beacon On Motor contiuous current (A)				0,085	0,15	

PEL-4-20D Intense White										
Intense white				Red & Green				January 23		
10,000 cd/m2 Bkgnd (Nm) @0.74T	5,000 cd/m2 Bkgnd (Nm) @0.74T	Night Range (Nm) @0.74T	White Intensity (cd)	10,000 cd/m2 Bkgnd (Nm) @0.74T	5,000 cd/m2 Bkgnd (Nm) @0.74T	Night Range (Nm) @0.74T	Intensity (cd)	Current (A) @25C, 24V	Current (A) @25C, 12V	Prog Code (six digits) **
1,5	2,0	14,8	13000	1,0	1,3	12,4	4400	1,89	3,92	004 400
1,4	1,9	14,3	10750	0,9	1,2	12,0	3640	1,55	3,19	003 640
1,2	1,6	13,7	8240	0,8	1,0	11,4	2790	1,18	2,42	002 790
1,1	1,5	13,1	6130	0,7	0,9	10,8	2075	0,88	1,80	002 075
0,9	1,3	12,3	4370	0,6	0,8	10,1	1480	0,63	1,29	001 480
0,8	1,1	11,5	2950	0,5	0,7	9,3	1000	0,38	0,78	001 000
0,6	0,9	10,5	1830	0,4	0,5	8,4	620	0,23	0,49	000 620
0,5	0,7	9,3	1000	0,3	0,4	7,3	340	0,13	0,27	000 340
0,3	0,3	7,8	443	0,2	0,3	6,0	150	0,06	0,12	000 150
0,1	0,2	5,6	118	0,1	0,1	4,1	40	0,02	0,04	000 040
0,0	0,0	0,0	0	0,0	0,0	0,0	0	0,00	0,00	000 000
Max Candela (kcd) -30C to +50C			13				4,4			
Max Current Consumption (A @25C)								1,9	3,9	
Beacon On Controller contiuous current (A) *								0,008	0,01	
Beacon Off Controller contiuous current (A)								0,008	0,01	
Beacon Off Motor contiuous current (A) ***								0,085	0,15	
Beacon On Motor contiuous current (A)								0,085	0,15	

Legend:

** The 'On' current is drawn during flash-on periods when the PEL-4 is on. The 'Off' current is drawn during flash-off periods when the PEL-4 is on, and continuously while the PEL-4 is off.*

***The PEL-4 intensity programming is not limited to the values shown. Any value can be set within the specified range and within the available precision of the programming code.*

**** In an Oscillating Boundary PEL-4, the 'On' current is drawn when the PEL-4 is on and the 'Off' current is drawn when the PEL-4 is off. In a Fixed Boundary PEL-4 this current is zero in the on and off states.*

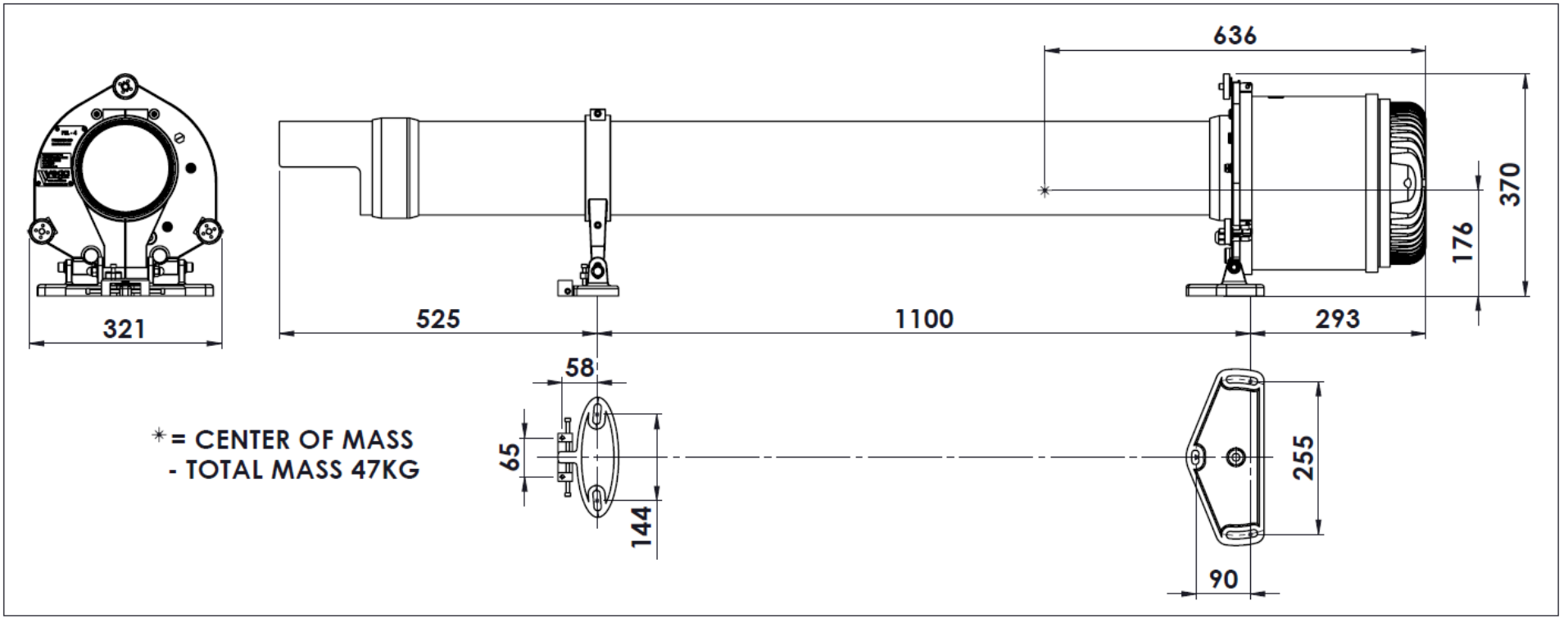
Notes:

1. Currents are based on operation at an ambient temperature of 25ºC and are rounded.
2. A +10% tolerance should be added to the currents shown.
3. Currents are temperature-dependent.
4. The PEL-4 is rated to operate over the ambient temperature range, -30ºC to +50ºC. At temperatures above +50ºC, including the effect of solar heating, the LED current will be reduced to protect the device.

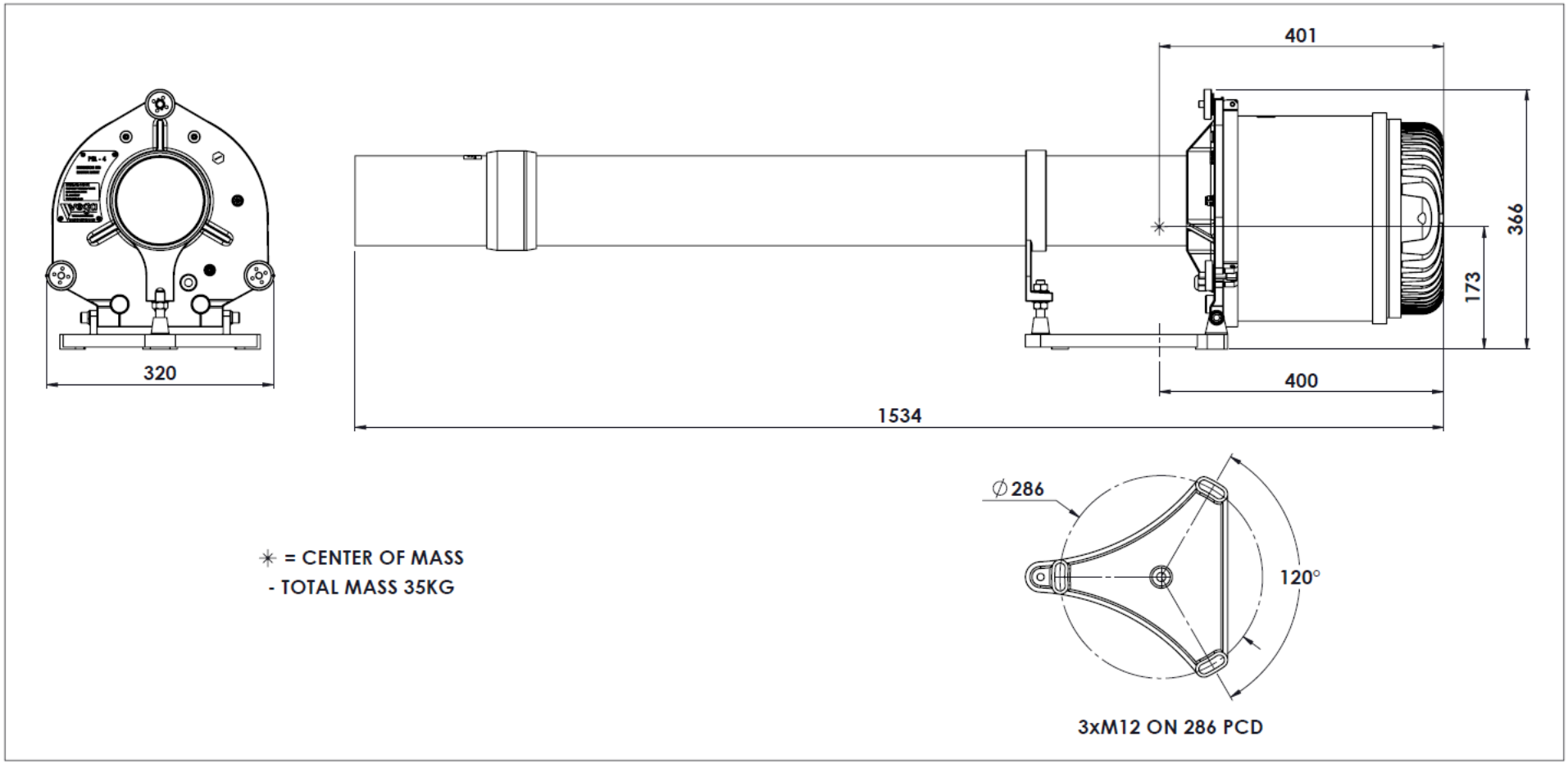
Background current consumption information.

Typical average background current at 12V	
Beacon State, Mode &/or Option	Per product (excluding oscillating boundary)
Background day or night current (whether LED is on or off)	10mA
Storage mode; Low Battery mode; Calendar mode in hibernation.	~0.5mA
Serial port buffer power consumption (only if external serial interface is electrically connected.)	Add ~1.3mA

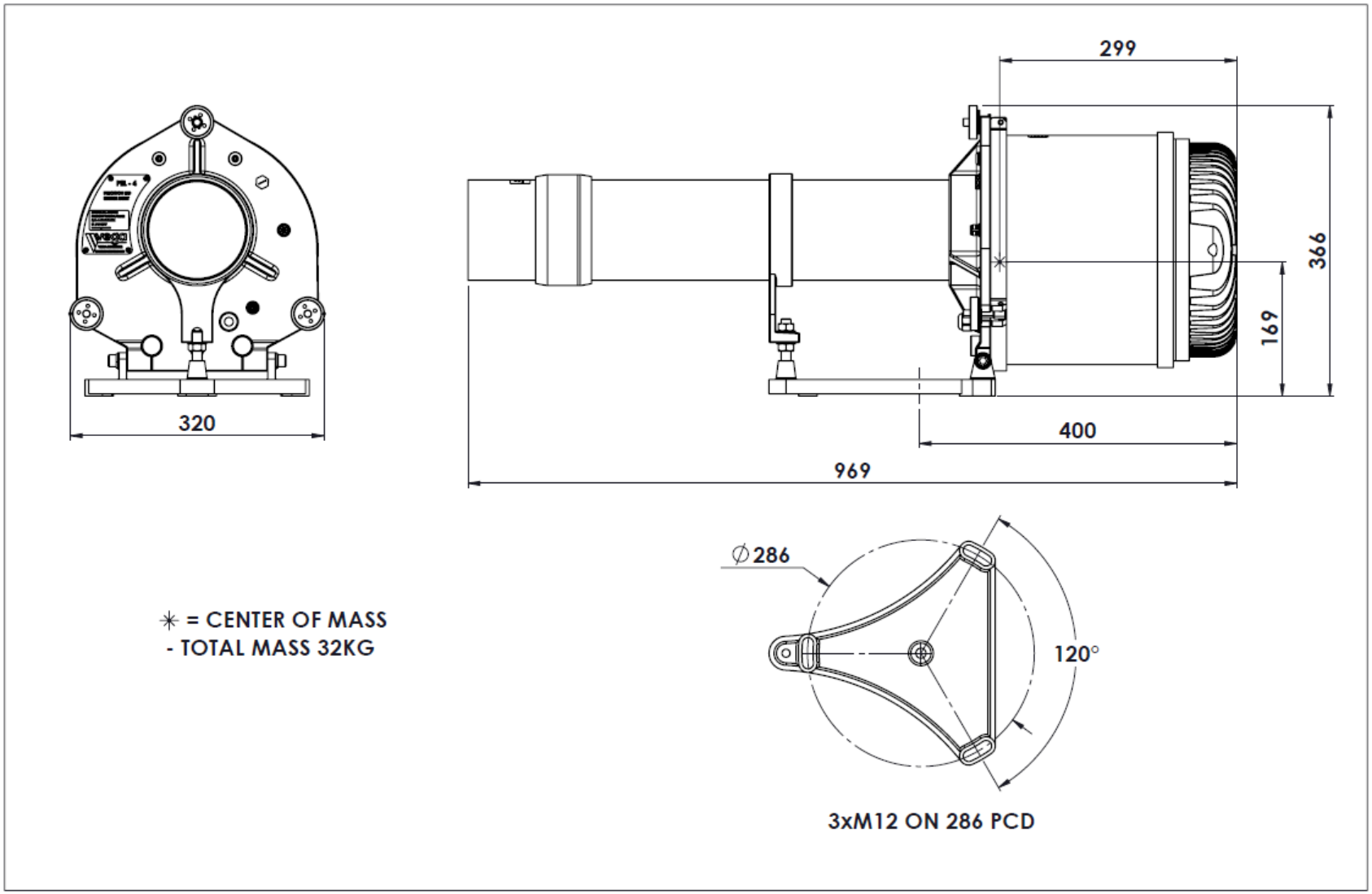
APPENDIX C PEL-4 DIMENSIONS BY MODEL



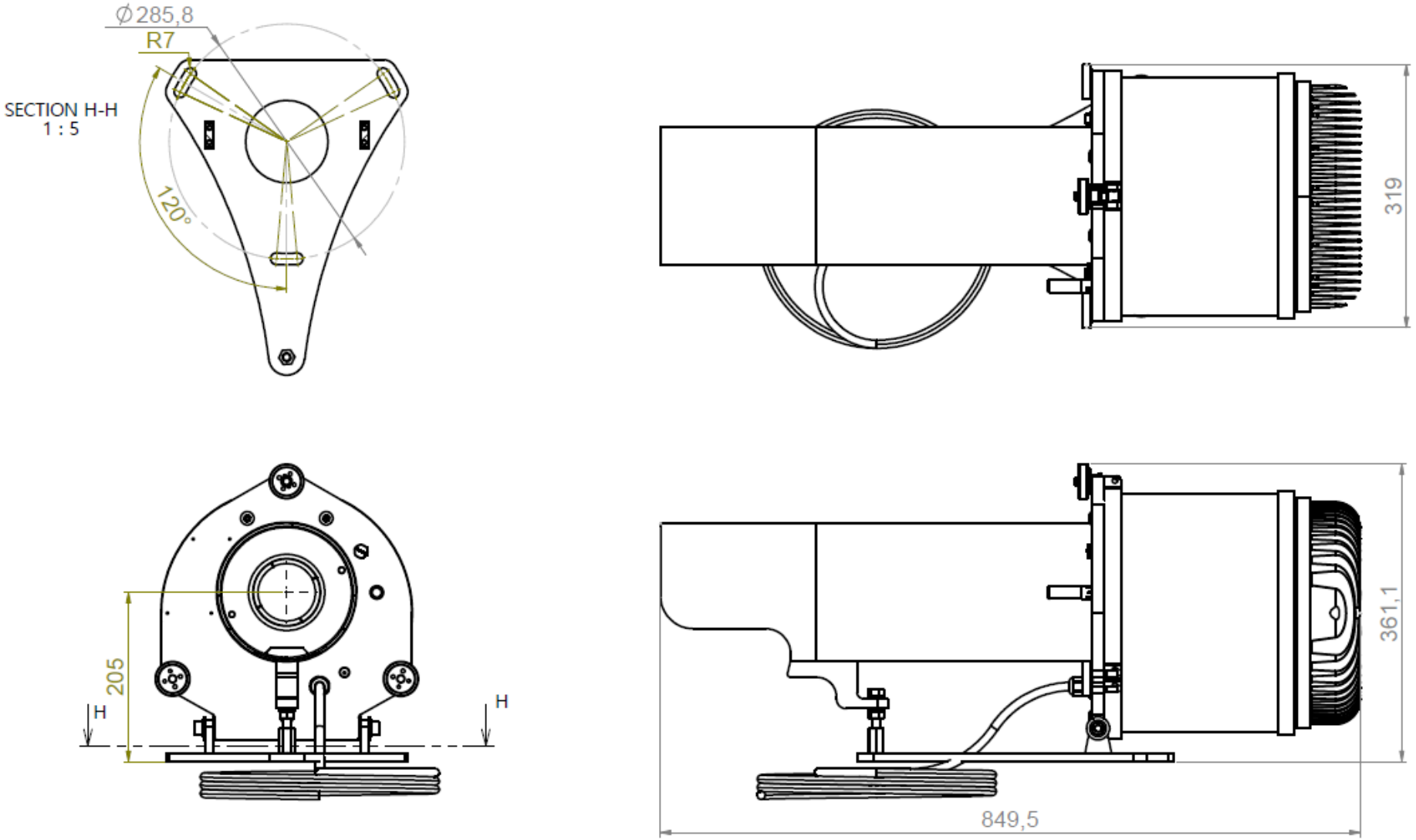
PEL-4 3.5D General Assembly Drawing



PEL-4 5D General Assembly Drawing



PEL-4 10D General Assembly Drawing



PEL-4 20D General Assembly Drawing

APPENDIX D SPECIFICATIONS OF PEL-4

Optics

Light Source	High-Intensity Light-Emitting Diode
Colours Available	Red, Green, White
Intensity	See Appendix B
Colour Boundary Precision	PEL-4: typ. 1' of arc (0.017 degrees)
Effective intensity settings	Programmable in 1 Candela steps for the ranges shown in Appendix B.
Peak Intensity	Effective Intensity (default IALA E-200-4 2017 or alternative IALA E-200-4 2008 flash compensation) and Peak Intensity (no compensation) programming options.
Flash Characters	246 standard characters plus one custom character 20 factory set custom characters if required
Horizontal Subtense	PEL-4-3D5: 3.5° PEL-4-5D: 5.0° PEL-4-10D: 10.0° PEL-4-20D: 20.0°
Vertical divergence	PEL-4-3D5: 2.6° PEL-4-5D: 3.75° PEL-4-10D: 6.7° PEL-4-20D: 14°
Chromaticity Co-ordinates	Red IALA E-200-1 Red Temporary Region White IALA E-200-1 White Optimum Region Green IALA E-200-1 Green Optimum Region
Synchronisation	Hard-wired sync is standard, delay up to 9.9 seconds in 0.1 second steps.

Calendar

Internal Real-time Clock	Estimated worst-case drift of 1 hour per year at a continuous -30°C internal temperature with a precision of +/-62 seconds, excluding resets and power blackouts.

Electrical

Voltage	Nominal 12VDC and 24VDC; operating range 10VDC to 30.0VDC, inclusive. Absolute max input voltage 35.0VDC. Programmable low voltage cut off threshold
Light on current	See Appendix B
Current between flashes	See Appendix B
Oscillating boundary motor current	See Appendix B
Day / Night transition	Photo sensor projecting from mainframe. Twelve program settings for the day/night transition. Accuracy of sensor ±20 lux
Reverse Polarity	Internally protected against reverse polarity connection

Material for Projector

Lenses	Glass objective; Acrylic condenser
Housing	Marine grade metals
Finish	Two-pot, three-coat epoxy primers and paint
Sealing	O-rings
Mounting Bolts	Three M12 bolts or studs

Environmental

Operating Temperature	Specified operation over -30°C to +50°C, Safe operation over -30°C to +85°C
Thermal Protection	LED intensity reduced above 50°C
Salt	Rated for continuous exposure to salt water and spray
Cooling	Natural convection
Immersion	IP 67 rating, 30 minutes immersion at 1 metre head of water

Programming	Vega Remote02 Infra-Red programmer & RS232 Serial Interface

TVIR Programmer: Remote02

Coding Scheme:	RC5 code with centre frequency 36.7 kHz
Dimensions:	87mm x 41mm x 6.5mm
Weight:	18gms
Power Supply:	1 x 3V lithium coin cell battery, CR2025 type

Battery Replacement on TVIR Programmer

Place the remote face down, and push the latch on the battery holder towards the centre of the programmer case, while at the same time levering the slot on the battery holder outward as shown in the illustration below.

(1) Pull the battery holder out of the case.

(2) Remove the old battery and insert a new one, ensuring that the + side of the battery is facing upwards as shown.

(3) Insert the battery holder into the programmer case, and press it until the latch clicks into place.

APPENDIX E FLASH CHARACTER TABLE WITH PROGRAMMING CODES

FIXED		DETAIL
000	Fixed	On
ISO		DETAIL
100	ISO 2s	1.0s, 1.0s
101	ISO 3s	1.5s, 1.5s
102	ISO 4s	2.0s, 2.0s
103	ISO 5s	2.5s, 2.5s
104	ISO 6s	3.0s, 3.0s
105	ISO 8s	4.0s, 4.0s
106	ISO 10s	5.0s, 5.0s
OCCULT		DETAIL
200	OC 1.25s 0.75	0.75s, 0.5s
201	OC 3s 2.0	2s, 1s
202	OC 3s 2.5	2.5s, 0.5s
203	OC 3.5s 2.5	2.5s, 1s
204	OC 4s 2.5	2.5s, 1.5s
205	OC 4s 3.0	3s, 1s
206	OC 5s 3.0	3s, 2s
207	OC 5s 4.0	4s, 1s
208	OC 5s 4.5	4.5s, 0.5s
209	OC 6s 4.0	4.0s, 2s
210	OC 6s 4.5	4.5s, 1.5s
211	OC 6s 5.0	5s,1s
212	OC 7s 4.5	4.5s, 2.5s
213	OC 8s 5.0	5s, 3s
214	OC 8s 6.0	6s, 2s
215	OC 9s 6.0	6s, 3s
216	OC 10s 6.0	6s, 4s
217	OC 10s 7.0	7s, 3s
218	OC 10s 7.5	7.5s, 2.5s
219	OC 12s 8.0	8.0s, 4s
220	OC 15s 10.0	10s, 5s
221	OC(2) 8s 3.0 2.0	3.0s, 2.0s, 1.0s, 2.0s
222	OC(2) 8s 5.0 1.0	5s, 1s, 1s, 1s
FLASH		DETAIL
300	FL 1.5s 0.2	0.2s, 1.3s
301	FL 1.5s 0.3	0.3s, 1.2s
302	FL 1.5s 0.4	0.4s, 1.1s
303	FL 1.5s 0.5	0.5s, 1s
304	FL 2s 0.2	0.2s, 1.8s
FLASH		DETAIL

305	FL 2s 0.3	0.3s, 1.7s
306	FL 2s 0.4	0.4s, 1.6s
307	FL 2s 0.5	0.5s, 1.5s
308	FL 2s 0.7	0.7s, 1.3s
309	FL 2s 0.8	0.8s, 1.2s
310	FL 2.5s 0.3	0.3s, 2.2s
311	FL 2.5s 0.5	0.5s, 2s
312	FL 2.5s 1.0	1s, 1.5s
313	FL 3s 0.2	0.2s, 2.8s
314	FL 3s 0.3	0.3s, 2.7s
315	FL 3s 0.4	0.4s, 2.6s
316	FL 3s 0.5	0.5s, 2.5s
317	FL 3s 0.6	0.6s, 2.4s
318	FL 3s 1.0	1s, 2s
319	FL 4s 0.2	0.2s, 3.8s
320	FL 4s 0.3	0.3s, 3.7s
321	FL 4s 0.4	0.4s, 3.6s
322	FL 4s 0.5	0.5s, 3.5s
323	FL 4s 0.6	0.6s, 3.4s
324	FL 4s 0.8	0.8s, 3.2s
325	FL 4s 1.0	1s, 3s
326	FL 4s 1.5	1.5s, 2.5s
327	FL 5s 0.2	0.2s, 4.8s
328	FL 5s 0.3	0.3s. 4.7s
329	FL 5s 0.5	0.5s, 4,5s
330	FL 5s 0.9	0.9s, 4.1s
331	FL 5s 1.0	1s, 4s
332	FL 5s 1.5	1.5s, 3.5s
333	FL 6s 0.2	0.2s, 5.8s
334	FL 6s 0.3	0.3s, 5.7s
335	FL 6s 0.4	0.4s, 5.6s
336	FL 6s 0.5	0.5s, 5.5s
337	FL 6s 0.6	0.6s, 5.4s
338	FL 6s 1.0	1s, 5s
339	FL 6s 1.5	1.5s, 4.5s
340	FL 7s 1.0	1s, 6s
341	FL 7s 2.0	2s, 5s
342	FL 7.5s 0.5	0.5s, 7s
343	FL 7.5s 0.8	0.8s, 6.7s
344	FL 8s 0.5	0.5s, 7.5s
345	FL 9s 0.9	0.9s, 8.1s
346	FL 10s 0.2	0.2s, 9.8s
347	FL 10s 0.3	0.3s, 9.7s
348	FL 10s 0.5	0.5s, 9.5s
349	FL 10s 0.8	0.8s, 9.2s

FLASH		DETAIL
350	FL 10s 1.0	1s, 9s
351	FL 10s 1.5	1.5s, 8.5s
352	FL 12s 1.2	1.2s, 10.8s
353	FL 12s 2.5	2.5s, 9.5s
354	FL 15s1.0	1s, 14s

MULTI FLASH		DETAIL
400	Fl(2) 4s 0.5	0.5s, 1s, 0.5s, 2s
401	Fl(2) 4.5s 0.3	0.3s, 1s, 0.3s, 2.9s
402	Fl(2) 4.5s 0.4	0.4s, 1s, 0.4s, 2.7s
403	Fl(2) 4.5s 0.5	0.5s, 1s, 0.5s, 2.5s
404	Fl(2) 5s 0.2 0.8	0.2s, 0.8s, 0.2s, 3.8s
405	Fl(2) 5s 0.2 1.2	0.2s, 1.2s, 0.2s, 3.4s
406	Fl(2) 5s 0.4	0.4s, 0.6s, 0.4s, 3.6s
407	Fl(2) 5s 0.5	0.5s, 1s, 0.5s, 3s
408	Fl(2) 5s 1.0	1s, 1s, 1s, 2s
409	Fl(2) 5.5s 0.4	0.4s, 1.4s, 0.4s, 3.3s
410	Fl(2) 6s 0.2 1.4	0.2s, 1.4s, 0.2s, 4.2s
411	Fl(2) 6s 0.3	0.3s, 1s, 0.3s, 4.4s
412	Fl(2) 6s 0.4	0.4s, 1s, 0.4s, 4.2s
413	Fl(2) 6s 0.5	0.5s, 1s, 0.5s, 4s
414	Fl(2) 6s 0.5 1.5	0.5s, 1.5s, 0.5s, 3.5s
415	Fl(2) 6s 0.8	0.8s, 1.2s, 0.8s, 3.2s
416	Fl(2) 6s 1.0	1s, 1s, 1s, 3s
417	Fl(2) 6s 3.0	3s, 1s, 1s, 1s
418	Fl(2) 7s 1.0	1s, 1s, 1s, 4s
419	Fl(2) 8s 0.4	0.4s, 1s, 0.4s, 6.2s
420	Fl(2) 8s 0.5	0.5s, 1s, 0.5s, 6s
421	Fl(2) 8s 1.0	1s, 1s, 1s, 5s
422	Fl(2) 10s 0.4	0.4s, 1.6s, 0.4s, 7.6s
423	Fl(2) 10s 0.5 1.0	0.5s, 1s, 0.5s, 8s
424	Fl(2) 10s 0.5 1.5	0.5s, 1.5s, 0.5s, 7.5s
425	Fl(2) 10s 0.5 2.0	0.5s, 2s, 0.5s, 7s
426	Fl(2) 10s 0.6 2.4	0.6s, 2.4s, 0.6s, 6.4s
427	Fl(2) 10s 0.8 1.2	0.8s, 1.2s, 0.8s, 7.2s
428	Fl(2) 10s 1.0 1.0	1s, 1s, 1s, 7s
429	Fl(2) 10s 1.0 1.5	1 s, 1.5s, 1s, 6.5s
430	Fl(2) 10s 3.0 1.0	3s, 1s, 5s, 1s
431	Fl(2) 12s 0.4 1.0	0.4s, 1s, 0.4s, 10.2s
432	Fl(2) 12s 0.5 1.0	0.5s, 1s, 0.5s, 10s
433	Fl(2) 12s 1.0 2.0	1s, 2s, 1s, 8s
434	Fl(2) 12s 1.5 2.0	1.5s, 2s, 1.5s, 7s
435	Fl(2) 15s 1.0 2.0	1s, 2s, 1s, 11s
436	Fl(2) 20s 1.0 3.0	1s, 3s, 1s, 15s
437	Fl(2) 25s 1.0 1.0	1s, 1s, 1s, 22s

MULTI FLASH		DETAIL
438	Fl(3) 6s 0.5	0.5s, 1s, 0.5s, 1s, 0.5s, 2.5s
439	Fl(3) 6.1s	0.4s, 1s, 0.4s, 1s, 0.4s, 2.9s
440	Fl(3) 8s 0.5	0.5s, 1s, 0.5s, 1s, 0.5s, 4.5s
441	Fl(3) 9s 0.3	0.3s, 1s, 0.3s, 1s, 0.3s, 6.1s
442	Fl(3) 9s 0.8	0.8s, 1.2s, 0.8s, 1.2s, 0.8s,
443	Fl(3) 10s	0.5s, 1.5s, 0.5s, 1.5s, 0.5s,
444	Fl(3) 10s	1s, 1s, 1s, 1s, 1s, 5s
445	Fl(3) 12s	0.5s, 1.5s, 0.5s, 1.5s, 0.5s,
446	Fl(3) 12s	0.5s, 2s, 0.5s, 2s, 0.5s, 6.5s
447	Fl(3) 12s	0.8s, 1.2s, 0.8s, 1.2s, 0.8s,
448	Fl(3) 12s	1s, 2s, 1s, 2s, 1s, 5s
449	Fl(3) 15s	0.3s, 1.7s, 0.3s, 1.7s, 0.3s,
450	Fl(3) 15s	0.4s, 1s, 0.4s, 1s, 0.4s, 11.8s
451	Fl(3) 15s	0.5s, 1.5s, 0.5s, 1.5s, 0.5s,
452	Fl(3) 20s	0.5s, 1.5s, 0.5s, 1.5s, 0.5s,
453	Fl(3) 20s	0.5s, 3s, 0.5s, 3s, 0.5s, 12.5s
454	Fl(3) 20s	0.8s, 1.2s, 0.8s, 1.2s, 0.8s,
455	Fl(3) 20s	1s, 1s, 1s, 1s, 1s, 15s
456	Fl(3) 30s	1s, 4s, 1s, 4s, 1s, 19s
457	Fl(4) 10s	0.5s, 1s, 0.5s, 1s, 0.5s, 1s,
458	Fl(4) 10s	0.5s, 0.5s, 0.5s, 0.5s, 0.5s,
459	Fl(4) 10s	0.8s, 1.2s, 0.8s, 1.2s, 0.8s,
460	Fl(4) 12s	0.3s, 1.7s, 0.3s, 1.7s, 0.3s,
461	Fl(4) 12s	0.5s, 1.5s, 0.5s, 1.5s, 0.5s,
462	Fl(4) 12s	0.8s, 1.2s, 0.8s, 1.2s, 0.8s,
463	Fl(4) 15s	0.5s, 1.5s, 0.5s, 1.5s, 0.5s,
464	Fl(4) 15s	1s, 1s, 1s, 1s, 1s, 1s, 1s, 8s
465	Fl(4) 16s	0.5s, 1.5s, 0.5s, 1.5s, 0.5s,
466	Fl(4) 20s	0.3s, 3s, 0.3s, 3s, 0.3s, 3s,
467	Fl(4) 20s	0.5s, 1.5s, 0.5s, 1.5s, 0.5s,
468	Fl(4) 20s	1.5s, 1.5s, 1.5s, 1.5s, 1.5s,
469	Fl(4) 30s	0.5s, 0.5s, 0.5s, 0.5s, 0.5s,
470	Fl(5) 20s	0.5s, 1.5s, [x 4], 0.5s, 11.5s
471	Fl(5) 20s	0.8s, 1.2s, [x 4], 0.8s, 11.2s
472	Fl(2+1) 6s	0.3s, 0.4s, 0.3s, 1.2s, 0.3s,
473	Fl(2+1) 10s	0.5s, 0.7s, 0.5s, 2.1s, 0.5s,
474	Fl(2+1) 12s	0.8s, 1.2s, 0.8s, 2.4s, 0.8s, 6s
475	Fl(2+1) 12s	1s, 1s, 1s, 4s, 1s, 4s
476	Fl(2+1) 15s	1s, 2s, 1s, 5s, 1s, 5s

VERY QUICK		DETAIL
500	VQ 0.5s	0.15s, 0.35s
501	VQ 0.5s	0.2s, 0.3s

502	VQ 0.6s	0.2s, 0.4s
503	VQ 0.6s	0.3s, 0.3s

VERY QUICK		DETAIL
504	VQ(2) 4s 0.20	0.2s, 1s, 0.2s, 2.6s
505	VQ(2) 8s 0.20	0.2s, 1s, 0.2s, 6.6s
506	VQ(3) 5s 0.15	0.15s, 0.35s, 0.15s, 0.35s,
507	VQ(3) 5s 0.20	0.2s, 0.3s, 0.2s, 0.3s, 0.2s,
508	VQ(3) 5s 0.3	0.3s, 0.2s, 0.3s, 0.2s, 0.3s,
509	VQ(3) 5s 0.3	0.3s, 0.3s, 0.3s, 0.3s, 0.3s,
510	VQ(3) 15s 0.10	0.1s, 0.5s, 0.1s, 0.5s, 0.1s,
511	VQ(9) 10s 0.15	0.15s, 0.35s, [x 8], 0.15s,
512	VQ(9) 10s 0.20	0.2s, 0.3s, [x 8], 0.2s, 5.8s
513	VQ(9) 10s 0.30	0.3s, 0.3s, [x 8], 0.3s, 4.9s
514	VQ(6)+LFl 10s	0.15s, 0.35s, [x 6], 2s, 5s
515	VQ(6)+LFl 10s	0.2s, 0.3s, [x 6]s, 2s, 5s
516	VQ(6)+LFl 10s	0.3s, 0.3s, [x 6], 2s, 4.4s

QUICK		DETAIL
600	Q 1s 0.2	0.2s, 0.8s
601	Q 1s 0.3	0.3s, 0.7s
602	Q 1s 0.4	0.4s, 0.6s
603	Q 1s 0.5	0.5s, 0.5s
604	Q 1s 0.8	0.8s, 0.2s
605	Q 1.2s 0.3	0.3s, 0.9s
606	Q 1.2s 0.5	0.5s, 0.7s
607	Q 1.2s 0.6	0.6s, 0.6s
608	Q(2) 5s 0.3	0.3s, 0.7s, 0.3s, 3.7s
609	Q(2) 5s 0.5	0.5s, 0.5s, 0.5s, 3.5s
610	Q(2) 6s 0.30	0.3s, 0.7s, 0.3s, 4.7s
611	Q(2) 6s 0.35	0.35s, 0.7s, 0.35s, 4.6s
612	Q(2) 10s 0.6	0.6s, 0.4s, 0.6s, 8.4s
613	Q(2) 15s 0.2	0.2s, 0.8s, 0.2s, 13.8s
614	Q(3) 5s 0.5	0.5s, 0.5s, 0.5s, 0.5s, 0.5s,
615	Q(3) 6s 0.3	0.3s, 0.7s, 0.3s, 0.7s, 0.3s,
616	Q(3) 10s 0.30	0.3s, 0.7s, 0.3s, 0.7s, 0.3s,
617	Q(3) 10s 0.35	0.35s, 0.65s, 0.35s, 0.65s,
618	Q(3) 10s 0.50	0.5s, 0.5s, 0.5s, 0.5s, 0.5s,
619	Q(3) 10s 0.60	0.6s, 0.6s, 0.6s, 0.6s, 0.6s,
620	Q(3) 30s 0.4	0.4s, 4.6s, 0.4s, 4.6s, 0.4s,
621	Q(4) 6s 0.3	0.3s, 0.7s, 0.3s, 0.7s, 0.3s,
622	Q(4) 6s 0.4	0.4s, 0.6s, 0.4s, 0.6s, 0.4s,
623	Q(4) 10s 0.3	0.3s, 0.7s, 0.3s, 0.7s, 0.3s,
624	Q(4) 12s 0.3	0.3s, 0.7s, 0.3s, 0.7s, 0.3s,
625	Q(4) 15s 0.35	0.35s, 0.7s, 0.35s, 0.7s,
626	Q(4) 20s 0.5	0.5s, 0.5s, 0.5s, 0.5s, 0.5s,
627	Q(9) 15s 0.3	0.3s, 0.7s, [x 8], 0.3s, 6.7s
628	Q(9) 15s 0.35	0.35s, 0.65s, [x 8], 0.35s,
629	Q(9) 15s 0.6	0.6s, 0.6s, [x 8], 0.6s, 4.8s

QUICK		DETAIL
630	Q(6)+LFl 15s	0.2s, 0.8s, [x 6], 2s, 7s
631	Q(6)+LFl 15s	0.3s, 0.7s, [x 6], 2s, 7s
632	Q(6)+LFl 15s	0.35s, 0.65s, [x 6], 1.05s,
633	Q(6)+LFl 15s	0.6s, 0.6s, [x 6], 2s, 5.8s

LONG FLASH		DETAIL
700	LFl 5s 2.0	2s, 3s
701	LFl 6s 2.0	2s, 4s
702	LFl 8s 2.0	2s, 6s
703	LFl 8s 3.0	3s, 5s
704	LFl 10s 2.0	2s, 8s
705	LFl 10s 3.0	3s, 7s
706	LFl 10s 4.0	4s, 6s
707	LFl 12s 2.0	2s, 10s
708	LFl 15s 4.0	4s, 11s

MORSE		DETAIL
800	MO(A) 6s 0.3	0.3s, 0.6s, 1s, 4.1s
801	MO(A) 8s 0.4	0.4s, 0.6s, 2s, 5s
802	MO(A) 8s 0.8	0.8s, 1.2s, 2.4s, 3.6s
803	MO(A) 10s 0.5	0.5s, 0.5s, 1.5s, 7.5s
804	MO(A) 12s	1s, 1s, 3s, 7s
805	MO(A) 15s 0.5	0.5s, 1.5s, 2s, 11s
806	MO(B) 15s 1.5	1.5s, 0.5s, 0.5s, 0.5s, 0.5s,
807	MO(D) 10s 5.0	5s, 1s, 1s, 1s, 1s, 1s
808	MO(N) 8s 5.0	5s, 1s, 1s, 1s
809	MO(U) 10s 0.2	0.2s, 0.8s, 0.2s, 0.8s, 0.6s,
810	MO(U) 10s 0.3	0.3s, 0.7s, 0.3s, 0.7s, 0.9s,
811	MO(U) 10s 0.4	0.4s, 0.6s, 0.4s, 0.6s, 1.2s,
812	MO(U) 10s 0.5	0.5s, 0.5s, 0.5s, 0.5s, 1.5s,
813	MO(U) 15s	0.4s, 0.5s, 0.4s, 0.5s, 1.2s,
814	MO(U) 15s	0.45s, 0.45s, 0.45s, 0.45s,
815	MO(U) 15s	0.5s, 0.5s, 0.5s, 0.5s, 1.5s,
816	MO(U) 15s	0.55s, 0.35s, 0.55s, 0.35s,
817	MO(U) 15s	0.6s, 0.3s, 0.6s, 0.3s, 1.4s,
818	MO(U) 15s 0.7	0.7s, 0.5s, 0.7s, 0.5s, 1.9s,
819	MO(U) 15s 0.7	0.7s, 0.7s, 0.7s, 0.7s, 2.1s,
820	MO(U) 15s	0.75s, 0.15s, 0.75s, 0.15s,
821	MO(U) 15s	0.75s, 0.45s, 0.75s, 0.45s,
822	MO(U) 15s	1.15s, 0.75s, 1.15s, 0.75s,
823	MO(U) 15s	1.3s, 0.7s, 1.3s, 0.7s, 3.3s,

SPECIAL	DETAIL
900 Fl 3s	0.45s, 2.55s
901 Fl 4s	0.55s, 3.45s
SPECIAL	DETAIL
902 Fl 5s	0.55s, 4.45s
903 Fl 6s	0.65s, 5.35s
904 Fl 9s	0.65s, 8.35s
905 Fl 10s	0.65s, 9.35s
906 Fl 15s	0.6s, 14.4s
907 Fl (2) 8s	0.55s, 1.45s, 0.55s, 5.45s
908 Fl (2) 10s	0.65s, 1.35s, 0.65s, 7.35s
909 Fl (2) 12s	0.65s, 1.35s, 0.65s, 9.35s
910 Fl (2) 15s	0.65s, 1.35s, 0.65s, 12.35s
911 Fl (3) 10s	2 x (0.65s, 1.35s), 0.65s,
912 Fl (3) 15s	2 x (0.65s, 1.35s), 0.65s,
913 Fl (3) 18s	2 x (0.65s, 1.85s), 0.65s,
914 Fl (4) 10s	3 x (0.4s, 1.2s), 0.4s, 4.8s
915 LFl 10s	2.15s, 7.85s
916 Morse A	0.45s, 0.25s, 1.45s, 2.85s
917 Q 15s	1s, 14s
918 Fl (5) 30s	4 x (1s, 1s), 1s, 21s
919 Fl (5) 30s	4 x (1s, 1.5s), 1s, 19s
920 OC 3.5s	3.2s, 0.3s
921 OC 4s	2.4s, 1.6s
922 OC 4s	3.5s, 0.5s
923 MO (F) 4.2s	2 x (0.3s, 0.3s), 0.5s, 0.3s,
924 MO (U) 20s	2 x (0.5s, 3s), 5s, 8s
925 Q 15s	0.5s, 14.5s
926 OC 15s	9s, 6s
927 LF1 (2) 12s	2s, 2s, 2s, 6s
928 Fl (04) 10s	4 x (1s, 1.5s)
929 Fl (04) 20s	3 x (1s, 1.5s), 1s, 11.5s
930 Fl 15s 0.8s	0.8s, 14.2s
931 Fl (4) 30s	3 x (0.8s, 4.2s), 0.8s, 14.2s
932 Q60	0.3s, 0.7s
933 Q92	0.3s, 0.35s
934 Q44	0.3s, 1.05s
935 Fl 30s 5s	5s, 25s
936 Fl 20s 0.5s	0.5s, 19.5s
937 Fl 8s 1.5s	1.5s, 6.5s
938 Fl 20s 1s	1s, 19s
939 Fl (2+1) 9s	0.5s, 0.5s, 0.5s, 1s, 0.5s,
940 Fl(3) 20s (0.8s	0.8s, 0.8s, 0.8s, 0.8s, 0.8s,
941 Fl 10s 0.7s	0.7s, 9.3s
942 Fl (3) 8s 1s	1s, 1s, 1s, 1s, 1s, 3s
943 ISO 1.5s	0.75s, 0.75s
944 Q(6)+LFl 15s	6 x (0.5s 0.5s) 2s 7s
945 Q(9) 15s 0.5s	8 x (0.5s 0.5s) 0.5s 6.5s
946 Oc (2) 12s	6s, 1s, 4s, 1s
947 Fl (2) 4s	1s 0.5s 1s 1.5s
948 Fl 4s, 0.7	0.7s, 3.3s

APPENDIX F SERIAL INTERFACE COMMANDS

The PEL-4 offers a serial interface control and monitoring capability.
Many of these commands can be found in Appendix A as annotations to their related TVIR commands.
Any command can be turned into a query by inserting a question-mark character, '?' instead of the standard parameter. The consequent read-back format is the same as the command format, including the pseudo-XML tag.

The serial interface defaults to 115.2kbaud, 8 bits, no parity, 1 stop bit (8N1).

Command (Pseudo-XML Tag)	Command or Query Name	Valid Parameter Range & Unit	Acts Immediately or Requires Restart	Description
<NRG>X/	Night Range	X = 0 to 999999 Candela	Restart required	Sets night intensity in Candela. Zero turns the PEL-4 off at night. 9999 or any value greater than or equal to the maximum intensity specification for the PEL-4 sets the maximum intensity value (See Appendix B).
<DRG>X/	Day Range	X = 0 to 999999 Candela	Restart required	Sets day intensity in Candela. Zero turns the PEL-4 off during the day. 9999 or any value greater than or equal to the maximum intensity specification for the PEL-4 sets the maximum intensity value (See Appendix B).
<SYD>YY/	Sync Delay	YY = 0 to 99 tenths of a second	Restart required	Sets flash sync delay.
<OSO>B/	On Sync Only	B = 0 for sync-master or B = 1 for sync-slave	Restart required	Sets sync master/slave mode.
<DNT>0YY/	Day/Night Threshold	YY = 01 through 12 thresholds	Restart required	Sets day/night thresholds.

Command (Pseudo-XML Tag)	Command or Query Name	Valid Parameter Range & Unit	Acts Immediately or Requires Restart	Description
<DFI>B/	Display Indicator Off	B = 0: Display indicator is on B = 1: Display indicator is off	Restart required	Turns off the red LED mimic of the flash character that is mounted on the driver circuit board. The mimic LED always operates during TVIR programming.
<OPM>X/	Operation Mode	X = 1 to 4 (A subset of values shown in Appendix A for Operation Mode command)	Restart required	Sets PEL-4 main operation mode. Used for enabling/disabling remote control & traffic light modes; setting fail-safe vs best-effort operation.
<BLW>YYY/	Low battery threshold	YYY: Threshold in tenths of a volt or disable code 999.	Restart required	Refer to Appendix A.
<BHI>YYY/	High battery threshold	YYY: Threshold in tenths of a volt or reset code 999.	Restart required	Refer to Appendix A.
<VER>?/	Software version query	Only ‘?’ allowed	Immediate	Queries software version as per system command section of Appendix A.
<LED>?/	LED version query	Only ‘?’ allowed	Immediate	Queries LED version as per system command section of Appendix A.
<CAR>?/	Characterisation version query	Only ‘?’ allowed	Immediate	Queries optic characterisation version as per system command section of Appendix A.
<FID>XYY/	Flash Character Index	XYY = 0 through 999 as per valid characters in Appendix F. ‘999’ represents the Custom character that is manually entered.	Restart required	Defines the default flash character that is used in single character mode. In dual character mode this is the night character.

Command (Pseudo-XML Tag)	Command or Query Name	Valid Parameter Range & Unit	Acts Immediately or Requires Restart	Description
<SPC>…/	Special (Custom) Character	A sequence of comma-separated on/off pairs terminated with a '0' as last parameter, as per the definition in Appendix A.	Restart required	Defines the manually-entered custom character. This custom character can be selected by <FID> and/or <AID> by using index parameter 999.
<SER>?/	Serial number query	Only '?' allowed	Immediate	Queries PEL-4 serial number as per system command section of Appendix A.
<SDA>B/	Sync disabled	B = 0: Sync pulse generation enabled B = 1: Sync pulse generation disabled.	Restart required	Enables or disables sync pulse generation.
<REB>1/	Reboot command	Value doesn't matter	Immediate	Causes a reboot from the bootloader, which has a startup delay before the PEL-4 application is entered. Intended to allow updating of PEL-4 application software through the bootloader.
<MON>B/	Monitoring function	B = 0: disable monitoring B = 1: enable monitoring	Immediate	Enables monitoring the output stream over the serial interface. The stream can be set to free-running or on demand with the <MFR> command.
<MFR>B/	Monitoring free-run	B = 0: On-demand monitoring enabled B = 1: Free-running monitoring	Immediate	Enables free-running monitoring in which a semi-continuous stream of data is output. On-demand monitoring sends one or more data packets on receipt of a '/' character.
<RCM>XYZ/	Remote Control Mode	Refer to Appendices A.1, A.3, A.4, A.5	Immediate	Enables remote control mode.

Command (Pseudo-XML Tag)	Command or Query Name	Valid Parameter Range & Unit	Acts Immediately or Requires Restart	Description
<ODS>B/	On-demand sync	B = 0: Disables On-demand sync behaviour (default, normal operation) B = 1: Enables on-demand sync behaviour	Restart required	When set the PEL-4 turns off when sync is low and operates normally when sync is open-circuit or high.
<SSF>YY/	Slave sync flash count	YY = 002 to 099	Restart required	Sets the number of cycles that a PEL-4 will continue to flash after loss of sync.
<TST>/	Test alarm	(No parameter required)	Immediate	Deactivates the Beacon OK output; activates the alarm output; waits ten seconds with PEL-4 functionality stopped; after timeout clears alarm, sets OK and resumes PEL-4 operation.
<RST>1/	Restart the PEL-4	Any value	This is the restart command	This command must be sent after any command or sequence of commands that are listed as requiring a restart. It causes the PEL-4 application software to restart without waiting in the bootloader. A restart causes the non-volatile settings information to be copied into volatile, operational memory in the PEL-4.
<GPS>?/	GPS detected query	'?' only	Immediate	Identifies whether both a GPS daughterboard option is present (value=1 when detected, =0 when not) in the PEL-4 and a GPS satellite lock has been obtained (value = 2).

Command (Pseudo-XML Tag)	Command or Query Name	Valid Parameter Range & Unit	Acts Immediately or Requires Restart	Description
<GPE>B/	GPS enabled	B = 0: Disable GPS B = 1: Enable GPS (default)	Restart required	When set to 1, GPS auto-detection is enabled. When cleared to 0, GPS detection will not occur and a GPS lock will never be established. Useful when deprecating a GPS unit so that it can be day/night synchronised in a hardwire sync connection to an enabled GPS unit.
<FCM>Z/	Flash compensation mode	Z = 0: Effective intensity mode enabled compliant with IALA E-200-4 2017. Z = 1: Peak intensity during the flash mode enabled (no flash compensation). Z = 2: Effective intensity mode enabled compliant with IALA E-200-4 2008.	Immediate	Sets the flash compensation mode. 'Z' is the same parameter as appears in TVIR command 7-2-XYZ. Mode Z = 0 sets flash compensation compliant with IALA E-200-4 2017. (SC constant c = MA constant a = 0.1s for night flash except blue beacons. All beacon colours use a = 0.1s during the day). Mode Z = 1 turns off flash compensation. Mode Z = 2 sets flash compensation compliant with IALA E-200-4 2008. (SC constant c = 0.2s for night flash, which is always true for blue beacons. All beacons use c = 0.1s during the day).
<RON>B/	Remote On/Off State	B = 0: Turn off PEL-4 B = 1: Turn on PEL-4	Immediate	Turns the PEL-4 on or off if the On/Off input is enabled with the <RCM> command and if <OPM> is set to enable remote control. Interacts with the hardwire On/Off input. Refer to Appendix A.

Command (Pseudo-XML Tag)	Command or Query Name	Valid Parameter Range & Unit	Acts Immediately or Requires Restart	Description
<RFF>B/	Remote Flash/Fixed State	B = 0: Fixed character B = 1: Flash character	Immediate	Selects the programmed <FID> or <AID> flash character as defined by other settings and states or forces the PEL-4 into fixed character if the Flash/Fixed input is enabled with the <RCM> command and if <OPM> is set to enable remote control. Interacts with the hardwire Flash/Fixed input. Refer to Appendix A.
<RDN>B/	Remote Day/Night State	B = 0: Night state B = 1: Day state	Immediate	Selects the night or day state within the PEL-4 if the Day/Night input is enabled with the <RCM> command and if <OPM> is set to enable remote control. Interacts with the hardwire Day/Night input. Refer to Appendix A.
<FOM>XYZ/	Flash operation mode	XYZ: Refer to Appendix A, command 7-2-XYZ	Restart required	Sets the flash operation mode.
<RPM>X/	RPM (Oscillating Boundary) Alarm Enable/Disable	X = 0 or 2000 (0: Fixed Boundary) (2000: Osc Boundary)	Restart Required	Sets the nominal RPM value expected from the oscillating boundary detector inside the PEL. If set to zero, disables oscillating boundary monitoring. If set to 2000, enables monitoring with +/- 30% tolerance. Other values are accepted but not recommended.
<R2B>X/	Set baud rate	X: Standard baud rates: 4800, 9600, 14400, 19200, 38400 (AIS), 57600, 115200 (default & VegaWeb).	Restart required	Sets the command & monitoring serial interface to the required baud rate.

Command (Pseudo-XML Tag)	Command or Query Name	Valid Parameter Range & Unit	Acts Immediately or Requires Restart	Description
<TYR>XY/	Projector Bus Addressing	X = total projectors; Y = this projector's address (0 for master, 1 to (X-1) for slaves.) Address must be unique.	Restart required	Sets the master-slave bus address range and value for an individual projector. Critical to beacon operation.

Command (Pseudo-XML Tag)	Command or Query Name	Valid Parameter Range & Unit	Acts Immediately or Requires Restart	Description
<ERR>B/	Error logging readout	B: defines decimal or hexadecimal error code readout and whether logged error value is included in monitoring output. 0: decimal, not monitored (default) 1: hex, not monitored. 10: decimal, monitored. 11: hex, monitored.	Immediate	Reads back the error log values, with the error code in decimal or hex format and other values in decimal format. Sets whether the error log is included in the monitoring stream (default is not and not recommended for VegaWeb or AIS monitoring). Output Parameters: Error code (log of first master error condition); Quantity of errors of any kind; Quantity of nights before first error; Quantity of nights between first and last error; Quantity of nights after last error; Quantity of Restarts; Control flag value (i.e. 'B' input parameter setting). This output format is maintained for both casual enquiry using the <ERR> command and when the <ERR> tag is included in the monitoring stream. Error logging commences 30 seconds after startup.
<CLE>/	Clears logging values	None or any parameter	Immediate	Clears all logged parameters apart from the control flag as used in the <ERR> command. Reads out the new (zeroed) logging data in the <ERR> format.

Command (Pseudo-XML Tag)	Command or Query Name	Valid Parameter Range & Unit	Acts Immediately or Requires Restart	Description
<BAT>?/	Battery voltage	'?' only	Immediate	Outputs battery voltage in tens of mV identically to monitoring stream tag <BAT>. This unit (tens of mV) is expected by the VegaAIS.
<LIT>?/	Light level	'?' only	Immediate	Outputs detected daylight level in normalized units 0-1000 identically to the monitoring stream tag.
<TMP>B/	Temperature	B: Null, '?' or 0 sends data from the active sensor; 1 sends data from the on-board sensor; 2 sends data from the off-board sensor. 3 sends on-board data, space, off-board data.	Immediate	Outputs the measured temperature in tenths of degrees Kelvin from the selected sensor. Use parameter value 0 or '?' to get the same data as the monitoring stream tag. The tenths of Kelvin parameter is expected by the VegaAIS. To convert to Celsius: [°C = Value/10 – 273]
<LOI>?/	LED On Current	'?' only	Immediate	Outputs the average LED on current (during flash-on) in milliamps. In a master-slave bus product, the master's readout is the sum of all projectors' currents as if the flashes were synchronised.
<LDI>?/	Load Current	'?' only	Immediate	Outputs the average load current (i.e. averaged over flash-on and flash-off) in milliamps. In a master-slave bus product, the master's readout is the sum of all projectors' currents.
<SLI>?/	Solar Current	'?' only	Immediate	Outputs the average solar current in milliamps.

Command (Pseudo-XML Tag)	Command or Query Name	Valid Parameter Range & Unit	Acts Immediately or Requires Restart	Description
<MER>B/ <MEX>?/	Master Error Code	B: '?' or 0: With <MER> tag, decimal readout of master error code; 1: hex readout. <MEX> tag always provides hex readout.	Immediate	Outputs the current master error code (0 or 0x0 if none).
<ROT>?/	Rotation data	'?' only	Immediate	Outputs the half-rotation period in 50ms counts. E.g. a 1RPM rotation rate will output a nominal value approximating 600 = (60s/2 * 20). This data format is identical to that of the monitoring tag.
<GUD>?/	Good status	'?' only	Immediate	A '1' value indicates that the beacon is in a good (non-error, non-alarm) state. A '0' indicates an error and alarm state. This data format is identical to that of the monitoring tag.
<AON>?/	Beacon On	'?' only	Immediate	A '1' value indicates that the beacon is on, i.e. creating a flash or fixed character of non-zero intensity. A '0' that the beacon is dark. This data format is identical to that of the monitoring tag. This tag was previously named <BON>.
<DAY>?/	Day State	'?' only	Immediate	A '1' value indicates that the beacon is in day mode. A '0' that the beacon is in night mode. This data format is identical to that of the monitoring tag.

Command (Pseudo-XML Tag)	Command or Query Name	Valid Parameter Range & Unit	Acts Immediately or Requires Restart	Description
<TLS>?/	Traffic Light State	'?' only	Immediate	A numeral indicating the traffic light state of a beacon operating in traffic light mode. This identical tag is present in the monitoring stream if traffic light mode is enabled.
<TYP>?/	Beacon Type (string)	'?' only	Immediate	A string naming the beacon product type.
<HIC>X/	Hibernate check-in timeout	X: Value in seconds between 60 and 32000. Default value is 10400 (3 hours).	Restart required.	This is the timeout period communicated by the master to all slaves that all master and slaves use to wait before attempting resynchronisation of their command & control RS485 bus communications. This process bus shutdown, wait and resynchronisation is only performed during low power sleep.

APPENDIX G ERROR CODES

The following error codes are available using the 3-9-10X commands and through the <MER>, <MEX> and <ERR> RS232 serial commands.

The error codes are a combined set of information.

If no error is present then a single, zero digit will be returned. If an error is present or has been logged then five digits of error code will be returned by the TVIR 3-9-100 (display master error code) and 3-9-101 (display logged error code) commands, respectively.

Decimal Error Code	Explanation	Suggested Action
0	No error present or no error logged.	None required
33344 to 33375	Slave communications error	Not relevant to this product or indicates that the bus address has been incorrectly modified.
33408 to 33414	Slave operation error (address of the slave with an error is the returned value minus 33408)	Not relevant to this product or indicates that the bus address has been incorrectly modified.
33472 to 33503	Slave operation and communications error	Not relevant to this product or indicates that the bus address has been incorrectly modified.
33536	Low battery error	Check power supply wiring and voltage to the beacon. Check low battery threshold setting.
35328	Open LED error	Check for an inoperative optic or optics and report information to Vega.
49664	High temperature error	This is a temporary state when a beacon detects over-heating due to either or both internal and external conditions. The LED(s) will be protected automatically unless another internal fault is present. If the cause is due to external temperature rise then once the temperature has returned to the specified operating range the beacon will resume normal operation and will cancel the error. The recommended action is to gain an understanding of whether external temperature and/or solar loading could be the cause and if so, reduce the risk of such events. Externally-caused errors will result in a reduction in intensity from the beacon but it should never turn off. If no external cause can be attributed to the error then please provide a report to Vega.

If error information is requested by RS232 serial commands then these same codes will be returned, in both decimal and hexadecimal formats. Hexadecimal format is easier to use for decoding the meaning of multiple, simultaneous errors.

Hexadecimal error codes in the <MEX> tag (and sometimes in the <MER> or <ERR> tags if requested) can be decoded through addition of independent hexadecimal error codes for each nibble. A nibble is a single character position within a hexadecimal error code. For example, in the code 0xCA00, each of the four characters after the '0x' (which indicates a hexadecimal numeral) is a nibble and can be decoded separately from every other nibble. Each nibble represents a number from zero through fifteen using characters 0, 1, …9, A (for decimal 10), B (for decimal 11), C (decimal 12), D (decimal 13), E (decimal 14) and F (decimal 15).

For example, to decode error code 0xCA00, beginning with the left-hand character, 'C' (decimal 12), it can be seen that error codes 0x8000 and 0x4000 uniquely add to create 0xC000 (i.e. 8+4 = C (decimal 12)). Therefore, 0xC000 is decoded as both 'Error present' and 'High temperature error'. The 0x0A00 portion of 0XCA00 can similarly be decoded as 0x0800 added to 0x0200 (i.e. 8+2=A (decimal 10)), meaning that an 'Open LED error' and the 'Alarm Flag' are both indicated. So, the total set of errors indicated for code 0xCA00 is all four of the items decoded above.

To decode the lowest nibble, consult the value of the next highest nibble. If the value 0x0080 or greater (i.e. 0x00C0, 0x00E0, or 0x00F0) is present then the lowest nibble represents the address of a slave that has operational errors (i.e. 0x0001 through 0x0007 are valid slave addresses). The slave's operational errors will be displayed in the higher nibbles of the master's error code (e.g. high temperature, or open LED error, etc).

If the second-lowest nibble has a value less than 0x0080 (i.e. 0x0040, 0x0060 or 0x0070) then the lowest nibble should be decoded as a set of possible communications error flags, using the usual addition rules explained above.

RS232 Serial Hexadecimal Error Codes per Nibble	**Explanation**
0 (in any nibble)	No error or no logged error from the relevant nibble
0x8000	Error present or logged (always present with an error)
0x4000	High temperature error
0x2000	Emergency mode error
0x1000	Rotation alarm error
0x0800	Open LED error
0x0400	Not used
0x0200	Alarm flag (always present with an alarm)
0x0100	Low battery error
0x0080	Slave operation error (not relevant to PEL-4)
0x0040	Slave comms error (not relevant to PEL-4)
0x0020	Undefined
0x0010	Slave comms command reject error
The following nibble values are only relevant if there is a slave comms error and NOT a slave operation error (i.e. the nibble above must be less than 0x0080 in value).	
0x0008	Slave comms command/response sequence error
0x0004	Command destination error
0x0002	Slave command receive timeout error
0x0001	Slave comms failure error
The following lowest nibble values represent slave addresses if a Slave Operation Error was declared (i.e. a value of 0x0080 or greater is present in the next higher nibble).	
0x0001 to 0x0007	Address of slave with operations error or which has failed to communicate after low power sleep.
0x0000	Not a valid value for a Slave Operations Error.