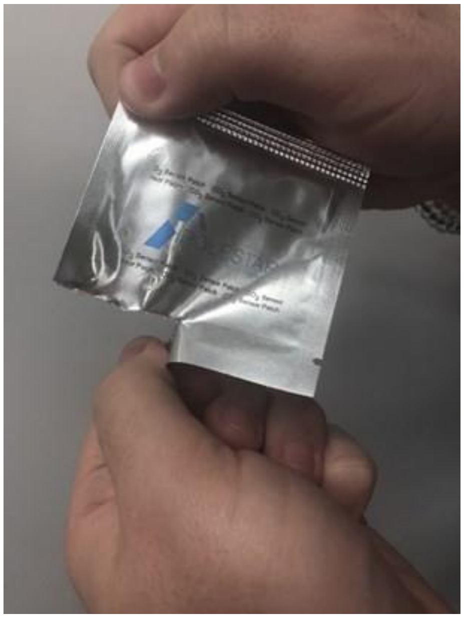
Polestar Technologies CO2 Digital Sensor Module 59-36601

Quick Start Guide and Application Reference Manual



Peel sensor patch package across the bottom, at the notch, as shown.

Figure A

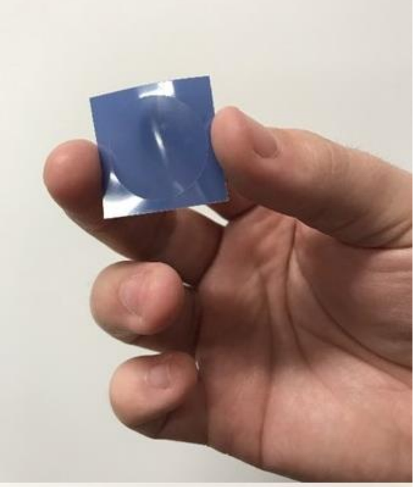


Figure B

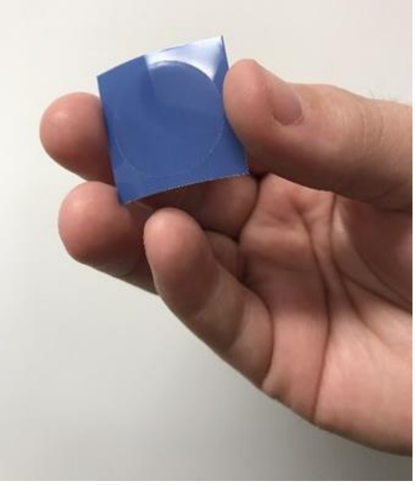


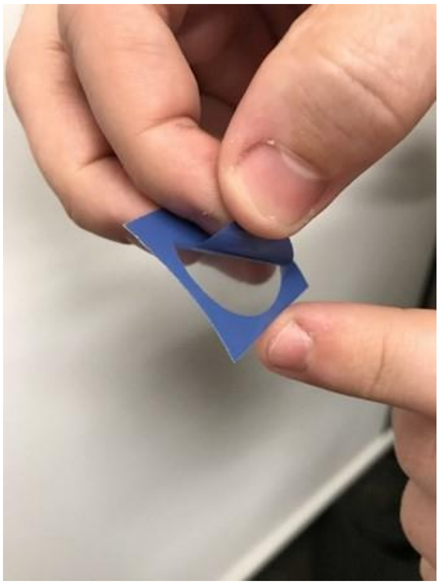
Figure A depicts the back of the sensor patch which is covered by a clear film release liner that protects the adhesive layer of the sensing patch.

The release liner side of the patch is smoother than the sensing layer on the front. Small air bubbles may also be visible around the cut line on the patch when viewed through the release liner.

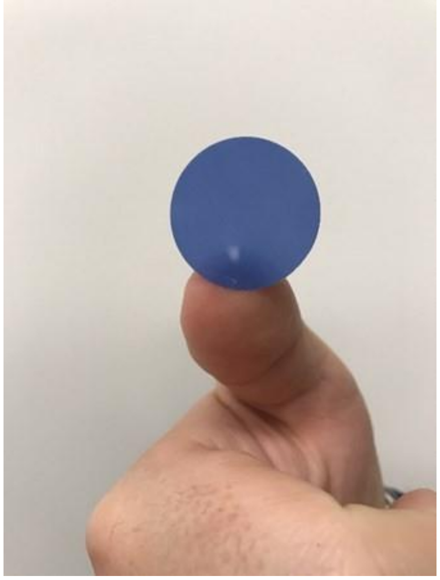
Figure B shows the top sensing layer side of the sensor patch.

To peel the sensor patch off of the film, hold it so the top is facing upwards. Gently fold down the corner of the square while using your thumb to peel the sensor patch upwards.

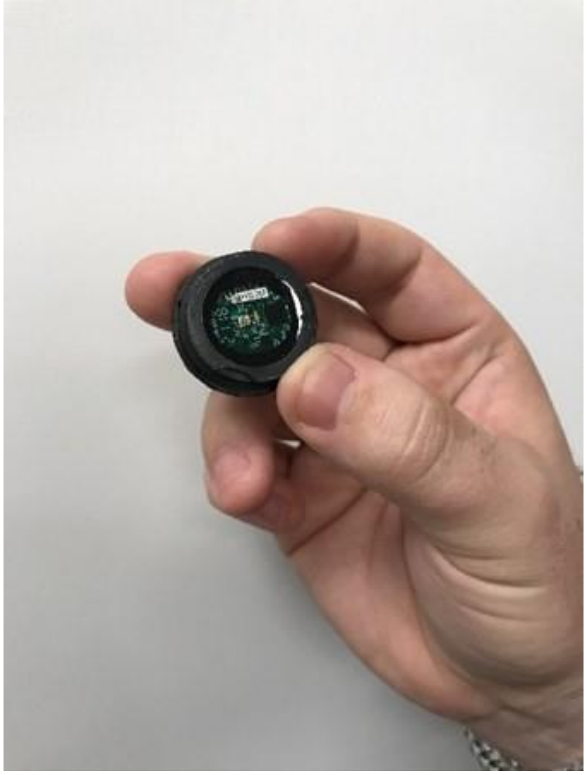
Use of abrasives or sharp objects with the patch can lead to damage of the sensing layer and should be avoided. Yellowing may indicate damage or excessive aging of the sensing layer. Yellowed sensing patches should not be used with the sensing electronics.

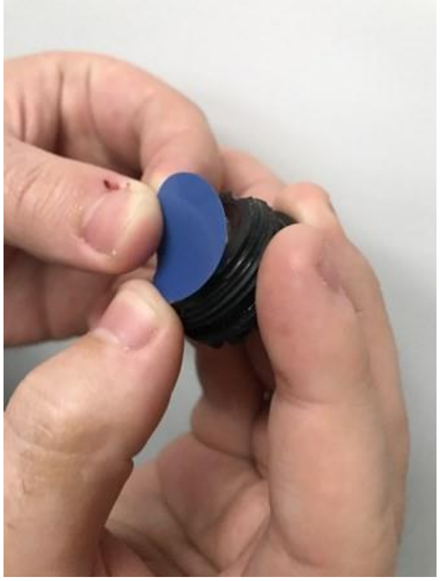


Hold the sensing electronics as shown below with the four-pin connector facing away from you.



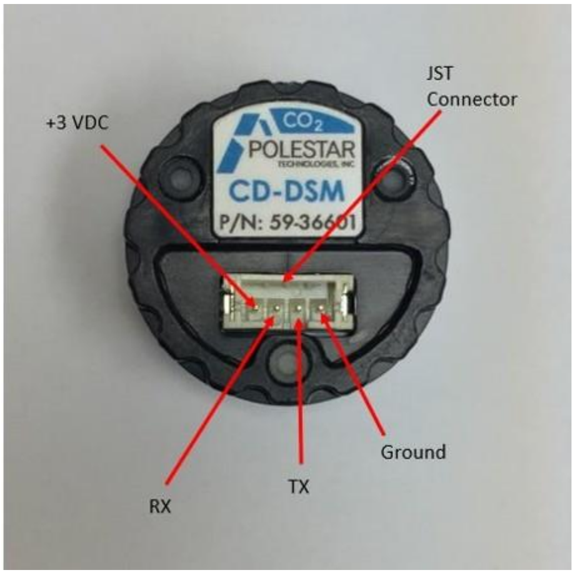
Place the edge of the sensor patch at the edge of the sensor electronics where your thumb is placed. Slowly roll the patch onto the sensor’s clear flat surface making sure the edges line up.





To remove air bubbles trapped between the sensing patch and sensor surface, gently roll your thumb over the applied patch from one side of the sensor to the other.

DO NOT SWEEP THE FINGER FROM SIDE-TO-SIDE AS ABRASION MAY DAMAGE THE SENSING LAYER.



Wiring Guide Schematic:

Depicted JST female connector shown with male pins mates with manufacturer JST PHR-4 connector.

These connectors are available online or consult Polestar Technologies for availability.

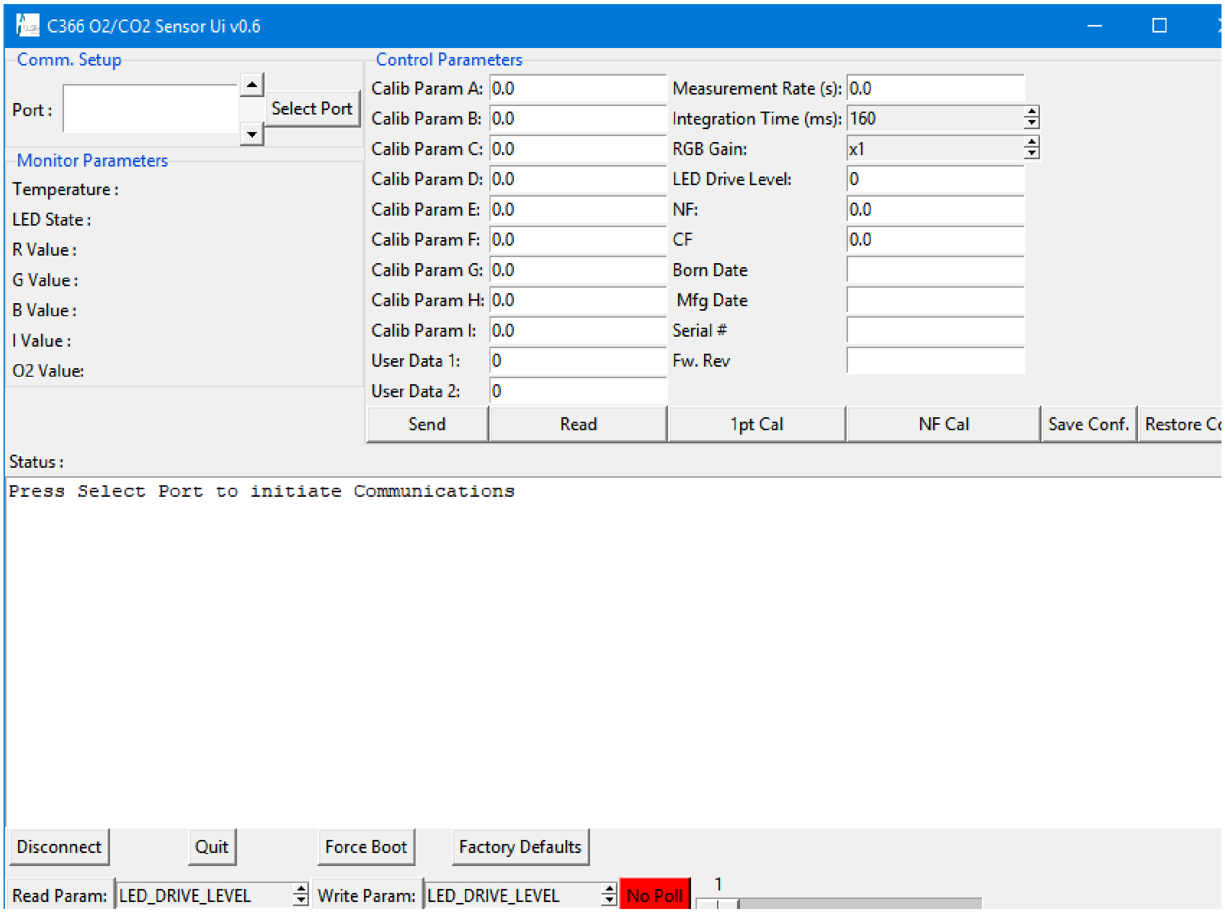
C366 GUI User's Manual

OVERVIEW:

New software has been created to duplicate much of the function of the earlier sensor GUI as well as provide some additional capabilities. Like the legacy GUI, the sensor communicates with a host device via a full duplex, 19200 baud, 8 data, no parity, 1 stop bit serial port. In parallel with the sensor firmware development, an enhanced version of the User Interface application (PN 77-36600) has been developed. This document describes the User Interface Application.

MAIN APPLICATION SCREEN (C366)

Illustration



Port :

Temperature :
LED State :
R Value :
G Value :
B Value :
I Value :
O2 Value:

Calib Param A: 0.0
Calib Param B: 0.0
Calib Param C: 0.0
Calib Param D: 0.0
Calib Param E: 0.0
Calib Param F: 0.0
Calib Param G: 0.0
Calib Param H: 0.0
Calib Param I: 0.0
User Data 1: 0
User Data 2: 0

Measurement Rate (s): 0.0
Integration Time (ms): 160
RGB Gain: x1
LED Drive Level: 0
NF: 0.0
CF 0.0
Born Date
Mfg Date
Serial #
Fw. Rev

Status :

```
Press Select Port to initiate Communications
```

Read Param: LED_DRIVE_LEVEL
Write Param: LED_DRIVE_LEVEL

Comm. Setup Frame

The comm. Setup screen appears in the upper left corner of Illustration 1.   On startup, the GUI application scans the host PC for all currently connected comm ports and populates the “Port:” scrollable list with the names of the detected comm ports. Note that only ports in the range COM1 – COM99 will be scanned.   The operator selects a sensor to communicate with by scrolling the Port list using the up/dn arrows and then highlighting one of the ports from the list. Clicking on the “Select Port” button opens the highlighted serial port and begins communication with the attached sensor.

Monitor Parameters Frame:

Parameters in this frame provide a real time display of the LED drive status, raw RGBI sensor channel values, temperature, and CO2 (or O2) in mbar.

Control Parameters Frame:

Control parameters change values which affect the sensor's sampling cycle and the conversion of raw color sensor bit counts to CO2 (or O2) values. The “Read” command button fetches the values of all control parameters from the attached sensor. The “Send” command button writes all the control parameters to an attached sensor.

The “1pnt Cal” button initiates a 1-point calibration to remove offsets in the sensor data. This applies only to O2 sensor mode and the sensor must be exposed to air during the cal. Procedure.

The “NF Cal” button invokes an automatic procedure which acquires 10 samples of the raw sensor data, averages them, and computes a new NF parameter. The sensor must be exposed to a pure white target sample for the NF cal to produce valid results.

Save/Restore buttons allow the control parameters (Parameter A – NF) to be saved to a user specified disk file or restored from a disk file. Note that this commands only save the application control parameters to/from disk. To actual read/write values from/to the sensor use the “Read”/”Send” buttons.

Status Frame:

The status frame incorporates a scrolling text region where sensor status messages and raw data log entries appear. Status frame command buttons allow the user to “Disconnect” from a currently open serial port, “Quit” the application.

“Force Boot Mode” causes a connected sensor to enter the serial bootload mode and prompts the operator to select a hex file for upload to the sensor.

“Factory Defaults” erases the sensors control parameter storage area. On the next sensor power cycle, the sensor will initialize its control parameters from the hard-coded factory defaults.

Read/Write Parameter Controls:

The Read/Write Param: command buttons allow the operator to read or write a single control parameter value. The parameter to be read/written is selected by the scrollable selection list and the value of the parameter is taken from the numeric display in the Control Parameters Frame.

Poll Button and Slider:

A new feature of the C366 sensor is the ability to suspend automatic/timed conversions and instead only perform a measurement when polled by the host. Clicking the Poll button will toggle polled mode on/off and the seconds between polls is controlled by the slider control.

SPECIAL CONSIDERATIONS

"I can't change the sensor serial number control parameter"

The sensor serial number is a "write once" parameter. It can be set only once after manufacture.

"I can't change/update the Born Date or Mfg Date"

These parameters can only be changed BEFORE the sensor SN has been programmed. After that write attempts are ignored.

"I can change the firmware version string"

The firmware version string is read only. The value is hard coded into the sensor's hex file and cannot be changed without recompiling the code.

"I tried to reflash/bootload my sensor and now nothing works"

In some (rare) cases, a serial bootload operation may fail leaving the sensor inoperable. The sensor hardware is not damaged, but the recovery procedure may require re-initialization of the serial bootload flash block using special hardware and software tools.

SPECIAL OPERATIONS FOR A NEW/NEVER PROGRAMMED SENSOR

All sensors come factory programmed with a serial bootloader. On power up, the bootloader will detect that valid application code is not present begin waiting for a code upload. In some cases, the GUI application's serial messages can "confuse" the bootloader and result in an incomplete/partial upload.

To program a new/previously unprogrammed sensor, the following steps must be followed.

1. Begin with the UI application closed.
2. Connect the new sensor to the PC and launch the C366 GUI.
3. Examine the "Ports:" list. Highlight the port connected to the new sensor **but do not click on the "Select Port" button.** This identifies the port to use but does not actually open the port for communications yet.
4. Now click on the "Force Boot" button. C366 recognizes that a serial port has been selected but is not currently open and assumes that the attached sensor is brand new and already in bootload mode.
5. Follow the dialog prompts to select a hex file to load. Verify that the bootload process completes with 0 errors reported.
6. Now click on the "Select Port" button to (re)open the serial port and begin "normal" sensor communications.

Re: ICD-77-36601 (CO2 Sensor Interface Control document.)

OVERVIEW:

Polestar has developed new optical CO2/O2 sensors. Although based on similar physical principles the new sensors differ from the legacy designs in the following ways:

- Temperature is measured with a digital sensor which directly reports degrees C. No field or factory calibration is required
- An direct to digital optical sensor is used (R,G,B,I 16bit)

New software has been created to duplicate much of the function of the earlier sensors as well as provide some additional capabilities. Like the legacy sensor, the new sensor communicates with a host device via a full duplex, 19200 baud, 8 data, no parity, 1 stop bit serial port This document outlines the electrical and protocol interfaces.

HARDWARE:

As noted the serial interface supports a data rate of 19200 baud with no parity and one stop bit. The hardware does NOT provide a voltage level translation so all interface levels are 3.3V TTL.

PROTOCOL:

Messages to/from the host device from/to the sensor are formatted as individual packets. Each packet starts with the “Start Of Packet” character (SOP) which is 'S'. The last character of each packet must be “End of Packet” (EOP) which is 'E'. A packet layout is defined in the table below.

Byte Offset	Value	Description
0	'S'	SOP
1	Msg Type Code	See Table 2,3
2	Payload first Byte	
N+2	Payload last byte	N = Payload length
N+3	Error check Byte	
N+4	'E'	EOP

Table 1

Valid payload lengths are N= 4,16,24 bytes. Payload size is determined by the Msg Type Code . NOTE: The INIT command/response is an exception. See detail for INIT command.

Float/Integer pay load content is sent most significant byte first. Floating point values are represented with 32 bits (IEEE-754 standard).

Valid Message Type Codes (Host → Sensor)

Message Type	Type Code	Payload Length (N)	Description/Payload format/valid range
LED_DRIVE_LEVEL	0x01	4	Unsigned int32 (0 - 255)
RGB_GAIN_PRESCALER	0x02	4	Not used
READ_TEMPCOUNT	0x05	4	Read/Request temperature sensor value
SET_INT_TIME	0x06	4	Integration time (ms). See Note 1
SET_RATE	0x07	4	Seconds between data reports (0 = poll)
CALIB_PARAM_A	0x08	4	Float
CALIB_PARAM_B	0x09	4	Float
CALIB_PARAM_C	0x0A	4	Float
CALIB_PARAM_D	0x0B	4	Float
CALIB_PARAM_E	0x0C	4	Float
CALIB_PARAM_F	0x0D	4	Float
CALIB_PARAM_G	0x0E	4	Float
CALIB_PARAM_H	0x0F	4	Float
CALIB_PARAM_I	0x10	4	Float
SET_GAIN	0x11	4	Valid range [0,1,2] corresponding to gains of x1,x2,x16. Default is x16
SET_OFFSET	0x12	4	Not used (Ignored)
USER_DATA1	0x13	4	Int32
USER_DATA2	0x14	4	Int32
CALIB_PARAM_NF	0x16	4	Float
CALIB_PARAM_CF	0x17	4	Float (Read Only, Write Ignored, not used for CO2)
CALIB_BORN_DATE	0x18	24	24 character string* (Note 3)
CALIB_MFG_DATE	0x19	24	24 character string* (Note 3)
CALIB_FW_REV	0x1A	16	Read Only ((Note 3)
CALIB_UNIT_SN	0x1B	16	16 character Unit Serial number *(Note 3)
QUERY_CMD	0x1C	4	Unsigned Int32
CALIB_RST_REASON	0x1D	4	Read Only, reset reason code
INITIALIZATION	0xAA	4	Payload Ignored
FORCE_BOOT	0xFB	4	Force Sensor into serial boot loader mode

Table 2 – Message Type Codes

* - These message types are readable at any time but can only be written when the Unit Serial Number field is all spaces or all 0xFF.

Note 1 – The sensor hardware only supports integration times of [160,320,640,1280,2560,5120]. The integration time set via `SET_INT_TIME` controls two characteristics of the sampling process. First, the LED on time is set to whatever integration time the host specifies. Second, the sensor's integration time is set to whatever value from the list above which does not exceed the user specified integration time. Example: Host specifies an integration time of 400ms. This would cause the sensor to use an integration time of 320ms but the LED will be driven ON for a total of 400ms. *Except for certain diagnostic operations the integratino time should never be set to less than 160ms and should not be configured for more than ½ the configured number of seconds between samples.*

Note 2 – The actual interval between measurements is 2x Integration time plus the configured number of seconds between samples. If the integration time is 160ms and the intervale is 4 seconds the total time between samples is (2x160) + 4000 = 4320ms.

Note 3 - String values have fixed lengths of either 16 (SN, Fw Rev) or 24 bytes (dates). These values are always sent/received as fixed length byte sequences. On reception the sensor will ensure that a NULL termination is added at the 17th or 25th byte position.

Valid Message Type Codes (Sensor → Host)

Message Type	Type Code	Payload length (N)	Description/Payload format/valid range
RES_LED_DRIVE_LEVEL	0x81	4	Report active LED Drive level
RES_RGB_GAIN_PRESCALER	0x82	4	Report active gain prescaler (not used)
RES_RGB_SENSOR_CONFIG_M	0x83	4	Report (R (upper 16 bits),G (lower 16 bits)) values
RES_RGB_SENSOR_CONFIG_L	0x84	4	Report (B (upper 16 bits),I (lower 16 bits)) values
RES_READ_TEMPCOUNT	0x85	4	Report temperature (float degC)
RES_SET_INT_TIME	0x86	4	Report integration time (ms)
RES_SET_RATE	0x87	4	Report measurement rate in seconds/per
RES_CALIB_PARAM_A	0x88	4	Report calibration Parameter A (float)
RES_CALIB_PARAM_B	0x89	4	Report calibration Parameter A (float)
RES_CALIB_PARAM_C	0x8A	4	Report calibration Parameter A (float)
RES_CALIB_PARAM_D	0x8B	4	Report calibration Parameter A (float)
RES_CALIB_PARAM_E	0x8C	4	Report calibration Parameter A (float)
RES_CALIB_PARAM_F	0x8D	4	Report calibration Parameter A (float)
RES_CALIB_PARAM_G	0x8E	4	Report calibration Parameter A (float)
RES_CALIB_PARAM_H	0x8F	4	Report calibration Parameter A (float)
RES_CALIB_PARAM_I	0x90	4	Report calibration Parameter A (float)
RES_SET_GAIN	0x91	4	0,1,2 corresponding to x1,x2,x16 gains

RES_SET_OFFSET	0x92	4	Report offset (float). Not used
RES_USER_DATA1	0x93	4	Report User_Data_1 value (int32)
RES_USER_DATA2	0x94	4	Report User_Data_2 value (int32)
RES_CO2_COMPUTATION	0x95	4	Report CO2 computation result (float, mbar)
RES_CALIB_PARAM_NF	0x96	4	Report NF (float).
Reserved	0x97	-	
RES_BORN_DATE	0x98	24	Report Born date string (chr24)
RES_MFG_DATE	0x99	24	Report Mfg date string (chr24)
RES_FW_REV	0x9A	16	Report Firmware version string (chr16)
RES_UNIT_SN	0x9B	16	Report Unit Serial Number (chr16)
Reserved	0x9C		
RES_RST_REASON	0x9D	4	Report reset reason code (int32)
'INIT'<payload>'INIT'	-	68	See detailed command description.

Table 3 – Message Type Codes

COMMAND/RESPONSE MESSAGE SPECIAL CASES:

A few of the defined commands have non-standard side effects and/or bear further description.

INITIALIZATION Command Response:

This command triggers a binary dump of (most of) the calibration/configuration structure from the sensor to the host. The total payload length is 68 bytes preceded and followed by the string 'INIT'. This command is provided for backwards compatibility only and its use is deprecated for several reasons. First, the payload is a binary image so content depends on the endianess of the compiler and how the structure packing is done. Second, due to the backward compatibility requirements, this command will not retrieve any new/additional configuration fields (eg mfg date, born date, Unit SN, Fw Revision).

SET_RATE Command:

This command has two functions. The standard/legacy compatible function is to define the time interval (in seconds) between successive measurement data reports. If the interval is set to 0 seconds, the sensor will interpret this as a command to immediately initiate a new sensor sampling cycle (if one is not already in progress), and will further inhibit any future automatic sensor data reports. Thus, the sensor can be operated in a polling mode with the time interval between reports controlled by the host.

Measurement Data Reports:

Whether initiated by the sensor's internal timer or in response to a host SET_RATE = 0 command, the data sample cycle consists of two phases. Phase 0 is the dark/led off sample values, Phase 1 is the LED on sample values. For each of the two phases the following data messages are sent by the sensor to the host…

```
RES_CO2_COMPUTATION
RES_RGB_SENSOR_CONFIG_M
RES_RGB_SENSOR_CONFIG_L
RES_READ_TEMPCOUNT
RES_LED_DRIVE_LEVEL
```

The phase 0 (dark) phase results will report a drive level of 0, the LED On phase will report a drive level of 1.

QUERY_CMD Handling:

The QUERY_CMD provides a way to request the value of any defined cal/config setting. The QUERY_CMD has an integer 32 bit payload but only the least significant byte is used to specify which parameter is desired to be read. This command is the preferred method for a host device to query the sensor's cal/config settings. Unlike the Initialization command, it allows access to any/all message type codes including Unit SN, dates, etc.

```
Example:
      'S',QUERY_CMD,0x00,0x00,0x00,0x1b,<error check>,'E'  → Request Unit SN

      Response from Sensor:
      'S',RES_UNIT_SN,<16 character ascii SN string>,<error check>,'E'
```

FLASH MEMORY MANAGEMENT:

Calibration/configuration values are stored in a reserved sector of the sensor's processor flash memory. This sector is erased/rewritten whenever any of the configuration settings are *changed*. Multiple writes of the same calibration parameter with **exactly the same value** do not cause additional erase/rewrite cycles. In addition, on any change to flash, an internal 500ms timer is initialized. *The actual flash update does not occur until the 500ms count down expires.* This allows multiple flash configuration parameters to be changed in quick succession without triggering unnecessary flash erase/write activity *however it is imperative that the sensor remain powered for at least 2x500ms after a configuration parameter change.*

ERROR CHECK CODES:

All messages (except the “INIT” command response) have an error check byte just before the EOP code. This error check byte consists of the xor all the message bytes from the msg type code through the message payload. When computing the error check byte it is initially set to zero prior to beginning the xor'ing.

Note that the sensor generates message check bytes on output but does not check/verify them on input.