

Sky Quality Meter Lens Ethernet

SQM-LE

User manual

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1 Theory of operation

The SQM-LE measures the darkness of the night sky to provide readings of magnitudes per square arc second through an Ethernet connection.

A light sensor (TSL237) provides the microcontroller with a light level, and readings from the temperature sensor are used to compensate the light sensor readings for various operating temperatures.

Commands sent from a PC through the Ethernet cable to the Ethernet interface are relayed to the microcontroller.

The microcontroller responds to commands by sending data strings to the Ethernet interface which are then relayed to the PC.

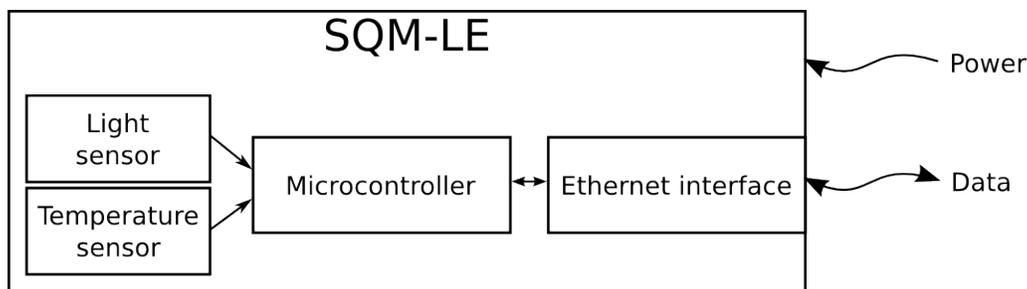


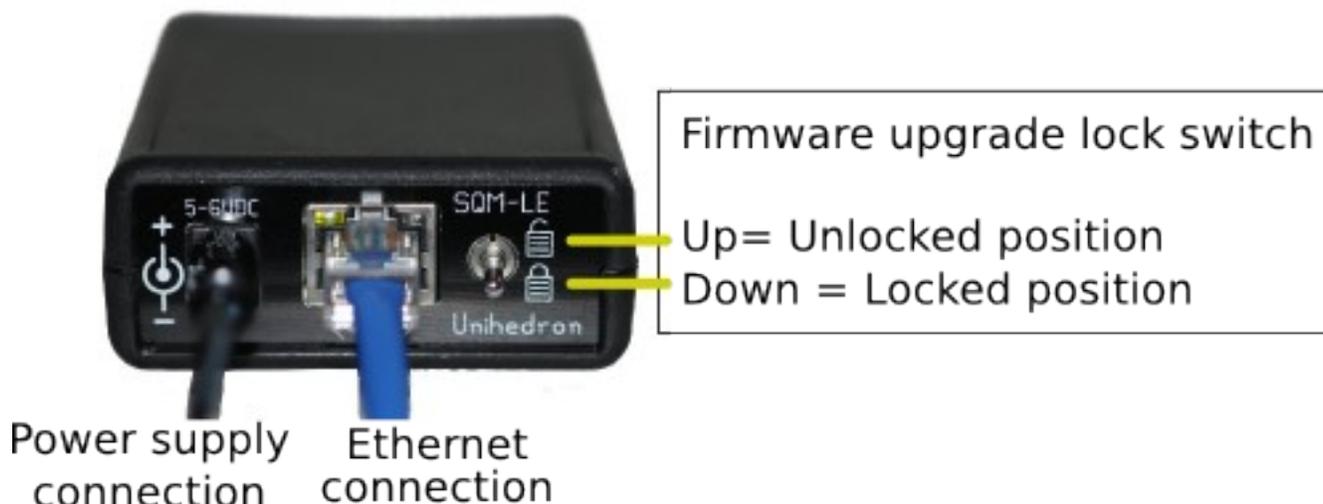
Illustration 1: SQM-LE block diagram

1.1 Quick start

1. Check out [3.Hardware connections](#) for the method of connection that you want to use, and make that connection using the supplied Ethernet cable and power adaptor.
2. Determine the IP address method you want to use (DHCP or fixed IP). You can use the “Lantronix Device Installer” on the CD (DI_4.2.0.0_Web.exe) to determine what the IP address is of the installed SQM-LE. You can also use this same software to fix the IP address. This IP address will be used in the next step. If you are using SQM-Reader-Pro by Knightware , it will automatically find the IP address of the SQM-LE for you.
3. If you are using Windows, then download and install the Knightware SQM-Reader from www.knightware.biz/sqm . Follow the instructions for installing and using that software. If you are using other operating systems, you can use the software on the CD for accessing the SQM-LE.

2 Specifications

Input power supply	5-6VDC 300mA Multi-National connection: 2.1mmI.D., 5.5mmO.D. connector North American connector: 2.5mmI.D., 5.5mmO.D. connector
Ethernet connection	10/100 Mbit (One connection at a time)
Connection timeout	Programmable, default = 2 minutes
Physical Size	3.6 x 2.6 x 1.1"
Meter precision	Each SQM-L is factory-calibrated. The absolute precision of each meter is believed to be $\pm 10\%$ (± 0.10 mag/arcsec ²). The difference in zeropoint between each calibrated SQM-L is typically $\pm 10\%$ (± 0.10 mag/sq arcsec)
Operating temperature range	-40°C to 85°C
Temperature sensor range (measures temperature at light sensor)	-40°C to +125°C
Temperature Accuracy	$\pm 2^\circ\text{C}$ maximum at 25°C
Temperature update rate	4.3 seconds 256 samples taken at 60Hz then averaged



Power supply connection Ethernet connection

Illustration 2: Back of unit

3 Hardware connections

The SQM-LE requires two connections; power, data.

The power connection is made with the supplied AC Adaptor.

Region	Input Voltage	Output voltage	Manufacturer, Model number
North America	120VAC	5VDC (desired)	CUI, EPS050100-P6P
		6VDC (optional)	CUI, EPS060100-P7P
International	240VAC	5VDC (desired)	CUI, EMS050120-P5P-SZ
		6VDC (optional)	CUI, EMS060100-P5P-SZ

Table 1: AC to DC adaptors

3.1 Hub/Switch connection

The Ethernet hub/switch connection is probably the most common method for connecting the SQM-LE into your system. An Ethernet hub/switch is used to connect the SQM-LE to the same subnet as the PC which accesses it.

The SQM-LE can serve one TCP connection at a time. So, once a TCP connection is made with the PC software, no other PCs can access that SQM-LE. The TCP connection must be released before other PCs can access it.

More than one SQM-LE may be placed on the network, each will have its own IP address.

It is desirable for the SQM-LE to have a fixed IP address so that accessing from the OPC is consistent. Fixed IP addressing can be assigned using a DHCP router capable of fixing IP addresses to MAC addresses. The SQM-LE MAC address can be identified with the Lantronix Device Installer software, it is also printed on the Ethernet interface inside the SQM-LE.

Another method of assigning an IP address of the SQM-LE is to use the Lantronix Device installer software or Telnet into the SQM-LE and follow the Lantronix instructions in the document *Xport_User Guide.pdf* provided with the SQM-LE.

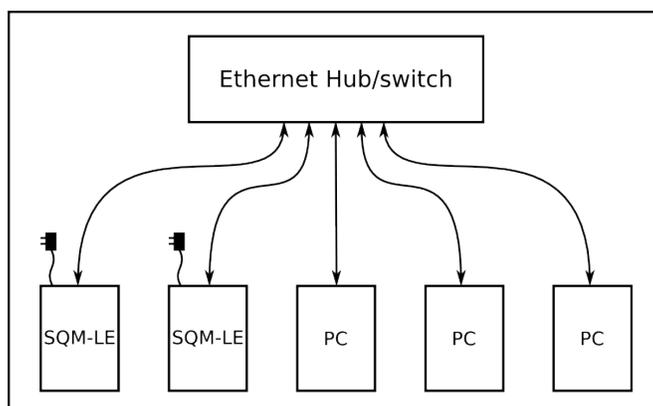


Illustration 3: Hub/switch connection

3.2 *Wireless connection (wireless client bridge)*

It is possible to communicate with an SQM-LE using a so-called “wireless client bridge”. In this situation, the PC either acts like an access point (if it has this capability) or is connected to one by a regular ethernet patch cable. The Linksys WRT54GL may be flashed with free, open source firmware from <http://www.dd-wrt.com/> and configured either as the wireless access point or the wireless client bridge.

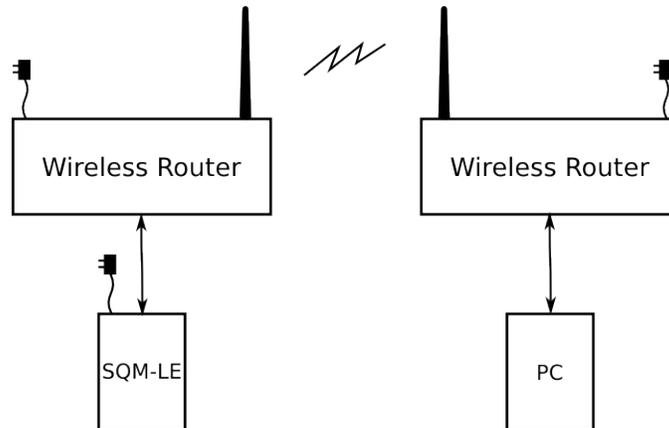


Illustration 4: Wireless client bridge connection

3.3 More than one SQM-LE

If more than one SQM-LE is required to be accessed on one subnet from another subnet, your router may be able to be configured for port forwarding to each SQM-LE. Normally port 10001 is used. That default port can be changed using either the Lantronix Device Installer software or by Telnet into port 9999.

On the LAN side, the SQM-LEs can be addressed like so:

```
SQM#1 192.168.1.132 10001
SQM#2 192.168.1.133 10001
SQM#3 192.168.1.134 10001
SQM#4 192.168.1.135 10001
```

If the router is has a dynamic DNS address of sqmcity.dyndns.org then these same SQM-LEs could be accessed from the Internet in the following way, provided the port forwarding shown in the image was adopted:

```
SQM#1 sqmcity.dyndns.org 10001
SQM#2 sqmcity.dyndns.org 10002
SQM#3 sqmcity.dyndns.org 10003
SQM#4 sqmcity.dyndns.org 10004
```

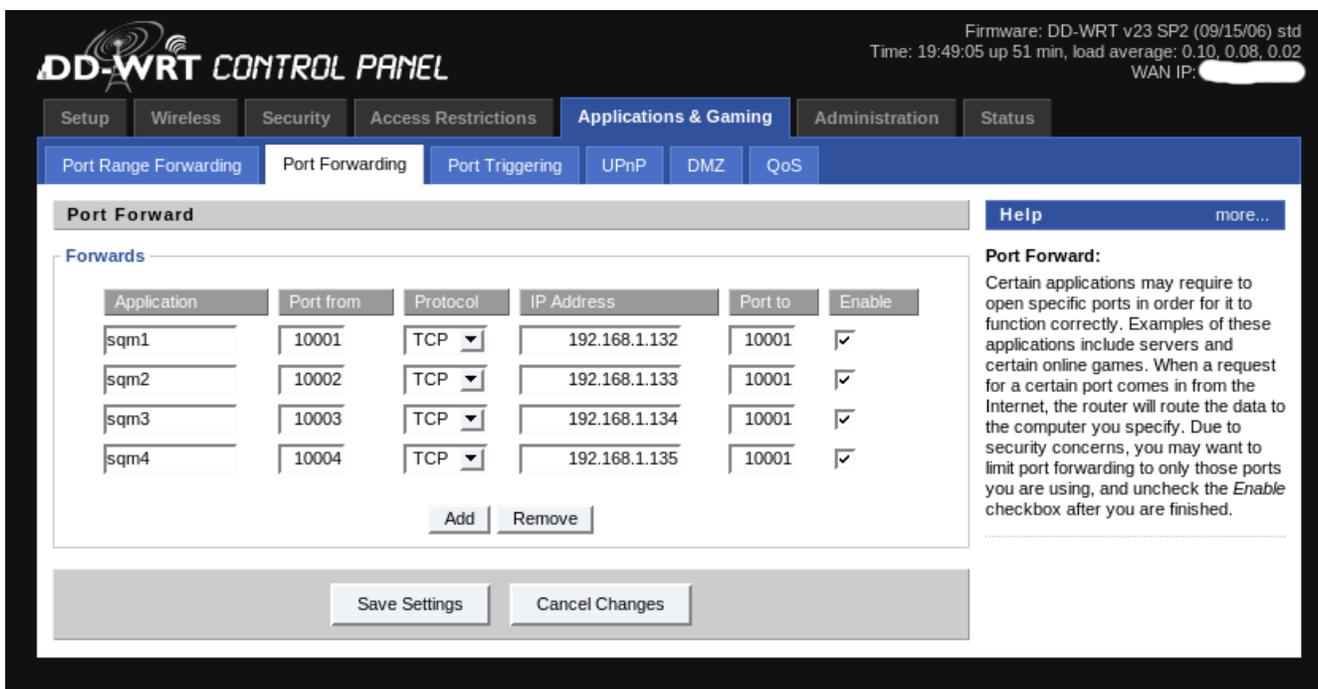


Illustration 5: Port forwarding example

3.4 Direct connection

A direct data connection from the SQM-LE can be made to a PC with the use of a crossover cable.

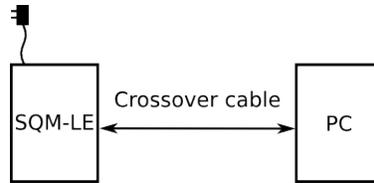


Illustration 6: Direct connection with crossover cable

The SQM-LE does not come shipped with a fixed IP address, so it is necessary to fix that address before installing the unit into such a direct connection system. Use the following steps to set the IP address of the unit:

1. Install the unit into a DHCP system where the IP addresses are assigned to connected devices.
2. Determine the SQM-LE IP address by querying the router or using the Lantronix Device Installer in Windows. In Linux, you may also use nmap to discover connected device IP addresses.
3. Use a browser to go to the SQM-LE IP address as in the following example:
<http://192.168.1.140>
4. There is no default username and password, just press OK.
5. The built in Lantronix XPort Device Server Configuration Manager will appear.
6. Select NETWORK from the left side.
7. Select the radiobutton associated with “Use the following Ipconfiguration:”, and enter the IP address that you would like the unit to occupy in your direct connection system. For example:
IP Address: 192.168.1.141
Subnet Mask: 255.255.255.0
(The “Default Gateway:” field may be left blank.)
8. Press “OK” at the bottom then “Apply Settings” on the menu of the left side of the page and the unit will apply the settings and reboot in about 15 seconds. Since you may have changed the IP address, the web browser will not respond unless you browse to the new address.
9. The unit is now ready for connection into a non-DHCP system or a direct connection system with a crossover cable.

4 Software development

While many languages can be used to connect to the SQM-LE, a Java example is provided because of its portability.

You can modify the Java interface program yourself using the free Sun Java Development Kit (JDK/SDK) which be downloaded from the Sun Microsystems web site.

A simple Java utility is directly installed on the SQM-LE which produces all necessary SQM-LE data. You can browse to <http://xxx.xxx.xxx.xxx/test.html> to see this. You will need at least the following version of Java installed on your computer and accessible by your browser:

- Java Runtime Environment 5 for Windows
- JRE (1.5.0) to be compatible with older Mac installations

To run the Java code from the command line, after installing the JDK, you must make sure that the javac.exe and java.exe executables are accessible from the PATH in DOS.

The java code *.java must be compiled, see Makefile for method.

Only one connection can be made to the SQM-LE at a time. Therefore leaving a connection open constantly prevents other connections from being made.

Interface Program overview:

- A TCP connection must be made directly to the IP address assigned to the SQM-LE.
- The default port of access is 10001.
- Data commands are sent to the SQM-LE, and it responds with a string of characters.

5 Commands and responses

The SQM-LE accepts a sequence of characters as a command, then executes those commands and usually provides a response of a sequence of characters.

5.1 Commands

Commands consist of a string of characters.

The first character is the command type

Command	Description
rx	Reading request
Rx	Reading request with serial number listed
cx	Calibration information request
ix	Unit information request (note lower case i)
zcalAx	Arm Light Calibration command
zcalBx	Arm Dark Calibration command
zcalDx	Disarm Calibration command
zcal5#####x	Manually Set Light Calibration Offset
zcal6#####x	Manually Set Light Calibration Temperature
zcal7#####x	Manually Set Dark Calibration Time Period
zcal8#####x	Manually Set Dark Calibration Temperature
0x19	Reset microcontroller (see bootloader). Hexadecimal value 19.
:	Intel Hex firmware upgrade initiation (see bootloader)
P#####x	Set period (in seconds) for interval reporting to EEPROM and RAM for booting and immediate use. Firmware feature=13.
p#####x	Set period (in seconds) for interval reporting to RAM for immediate use. Firmware feature=13.
T#####x	Set threshold (in mag/arcsec ²) for interval reporting only to EEPROM and RAM for booting and immediate use. Firmware feature=13.
t#####x	Set threshold (in mag/arcsec ²) for interval reporting only to RAM for immediate use. Firmware feature=13.
Ix	Request interval settings (note upper case I). Firmware feature=13.

Table 2: Command summary

5.2 Response details

5.2.1 Reading request

The “Reading” request “rX” or “RX” commands the SQM-LE to provide the current darkness value as well as all variables used to generate that result.

The format of the response is:

Column	Value	Description
0	r	Indicates that a reading is being returned.
2-8	06.70m	Reading in magnitudes per square arc second. Leading space for positive value. Leading negative sign (-) for negative value. A reading of 0.00m means that the light at the sensor has reached the upper brightness limit of the unit.
10-21	0000022921Hz	Frequency of sensor in Hz.
23-33	0000000020c	Period of sensor in counts, counts occur at a rate of 460.8 kHz (14.7456MHz/32).
35-46	0000000.000s	Period of sensor in seconds with millisecond resolution.
48-54	039.4C	Temperature measured at light sensor in degrees C. Leading space for positive value. Leading negative sign (-) for negative value.
55-56		Carriage return (0x0d), Line feed (0x0a).

Table 3: Reading request response

An example is:

```
r, 06.70m,0000022921Hz,0000000020c,0000000.000s, 039.4C
01234567891012345678920123456789301234567894012345678950123456
```

Future revisions of this reading string will only modify reported values beyond position 54. Characters 0 to 54 may be considered stable.

Special case “RX” command returns the serial number in the same format as the interval report does. See page 22 “Setting Interval reporting parameters” for report details.

5.2.2 Calibration information request

The calibration information request “cx” returns all data about the specific light sensor in the unit required for to calculate a reading.

The format of the response is:

Column	Value	Description
0	c	Indicates that the calibration information is being returned.
2-13	00000017.60m	Light calibration offset in magnitudes per square arc second.
15-26	0000000.000s	Dark calibration time period in seconds with millisecond resolution.
28-34	039.4C	Temperature in degrees C measured during light calibration. Leading space for positive value. Leading negative sign (-) for negative value.
36-47	00000008.71m	Offset of light sensor based on manufacturing category.
49-55	039.4C	Temperature in degrees C measured during dark calibration. Leading space for positive value. Leading negative sign (-) for negative value.
56-57		Carriage return (0x0d), Line feed (0x0a).

Table 4: Calibration information request response

An example is:

```
c,00000017.60m,0000000.000s, 039.4C,00000008.71m, 039.4C
012345678910123456789201234567893012345678940123456789501234567
```

5.2.3 Light calibration command

Calibration of the SQM-LE is done at the factory in a controlled light and temperature environment.

Executing the Light calibration command “zcalAx” arms the light calibration mode. Flipping the switch to “unlock” triggers the light calibration and modifies the calibration values in the unit.

A calibrated light source of approximately 13.5fc is supplied to the sensor

The format of the response is:

Column	Example value	Description
0	z	Indicates that a “Calibration” response is being returned.
1	A	Light Calibration
2	a	armed
3	L	L = Locked; Wait for unlock before calibrating after Arm command, firmware upgrades are disabled. U = Unlocked; Calibrate immediately after Arm command, Enable firmware upgrade.
4-5		Carriage return (0x0d), Line feed (0x0a).

Table 5: Light calibration response

An example is:

zAaL

012345

5.2.4 Dark calibration command

Dark Calibration is done at the factory along with Light calibration and calibration temperature recording.

Executing the dark calibration command “zcalBx” arms the dark calibration mode. Flipping the switch triggers the dark calibration and modifies the calibration values in the unit.

Dark calibration is performed in a completely dark environment. Check a reading to ensure that the period is correct after entering the dark environment, it could take a few minutes to collect an accurate dark period. A dark period of only a few seconds is too small.

The format of the response is:

Column	Example value	Description
0	z	Calibration response is being returned.
1	B	Dark Calibration.
2	a	Armed.
3	L	L = Locked; Wait for unlock before calibrating after Arm command, firmware upgrades are disabled. U = Unlocked; Calibrate immediately after Arm command, Enable firmware upgrade.
4-5		Carriage return (0x0d), Line feed (0x0a).

Table 6: Dark calibration response

An example is:

zBaL

012345

5.2.5 Disarm calibration command

The Disarm calibration command “zcalDx” disarms calibration modes from being triggered by the unlock mode.

The format of the response is:

Column	Example value	Description
0	z	Calibration response is being returned.
1	x	All calibration modes.
2	d	Disarmed.
3	L	L = Locked; Wait for unlock before calibrating after Arm command, firmware upgrades are disabled. U = Unlocked; Calibrate immediately after Arm command, Enable firmware upgrade.
4-5		Carriage return (0x0d), Line feed (0x0a).

Table 7: Disarm calibration response

An example is:

zxdL

012345

5.2.6 Unit information

Unit information command “ix” provides details about the software in the microcontroller.

The format of the response is:

Column	Example value	Description
0	i	Indicates that the unit information response is being returned.
2-9	00000002	Protocol number (8 digits). This will always be the first 8 characters (after the “i,” response). This value indicates the revision number of the data protocol to/from the SQM-LE. The protocol version is independent of the feature version.
11-18	00000003	Model number (8 digits). The model value identifies the specific hardware model that the firmware is tailored for.
20-27	00000001	Feature number (8 digits). The feature value identifies software features independent of the data protocol.
29-36	00000413	Serial number (8 digits). Each unit has its own unique serial number.
37-38		Carriage return (0x0d), Line feed (0x0a).

Table 8: Unit information request response

An example is:

```
i,00000002,00000003,00000001,00000413
012345678910123456789201234567893012345678
```

5.2.7 Manually set light calibration offset

Calibration is done at the factory, however, in the case where calibration values must be restored or set to something else, this command allows a new calibration value to be placed into the SQM-LE.

Executing the command “zcal5#####.##x” manually sets the light calibration offset to the value specified in “#####.##”. The units are $\frac{\text{magnitudes}}{\text{arcsecond}^2}$.

The format of the response is:

Column	Example value	Description
0	z	Calibration response is being returned.
2	5	Manual Set Light Calibration Offset
4-15	00000017.60m	Value that was set into EEPROM
16-17		Carriage return (0x0d), Line feed (0x0a).

Table 9: Response for manual setting of light calibration offset

An example is:

z,5,00000017.60m

0123456789¹⁰1234567

5.2.8 Manually set light calibration temperature

Calibration is done at the factory, however, in the case where calibration values must be restored or set to something else, this command allows a new calibration value to be placed into the SQM-LE.

Executing the command “zcal6#####.##x” manually sets the light calibration temperature to the value specified in “#####.##”. The units are °C.

Note: The SQM-LE records the temperature in a raw value with different resolution, so the reply back may not be exactly the same as the value sent.

The format of the response is:

Column	Example value	Description
0	z	Calibration response is being returned.
2	6	Manual Set Light Calibration Offset
4-9	019.0C	Value that was set into EEPROM
10-11		Carriage return (0x0d), Line feed (0x0a).

Table 10: Response for manually setting of light calibration temperature

An example is:

z,6,019.0C

0123456789¹⁰1

5.2.9 Manually set dark calibration time period

Calibration is done at the factory, however, in the case where calibration values must be restored or set to something else, this command allows a new calibration value to be placed into the SQM-LE.

Executing the command “zcal7#####.###x” manually sets the light calibration offset to the value specified in “#####.###”. The units are in seconds.

The format of the response is:

Column	Example value	Description
0	z	Calibration response is being returned.
2	7	Manual Set Light Calibration Offset
4-15	0000300.000s	Value that was set into EEPROM
16-17		Carriage return (0x0d), Line feed (0x0a).

Table 11: Response of manually setting dark calibration time period

An example is:

z,7,00000300.00s

0123456789¹⁰1234567

5.2.10 Manually set dark calibration temperature

Calibration is done at the factory, however, in the case where calibration values must be restored or set to something else, this command allows a new calibration value to be placed into the SQM-LE.

Executing the command “zcal8#####.##x” manually sets the light calibration offset to the value specified in “#####.##”. The units are °C.

Note: The SQM-LE records the temperature in a raw value with different resolution, so the reply back may not be exactly the same as the value sent.

The format of the response is:

Column	Example value	Description
0	z	Calibration response is being returned.
2	8	Manual Set Light Calibration Offset
4-9	019.0C	Value that was set into EEPROM
10-11		Carriage return (0x0d), Line feed (0x0a).

Table 12: Response for manually setting of light calibration temperature

An example is:

z,8,019.0C

0123456789¹⁰1

5.2.11 Setting Interval reporting parameters

For firmware feature 13 and above, the SQM-LE is capable sending timed interval reports. Each interval report is the same as the reading request report except that the serial number (feature 14 and above) is attached at the end so that numerous reporting SQM-LEs can be distinguished from each other.

The format of the interval report is:

Column	Value	Description
0	r	Indicates that a reading is being returned.
2-8	06.70m	Reading in magnitudes per square arc second. Leading space for positive value. Leading negative sign (-) for negative value. A reading of 0.00m means that the light at the sensor has reached the upper brightness limit of the unit.
10-21	0000022921Hz	Frequency of sensor in Hz.
23-33	0000000020c	Period of sensor in counts, counts occur at a rate of 460.8 kHz (14.7456MHz/32).
35-46	0000000.000s	Period of sensor in seconds with millisecond resolution.
48-54	039.4C	Temperature measured at light sensor in degrees C. Leading space for positive value. Leading negative sign (-) for negative value.
55-63	00000413	Serial number (8 digits). Each unit has its own unique serial number.
64-65		Carriage return (0x0d), Line feed (0x0a).

Table 13: Interval report

An example is:

```
r, 06.70m,0000022921Hz,0000000020c,0000000.000s, 039.4C,00000413
012345678910123456789201234567893012345678940123456789501234567896012345
```

Interval reporting is available for sending timed reports to a listening server in the case where the SQM-LE IP address will not be known, but the server IP address will be fixed. One such application is where an SQM-LE is connected via a telephone/cell-phone based router to an Internet Service Provider. The server must have listening software running similar to the following:

```
#!/usr/bin/perl
use IO::Socket;
while(1){
my $sock = new IO::Socket::INET (
    LocalHost => '192.168.1.145',    #IP address of this computer/server
    LocalPort => '10002',          #Port defined by
    # XPort:Channel_1:Connection:Endpoint_Configuration:RemotePort
    Proto => 'tcp',
    Listen => 1,
    Reuse => 1,
);
    die "Could not create socket: $!\n" unless $sock;

my $new_sock = $sock->accept();
while(<$new_sock>) {
    ($sec,$min,$hour,$mday,$mon,$year,$wday,$yday,$isdst)=localtime(time);
    printf "%04d-%02d-%02d,%02d:%02d:%02d,", $year+1900,$mon+1,$mday,$hour,$min,$sec;
    print $_;
}
close($sock);
}
```

Text 1: Listener script for interval based reports

To prevent reports being sent during daylight when the meter is saturated with light, a threshold value can be set. Readings exceeding the threshold (dark) will be reported, low readings (too bright) will be suppressed.

Due to the construction nature of EEPROM, there is a limited number of times that this memory can be written to before it becomes unreliable. In the case of the SQM-LE, the erase/write cycle is 1 million times. For this reason, it is recommended that frequent parameter changes be done in RAM rather than in EPROM. Only set the parameter to EEPROM when you want the unit to boot up with your setting. See following sections for how to set EEPROM or RAM.

Loading firmware clears resets the micro-controller effectively copying the EEPROM values into RAM.

Note: the above listener script is a simple receive only program. In a telephone mode system, the SQM-LE sends the response to the listener, and nothing can send requests back to the SQM-LE. So it is advised that all settings be tested before isolating the SQM-LE in remote locations. The other option to getting new requests back to the SQM-LE would be altering the listener script to queue requests during the short time that the SQM-LE connects back to the listener server.

5.2.11.1 XPort settings for interval reporting mode

The Ethernet adaptor module must be configured for sending interval based reports to a server. To set the SQM-LE to know the listener IP address use a web browser to access the SQM-LE, just type in the IP address of the SQM-LE into a web browser and you will be asked for a name and password, just hit enter, there is nothing set at default. You will be given a XPort configuration screen. You can also do the same things with the Lantronix Windows based "Device Installer" program included on the CD. Set the XPort as shown in this example:

```
Channel_1:Connection:
  Active_Connection:ActiveConnect = "With_Any_Character"
  Endpoint_Configuration:RemotePort = 10002
  Endpoint_Configuration:RemoteHost = 192.168.1.145
  Disconnect_Mode:Inactivity Timeout: = 0:2 (mins:secs)
```

Text 2: XPort settings for interval reporting mode

Note: The `RemotePort` is different than the typical 10001 to avoid problems with regular SQM-LE clients. Also, the `RemoteHost` is set to the IP address of your listener server. If the modem takes a long time to connect then the timeout should be extended.

The Inactivity timeout should not exceed the interval time otherwise the unit may lock out other communications requests. If this occurs, you can recover by way of the Lantronix device installer or Lantronix web interface by typing the SQM-LE IP address into a web browser (hit enter on user name/password). Then set the `Channel1:Connection:Disconnect-Mode:Inactivity-Timeout=0:2 (mins:secs)`, then press OK, then "Apply Settings".

If the Inactivity timeout is too short, a telephone modem connection system may not have enough time to send the message before the XPort gives up.

If the Inactivity timeout is too long, then a telephone modem connection may stay active all the time resulting in excessive connection costs.

5.2.11.2 Interval reporting period setting

Executing the command "P#####x" (note upper case "P") sets the period of the timed interval reports to the EEPROM and RAM for booting and immediate use.

Executing the command "p#####x" (note lower case "p") sets the period of the timed interval reports to RAM only for immediate use.

The units are seconds. For example, p0000000360x sets the reporting time to once every 360 seconds.

5.2.11.3 Threshold setting for interval reporting

Executing the command “T#####.##x” (note upper case “T”) sets the threshold of the timed interval reports to EEPROM and RAM for boot and immediate use.

Executing the command “t#####.##x” (note lower case “t”) sets the threshold of the timed interval reports to RAM for immediate use only.

The units are $\frac{\text{magnitudes}}{\text{arcsecond}^2}$. For example, t00000016.00x limits reporting to values only over 16.00 $\frac{\text{magnitudes}}{\text{arcsecond}^2}$.

5.2.11.4 Interval setting response

Either making the request “Ix” (note upper case “I”) or any request to set the interval report setting produces the following response:

Column	Example value	Description
0	I	Interval settings from EEPROM and RAM are being returned.
2-12	0000000360s	Interval period that was set into EEPROM
14-24	0000300360s	Interval period that was set into RAM
26-37	00000017.60m	Threshold value that was set into EEPROM
39-50	00000017.60m	Threshold value that was set into RAM
51-52		Carriage return (0x0d), Line feed (0x0a).

Table 14: Response of viewing or setting interval reporting parameters

An example response is:

```
I,0000000360s,0000000360s,00000017.60m,00000017.60m
012345678910123456789201234567893012345678940123456789501
```

6 Electrical connection

An AC/DC adaptor is provided. The SQM-LE uses a voltage regulator to bring the incoming DC voltage down to 3.3VDC. The lowest voltage at the input should be 4.5VDC (3.3 + 1.2VDC). Higher voltages above 6VDC will cause heating on the regulator and thermal shutdown in high ambient temperatures.

For remote applications, a deep-cycle (Lead Acid) 6VDC battery can be used.

The SQM-LE unit is NOT protected against over-voltage (above 20V) or reverse polarity voltage.

7 Mechanical installation

Unihedron sells an enclosure that is suitable for mounting either the SQM-LE or SQM-LU into. You can read more about it, including plans to build your own here:

<http://unihedron.com/projects/sqmhousing/>



Illustration 7: Housing

7.1 Cover selection

If the unit is to be mounted in exposed location, we recommend an acrylic dome. Acrylic domes will last 2-3 years but eventually weather on the surface. It is not clear that this will affect the reading much. The best test would be to swap a weathered and new one back and forth when changing one out. Presumably the main consideration would be to keep the domes clean every so often and to make sure that the mounting plane is painted black to that it doesn't reflect light back to the inside of the dome and then back into the meter.

Source of Acrylic domes: <http://www.globalplastics.ca/domes.htm>

7.2 Cover calibration

Since the SQM-LE is not weather-proof, it must be protected in some way from the elements. A plastic dome is recommended. This may reduce the incoming light by about 15-20%.

Because a covering will reduce the incoming light, the resultant reading will be darker (higher

magnitudes per arcsecond² value). The offset determined by a simple light experiment should be subtracted from the reading.

A pending firmware edition will allow for built in manual offset. Apply this subtraction offset as a negative value, i.e. if you measured 16.60 outside the covering, then 16.75 under the dome, then an offset of -0.15 should be applied to all readings.

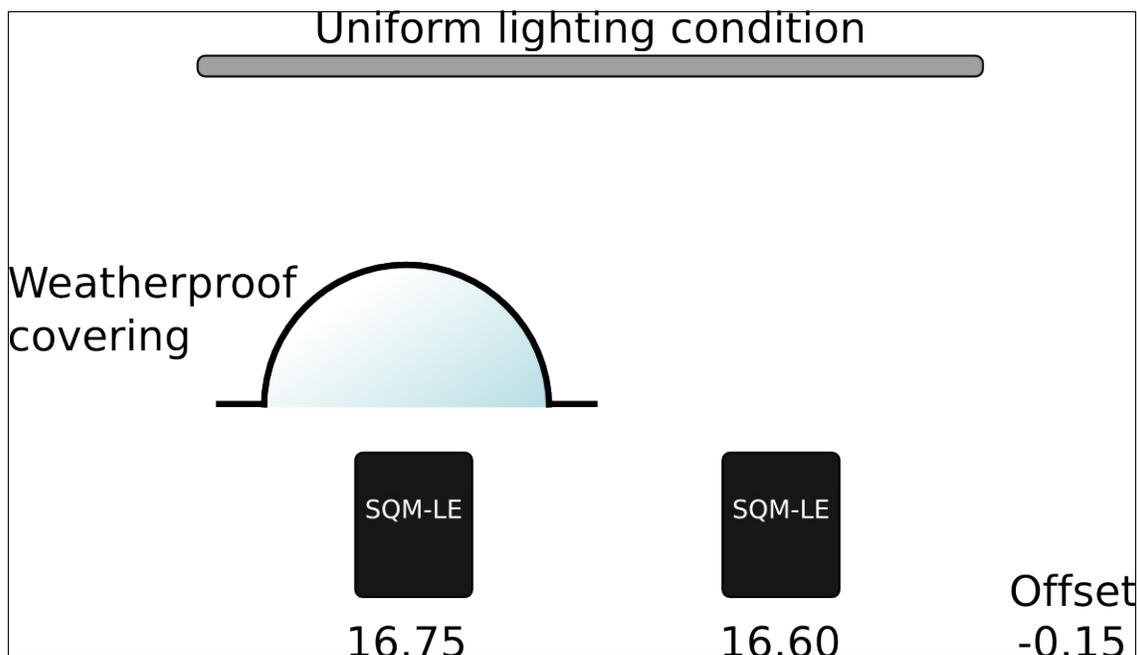


Illustration 8: Example cover calibration

7.3 Cover maintenance

Keep the covering clean of dust, water, ice, and bird droppings.

8 Default settings

The XPort Ethernet interface has been programmed with the following default settings so that it can communicate with the SQM-LE microcontroller:

Setting description	Value
Configurable pins: CP2:	HW Flow Control In (CTS from microcontroller)
Channel 1: Serial Settings: Baud rate	115200
Channel 1: Serial Settings: Flow control:	CTS/RTS Hardware

Table 15: Default settings

If for some reason these settings are altered, they can be restored using the Lantronix Device Installer under Windows.

Also, a small web page and some Java files have been installed onto the XPort Ethernet interface so that the SQM-LE can be accessed as a web page. The following steps were used to install that software:

```
C:> web2cob /d source /o web1.cob
```

```
C:> tftp -i xxx.xxx.xxx.xxx PUT \web\web1.cob WEB1
```

Note, replacing WEB1 will overwrite the Ethernet Web reconfiguration pages, consider using WEB6 if you want to retain the existing pages on the XPort Ethernet interface.

More details for installing your own web page and Java software can be found at the Lantronix website in their FAQ titled: **Web Enabling Your Serial Device** .

9 Firmware upgrade

9.1 Obtain update

1. Visit unihedron.com/projects/sqm-le/cd
2. You should see a list of files. The updates have names like **SQMLEUPDATE-3-3-xx.zip**
3. Download the most recent version (with highest number in filename), select “**save link as**” or “**save target as**”.

9.2 Install update

1. Uncompress the zip file that you downloaded into a directory. If you are using Windows-XP, the file may already have been uncompressed automatically into a folder on your desktop.

9.3 Preparing the SQM-LE for firmware update

1. Ensure that the unit is unlocked (switch in unlock position (up) or on older units, the jumper must be installed at back of unit).
2. Make sure you know what IP address the SQM-LE occupies, use the Lantronix device installer software if necessary, available at <http://unihedron.com/projects/sqm-le> .

9.4 Run update

1. Using the command line, navigate to the directory that contains the installed files.
2. Run the Java updater program. to get usage instructions, type:

```
java -jar jsQM-LE.jar -h
```

Description for jsQM-LE.jar:

- o Multiplatform tool for use with the Unihedron SQM-LE
- o Identify IP address. Test functionality. Load firmware

Usage:

```
java -r jsQM-LE.jar [-i<ip-address>] [-p<port>] [-f<filename>]
```

Where:

<ip-address> is the optional IP address of the SQM-LE.

<port> is the optional port of the SQM-LE, the default port is 10001.

<filename> is the name of the optional loadable firmware file.

Examples:

```
java -jar jsQM-LE.jar
```

```
java -jar jsQM-LE.jar -i192.168.1.140 -p10001 -fSQMLE-3-3-13.hex
```

Text 3: Java updater usage

The following image shows what the updater looks like when first started:

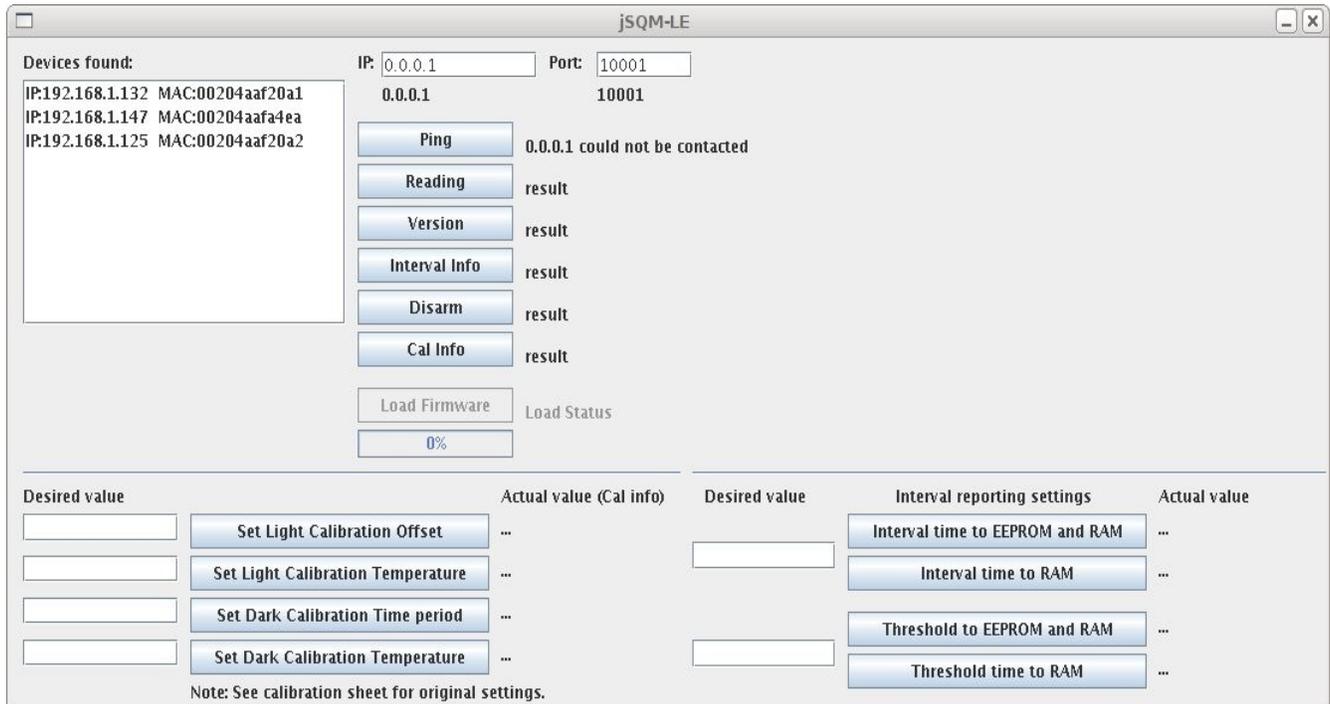


Illustration 9: Java updater screen

Click on the line in device found list where the MAC: number matches your SQM-LE MAC as defined on the back of the unit.

Press the PING button.

You should get xxx.xxx.xxx.xxx is reachable, if not, then the unit is not accessible to your computer, check the connection and retry the “Ping” button.

To ensure that you are connected to an SQM-LE, try the “Reading” button. An SQM-LE will respond with a string of characters as defined in the reading section, anything else will time out with no response.

Pressing the Disarm button will report if the unit is Locked or Unlocked. A U as the final character indicates Unlocked and ready for firmware uploads, (ex. result=zxdU).

When you are ready to load the firmware into the unit, press the “Load Firmware” button. You will see the progress bar increment until 100% then the Load Status will display “Finished”.

If the firmware button is inactive, then make sure you specified the firmware version on the command line as with the -f option as shown above in Text 3: Java updater usage on page 30.

Pressing the Load Firmware button sets the Interval period in RAM to 0 to prevent the SQM-LE from sending reports out and polluting the receive buffer. After the firmware has been loaded successfully, the SQM-LE restarts the micro-controller and sets the RAM value to the EEPROM value. So you should confirm that all your Interval settings as you wish after any firmware installation.

9.5 Details

The SQM-LE microcontroller is equipped with a bootloader mechanism which is enabled within a few seconds after reboot/reset.

Intel hex strings sent to the unit will be used to overwrite program memory. The following link contains a thorough description of the Intel Hex format: <http://en.wikipedia.org/wiki/hex>

The included Java updater application can be examined for operation. The basic requirements for firmware uploading are:

1. Reset microcontroller by sending the hex character 0x19
2. Within a few seconds, send the first Intel hex record. The colon “:” character indicates the beginning of an Intel Hex record.
3. Wait for a response of “Ok” followed by “CR LF” which indicates that the record was processed properly.
4. Continue sending records and waiting for the acknowledgement.
5. The unit will reset on its own when no more records have been sent for a few seconds.

10 Calibration

The SQM is factory calibrated and a sheet of the calibration values was provided. Contact Unihedron with your unit's MAC address if you need a copy of the original calibration sheet.

Some possible reasons for recalibration are:

1. A new covering/housing is being used besides the small case that the unit was shipped with.
2. A regular maintenance program is desired. There is no great need for this as the SQM has no analog components.
3. Compensation for aged housing, if a plastic dome is used that might have degraded over time.
4. Replaced lens or changed field of view for experimental reasons.

1.2 Light calibration

The sensor must have a reference point for an amount of light against the signal produced. It is not recommended that this be done after factory calibration and relied upon since an improper setup will result in non-standard results.

A fluorescent light is used to simulate the spectrum that the meter would see during the night sky. A light meter is used to adjust the light reading to 13.5 fc at the place of the SQM. The light calibration routine inside the SQM expects to see this value.

The light that the SQM and light meter see must be coming from an evenly lit surface.

The `light calibration` command can be sent to the unlocked SQM to set the calibration value.

1.3 Dark calibration

The optical sensor in the SQM produces a reading even when totally dark. This `dark level` reading must be determined so that the meter can compensate for it.

The method of dark calibration is simply to prevent any light from entering the meter then execute a `dark calibration` command to the unit. A darkroom bag is one way to prevent light from entering the unit.

The optical sensor provides timed pulses depending on the amount of light entering. In a dark environment the pulses will be long. The meter has a timeout of 300 seconds, so the dark calibration will take at least 5 minutes (300 seconds) to perform.

Place the unit in a dark environment and monitor the timed readings (rx reading request) consistent, normally the value is in the 80-300second range

Execute the `dark calibration` command.

1.4 Confirmation

Once the calibration has been done, you should be able to get a light reading from the unit at the calibration light level of the same value as the value printed on your calibration sheet in the

Calibration offset field, Normally this field has a value of 8.71 mags/arcsec²

11 Troubleshooting

Communication: Check connection lights on SQM-LE Ethernet port.

Reading: too bright, too hot, inspect lens for IR filter.

Problem	Unit will not respond to ping or any network activity
Cause	Ethernet interface did not properly negotiate an IP address when starting up
Solution	<ol style="list-style-type: none"> 1. Re-cycle power on SQM-LE so that its Ethernet port can re-negotiate an IP address. 2. Use the Lantronix Device Installer program under Windows (supplied on CD as DI_4.2.0.0.exe). This will identify all SQM-LE units on the attached network. 3. It is possible that a firewall may be running, especially on Windows Vista. Try shutting off the firewall temporarily.

Problem	Error 404 when trying to reconfigure Ethernet port using the web interface
Cause	<p>The interface pages may have been overwritten by a “tftp put” to the wrong remotefile.</p> <p>The default XPort Ethernet reconfiguration web interface occupies at least 3 blocks of 64k (WEB1-WEB4). WEB5-6 could be used for custom application pages (like test.html) which take up to 128K.</p>
Solution	<p>Get the web interface from Lantronix for the XPort-03, then install using the following tftp command:</p> <p>for Windows:</p> <pre>tftp-i <ip address> put xpt_webm_1602.cob WEB1</pre> <p>for Linux (using tftp-hpa):</p> <pre>tftp <ip address> -m binary -c put xpt_webm_1602.cob WEB1</pre>

Problem	Unit can be pinged but readings are not returned
Cause	The default communication settings between the XPort micro-controller may have been changed.
Solution	Check section 8 (Default settings) for proper baud rate, etc.

Problem	SQM-Reader version 1.2 and earlier while reports reading errors while the Java updater utility correctly reports text strings.
Cause	Regional settings in Windows may be set for the European standard for decimal separators as commas “,” instead of periods “.”.
Solution	Upgrade to a newer version of SQM-Reader by Knightware or modify your regional settings to use periods as the decimal point separators.

12 Company contact information

Mailing address	Unihedron 4 Lawrence Avenue Grimsby, Ontario L3M 2L9 Canada
Telephone	(905) 945-1197
Fax	(905) 945-6770
Website	unihedron.com
Email	info@unihedron.com

13 Glossary

DHCP	Dynamic Host Configuration Protocol (DHCP) is a network application protocol used by devices (<i>DHCP clients</i>) to obtain configuration information for operation in an IP network. Routers equipped with DHCP are capable of assigning an IP address to the SQM-LE
EEPROM	Electrically Erasable Programmable Read Only Memory is a type of memory that retains its contents after the power has been removed. This type of memory has a limited write/erase cycle as well as a lifetime for data retention. .In the SQM-LE, the parameters in the micro-controller can be written 1 million times and last for 100 years.
SQM-LE	Sky Quality Meter with lens and Ethernet connectivity.
IP address	Internet Protocol address is the numerical identification of a device on a network The SQM-LE, by default, has an assignable IP address, but can also be set to have a fixed IP address.
MAC address	Media Access Control address is the hardware address assigned to Ethernet enabled devices. This address is usually unchangeable.

14 Appendix A Revision history

14.1 Manual Revision history

Revision	Description
1.0	Initial product release.
1.1	Added Company contact information.
1.2	Added image of unit back exterior.
1.3	Added instructions for manually setting calibration values.
1.4	Corrected string length description of manual set calibration values.
1.5	Update specifications with more details.
1.6	Clarify instrument precision specification.
1.7	Added some troubleshooting tips.
1.8	Added troubleshooting on decimal separator.
1.9	Addition of Interval reporting commands for firmware feature 13.
1.10	Update Java usage instructions for firmware loading.
1.11	Added notes about “Load Firmware” actions with Interval reporting RAM settings.
1.12	Added Quick Start section
1.13	Added Interval reporting serial number.
1.14	Added operating temperature range specification.
1.15	Addition of Unihedron housing description
1.16	Addition of calibration description. Add troubleshooting note about Windows firewall.
1.17	Addition of “Rx” command for unit serial number included in report string.

14.2 Protocol revision history

Revision	Description
3	Initial product release.
4	Interval report (reading) includes serial number at end.

14.3 Feature revision history

Revision	Description
9	Initial product release.
10	Power up default reset for command busy.
11	Ability to manually sett calibration values.
12	Temperature averaging added.
13	Interval report feature added.
14	Interval report includes serial number.
16	Rx report includes serial number.