

SXL1

USERS MANUAL



SXL1 Asset Tracking Solution
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DRAFT

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SXL1

The SXL1 is a small but fully self-contained, global satellite-based tracking device capable of determining location using GPS and reporting the location over a low earth orbit (LEO) satellite network. The SXL1 is powered by a field replaceable battery and requires no wiring or harnesses for use.

The SXL1 communicates data via the Globalstar Simplex Data Service. This satellite service utilizes low power, one-way transmitters to relay data from locations globally to a back office server accessible over the internet through secure connection. The use of one-way, simplex satellite communications is a proven, reliable method to inexpensively collect widely scattered asset data. The device is speak only, so there is no way to communicate to the device in the field. This feature is mitigated by a rich configuration capability that enables the SXL1 to automatically detect situations where a data update is desired, such as start and stop or while in motion.

This Users Manual describes how the SXL1 is configured and the protocol for on-air data payload and internet XML packets. This document provides a generalized overview only. Consult Numerex for more details and options of relaying data.

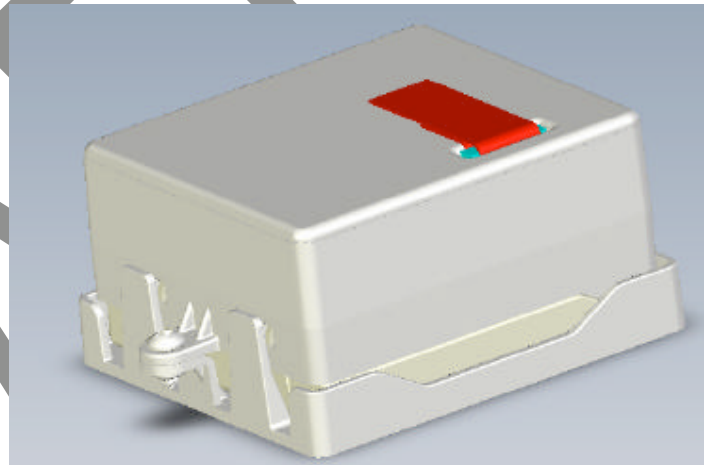
Connecting the SXL1 to the Computer

The SXL1 is available in preconfigured operational modes. These modes are determined at point of manufacture or at OEM depot distribution. Field configuration should only be performed by installation specialists to avoid configuration errors. Since the device does not support over-the-air configuration and must be connect using a short range RF link, it is important the devices are properly configured for use.

The SXL1 contains a short range RF transceiver for setting the device for operation. This transceiver communicates with a like transceiver in the SXL1 programmer. The SXL1 programmer provides the interface for configuring the device using the SXL1_Programmer setup tool available from Numerex.

The SXL1_Programmer software tool is designed to operate on a Microsoft Windows® XP-based computer. The Microsoft .NET framework is also required to run the configuration setup software. This is a default Windows® XP add-on, and may also be downloaded from www.microsoft.com without charge.

A USB Type A cable coming from the SXL1 programmer (right) is used to connect to the computer being used to configure the device. Connect the computer to the SXL1 programmer using the USB cable, and then run the SXL1_Programmer software tool. The SXL1_Programmer software will automatically begin searching for available SXL1 units.



SXL1_Programmer Software

The SXL1_Programmer is a Windows® executable software program designed to access and configure the SXL1. The program can simply be copied to a directory on the computer.

When launched, the program will auto-detect a SXL1 programmer. If a programmer is detected the SXL tab will appear along the top of the program window

The SXL1_Programmer tool is structured as a standard Windows application with tabs along the top of the display area that groups similar configuration controls and displays. The bottom of the display remains constant; showing the ESN of the connected SXL1, sleep mode indicator/control, and two buttons used to read back a device configuration or write/configure a device for operation.

The “Sleep SXL1” button queries the configuration of the connected device (populating the dialog boxes of the tool) and then places the device to sleep. This button is used to force a device to sleep without changing the configuration.

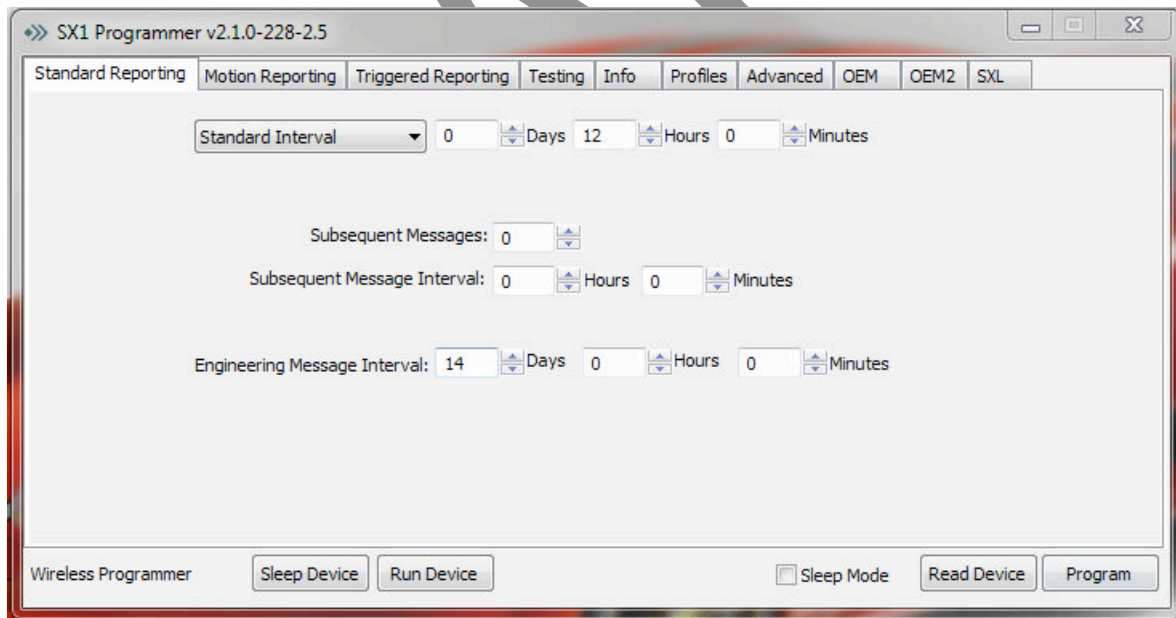
The “Run SXL1” button queries the configuration of the connected device (populating the dialog boxes of the tool) and then places the device into run mode. This button is used to force a device to run using the pre-configured settings.

The “Sleep Mode” checkbox is used to select the operating mode of the device subsequent to configuration. If checked, a unit is left in low-power sleep mode following programming. If unchecked, the device is left in run-mode following programming. If a device is read for configuration, the sleep mode checkbox will reflect the current state of the device being queried.

The “Read SXL1” button queries the device connected for configuration. The current configurations held in the dialog boxes of all the tabs will be overwritten by the settings of the device being queried.

The “Program” button configures the device connected using the dialog boxes of all the tabs. The button may be used repetitively on subsequent units to configure a set of devices identically.

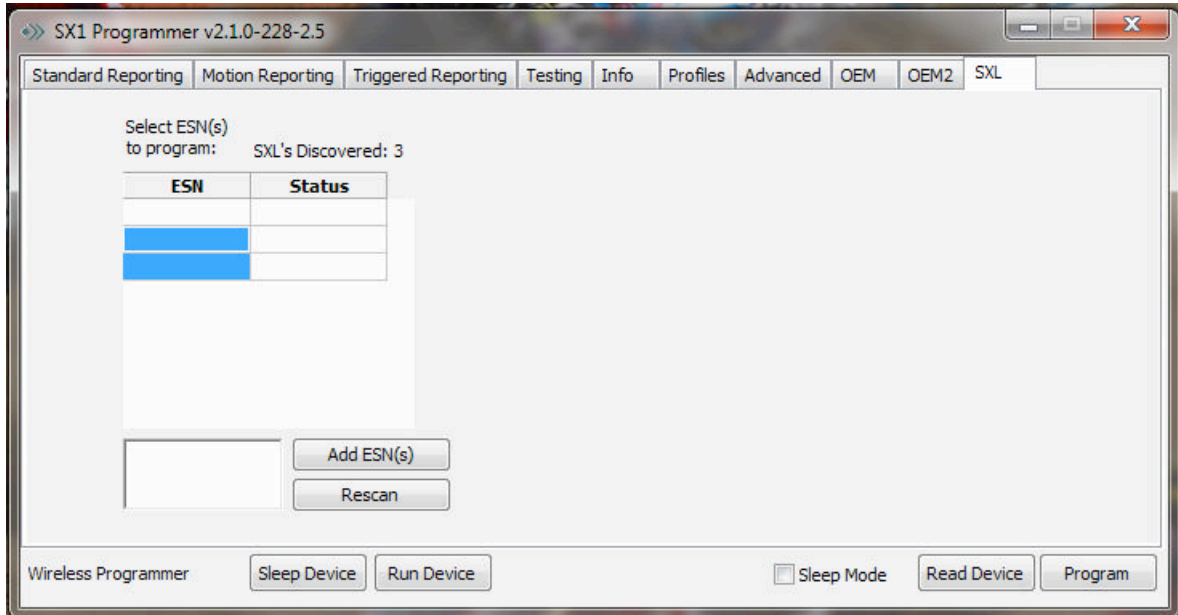
When a device is connected to the computer and read, the SXL1_Programmer panel will show the ESN in the lower left corner.



When the program is started the dialog boxes are initialized to the manufactured standard configuration. If a device is read after being connected to the computer the dialog boxes are populated with the device configuration. Connecting to a device after the program is launched will not change the dialog boxes.

SXL Tab

The “SXL” tab only appears if the program detects that a SXL1 programmer is attached to the computer. The SXL tab contains functions specific to the RF link between the transceiver in the SXL1 and the SXL1 programmer.

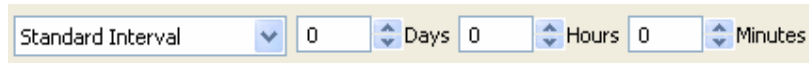


When the program is first opened and it detects a SXL1 programmer, it will initiate a scan for SXL1 devices within its RF range. The scan will last approximately 7.5 seconds. If the ESN of the desired SXL1 does not show up in the discovered SXLs dialog box there are 2 ways to try acquire a RF link with it. The first is to click the “Rescan” button. This will start another 7.5 second scan for available devices. If the ESN is known it may be typed into the lower dialog box and the “Add ESN(s)” button is clicked. This causes the programmer to try and talk specifically to the specified device. Once the device is found it will show up in the dialog box with the Status of connected listed next to it. Click on the ESN that you would like to configure.

If the desired profile is currently being displayed by the setup tool and there are more than one SXL1 that needs to be configured with this profile, click and drag down, highlighting all of the devices to be configured. Once the devices are high lit, click the “Program” button to configure them all at the same time.

Standard Reporting Tab

The “Standard Reporting” tab is used to configure the device for routine position reporting. The SXL1 can be configured to report on a time delay between reports (Standard Interval) or at a specific time of day (Time of Day). The pull down dialog box is used to select one or the other mode.



Standard Interval Days Hours Minutes

Or



Time of Day Hours Minutes

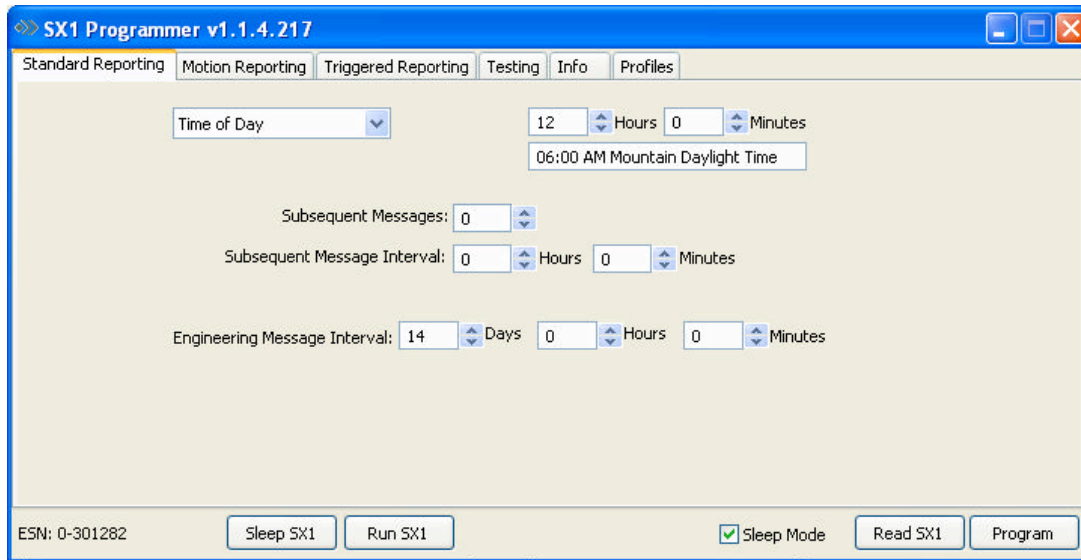
Note that if Standard Interval is selected, the user may use the “Days, Hours, Minutes” controls to set the amount of time between a standard location report. If “Time of Day” is selected, the “Days” control is not available, the user is prompted to select the hour and minute of the day for reporting. The device will wake once a day at this time to perform the standard report. Time of Day is provided in UTC (GMT) format only. Displayed below the UTC setting is the correlating time of your current time zone as set by your computer. If enabled for Time of Day, the user should specify the time at Greenwich Mean Time for operation.

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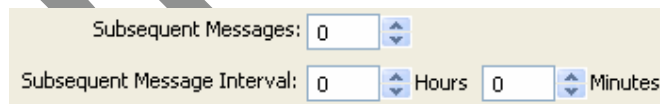
Note: When programming SXL1 for Time of Day reporting:

Programming for Time of Day mode within 1 hour of the scheduled time will result in the first days message being pushed out 24 hours. Also, if the device time is not current, the first time of day event may take a complete 24 hours from time of program to complete. Users should thus allow up to 48 hours for the unit to begin reporting on schedule.

Time of day reporting mode is set in UTC. Displayed below the UTC setting is the correlating time of your current time zone as set by your computer.

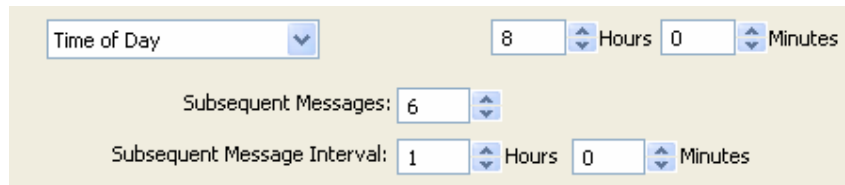


The Subsequent Message function is configured using the Subsequent dialog entry boxes:



Subsequent Messages are sent following the Standard report. The “Subsequent Messages” dialog configures the count of messages to be sent subsequent to the standard report. The “Subsequent Message Interval” sets the time in hours and minutes between subsequent reports.

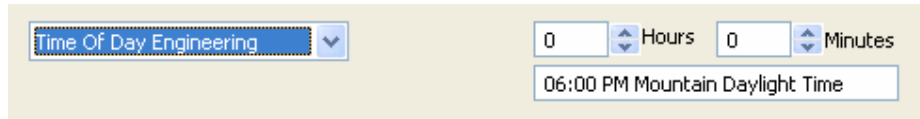
For example, a device configured to report daily at 8 AM and hourly thereafter for 6 hours would be configured as:



Also, on the Standard Interval tab is the dialog to configure the Engineering Message. The Engineering Message is a transmitted message containing data related to the health and operation of the SXL1. It is advisable to send the Engineering Message routinely, typically monthly or bi-weekly.



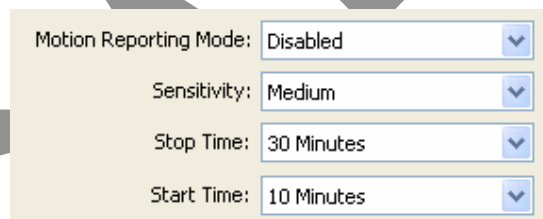
The Engineering message interval may also be configured for time of day operation. This is useful, for example, when requiring a daily count of engine runtime.



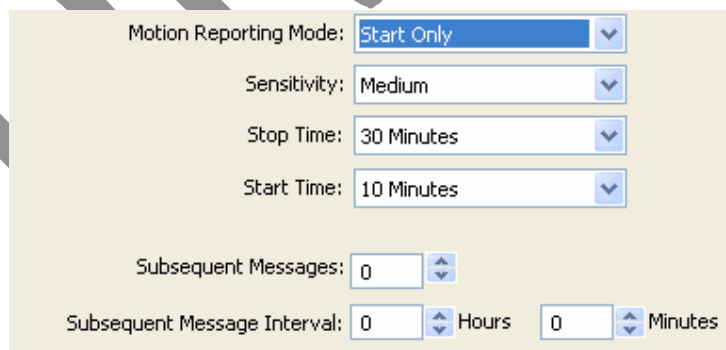
Motion Reporting Tab

The “Motion Reporting” tab is used to configure the device for detecting and reporting while in motion. The Motion Reporting Mode pull down dialog box is used to select one of four modes of motion detection and operation:

Disabled: Disabled mode configures the device to do nothing regarding motion. The Sensitivity and Stop Time dialogs are ignored.



Start Only: Start Only mode configures the device to detect start of motion and report. The Sensitivity sets the device for low, medium and high sensitivity. Stop Time sets the amount of time in minutes that the unit does not detect motion, before the device drops out of motion. The Start Time sets the amount of time in minutes that the unit detects motion, before the device reports in motion.



As with the Standard reporting function, the device may be configured to report subsequently following motion start detection. For example, a device may be configured to detect motion start and report every 30 minutes subsequently for 4 reports.

Start / Stop: Start / Stop mode configures the device to detect start or stop of motion and report. The Sensitivity and Start and Stop Time configurations are as described earlier. The device only reports start and stop of motion. No subsequent reporting is configurable in this motion mode.

Motion Reporting Mode: Start / Stop

Sensitivity: Medium

Stop Time: 30 Minutes

Start Time: 10 Minutes

In Motion: In Motion mode configures the device to detect start and stop of motion and report at a set interval while remaining in motion. The Sensitivity and Start and Stop Time configurations are as described earlier. The Subsequent Message Interval controls set the time between reports while the unit remains in motion. The Subsequent Message dialog (count) is ignored.

Motion Reporting Mode: In Motion

Sensitivity: Medium

Stop Time: 30 Minutes

Start Time: 10 Minutes

Subsequent Messages: 0

Subsequent Message Interval: 0 Hours 0 Minutes

Triggered Reporting Tab

The “Triggered Reporting” tab is used to configure the device for alarm detection and reporting. The SXL1 has two integral alarms that may be configured, magnet reed switch.

The magnet reed switch detects the presence or removal of the magnet inserted in the top of the SXL1 enclosure. Removal of the magnet while the device is asleep will initiate operation of the device. Action on reinsertion/removal of the magnet is configurable. Three modes of operation are supported for magnet function while the device is in run mode.

Disable: Disable magnet mode configures the device to ignore any magnet reinsertions or removals while in run mode.

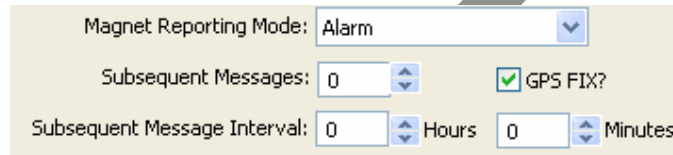
Magnet Reporting Mode: Disable

Resume Sleep: Resume Sleep magnet mode configures the device to return to low-power sleep state when the magnet is inserted for 15 seconds. This mode configures the device to use the magnet as an on/off switch. Off when the magnet is inserted and on when it is removed.

Magnet Reporting Mode: Resume Sleep

Alarm: Alarm magnet mode configures the device to initiate an alarm message operation. In this mode the magnet is recognized by the SXL1 but does not trigger “sleep mode”. When the device detects the magnet inserted for at least 15 seconds, the device will arm itself for alarm on magnet removal. The alarm is triggered on magnet removal only, not insertion. The dialog “GPS FIX?” checkbox is used to instruct the SXL1 to send an alarm message with or without GPS location. If the checkbox is unchecked, the alarm message will be sent immediately with null (zero) data in the GPS fields. If the SXL1 has not detected motion since it’s GPS fix it will send those coordinates instead of null data.

Subsequent messages may also be configured that will follow the initial alarm message. The subsequent messages will also contain or not contain GPS data depending on the GPS FIX checkbox. If a quantity of 31 subsequent messages is entered, the alarm will be considered infinite until the alarm is reset.



Magnet Reporting Mode: Alarm

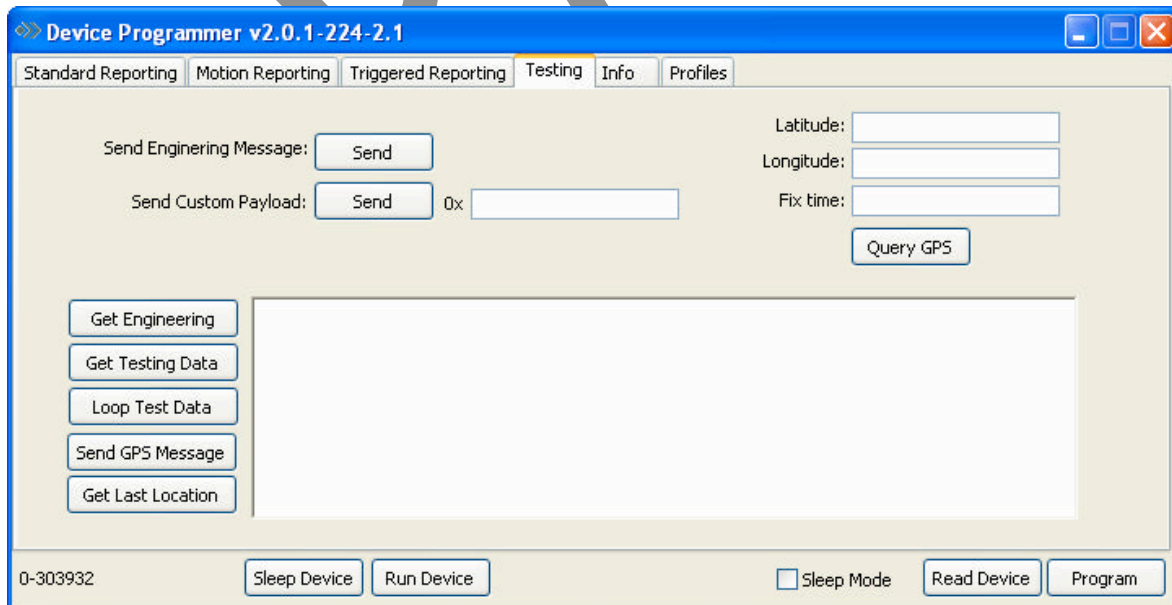
Subsequent Messages: 0 GPS FIX?

Subsequent Message Interval: 0 Hours 0 Minutes

Cut Wire / Dry Contact Operation: The SXL1 does not support the Cut Wire functionality of the SX1.

Testing Tab

The “Testing” tab supports field evaluation and testing of devices using a variety of manual commands and queries. The Testing tab provides the interfaces to force message transmissions or query GPS or evaluate engineering data. In order to receive the on-air messages the SXL1 must be outside or taken outside immediately after clicking the button. To query the GPS, the SXL1 must be outside when the query is initiated. The tab dialog window appears as shown below:



Device Programmer v2.0.1-224-2.1

Standard Reporting | Motion Reporting | Triggered Reporting | **Testing** | Info | Profiles

Send Engineering Message: Latitude:

Send Custom Payload: 0x Longitude:

Fix time:

0-303932 Sleep Mode

Send Engineering Message: This button triggers the SXL1 to send an on-air Engineering Message.

Send Custom Payload: This button triggers the SXL1 to send an on-air Raw Data Message containing the first 8 bytes entered into the text box to the right. The data must be entered in hexadecimal form.

Query GPS: This button triggers the SXL1 to get a GPS fix and populate the Latitude, Longitude and Fix time textboxes above the button.

Get Engineering: This button queries the SXL1 to retrieve the Engineering Message data to the large textbox to the right of the button.

Get Testing Data: This button queries the SXL1 to perform a device self-test. The SXL1 will return self-test results to the textbox to the right after 5 seconds.

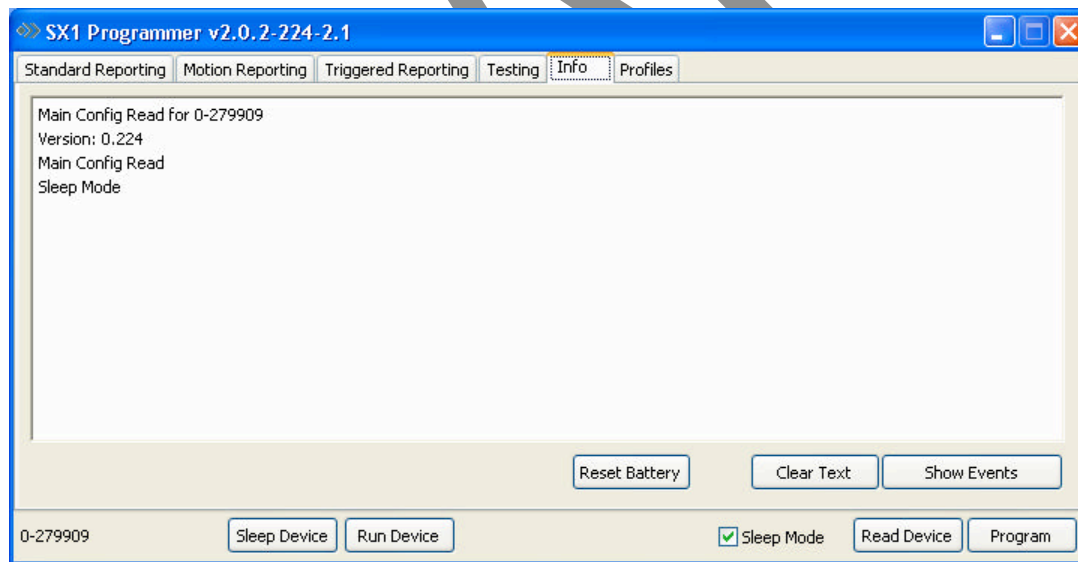
Loop Test Data: This button queries the SXL1 to perform a repetitive device self-test. The SXL1 will return self-test results to the textbox to the right after a couple of seconds (~7) and repeat until canceled. Test data is logged to a test file C:\Program Files\SXL1\SXL1.log.

Send GPS Message: This button triggers the SXL1 to send an on-air location message. Allow for up to 30 minutes for the SXL1 to determine the GPS location and send the message.

Get Last Location: This button returns the latitude, longitude, and time of the last GPS fix performed. Note that this is not necessarily the current location and time.

Info Tab

The “Info” tab collects all communications to and from connected devices in a scrolling textbox. It supports testing and evaluation of devices connected.



Reset Battery: Resets the battery counter on the SXL1, a window will pop up to verify the change.

Clear Text: Clears the text in the information box.

Show Events: Shows pending and recent events that are in the SXL1 scheduler.

Profiles Tab

The “Profiles” tab is used to save and retrieve device configuration files called Profiles. A configuration may be saved to a new file by entering a filename in the topmost textbox and selecting “Save as New Profile”. Existing profiles appear in the bottom textbox and may be loaded into the tab configuration boxes by selecting “Load Profile” or deleted by selecting “Delete”. The “Save as Selected” allows a previously saved profile to be edited.

Profiles are kept in a database file

C:\Program Files\SXL1\SXL1.db



Operational Standards

The SXL1 is a fully self-contained, small profile asset tracking device suitable for extended exposure to outdoor and industrial environments. It is 3.25 inches wide, 3.25 inches long and 2.0 inch in height. The device enclosure is molded polycarbonate. The enclosure is ultraviolet resistant and designed to survive physical and temperature shock. The battery is field replaceable. The SXL1 only need be snapped out of it's mounting sled to replace the battery.

The enclosure is divided into two sections, one holding the electronics assembly and the other holding the battery assembly. The two sections are environmentally sealed from each other and from the outside of the device. The electronics assembly passes all electrical signals through the barrier between the two sections.

The unit contains a recessed well in the lid used to insert a magnet. This magnet aligns with the embedded reed switch and is used to wake the device or trigger an alarm message. The magnet must be removed for the device to function.

Mounting Provisions

The SXL1 mounting plate is smooth surfaced on the bottom to provide for adhesives mounting. Additionally four countersunk screw holes are provided for screw mounting. The SXL1 snaps into the mounting plate and can be secured to the mounting plate with a zip-tie or a #10 x 1/2" self tapping screw.

Select a mounting location for the device that provides the clearest unobstructed view of the sky as possible on the highest, flattest, hardest surface possible. A location that allows mounting of the unit in a horizontal orientation provides the best view of the sky and thus greater thru put. Contact Numerex for vertical mount considerations. A location that protects the unit from potential damage due to tie-down straps, forklift, shifting cargo, container stacking, etc. is recommended. Note that these hazards can also hinder message thru put.

When mounting, ensure that the unit has been properly programmed, has been placed in RUN mode and the magnet has been removed. Several mounting techniques are available and may vary due to application of use: VHB tape, screws, etc.

Power Standards Outline

The SXL1 operates using series pairs of 3.0V lithium metal batteries. The device uses the 6.0V DC voltage for all battery powered operation. The battery assembly is intrinsically safe.

Each of the 3V batteries has an operational range of 2.1 to 3.0V, with end of life near 1.85V (3.7V for each series pair).

New Battery Installation

For installation of a battery on a new SXL1, remove battery from packaging. Ensure that the gray neoprene gasket is in place around the oval connection port to the electronic assembly section of the SXL1. Verify that you have two 6/32 T10 Torx security screws to affix the battery to the unit. Slide the rear of the battery into the notches on the SXL1, rotate the front of the battery down gently into place being careful not to damage the connection pins. Place one 6/32 screw into each hole on top of the battery and tighten to approximately 10 inch pounds

Battery Replacement

In order to replace the battery of the SXL1 remove the zip-tie or screw securing the SXL1 to the mounting plate. While lightly pulling up on the SXL1, use a screwdriver to gently pry the locking tabs away from the body of the SXL1. Once the SXL1 is removed from the mounting plate remove the two screws holding the battery to the SXL1 using a T10 Torx security screwdriver. Rotate the front portion of the battery up and remove the battery. Inspect the gaskets and connection ports for debris and clean if necessary. Remove the replacement battery from its packaging, ensuring that the gray neoprene gasket is in place around the oval connection port. Verify that you have two 6/32 T10 Torx security screws to affix the battery to the SXL1. Slide the rear of the battery into the notches in the SXL1 and rotate the front of the battery gently down into place being careful not to damage the connection pins. Replace the battery screws in each hole on the top of the battery and tighten to approximately 10 inch pounds. After replacing the battery use the SXL1 setup tool to reset the battery count; this will ensure the engineering messages reflect an accurate battery power remaining.

Battery Counter Reset

See “Info Tab” section (page 14) for directions.

Battery Voltage

The SXL1 operates over the voltage variations of the battery under load.

6Vbat = 3.8V to 6.0V at voltage of batteries

Pulse current = 500 mA at 6.0 V over temperature

The SXL1 incorporates a hardware watchdog and brown out detector that will reset the electronics of the device if the voltage drops below the minimum operable voltage. The electronics assemblies will resume operation following reset with no degraded performance. The SXL1 will experience no loss of non-volatile parameters.

Battery Low Threshold

The SXL1 triggers a Low Battery State when the battery capacity reaches 12.5% useful life remaining (calculated by the device in operation). The device also contains low voltage and brown out protection that will restart the unit upon a power interruption event.

Power Supply / Battery Life

The SXL1 is powered by field-replaceable lithium metal batteries. The typical operational battery life (and expected location report count) is a function of use as shown in the graph below. Extended temperature of use (outside -20 to +60 C) or obscured view of sky resulting in more cold-start GPS fixes can shorten battery life. The graphs below depict typical usage curves. Environmental conditions and device placement with respect to sky visibility will impact device performance.

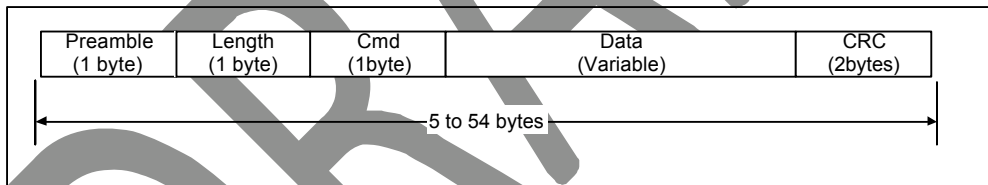
SXL1 Serial Message Protocol

The SXL1 uses the on board RF transceiver and the programmer for both configuration and support of wireless sensors. The SXL1 programmer can accept serial commands from a sensor or it can be connected directly to a open/closed or analog sensor. This user's manual contains the messaging for serial wireless sensors only. When the programmer is connected to an open/closed or analog sensor it uses the following protocol to send the appropriate message to the SXL1 for transmission.

Serial Protocol

The SXL1 may be configured using USB commands via the configuration connector. The SXL1 accepts USB serial logic levels between 0 to 5.0V DC. The interfacing connectivity provides voltage and inrush protection for the interface.

The serial protocol conforms to the following general format. Each message starts with a preamble byte followed by a length byte followed by a serial command designator, payload and concludes with a two-byte CRC.



Serial Set Format (Commands & Answers)

The different fields are defined as:

Serial Packet Fields

Position	Bytes
Preamble	Fixed pattern 0xAA
Length	Total number of bytes in the serial et including the preamble
Cmd	Command type (See section 3.2 below). Responses to commands carry the same command type as the command that initiated the answer
Data	Data associated with the command or answer
CRC low	Least significant byte of the 16-bit CRC
CRC high	Most significant byte of the 16-bit CRC

Serial CRC Algorithm

The CRC checksum uses the CCITT-16 Reversed (0x8408) algorithm:

The Security Field is a 16-bit CRC of all of the previous fields including the preamble, length, and command bytes. The remainder is initialized to all 1's (0xFFFF) and the CRC is inverted before being sent. Following is a sample C routine that implements the algorithm using the "reversed" technique:

```
WORD crc16_Isb(BYTE *pData, WORD length)
{
    BYTE i;
    WORD data, crc;
    crc = 0xFFFF;
    if (length == 0)
        return 0;
    do
    {
        data = (WORD)0x00FF & *pData++;
        crc = crc ^ data;
        for (i = 8; i > 0; i--)
        {
            if (crc & 0x0001)
                crc = (crc >> 1) ^ 0x8408;
            else
                crc >>= 1;
        }
    }
    while (--length);
    crc = ~crc;
    return (crc);
}
```

As an example, for a type (0x01) "Get ID" message made up of the following bytes:

AA 05 01

The following 2 byte CRC would be calculated:

D5 50

The complete message sent by the host to the SXL1 is:

AA 05 01 50 D5

Serial Sensor Messages Supported

The serial format is utilized for all serial messaging as described in the sections following. All messages are acknowledged with the command field of the response equal to the command field of the initiating message. Invalid formatted commands are negatively acknowledged by the SXL1.

Serial Sensor Message Types

Cmd	Description / Usage / Comment	Command Data Bytes	Acknowledge Data Bytes
0x04	Remote Data Command	See "Remote Data Command" pg 20	None
0x05	Remote Sensor Alarm Command	See "Remote Sensor Alarm Command" pg. 20	1 byte = alarm accepted

Remote Data Command (message type 0x04)

The SXL1 supports remote sensors or other devices that force a satellite transmitted message using this command. The external interface may relay up to 8 bytes of data for transmission by the SXL1 over the system. Format of the user data is undefined.

The SXL1 acknowledges receipt of the Remote Data Command immediately, then sends the data to the satellite system using message type 0xCF (Remote Message pg 24).

The Remote Data Command is in the following format:

Bit Mask for Remote Data Command

Bit	Parameter	Description	Configure (C) or Query (Q)
63:0	User Defined		C

Remote Sensor Alarm Command (message type 0x05)

The SXL1 does support remote sensors or other devices that force a satellite transmitted message and may optionally enable subsequent reporting using this command. Upon receipt of this command, the device enters the data parameters into the event table for reporting. If the event table is full, the device responds to the device with a negative acknowledge message.

If the event table can accept another entry, the SXL1 positively acknowledges receipt of the command immediately, and then initiates the alarm message function. Alarm messages are standard on-air Location Messages (pg. 21) with the alarm bits set accordingly. The Remote Sensor Alarm Command is in the following format:

Bit Mask for Remote Sensor Alarm Command

Bytes	Parameter	Description
0-1	Sensor Interval (minutes) + count	Bits 9:0 = alarm-triggered interval Bits 14:10 = alarm count Bit 15: 0= report null (0's) GPS data, 1=insert GPS
3	Message Cause	Bits 3:0 = message cause

Sending sensor interval and a count value of zero disables alarm messaging. This can be used to suspend (terminate) any ongoing alarm messaging.

Sending sensor interval and a count value ranging from 1 to 30 will initiate an alarm immediately and subsequent messages totaling the count value. Count value of 1 initiates a single alarm message. Count value of 31 initiates an infinite number of subsequent alarm messages.

The device will send alarm notifications containing or omitting GPS data per the setting of bit 15 of bytes 0&1.

Alarm triggered interval sets the minutes between first and subsequent alarm messages initiated by the SXL1. This term "set to zero" instructs the SXL1 to send the alarm message only once.

SXL1 On-Air Message Protocol

The SXL1 transmits data via the embedded satellite transmitter. The SXL1 initiates a satellite transmission following location determination or to relay engineering data that is useful for evaluating the health of the device over time. This section describes the on-air messages emanating from the

SXL1. Each message below describes the payload region of the satellite burst message. The network protocol is removed from this description for clarity. Network operators utilizing the resulting internet packets must refer to Globalstar documentation regarding Simplex Data Service use.

All on-air SXL1 messages follow the payload format depicted below. Because the satellite packet is restricted to 9 bytes total, the message fields are used sparingly. The first byte of every on-air message contains the message type identifier. The message type identifier is the least significant 2 bits of the first byte of data. The SXL1 may emit the following 4 types of on-air messages:

On-Air Message Type Definition

Message Type (5 LSbits of first byte)	Message Payload Content
11001011 (0xCB)	Location Message (contains GPS location data)
11001111 (0xCF)	Remote Message
11010011 (0xD3)	Termination Message
11010111 (0xD7)	Engineering Message

The least two significant bits are set to 0x11 with the upper six bits constrained to a range of 0x32 to 0x35 to avoid conflict with other satellite transmitters that use a similar on-air protocol.

The subsequent 8 bytes are encoded as described below depending on the message type. For data fields that span multiple bytes, the parameters are sent most significant byte first, most significant bit first in each byte.

Location Message Format

The SXL1 transmits location data using the Location Messaging format. The Location Message is denoted as message type 0xCB and will follow the format:

Location Message Format

Byte	Bits	Description
0xCB = Message Type	8	Bit 7:0 = 0xCB = SXL1 Location message type:
Latitude / Longitude	48	Byte 1 = Latitude MSByte Byte 2 = Latitude Byte 3 = Latitude LSByte Byte 4 = Longitude MSByte Byte 5 = Longitude Byte 6 = Longitude LSByte (see section 2.3.1 and 2.3.2 for encoding method)
Status	16	Bit 2:0 = battery status Bit 3 = 0 = standard interval report, 1 = subsequent interval report Bit 4 = alarm (0=no alarm, 1=alarm w/ cause defined) Bit 8:5 = message cause (valid when Bit 4 = 1) Bit 9 = 1 = engine run-time data is in message cause field Bit 10 = configuration change (toggles) Bits 13:11 = message count (modulo 7 count) Bit 14 = motion state, 0 = unit is stationary, 1 = unit in motion Bit 15 = 0=3D GPS Fix found, 1=2D GPS Fix found

Message Type (Byte 1)

The SXL1 standard location message shows 0xCB in the first byte denoting a standard location message.

Position (Bytes 2-8)

The Latitude and Longitude information is encoded in these bytes. Refer to Appendix B for calculating the Lat and Long from this information.

Status (Byte 9)

The Status byte contains various operational information about the SXL1.

Battery Status (Bits 2:0)

These bits hold the current battery status, calculated by the device and reflected proportionally in this field. Battery status starts at seven (7) and counts down in 12.5% resolution of usage. Replacing the batteries will require the user to reset to this count using command 0x31. Battery calculations suspend while in line power mode.

Report Mode (Bit 3)

When set to 0, the device is reporting a standard location message generated either from expiration of an interval timer or an alarm input. When set to 1, the device is reporting location triggered by the expiration of the subsequent interval timer.

Alarm Indication (Bit 4)

When set to 1, this denotes the location message is generated by an alarm. Bits 8:5 hold the message cause.

Message Cause (Bits 8:5)

These bits hold the binary value of the message cause as shown in the table below:

Message Cause

Bit Pattern	Description
0000	Standard Location Message
0001	Reed Switch
0010	Cut-wire (USB Cable) alarm
0011	Motion alarm
0100	Line Powered
0101	undefined
0110	undefined
0111	undefined
1000	Digital Custom Sensor 1
1001	Digital Custom Sensor 2
1010	Digital Custom Sensor 3
1011	Digital Custom Sensor 4
1100	Digital Custom Sensor 5
1101	Digital Custom Sensor 6

1110	Analog Custom Sensor 1
1111	Digital Custom Sensor 7

Note: Remote message cause 0 through 7 translate to message cause 8 through 15 (bit 4 = 1 = remote alarm initiated).

The message cause field alternatively can hold engine run time data as described below in the bit 9 description.

Engine Run Time (Bit 9)

This bit is zero unless the device is configured for engine run time (Cut Wire Configuration in Run State byte of the configuration message). If configured for engine run time and the SXL1 is reporting a standard, interval driven location message, this bit 9 is set and the message cause fields (bits 8:5) are redefined to hold 16-hour resolution count of engine run time. This means that the true message cause is 0000 and the field normally holding the message cause now contains engine run time count in 16 hour resolution.

This is only true for standard interval driven location messages. Event driven location messages such as alarms or motion will not contain engine run time data and this bit 9 will be cleared.

Configuration Change (Bit 10)

Toggles each time the device is reconfigured.

Message Count (Bits 13:11)

Modulo 7 count that increments each time the device sends a message (counts 0 to 7 then starts again at 0).

Motion State (Bit 14)

Holds current state of motion for the device. 0 is stationary while 1 is in motion.

GPS 2D/3D (Bit 15)

Validates the GPS fix as 2D or 3D. 0 is a 3D fix while 1 is a 2D fix.

Remote Message

The SXL1 supports remote generated messages containing 8 bytes of user data with a message type 0xCF. This is provided for remote sensors and other devices that serially issue a Remote Data command via the USB connection. This message is created upon receipt of serial command type 0x04, Remote Data Command (pg. 20)

Remote Message Format

Byte	Bits	Description
0xCF = Message Type	8	Bit 7:0 = 0xCF = SXL1 Remote message type:
Sensor Info	64	Sensor Defined information

Termination Message

The SXL1 automatically stops functioning, issuing a termination message upon completion of the termination count as configured by the configuration serial command. The Termination Message is the same format as a location message except the message type is 0xD3.

Termination Message Format

Byte	Bits	Description
0xD3 = Message Type	8	Bit 7:0 = 0xD3 = SXL1 Termination message type:
Latitude/Longitude	48	Byte 1 = Latitude MSByte Byte 2 = Latitude Byte 3 = Latitude LSByte Byte 4 = Longitude MSByte Byte 5 = Longitude Byte 6 = Longitude LSByte (see section 2.3.1 and 2.3.2 for encoding method)
Status	16	Bit 3:0 = undefined Bit 4 = alarm (0=no alarm, 1=alarm w/ cause defined) Bit 7:5 = message cause (valid when Bit 4 = 1) Bit 8 = configuration change (toggles) Bits 13:9 = message count (modulo 7 count) Bit 14 = motion state, 0 = unit is stationary, 1 = unit in motion Bit 15 = 0=3D GPS Fix found, 1=2D GPS Fix found

Engineering Message

The SXL1 automatically issues an Engineering Message following expiration of the Engineering Interval as set in the serial Configuration message. This data may also be extracted over the serial configuration port using the Query Engineering Data command.

Additionally, the Engineering Message is transmitted on first run of the device or if it encounters a watchdog reset. Associated bits in the message indicate the origination cause for the message.

The Engineering Message contains parameters that relay the operability of the device in use.

Engineering Message Format

Variable	Byte	Bits	Description
0xD7 = Message Type	0	8	Bit 7:0 = 0xD7 = SXL1 Engineering message type:
GPS Mean Search Time	1	8	Unsigned binary count in seconds for mean GPS search to acquire
# GPS Fails	2	8	Unsigned binary count in seconds of failed GPS attempts since last engineering message
#Transmissions	3-4	16	# of transmissions since device began service
HW configuration	5	3	defines hardware and battery configuration
Configuration Change	5	3	Modulo 7 count incrementing each time device is configured
Termination Reset	5	1	Toggles each time the termination count is reset
Motion Status	5	1	0=stationary, 1=motion
Battery Status	6	(2:0)	Battery status. Percent battery life remaining in 12.5% increments.
Magnet Status	6	3	0=magnet absent, 1=magnet present

undefined	6	(5:4)	undefined
Message Cause	6	(7:6)	00 = Engineering interval expired 01 = First run of device 10 = Watchdog reset 11 = Low battery warning (Engineering message generated upon reaching 12.5% remaining)
Engine Run Time	7-8	16	Hours of cut wire detection accumulated.

Message Type

The SXL1 Engineering message shows 0xD7 in the first byte denoting an Engineering message.

GPS Mean Search Time (Byte 2)

The second byte of the Engineering Message payload contains information about the average time to acquire GPS location. A problem with the GPS hardware may be detected in mean time to search as indicated by this data. Asset managers may use this data to find problematic installations as well as make better estimates for terminal battery life of the product. Mean time is calculated using a weighted average algorithm with a time base of at least 16 most recent transmissions.

If the Engineering Message was originated due to a First Run of the device, the GPS Mean Search Time will hold the seconds required to perform the first fix.

GPS Fails (Byte 3)

The third byte of the Engineering Message payload contains a count of the number of times the unit failed to acquire a GPS fix since the last Engineering message. This count is cleared following transmission of the Engineering message. This field will report a max value of 255, even if the transmission count exceeds 255.

Transmissions (Bytes 4:5)

The fourth and fifth byte of the Engineering Message payload contains a count of the number of satellite transmissions since the device was enabled. Redundant messages are not included in the count. All valid transmissions are included in the count including Engineering Messaging, and any forced messages. This count is cleared by resetting the termination count via the configuration connector. The fourth byte holds the most significant byte of the word. The count will roll-over 65535 to 0.

HW Configuration (Byte 6, bits 7:5)

The device reports the specific hardware configuration, primarily the battery capacity, for use by remote monitors to determine end of battery life. The HW Configuration is set in the Reset Battery Command (0x31). The following configurations are defined:

Bit pattern	Configuration
000	Primary Battery 3200 mAh

Configuration Change (Byte 6 bits 4:2)

Modulo 7 count that increments each time the device is configured (counts 0 to 7 then starts again at 0).

Termination Reset (Byte 6 bit 1)

This bit toggles each time the Termination Count is reset.

Motion Status (Byte 6 bit 0)

This bit shows whether the device is moving or stationary. 0 is stationary and 1 is moving.

Message Cause (Byte 7 bits 7:6)

These two bits show the reason for the Engineering Message as explained in the table below:

Bit Pattern	Explanation
00	Engineering interval expired
01	First run of device
10	Watchdog reset
11	Low battery warning

Note: The SXL1 will automatically generate an engineering message when the battery remaining is calculated at 12.5% setting message cause to type 3 (11).

Engine Run Time (Byte 7:8)

Bytes 7 and 8 are a 16 bit count of minutes of accumulated run time. Once the value reaches 65,535 hours it will rollover to 0.

Reserved (Byte 7 bits 5:0 and Bytes 8:9)

The remaining bits in the Engineering Message are currently undefined and reserved for future use.

Regulatory Approvals

See Appendix A for the SXL1 regulatory certifications

Labeling and Marking

The SXL1 displays all required regulatory and certification markings visible on the top, which will be labeled or indelibly printed on the plastic. The ESN of the device is labeled or printed in both decimal numerals and bar code. All markings are weather resistant and permanently affixed. Customers must leave these required marks visible or duplicate the data in their own labels.

Unit ID

Each unit has a unique Transmitter ID (ESN).

Appendix

Appendix A: Regulatory Notices

The SXL1 contains a GPS radio receiver and simplex radio transmitter as well as a digital-computing host interface board. The FCC requires the following notification for the device in compliance with 47CFR 15.105 for this Class B digital device. Full product test reports are available from Numerex upon request.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- ? Reorient or relocate the receiving antenna.
- ? Increase the separation between the equipment and receiver.
- ? Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- ? Consult the dealer or an experienced radio/TV technician for help.

WARNING: Changes or modifications not expressly approved by Numerex may render the device non-compliant to FCC and other regulatory body standards for operation and may void the user's authority to operate the equipment.

Accessory items that can be readily obtained from multiple retail outlets are not considered to be special accessories and are not to be marketed with the equipment. Only those accessory items provided by Numerex have been tested to ensure operation consistent with the regulatory standards that the device is required to perform.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.



NOTICE: This equipment complies with the FCC RF Exposure Limits. A minimum of 20 centimeters (8 inches) separation between the device and the user and all other persons should be maintained.

FCC and IC certified transmitter
FCC ID: TWV-SXL1
IC: 6322A-SXL1
Contains: FCC ID: TWV-SXL1FLEX
Contains: IC: 6322A-SXL1FLEX

The SXL1 is certified to the following safety standards:

UL60950-1/CSA C22.2 No. 60950-1, Second Edition: Safety of Information Technology Equipment, dated March 27, 2007.

UL 913, 6th edition: Intrinsically Safe Apparatus and Associated Apparatus for use in Class I, II, and III, Division 1, Hazardous (Classified) Locations, revised August 9, 2004.

CSA C22.2 No. 157-92 R2006: Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations.

The SXL1's MET listing file number is:

Appendix B: Calculating Lat / Long

Calculating Lat / Long from SXL1 Messages

The SXL1 uses 3 byte fields to encode Latitude and Longitude information. The data is encoded to represent a specific location with sufficient accuracy and confidence to be used as data from the GPS system.

- ✍ The SXL1 encodes 180 degrees of LATITUDE as a 24-bit (3-byte) signed integer.
- ✍ The SXL1 encodes 360 degrees of LONGITUDE as a 24-bit (3-byte) signed integer.
- ✍ The encoded LATITUDE data is the first three bytes of the location data payload
- ✍ The encoded LONGITUDE data is the next three bytes of the location data payload.

Lat2	Lat1	Lat0	Long2	Long1	Long0
-------------	-------------	-------------	--------------	--------------	--------------

- ✍ **Lat2** – Latitude MSB
- ✍ **Lat1** – Latitude
- ✍ **Lat0** – Latitude LSB
- ✍ **Long2** – Longitude MSB
- ✍ **Long1** – Longitude
- ✍ **Long0** – Longitude LSB

CALCULATING LATITUDE FROM ENCODED SXL1 MESSAGES

Latitude may be calculated by converting the 3 encoded latitude bytes represented in hexadecimal to a decimal number and multiplying this decimal integer by the **DEGREES_PER_COUNT_LAT** conversion factor $\frac{90.0}{2^{23}}$.

Since the latitude is signed and can range from –90 to 90 degrees, if the above result is greater than or equal to 90 degrees, 180 must be subtracted from the result.

Negative Latitude corresponds to Latitude in the SOUTHERN Hemisphere.
Positive Latitude corresponds to Latitude in the NORTHERN Hemisphere.

CALCULATING LONGITUDE FROM ENCODED SXL1 MESSAGES

The longitude may be calculated by converting the 3 encoded longitude bytes represented in hexadecimal to a decimal number. This decimal integer is multiplied by the **DEGREES_PER_COUNT_LONG** conversion factor $\frac{180.0}{2^{23}}$.

If the above result is greater than or equal to 180 degrees, 360 must be subtracted from the result since the longitude is signed and can range from –180 to 180 degrees.

Negative Longitude corresponds to Longitude in the WESTERN Hemisphere.
Positive Longitude corresponds to Longitude in the EASTERN Hemisphere.

Appendix C: SXL1 Data Interface

Scope

This document describes the SXL1 Data Interface (Datastreams) transport methods and data formats available for machine-to-machine communications from a device to a Value Added Reseller (VAR) or customer's back office. All methods and formats described in this document can be configured in the FELIX Software Administration website. It is assumed the reader is familiar with the terms and technology described in this document.

Transport Layers

The Datastream functionality implements common Internet transport layers to facilitate ease of integration with the VAR back office. The following protocols can be utilized for data transport: HTTP/HTTPS, SMTP (E-Mail), and SFTP. For a description of these protocols please refer to the table below.

Acronym	Description	Reference
HTTP/HTTPS	Hypertext Transport Protocol (Secure) 1.1	http://tools.ietf.org/html/rfc2068
SMTP (E-mail / SMS)	Simple Mail Transport Protocol (Electronic Mail)	http://www.ietf.org/rfc/rfc0821.txt
SFTP	Secure File Transport Protocol	http://www.openssh.org/txt/draft-ietf-secsh-filexfer-02.txt

Data Formats

Tracker XML Description

trackermessages The root element of the Tracker XML which contains the individual tracker messages.

trackermessage: The element for each tracker message that generated the trigger. Normally only one tracker message will be sent during each transmission.

asset: The element containing the FELIX fields of the Asset. Values for the elements are attained at the time the message is forwarded.

esn: The Electronic Serial Number of the Tracking Device. The format of this field will be different, depending on the type of Tracking Device.

name: The FELIX Asset Name. This value is a free text field that may contain spaces and non alphanumeric characters.

user_data: The FELIX "Custom Fields" as configured by Administrative users and as assigned to the Asset. The data for the custom field is free text, spaces are allowed.

field name: The field name will represent the Organization defined custom field name as assigned to the asset. The "data" field will represent the value of the field defined for the Asset.

cause: This element and its children refer to the FELIX datastream trigger that is configured to forward the tracker message when certain conditions are met.

trigger: The FELIX datastream trigger that was configured to send this message. This will match the list of triggers found in FELIX.

condition: The condition that was matched that triggered this forwarded message. The options for this condition are specific to the tracking device sending the message unless the trigger is set for any message received.

position: The position information, and calculated address information of the position information.

coordinate: The Tracker XML outputs the coordinates in type "dd", decimal degrees.

latitude: The latitude reported in the forwarded tracker message, and determined by the hexadecimal field in the payload.

longitude: The longitude reported in the forwarded tracker message, and determined by the hexadecimal field in the raw payload.

address: The address calculated by the latitude and longitude. The address is an approximation made on available geographic data, it is not intended to be exact.

street_address: The approximation of the number and street information by the latitude and longitude. The address number may or may not be present, depending on the street type. The street may be a road, avenue, highway or other designated type and is an approximation of the nearest street to the location.

city: The city the address resides in.

state: The state the address resides in (if applicable).

zip: The US Postal zip code the address resides in (if applicable).

county: The county the address resides in (if applicable).

motion: The value reported by the tracking device for the motion status at the time of the report. This may be a different result than the motion sensor trigger that may be configured as they are derived by different methods.

payload: The following attributes will represent the parsed payload of the message data and the related value. The specific field names will depend on the message type and specific configuration of the tracking device.

Tracker XML Example

```
<?xml version="1.0" encoding="utf-8" ?>
<trackermessages version="1.0">
  <trackermessage type="SXL1_location" id="22844855" positional="true" unixtime="1231360613">
    <asset>
      <esn>0-301896</esn>
      <name>TEST UNIT</name>
      <user_data>
        <field name="customfield1" data="text" />
      </user_data>
    </asset>
    <cause>
      <trigger>All Devices: Any Message: Any Data is received</trigger>
      <condition>Message Received</condition>
    </cause>
    <position>
      <coordinate type="dd">
        <latitude>45.679092407227</latitude>
        <longitude>-111.03650093079</longitude>
      </coordinate>
      <address>
        <street_address>50 E Main St</street_address>
        <city>Bozeman</city>
        <state>MT</state>
        <zip>59715</zip>
        <county>Gallatin</county>
      </address>
    </position>
    <motion>>false</motion>
    <payload>
      <field name="SXL1_alarm_status" data="false" format="boolean" units="" />
      <field name="battery" data="100" format="numeric" units="" />
      <field name="SXL1_config_change" data="false" format="boolean" units="" />
      <field name="SXL1_engine_runtime" data="" format="numeric" units="" />
    </payload>
  </trackermessage>
</trackermessages>
```

```
<field name="2d_gps_fix" data="false" format="boolean" units="" />
<field name="latitude" data="45.679092407227" format="numeric" units="" />
<field name="longitude" data="-111.03650093079" format="numeric" units="" />
<field name="SXL1_alarm_type" data="0000" format="string" units="" />
<field name="SXL1_message_count" data="7" format="numeric" units="" />
<field name="motion" data="false" format="boolean" units="" />
<field name="raw_payload" data="CB40F740B10A6C3807" format="string" units="" />
<field name="status_code" data="CB" format="string" units="" />
<field name="SXL1_interval_report" data="false" format="boolean" units="" />
<field name="SXL1_termination_message" data="false" format="boolean" units="" />
</payload>
</trackermessages>
</trackermessages>
```

Delivery Methods

HTTP / HTTPS

The Datastream will encapsulate an SXL1 message in the XML format described above and POST the data to an HTTP/HTTPS server. A list of IP addresses will be provided to the VAR such that appropriate firewall rules may be established. HTTP Basic Authentication (<http://www.ietf.org/rfc/rfc2617.txt>) is available upon request. The Content-Type will be text/xml with no URL or other encoding. For an HTTP Post, the receipt of an acknowledgement (HTML Code in the 200's) is all that is necessary for FELIX to consider the transmission a success.

SMTP (E-Mail)

The Datastream will encapsulate a message in a Tracker Message XML document in the body of an email and will be delivered to the address or addresses specified in the VAR's FELIX Software Administration website. Multiple addresses can be specified by delimiting the address with the semicolon character, e.g. "user@domain.net;user2@domain2.net". The subject of the email will be "Numerex Alert" and the sender will be "noreply@orbit-one.com." Any message sent to this address will be ignored.

SFTP

The Datastream will encapsulate a message in a Tracker Message XML document and upload the file with the filename format of: ESN-UnixTimeStamp.xml (e.g. 0-123456-1196961753.xml) to a specified server. A user name and password will be required for this method. Please note that Numerex cannot be held responsible for the security of the login credentials and it is highly recommended to use a "chrooted" environment or a virtualized server to consume SFTP data. For more information on these methods, please refer to the system administrator.

Steps for Configuring the Datastream for an Asset in the FELIX Software Administration website

For more detailed information, please refer to the FELIX Help Documentation on Datastream Management

Create Delivery Method. A Delivery Method is the address and format information for sending data forwards and alerts.

1. Login to FELIX Admin and choose the Datastream link from the Admin Menu. On the Datastream Menu, choose Delivery Methods.
2. Fill out the Delivery Method Form with the desired Delivery Format and Delivery Type.

3. Determine the Failure Response. If FELIX is to ignore failures, retry for a certain number of attempts or retry for a certain number of minutes.
4. Fill in appropriate Contact Information for Numerex to use in case of failure to forward.
5. Save your changes. When saving a Delivery Method, FELIX will verify a connection can be made prior to saving the changes.
6. Next, you must create a Trigger.

Figure 1: Create Delivery Method

Figure 2: Save Delivery Method

Create Trigger. A Trigger defines the criteria that must be matched to initiate a Datastream.

1. From the Datastream Menu, choose Triggers and Create New Trigger.

2. Choose the Trigger Source. Every Trigger Source is determined by an incoming message from the tracker. In the case of triggering on payloads, the available payload fields are dependent on the GPS Device Type as some fields are specific to certain devices.
3. Choose the desired Message Type, Payload Field, Operator and Value. See the screenshot to see the configuration for a Trigger that will initiate a Datastream if the battery level gets below 50%.
4. Click Save.
5. Next, you must create an Action and assign Assets to it.

The screenshot shows the 'New Trigger' configuration form in the Datastream Management interface. The form includes the following fields and options:

- Trigger Source:** Payload
- Device Type:** SX1
- Message Type:** SX1 Location
- Payload Field:** Battery Level
- Operator:** less than
- Value:** 50
- Name:** SX1: SX1 Location: Battery Level less than 50
- Auto Generate:**
- Display on Map:**
- Enabled:**

Figure 3: Create Trigger

Create Action. An Action combines a Delivery Method, a Trigger (or Triggers), and Assets to form a Datastream.

1. Select Actions from the Datastream menu. Click Create New Action.
2. Choose the Device Type of the Action you wish to configure.
3. Choose the Trigger and/or Triggers you need for this Datastream. Choosing multiple Triggers will require the choice of Trigger Logic between the two (or more) triggers. "AND" represents all of the chosen Triggers, "OR" represents any of the Triggers.
4. Choose the Delivery Method(s) you want to configure to this Datastream.
5. Save the Action and move to Assign Assets to Action.
6. Scroll through the list of Assets and choose the Assets you wish to assign to this action. Use the Ctrl key while selecting Assets to select multiple Assets or use the double arrow button to select all Assets.
7. Click Save. You have now created a Datastream.

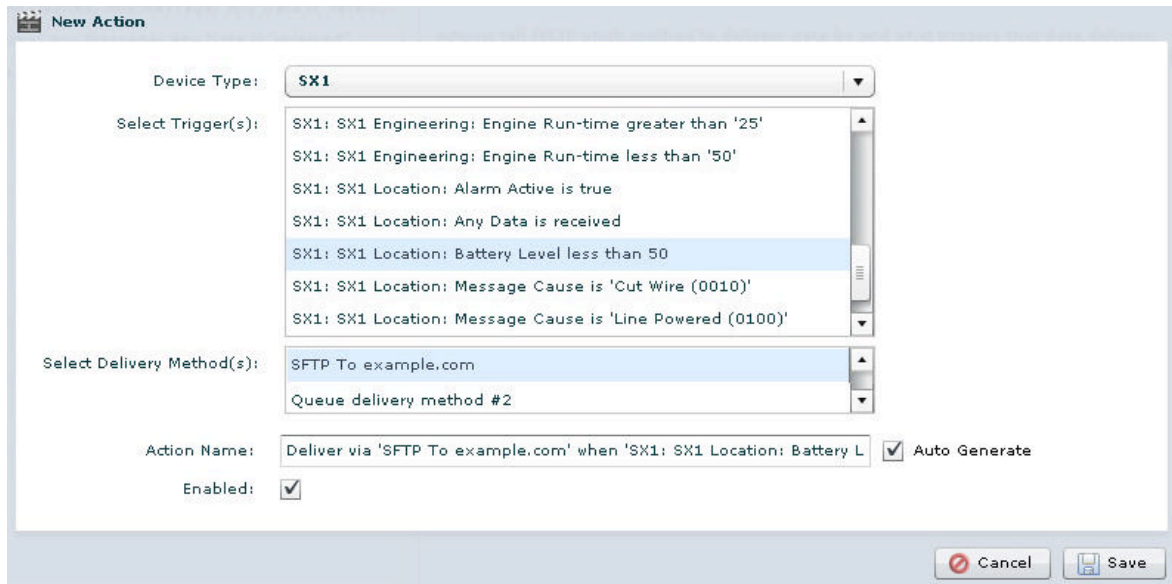


Figure 4: Create Action

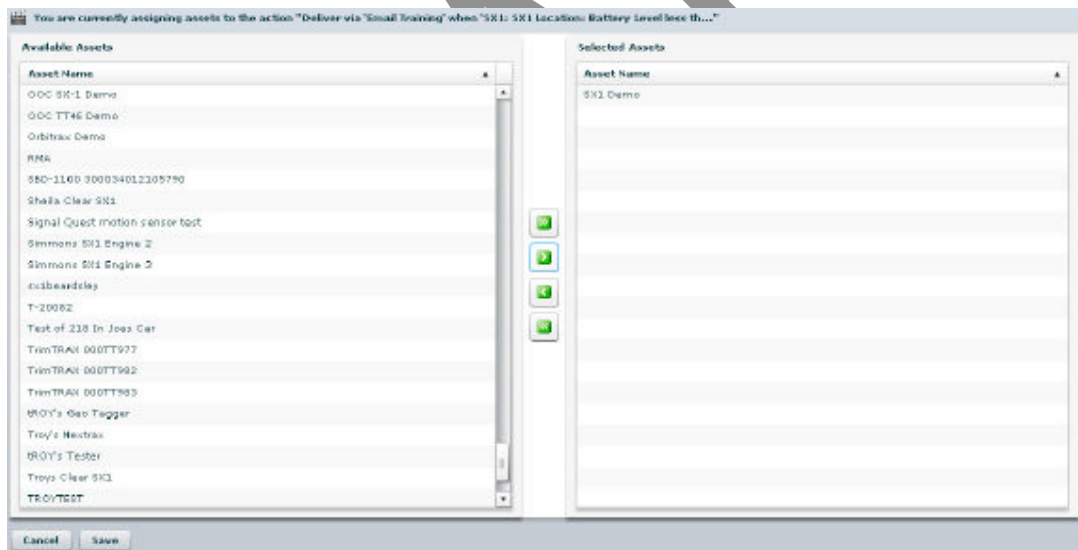


Figure 5: Assign Assets to Action

Queuing, VAR Back Office Acknowledgement, and Error Notifications

With the use of user defined data transfers it is up to the VAR to make sure data is being received at the VAR's back office properly. The Datastream assumes the VAR's back office is functioning properly and handling data without error.

Custom defined and future Datastream methods utilize a data queue that can be configured to retry every sixty seconds in the event of VAR back office failure or error response. Messages will be transmitted one at a time in a first-in, first-out fashion. It will be the responsibility of the VAR's back office to acknowledge accordingly as to whether or not the data was received and handled properly.

After a set number of failed attempts or error messages an alert will be emailed to an address provided notifying the VAR of failure.

Custom Defined Methods

Datastreams are capable of defining custom formats, transport layer methods, and acknowledgement states as defined by the VAR. Methods include but are not limited to: TCP, UDP, SSL, FTP, SOAP, etc. Data encapsulation formats include but are not limited to: CoT (Cursor On Target), custom XML schemas, custom binary encoding, etc. Development of custom methods are subject to the terms and conditions arranged with Numerex.

DRAFT