

**Oregon
Research
Electronics**



Product Manual

Acceleration Logger - Model AL101



31677 N. Lake Creek Drive, Tangent, OR 97389 USA
+1-541-928-7869 ORElectronics@comcast.net

Copyright 2020, Oregon Research Electronics

June, 2019, Rev November 2019, Rev December 2019, Rev November, 2020

Special Notices

TRADEMARKS: In the following, "ORE" and the "ORE Graphic" (in any size and color) are trademarks of Oregon Research Electronics. Other business names are the property of their respective copyright or trademark holders.

CONTACT: ORE can be reached at: ORElectronics@comcast.net

Certifications: This product is RoHS (EU's Reduction of Hazardous Substances) compliant. It is built to CE and FCC electromagnetic compatibility standards.

GENERAL WARRANTY: The AL101 is NOT warranted for use in any life-support application nor any application where malfunction could be reasonably expected to cause injury or damage. Specifically, ORE shall not be liable for any of the following:

- Damage to any equipment attached to the AL101.
- Consequences of decisions based on data gathered using the AL101.
- Injury incurred configuring, downloading data, or installing the AL101.
- Operation of any AL101 under conditions that exceed the Absolute Maximum Ratings stated in the device specifications.
- Operation with non-standard batteries, reversed batteries or leaking batteries.
- Use of the enclosure exposed to petro-chemicals.
- Damage caused by over-tightening or under-tightening the enclosure lid.

Oregon Research Electronics supplies the AL101 "AS IS", without any warranties, with all faults, at the buyer's and further users' sole risk. The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the

user indemnifies Oregon Research Electronics from all claims arising from the handling or use of the goods.

Oregon Research Electronics will replace any AL101 that the user deems unacceptable in performance, provided that it is returned in resalable condition. Oregon Research Electronics will replace the unit or refund the purchase cost at ORE's discretion. Shipping costs may be refunded at ORE's discretion.

Oregon Research Electronics will replace any unit that is defective in manufacture, at no additional cost to the customer.

If these conditions are unacceptable, return the unit in new condition to ORE for a refund.

Users who purchase ORE products from some place other than ORE are recommended to register their purchase at <http://www.orelectronics.net/register/>. This will insure that you receive all information about free product updates or alerts about product operation.

Table of Contents

PART 1: QUICK START	6
PART 1A: SET-UP	6
PART 1B: START RECORDING	9
PART 1C: STOP RECORDING	11
PART 1D: RETRIEVING DATA	11
PART 2: INTRODUCTION	13
PART 3: SPECIFICATIONS	15
PART 4: DATA COLLECTION.....	19
PART 4A: Sampling Strategies	19
PART 4B: Data Recording	20
PART 4C: Data Format	22
PART 4D: Data Quality & Integrity	23
PART 5: TERMINAL INTERFACE	26
PART 5A: Using USB	26
PART 5B: The Terminal	27
PART 5C: The Menu System	29
PART 5D: Terminal Commands	30
PART 6: GENERAL OPERATION.....	34
PART 6A: Controls	34
PART 6B: LEDs	35
PART 6C: Memory Card	36
PART 6D: Power	39

PART 6E: Real Time Clock	42
PART 6F: Enclosure	46
PART 6G: Mounting	49
PART 7: TROUBLESHOOTING	50
PART 7A: LED Flashes	50
PART 7B: Test Mode	53
PART 7C: Other Trouble Indicators	55
PART 8: RELEASE INFORMATION	57
PART 8A: Revision Log	57
PART 8B: Errata & "Work-Arounds"	57
APPENDIX I.....	60
Effect of Sample Rate, Burst Duration and Burst Period	60

PART 1: QUICK START

The following steps will start recording at a minimum effort. It does NOT set the Real-Time Clock, so you will need to keep track of the time and date when recording is started as described in this section. It uses default continuous sampling at 10Hz sample rate.

PART 1A: SET-UP

Step 1: Remove the AL101 cover by unscrewing the 4 corner screws. This requires a "Phillips" type screw driver with a shaft that is no larger than about 4mm or 3/16" (commonly known as "#1 Phillips").



Figure 1-1 Cover Screw Locations

The screws are usually (but not always) "captured" in the top of the enclosure and stay with the top. Lift the top from the enclosure, making certain that the foam battery retainer comes out with the top.

Step 2: Verify that the memory card (microSD card) is installed. It should be in an upright holder. The holder is marked “uSD” and is near the bottom edge of the board when the XYZ LEDs are to the left. See red oval in the image, below.



Figure 1-2 Memory Card Location

If there is none, you will need to obtain one. A suitable size is 8GB and any speed class should work; use of a card with a speed class higher than “2” MAY result in reduced battery life. If you need to install a memory card, the manufacturer printing goes toward the near wall of the enclosure. Insert the card until about 4mm or 3/16” is showing above the top of the holder.

Step 3: Install 1 C-size alkaline battery in either battery holder.

This is a common “flashlight” battery. Be very careful about battery polarity; the unit can be damaged if a battery is put in backwards. If you hold the side with the USB connector on the left, the positive or “+” end of the battery must be to the right, as shown in the next image. For longest recording time, install 2 batteries.; both are installed in the **SAME** direction.



Figure 1-3 Battery Orientation

Step 4: The LEDs begin to flash when the first battery is installed.

Each LED should flash green once (X->Y->Z), then red once (X->Y->Z). Then the Y LED should flash green once, the X LED should flash green several times more, then flashing should stop.

Step 5. Replace the cover, being careful that the battery retainer foam is in place, over both batteries, and does not block the view of the LEDs through the lid. Tighten the screws firmly. Do not tighten the screws too tightly as you may damage the enclosure.

PART 1B: START RECORDING

Step 1: Use the “magnetic wand” (supplied with the unit) to activate the “Start/ Stop” (**S/S**) switch. The switch location is marked with a label on the bottom side of the unit. the label contains the symbol shown in the next figure.

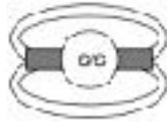


Figure 1-4 Start/Stop Label

The magnet in the end of the wand must be parallel to the base of the accelerometer. The circular magnet ends are visible on each side of the wand. The next image shows a wand in the proper position to activate the S/S switch.



Figure 1-5 Using Wand to Start Recording

The Z LED at the top of the unit should come on showing RED (not currently recording). Hold the wand in place until the Z LED changes to green (about 2 seconds).

Step 2: If the Z LED changed to green in the preceding step, the logger is now running and recording. Note the date and time. There is no visual indication that the AL101 is recording since that would use battery power.

Step 3: Attach it to the object where you want to measure acceleration. You may want to attach it in a particular orientation. The accelerometer axes are shown on the label in the cover of the AL101 and in the next figure; +Z axis is normal to the front face of the unit and points toward the back face of the unit.

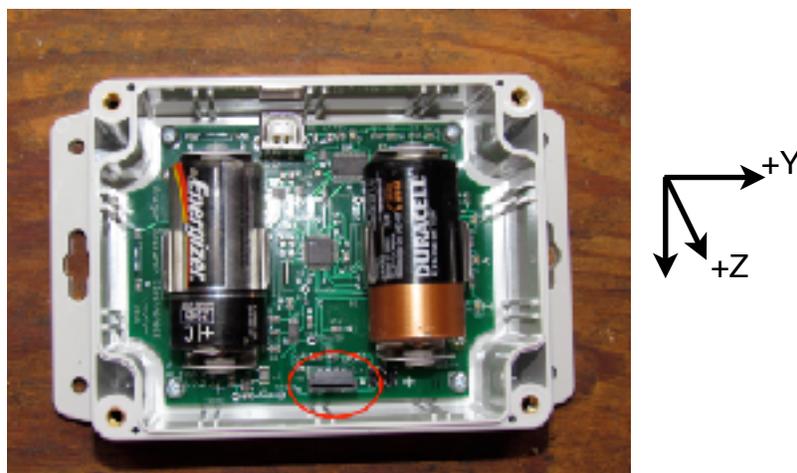


Figure 1-6 Axis Orientation

The logger can be attached with screws, string, wire, tape, bungee cord, or similar materials. It should be tight enough to the measured object that it does not shift position as the object moves. If you use screws, be careful as the flanges at the ends of the enclosure can break if too much stress is applied. The next image shows the logger in a tree, secured by a bungee cord.



Figure 1-7 Logger Mounted in Tree Using Bungee Cord

PART 1C: STOP RECORDING

Step 1: With the magnetic wand, activate the “**S/S**” (start/stop) switch at the bottom of the enclosure, as previously shown in Part 1B, Step 1. The Z LED should first turn green to indicate that it is currently recording. Hold the wand in place until the Z LED changes color to red, which indicates that recording has stopped.

PART 1D: RETRIEVING DATA

Step 1: Remove the cover of the enclosure.

Step 2: Remove the microSD card and place it into a card reader.

Step 3: When the card is “opened” with a computer, there may be several files and folders. Look for files named `ALOGxxx.csv` (where `xxx` is a number from 0 to 999; the file with the largest number is the most recent one). Copy this file to your computer and open it with a text editor. Verify that the expected data is present.

Step 4: Copy any other files of interest to the computer, and erase all files on the memory card to provide maximum recording space.

Step 5. Replace the memory card back into the AL101. The manufacturer printing on the card goes toward the near wall of the enclosure.

Step 6. If the AL101 is going to be used again, soon, go back to Step 5 of the “Start Recording” procedure. If it is NOT going to be used soon, remove the battery or batteries. If it is going to be stored with a battery to maintain the clock, remove the memory card to improve battery life. Replace the cover and tighten the cover screws lightly to keep moisture and contaminants away from the sensitive electronic components in the AL101.

Step 7. Sometimes, a spreadsheet is useful for basic data inspection. Beware that some spreadsheets will display only a limited number of lines imported from a CSV file. Notable is Apple “Numbers” 5.x that will only import some 65,500 records, and it does NOT tell you that some lines have been omitted!

PART 2: INTRODUCTION



Figure 2-1 - AL100/101

The AL101 is a general purpose 3-axis acceleration logger. It was designed to record movement of trees but it useful for a wide variety of applications. It can sample at rates from 20Hz to 0.4Hz and store the data in a microSD card. The logger is battery powered with an expected lifetime approaching 1 year using appropriate sample rates in burst mode.

The AL101 is “weather proof” (IP-65 rated). It can be easily attached to a variety of surfaces.

The AL101 is a direct descendant from the ORE AL100. Changes include the following features:

- Burst sampling has been added.
- Automatic (optional) startup after delay has been added.
- Battery monitoring has been added. This provides for an orderly shut-down at the end of battery life and less loss of data.
- Temperature resolution has been improved.
- The recorded data format is now the same for all records. This means that time stamp and other intermittent data fields are included in all records.
- All three acceleration axes are always recorded.
- Time stamp is recorded every second (or every sample for sample rates below 1Hz).
- User information data is combined into a single larger block.
- A new serial login character is added to prevent unexpected terminal behavior.
- File change-over interval is 24 hours starting at start of recording.
- File access commands have been removed.
- Serial Echo function has been removed.

In particular, burst sampling can improve the battery life by more than ten times, compared to continuous sampling at the same sample rate. The improvement in battery life depends on the ratio of the burst duration to the burst period. For example, burst measurement for 10 minutes once every hour (60 minutes) should result in a battery life improvement of about $(60 \text{ min}/10 \text{ min}) = 6$ times compared to steady sampling.

PART 3: SPECIFICATIONS

TBD = To Be Determined

A. Absolute Maximum Ratings

Maximum Temperature:	+85C
Minimum Temperature:	-40C
Maximum Ambient Pressure:	1.5 atmosphere estimated
Minimum Ambient Pressure:	0.5 atmosphere estimated
Maximum Battery Voltage:	5.5V
Minimum Battery Voltage:	0.9V
Shock Survivability:	20g estimated

B. Sensor (from manufacturer spec sheet)

Device:	STMicro LIS3DSH
Full Scale Acceleration Range:	+/-2g, +/-4g, +/-6g, +/-8g, +/-16g typical
Sensitivity:	varies with sample rate
Acceleration Accuracy:	unspecified
Acceleration Temperature Coefficient:	0.01%/C typical
Acceleration Zero Offset:	+/-40mg typical @ +/-2g
Acceleration Offset Temp. Coefficient:	0.5mg/C typical
Acceleration Noise:	15ug RMS @ 100Hz typical
Raw Sample Rate:	100Hz typical
Sample Rate Accuracy:	unspecified
Sample Rate Temperature Coefficient:	unspecified
Temperature Sensor Resolution:	0.1 C (via numerical proc)
Temperature Sensor Accuracy:	unspecified

C. USB Serial Port

Connector:	Standard Type B
USB Standard:	USB 2.0
Baud Rate:	9600 Baud
Data Bits:	8 data bits
Parity:	none
Stop Bits:	1
Hand shaking:	none

D. Real-Time Clock

Accuracy (worst case):	+/- 25ppm (~ +/-2.2 sec/day) at 25C
Temperature Sensitivity :	-110ppm @ 85C rel to 25C -130ppm @ -40C rel to 25C
Programmability:	year, month, day, hour, minute, second programmable via USB

E. Memory

Capacity:	8GB microSDHC supplied
Format:	FAT16 for 2GB or smaller FAT32 for 4GB to 32GB exFAT for 64GB or larger
Speed Grade:	2 or greater
Data Format:	ASCII, comma-separated-value (CSV)

F. Sample Rates

Rate: 100Hz/N where N is 4 to 250 (25Hz to 0.4Hz). "100Hz" value depends on sensor.

G. Power

Battery: 1 or 2 C-size cells
Life: Typically 45 days @ 10 s/sec sample rate, 2 cells, and 25C. Will maintain clock for approximately 10 additional days.
Estimated 1 year, no memory card, real time clock only.
USB: Battery power not used when USB is connected

H. Mechanical

Size: 145cm (length including mounting tabs) X 91.4cm (width) X 55cm (height including cover)
Weight: Estimated: 400gr incl batteries
Enclosure: Polycarbonate UV stabilized, weather proof (gasket seal), IP65-rated, UL rated fire resistant. Heavy duty integral mounting tabs. Not for use exposed to petro-chemicals.

Regulatory:

Meets RoHS (hazardous material free). Designed to meet FCC/CE emissions and susceptibility standards.

I. Shipping Package

AL101:

Enclosure & circuit board

USB Cable:

With Standard TypeB plug

Memory card:

MicroSDHC 8GB, Class 2 or 4,

Magnetic wand:

Included

Foam battery retainer:

Included

Batteries:

NOT included

PART 4: DATA COLLECTION

PART 4A: Sampling Strategies

The AL101 offers two significantly different sampling methods. The choice of sampling method effects power consumption (and, thus, battery life), it effects the response speed (high frequency response), and it effects frequency resolution. This choice also effects the odds of missing short-duration transient events.

CONTINUOUS SAMPLING does what the name suggests. Sampling occurs at a regular, settable, rate (Sample Rate) without interruption. This sampling method is best when very short events need to be captured (shipping shock, for example) or when an unbroken record is needed (vehicle motion, for example).

BURST SAMPLING samples for an interval called "Duration" then waits. During the Duration interval, it samples at a regular settable rate, the "Sample Rate". The duration interval is repeated once every "Period". Duration is settable in **seconds** from 1 to 65535 (zero value turns off burst sampling). Period is settable in **minutes** from 1 to 65535 (zero value turns off burst sampling).

This sampling method provides longer battery life (by the proportion of Period/Duration) and results in smaller file sizes. It is suitable when events to be captured or measured are longer than the period and when the required frequency resolution is higher than $(1/\text{Duration})$. Thus, if tree sway is to be monitored and wind events that drive tree sway typically last for several hours or more, one might sample for several minutes each hour. Burst sampling is not suitable if the events of interest are short in duration such that they might be missed during the time it is not sampling.

If a Duration interval should end while measurements are being accumulated for a sample interval, the duration interval will be completed. This will happen any time Duration does not last an integer number of samples. Thus, if a sample Duration of 8 seconds is specified with a sample divisor of 90 (1.111... Hz or 0.9

seconds/sample), 8.88... samples will have been accumulated at the end of the Duration. As a result, the actual running Duration will then be 8.2 seconds (9 full samples at 0.9 seconds per sample)

AUTOMATIC START AFTER DELAY is a third choice effects continuous and burst sampling equally. You can set the AL101 to begin sampling, in either continuous or burst modes, after some wait time, given in **minutes**. Any value for AUTOSTART DELAY that is greater than zero results in a delay. This delay is only implemented immediately after power-up or after USB disconnect if autostart did not previously run in this power-up cycle. If, during the delay time, you start recording manually (with the magnetic wand), then recording begins immediately. The purpose of this delay is to allow you to work on the unit in a location that is out of the weather, mount it, and have it start recording without further intervention and without data “noise” from the installation. During the delay interval, the green Z LED flashes slow flashes. This does take extra battery energy, so do not set the delay time longer than necessary.

If you stop recording, AUTOSTART DELAY does not start over. But, during the delay interval, if you should connect a terminal to configure the unit, the delay interval WILL restart if AUTOSTART NOW (see Part 5D5) after the terminal is disconnected.

PART 4B: Data Recording

With continuous sampling, you get data files that are up to 24 hours long at the rate specified through the terminal menu system. For example, if the sample rate is set to 10Hz, then a 24 hour file will contain $(10 \text{ samples per second}) * (60 \text{ seconds per minute}) * (60 \text{ minutes per hour}) * (24 \text{ hours per file}) = 864,000$ samples. Burst sampling results in fewer bytes per file but the files are still 24 hours long.

If a “new file event” should occur during a burst, the file change is delayed until the end of the burst. This keeps bursts intact within single files. However, this may result in files that appear to be other than 24 hours long. Similarly, if a new

file event should occur during the wait time between bursts, the first sample in the file will be later than the expected clock time and the header time by up to the burst wait time. Low battery voltage may cause the last file to be shorter than 24 hours.

Raw samples are averaged, according to the desired sample rate, from a sensor sample rate of 100Hz. Thus, if 5Hz sampling is selected (100Hz/20), samples are averaged in blocks of 20. The averaged result is the value that is stored as "data". This holds true for both acceleration and temperature.

To prevent loss of resolution gained through averaging, the stored value is multiplied by a constant that depends on the sample rate divisor, N, where $\text{SampleRate} = 100\text{Hz}/N$. If N is equal to or greater than 8, the constant is 8. If N is less than 8, the constant is N. The value is truncated and no fractional part is retained as data.

Please note that there is no sensor specification for the numeric value for "full-scale". Measuring each axis against the local gravity vector is about as good as you are going to get! Also, please note that each axis can have a 0g offset of as much as +/-20mg.

Every recorded sample has a sample number that is sequential across multiple files. Sample number is reset when power is removed or when reset through the terminal.

The time stamp is simply the total seconds reckoned from the most recent startup. The time stamp is included in the data in the next sample after each second "tick".

WARNING: Do not keep the memory card in the unit until the batteries are fully discharged. If you do, you MAY LOOSE ALL DATA on the card!

WARNING: When recording is stopped, the most recent 20 seconds, or more, may be lost. For a short duration event, continue recording for 30 seconds or more past the end of the event before stopping.

PART 4C: Data Format

AL101 data is stored in text files on a uSD “memory card”. As previously noted, the files contain up to 24 hours of data in each file. Files can be different from 24 hours by up to one Period in burst mode.

The data is arranged in comma-separated-variable (csv) records with a carriage-return terminator on each record. Thus, one can think of each record as containing data “fields”. All fields are present and delimited, even if that field happens to be empty in any given record. All values are stored as ASCII characters, both in data records and in the header.

Each file has a “header” which looks like:

```
AL101 Acceleration Logger
Version: 4.3
Sample Rate: 100Hz/10
Full scale: +/- 2G
Factory S/N: 00123
Label: Site #1
Date/Time: 2018-10-14 22:30:07
CONTINUOUS (or BURST 10 sec EVERY 20 min)
```

```
#, X, Y, Z, T, Sec, Vbatt
```

There is only one line in each file that begins with “#” and that line labels the data fields. All lines following this line are data records (except empty lines between bursts).

The record schema is as follows, by field:

1. Sample number, present in every record [unsigned 32-bit integer]
2. X-axis acceleration, present in every record [acceleration note, below]
3. Y-axis acceleration, present in every record [acceleration note, below]
4. Z-axis acceleration, present in every record [acceleration note, below]
5. Temperature, present in every record [float with one decimal fraction digit]

6. Time stamp (system “total seconds”), displayed every second, otherwise empty [unsigned 64-bit integer]. When the sample rate is 1Hz or faster, there will be more samples than time stamps. When slower than 1Hz, there is a time stamp on every sample.
7. Battery voltage measurement, displayed at the start of every burst or once an hour when sampling continuously; otherwise empty [unsigned 16-bit integer]

As noted in the previous section, the stored acceleration values are averages of values read from the sensor. If the sample rate is equal to or slower than 100Hz/8, then the recorded value is 8 times a normal sensor reading. This scheme is used to maintain resolution gained as the result of averaging.

PART 4D: Data Quality & Integrity

Several factors effect the quality and integrity of data produced by the AL101. These factors fall into two broad categories: (1) factors that can result in premature end of data logging, and (2) factors that can result in loss of data.

A. Premature Logging Termination

Logging can end for a variety of reasons. The most obvious, perhaps, is when the operator uses the magnetic wand to stop logging. This is one that we want to happen. Another, in a similar category, happens when the memory card is removed before logging is stopped using the wand. In this case, a small amount of data may be lost (typically, no more than about 1 minute of data). But, logging must stop because there is no place left to store data. A third is battery discharge: the unit can no longer log when the batteries are used up. These three cases are ones that most users would recognize as “expected”.

There are, however, some unexpected situations that can lead to an end of logging. All of these center around a failure, or failures, of writing data to the memory card on FOUR successive tries. Causes for a write failure are not entirely clear, though one potential cause is well known: memory cards do “wear out”.

While the internal card data manager can substantially compensate for this, a point will always be reached were the card data manager can no longer handle new data. There is no external way to control this, and there is no way to know, for certain, that it is happening; the only observable symptom is a failure to write, successfully!

Generally, an indicator of premature end of data logging is the presence of several empty data files. These will always be at the end of the file sequence, and the last, chronologically. If you suspect that this has happened, perhaps because there are fewer than expected data files, check the last files for presence of data.

B. Missing Data

Loss of data is quite a bit more subtle. And, it can take several forms.

1. Missing sample numbers - the symptom is that there is a break or discontinuity in the sample numbering (sample number is the first field in every data record). The logger firmware is written to prevent this but it is probably prudent to check. It is sufficient to verify that there is a sample number on every record and every sample number is one larger than the sample number preceding it.
2. Missing time stamps - the symptom is that there is a break or discontinuity in the time stamps (the 6th field in every data record, though, at sample rates faster than 1Hz, some records will have no time stamp). It is sufficient to verify that every time stamp is one larger than the time stamp preceding it. A time stamp CAN be missed if a memory write takes longer than 1 second. If a time stamp is missed, the internal clock DOES NOT loose time; the time stamp simply does not get added to the proper data record.
3. Missing data - this is the most subtle of the three forms of data loss. When it happens, it may not even be obvious. The way that you can tell that it has happened is that a 1 second logging interval will have fewer than the expected number of samples.

Caution is needed, however, in determining when this has happened. That is because of a quirk in the way the accelerometer operates. Its sample rate cannot be fully controlled. Thus, when you select a sample rate of 10Hz, it might actually be anywhere from (about) 9.7Hz to 10.3Hz. And it may vary with temperature. Thus, for 10Hz sampling, it is expected to see some second intervals with 9 samples, most with 10 samples, and some with 11 samples. For 10Hz sampling, data loss would be indicated by a second interval with fewer than 9 samples.

What can you do about data loss? In the case of missing sample numbers (an unexpected event), the only option seems to be to avoid the place in analysis where the data was lost. In the case of a missing time stamp, you can manually re-insert one into the data.

When there are indications of missing samples, about the best you can do is to omit such intervals from analysis.

Caution: sample intervals under 30 seconds (depending on sample rate) may result in a data file with no sensor data.

PART 5: TERMINAL INTERFACE

PART 5A: Using USB

To connect USB to an AL101, it is necessary to remove the top cover of the enclosure. This requires a “Phillips” type screw driver with a shaft that is no larger than about 4mm or 3/16” (commonly known as “#1 Phillips”).



Figure 5-1 Cover Screw Locations

The screws are usually (but not always) “captured” in the top of the enclosure and stay with the top. Lift the top from the enclosure, making certain that the foam battery retainer comes out with the top.

The USB connector on the AL101 requires a cable with a standard “Type B” connector. When a cable that is already connected to a host device (desktop computer, for example) is plugged into the AL101, the red Y LED will turn on steadily (no flashing).

Also, the USB status LEDs will flash, briefly, when the USB cable is first connected. These LEDs will also flash when the menu system is used. These LEDs are located near the upper-right corner of the accelerometer circuit board. There is one green LED and one red LED. One flashes when data is received from the host computer and the other flashes when data is sent from the accelerometer to the host.

PART 5B: The Terminal

Once the USB cable is plugged in and recognized by the AL101, the AL101 can be accessed by any computer terminal program or with "AccelTerm", a convenient "wizard"-based graphical user interface that eliminates the need to deal with the AL101 menu system and the terminal commands. Contact ORE for information about AccelTerm. Please note that "terminal", in this context, refers to a serial communications program, not the device of the same name for accessing the host command-line system.

The USB serial link operates as a classic COM port. The settings for this COM port are:

- Baud rate: 9.6 Kbaud
- Data bits: 8
- Parity: none
- Stop bits: 1
- Hand-shake: none

All of the data is standard ASCII text; the only control characters transmitted by the logger or recognized in the stream from the host are carriage-return, line-feed, SYN (control-V) or DC2 (control-R) for initial "sync", ENQ (control-E, from the host) for "keep-alive" handshaking, ACK (control-F) from the AL101, in response to ENQ, and EOT (control-D) to "close" the session. No tabs or other control characters are used or recognized. The space character IS a standard (non-control) ASCII character and is recognized.

To use the USB serial link, you must install a specific USB "driver" for the particular USB interface chip inside the logger. Drivers can be obtained by request from ORElectronics@comcast.net or from <http://www.ftdichip.com/Drivers/VCP.htm> Each driver comes embedded in an installer that is appropriate for the operating system.

On many computers (especially Windows machines), it is important to use the same physical USB connector each time you connect to the AL101. Windows has a tendency to assign a new COM port if a different physical connector is used.

The USB connection to the AL101 can be used when the instrument has no battery installed. It can be used when the instrument is IDLE (not sampling). It can be used when the low power LED indicator (slow double-flashing Z LED) is visible. It cannot be used in when sampling (either continuous or burst) or in TEST mode. No fault occurs when attempting to use a USB connection in the latter situations; it simply ignores the USB connection.

After the USB cable is plugged, the Y LED shows red. When the terminal program is operating, send the single character "control-R" to the AL101 to log in to the AL101. The red Y LED then changes to green and the AL101 will return with a login message that looks like:

```
*****
*                                     *
*           AL101 A-Logger           *
*           Version: 4.3             *
* Oregon Research Electronics       *
* ORElectronics@comcast.net       *
*                                     *
*****
OK
>
```

If you log in when the battery is so low that the AL101 is no longer operating under battery power, the login message has some additional lines:

```
WARNING: STOPPED - VERY LOW BATTERY
OK
>
```

To close a terminal session, send a "control-D" to disconnect, at which point the green Y LED changes back to red. Then, unplug the USB cable, which turns off

the Y LED. Nothing undesirable will happen if you simply unplug the USB cable without disconnecting.

Using "AccelTerm" eliminates consideration of most of these details, as well as having to deal with the menu system and its commands.

PART 5C: The Menu System

After connecting to the AL101 with a regular terminal program, simply type the "?" character followed by "ENTER" or "RETURN" (after this, indicated by <RET>) from your keyboard. This will list the menu and all of the current settings or values associated with each command.

An example of this is:

```
>?
C r : Acceleration: X = 000437, Y = 000283, Z = -0147928"
D rw: Date-Time = 2018-08-17 13:07:00
F rw: Accel Full Scale = 2g
G rw: AutoStart Delay = 10 minutes
H rw: Autostart Now = OFF
I rw: Period = 60 minutes
J rw: Duration = 120 seconds
K r : Batt Voltage = 432
L rw: Label = Experiment 9
M r : Temperature = 28.7 C
N r : Factory S/N = 1137
P rw: File Index = 0
R w: [Reset to System Defaults]
S rw: Sample Rate = 100 Hertz/10
V r : Firmware version = V4.3
Y w: [Reset confirmation]
? r : List All (this list)
>
```

For most of the menu items, entering a letter and <RET> gives you the current value of the corresponding parameter. For example, entering N<RET> gives you

```
Factory S/N = 1137
>
```

Similarly, entering a letter followed by the new parameter value, as described in the next sub-section, will change the parameter to its new value, provided that that new value has been entered correctly. This applies to “writeable” commands which have a “w” in the menu listing. Attempting to change non-writeable commands simply results in an error message.

The two exceptions are “R” and “Y”. Sending R<RET> tells the AL101 to return all parameters to their default values. However, it won’t do this immediately. Instead, the AL101 sends

```
Y to reset
Anything else to cancel
>
```

If you follow this with Y<RET>, the parameter reset will occur. If you follow with anything else, the reset is aborted.

PART 5D: Terminal Commands

The terminal commands associated with the menu are listed, next. For the readable commands, (r) or (rw), entering the command and <RET> gives you the current value. For the writeable commands, (rw) or (w), the command followed by the new parameter value changes the parameter. **All menu entries require an upper-case command character.** A space between the command character and a new value is optional.

1. **C (r) Read Acceleration:** Shows one acceleration sample on the terminal. The sample is obtained according to the same rules used for storage of data on the memory card. There is no “default” value.

2. **D (rw) Date & Time:** Shows or sets the real-time clock (RTC). The data is in the format of "YYYY-MM-DD HH:MM:SS". Note that ALL digits MUST be present; use "03" to represent the month of March, for example. There must be one space between the date and the time. Delimiters are dash ("-") for date and colon (":") for time. Default (never previously used) is "2000-01-01 00:00:00". Date & time are lost whenever there is no power (battery and USB).
3. **F (rw) Full Scale:** Shows or sets the nominal full scale range of the sensor. The permitted values are 2, 4, 6, 8, 16. These represent "g" or gravity units. For a value of 2 (default), the sensor can measure acceleration between +2g and -2g. 2g is the most sensitive setting.
4. **G (rw) Autostart Delay:** Sets or shows the Autostart delay time in minutes. A value of 0 turns off Autostart; in this case, a manual start with the magnetic wand is always required. Autostart ONLY acts on the first startup after new batteries are installed unless AutoStart Now is ON. The range of values is 0 to 255 minutes. The default value is zero.
5. **H(rw) Autostart Now:** Shows or sets Autostart behavior when USB is disconnected after THIS session. If Autostart is enabled (that is, Autostart > 0) and Autostart Now is ON, Autostart Delay will run when USB is disconnected. Otherwise, Autostart Delay will not run when USB is disconnected. Y turns this ON, any other entry turns it OFF. The default value is OFF; any entry when Autostart is not enabled returns an error message; if you want this, AutoStart must be enabled first. This setting resets itself to OFF after running once though it will still Autostart Delay on power-up.
6. **I (rw) Burst Period:** Shows or sets the period at which bursts recur, in integer minutes. A value of zero turns burst mode off; a duration of zero also turns burst off. The value can range from 0 to 65535 minutes and the default is 0 (continuous sampling). Default value is "0".

7. **J (rw) Burst Duration:** Shows or sets the duration of sample bursts, in **integer seconds**. A value of zero turns burst mode off; a period of zero also turns burst off. The value can range from 0 to 65535 seconds and the default is 0 (continuous sampling). The **burst duration MUST be less than the burst period**, in actual time. Thus, if the period is set to be 10 minutes (600 seconds), the duration must be less than 600 seconds. Default value is "0".
8. **K (r) Voltage:** Shows the device's battery voltage. With a relatively new battery, the value should be close to $(1.6V/3.3V)*1023 = 495$. Value may be very erratic if there is no battery while USB is connected. There is no "default" value.
9. **L (rw) Label:** Shows or sets the device's user set label. This can be up to 40 ASCII characters. It can be used to describe the device's location or the experiment it is part of. It is NOT capable of handling encodings such as UTF8 so that non-ASCII characters cannot be represented. Default is "empty" (that is, no text).
10. **M (r) Temperature:** Shows the current sensor temperature in degrees-C. Resolution is 0.1C and there is no specified accuracy. The sensed temperature is inside the acceleration sensor inside the AL101 enclosure. There is no "default" value.
11. **N (r) Factory Serial Number:** Shows the factory serial number.
12. **P (rw) File Index:** Shows or sets the index of the next file to be created. This number automatically increments each time a new file is created. The allowed range is 0 to 999. Default is 0.
13. **R (w) Reset to Factory Defaults:** Resets all settings except the clock to factory settings. When entered, it will prompt you for a confirmation; enter "Y" to complete the reset or anything else to cancel.

14. **S (rw) Sample Rate:** Shows or sets the sample rate divisor. The sample rate is $100\text{Hz}/N$, where N is the number entered with this command. The allowed range for N is 5 to 250 (20Hz to 0.4Hz). Default is 10 ($100\text{Hz}/10 = 10\text{Hz}$).
15. **V (r) Software Version:** Shows the version number of software currently installed in the AL101. Format is of the form "V 4.0" or "V 4.1" or "V 4.2" or "V 4.3". There is no "default".
16. **? (r) List All:** Shows the result of all preceding read command values, with the corresponding command, and whether that command is read, or write, or both.

PART 6: GENERAL OPERATION

PART 6A: Controls

The AL101 has two controls, a switch that starts and stops recording, and a switch that activates a test routine. Both switches are activated by a magnetic wand, so that the enclosure can be kept sealed, even if the weather is bad.

A. Start/Stop Switch

The Start/Stop (SS) switch is located just above the lower center mounting hole on the enclosure. Figure 6-1, below, shows its location with a magnetic wand in position to activate it.



Figure 6-1 Start/Stop Switch Activation

The location is also marked with a label carrying a symbol as shown in Figure 6-2.



Figure 6-2 Start/Stop Switch Symbol

If this switch is activated briefly (less than 2 seconds), the Z LED will indicate the current recording state - green for “currently recording” or “red for currently not recording” or “flashing red” for a memory card failure. If the switch is activated for a longer time, the recording state is toggled (switched to the opposite state). That is, if it is currently not recording and the switch is activated for more than 2 seconds, then the accelerometer starts recording and the Z LED changes from red to green. Likewise, if it is currently recording and the switch is activated for more than 2 seconds, the accelerometer stops recording (closing the current data file) and the Z LED changes from green to red. The actual change occurs when the wand is removed from the S/S switch.

B. Test Switch

Test is normally a “troubleshooting” function. See Part 7 for more details about activating the test switch, “test mode” and what test mode shows.

PART 6B: LEDs

The AL101 has 5 LEDs that indicate status and error conditions. Two are associated with the USB interface and are active only when USB is connected. The other three are used as general purpose status and test indicators.

The behavior of the X, Y, and Z LEDs during start-up is described in Part 1A, Step 4. The behavior of the Z LED while checking the recording status or starting and stopping recording is described Part 6A. LED display of various status and error conditions is described in detail in Part 7A.

USB status LED operation is described in Part 5A.

PART 6C: Memory Card

1. Card Size

It is important to note that the file access system for a memory card requires around 800KByte (0.8MB) of "FAT" (File Access Table). This is a sort of directory for the files on the card. This is generally true, no matter what the card size is. The FAT occupies some of the card memory space, so that you will never be able to write a full 8GB of data on an 8GB memory card.

As noted elsewhere, a continuous sample rate of 10Hz produces 315,360,000 records per year.. These amount to about 8,110,000,000 bytes. Since a KByte is 1024 bytes and a GByte is 1024 KBytes, about 7.7 GByte of data is generated. This might fit an 8GB flash card.

A half year would require an 4GB card and a quarter year would require a 2GB card. Slower sample rates or burst sampling would allow still smaller cards, though a larger card can always be used. Larger cards generally use more power and will result in shorter battery life; the card's "Speed Grade" also effects this. Thus, maximum battery life will be achieved if you use a memory card that is no larger than is necessary and has the lowest available speed grade. The supplied card has 8GB capacity and is Speed Grade (Class) 2 or 4. For best battery life, Bridgetek "Strontium" MS-C6-8G memory cards are highly recommended; battery life can be much shorter than specified with other cards.

If all available memory space is used, the logger simply stops recording.

2. Removing and Inserting the Card

If the card is removed while it is recording, you may loose up to several of the most recent data records. In some circumstances, you may loose the entire current data file.

The proper method to remove the card is as follows. If you are CERTAIN that data is NOT being recorded, you may skip the first three steps.

- a. Activate the **S/S** (Start/Stop) switch.
- b. If the Z LED shows red at first, immediately release the switch since it is NOT recording and it is safe to remove the card.
- c. If the Z LED shows green at first (indicating that it is recording), continue activating the switch (about 2 seconds) until it shows red (indicating that it has stopped recording).
- d. In either case, the card can now be removed. Its location is shown circled in red in the image, below.

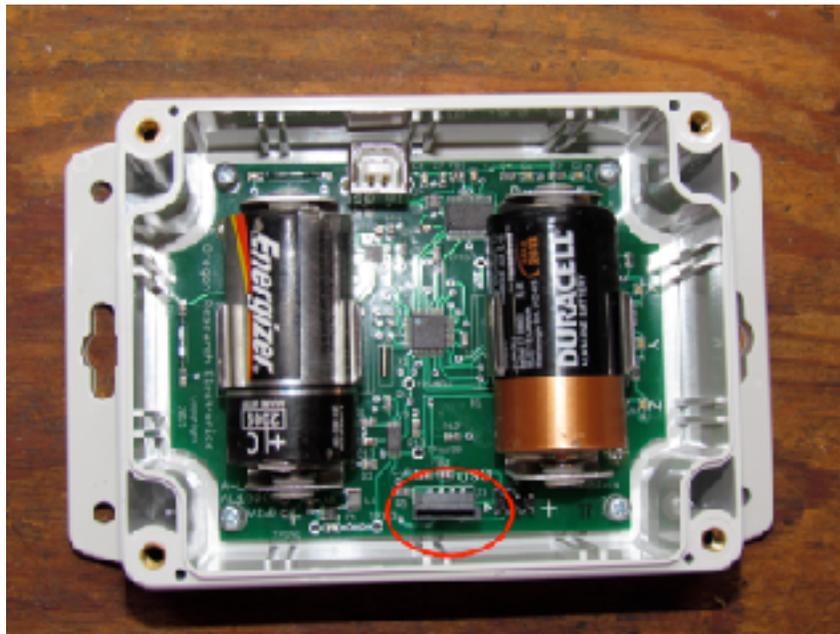


Figure 6-3 Memory Card Location

A card can be inserted at any time. It goes in the socket with the printing facing the near wall of the enclosure. If inserted backwards, it will go in only about half way. Properly inserted, it extends about 4mm or 1/8" above the socket.

3. Card Formatting

The memory card is best formatted on a regular computer; the AL101 WILL NOT format a memory card. FAT16 is required for cards having 2GB or smaller capacity, FAT32 for 4GB to 32GB cards, and exFAT for 64GB or larger cards. Many cards appear to be formatted when purchased.

For most complete formatting, use the formatter provided by the "SD Association" at <https://www.sdcard.org/downloads/formatter/index.html>. There are versions for both Windows and Macintosh computers. For best results, choose the over-write option. It takes around 15 minutes for an 8GB card, but can give more reliable recording.

4. Files

Because maximum file size is limited to 4GB for smaller uSD cards, the file system is broken into smaller files. While this may be slightly more awkward to process, there is another benefit: if anything happens to the write process, you could lose access to all of the data in a monolithic file. With smaller files, you might lose one file, but the others will stay intact.

The files are named `ALOGxxx.csv`, where xxx number from "0" to "999". A new file is created every time the **S/S** switch is activated to start logging. And, a new file is started every 24 hours (reckoned from the start of recording); in burst mode, every burst will be completed on the same file it began with, so there may be a variance of one burst duration in the file length. A new file may also be created if the file size reaches a certain limit. Each time a new file is created, the file number is incremented by 1 compared to the previous file.

To maximize storage, remove old files before each experiment. Note that "`ALOGxxxx.csv`" is at the "root level" on the uSD card. When the sequence counter reaches "999", the next one will be numbered "0". If a file to be written already exists on the card, recording stops. The numbering sequence continues no matter what numbered files are present on the card.

The file system only accepts “8.3 file names”: up to 8 character names with NO spaces or symbols. All alphabetic characters are upper case, first character must be alphabetic, and up to 3 character file extension which will be lower case.

See Part 6E: Real Time Clock, for information about file creation time and date.

5. File Write Errors

In the case of a non-recoverable file write error, the internal system will go to a state where it cannot be restarted without removing (and probably replacing) batteries. This is essentially the same state as when battery power gets too low. Attempting to close the current file with the magnetic wand will result in a flashing Z LED rather than the green or red steady Z LED that appears in normal operation. If batteries are too weak to turn on the Z LED, you may see no LED, at all.

PART 6D: Power

The AL101 will operate with either battery power or USB power. The logger will start and run with no batteries if USB is connected to a running host computer. If BOTH batteries and USB power are present, USB provides the power.

A. Battery Power

Without a USB connection, one or two C-cells are required. These should be the standard alkaline “C-Cell”, also known as a “flashlight” battery. The logger is shipped without batteries and should NOT be stored for an extended time with batteries. Rechargeable C-cells do not have the energy of an ordinary C-cell. Thus, if you need maximum running life, do not use rechargeable cells.

The battery voltage for even a short deployment should be no lower than 1.2V. For maximum field life, use batteries with at least 1.65V. Be careful of batteries that may have been stored for a long time, even if not connected to something.

A standard alkaline battery will lose 10% to 15% of their energy per year when stored at 25C and the loss rate is higher at warmer temperatures.

The operational battery life depends on a variety of factors including sample rate, burst mode duty cycle (duration/period), and temperature. Generally, at a constant temperature, the battery life, L, is given by

$$L = L_0 * (10\text{Hz}/F_{\text{sample}}) * (\text{Period}/\text{Duration})$$

where L₀ is the battery life at a sample rate of 10Hz sampling continuously (Period = Duration), F_{sample} is the sample frequency, Period is the burst Period in burst mode, and Duration is the burst time (Duration and Period must be in the same units). For continuous operation, simply assume that Duration = Period.

The Energizer Battery Manufacturing Company suggests that alkaline batteries have about 25% of their 25C life when operated at -20C, about 75% of their 25C life operated at 0C, and 125% of their 25C life when operated at 40C. The unused portion of the life will return when the temperature returns to 25C.

Do not mix alkaline and carbon-zinc batteries in an AL101. While still available in some places, carbon-zinc batteries (which may look like alkaline batteries) have less stored energy and do not work as well at temperature extremes.

Any of the device settings can be set while running under USB-only power. All settings except for the clock will be saved. Batteries ARE required to maintain clock time. If you remove both batteries and USB power, the clock will be reset. If you want to keep a clock setting, install at least one battery before removing USB power.

If batteries are in the unit, with logging turned off and memory card removed, power consumption is greatly reduced; a set of new batteries should last around 2 years in this condition.

B. Battery Installation



Figure 6-4 Battery Orientation

There is a metal holder for each battery. Note the “+” symbol on the circuit board near the right end of each holder. The positive battery ends are also indicated in Figure 6-4. The positive end of each battery must be oriented toward this symbol for the logger to work correctly. Note: **both batteries are oriented in the SAME direction!** If batteries are installed backwards, the logger may be damaged; ORE will not be liable for damage resulting from reversed batteries or batteries that are left in the unit for an extended time.

C. Battery Monitoring

The AL101 includes battery monitoring which was not included in the AL100. If the battery voltage is too low, most functions are shut down. If it is recording, the data file is closed. Sampling cannot be restarted.

When in low battery mode, there are no visible indications until you try to stop or start recording. Then, the Z LED will flash if there is enough battery power to

activate it. If a low battery is detected on start-up, it will not allow you to proceed until a new battery is installed.

PART 6E: Real Time Clock

A Real Time Clock (RTC) keeps time within the AL101. It carries out the following functions:

- Establishes the file creation time for data files.
- Provides a data start time in each data file header.
- Provides second "ticks" within the data records.
- Times burst duration and period.
- Times autostart delay.
- Times file duration (24 hours).
- Times various short intervals, LED flashes, and such.

A. Clock Initialization

Every time the AL101 is turned on from a no-power state, the clock has to be reset. Since there is no power backup for the clock, it does not keep time when the logger is unpowered.

When the logger is turned on for the first time, the "default time" is "2000-01-01 00:00:00". Each time recording is stopped (including automatic file changes), the current time is saved in the microcontroller's nonvolatile memory. This memory is preserved even when power is off. The saved time is used the next time the logger is powered-up. While this time will likely have a large error, it will not be as bad as any hard-programmed value. You will still need to set the clock for accuracy, but, if you forget to set the clock, this is the rule by which startup time is set.

There is only one way to set the clock: via the serial terminal (see Part 5D). If you send a "D" & <RET>, the AL101 will respond with its current time; the date & time. Text normally includes a year value of "2000" (Y2K) if the clock has NEVER

been set. "<RET>" represents the RETURN or ENTER key on your computer keyboard.

To set the clock, send "D yyyy-mm-dd hh:mm:ss<RETURN>" where "yyyy" is the 4-digit year, "mm" is the 2-digit numeric month of the year, "dd" is the 2-digit day of the month, "hh" is the 2-digit hour, "mm" is the 2-digit minutes value, and "ss" is the 2-digit seconds value. The clock is reset in less than 1 second from when the <RET> key is pushed. Thus, you may wish to enter a time some seconds in the future and press the <RET> key when that time arrives. For example, to set the clock to March 7, 2015 at 8:15:01 AM, you would enter "D 2015-03-07 08:15:01<RET>". **Note the different separators for date and for time.**

The clock is a 24 hour clock, so 8PM would be hour "20". Note that ALL date and time single-digit numbers must be expanded with a leading zero to make two full digits.

B. Daylight Savings Time

The clock ignores daylight savings time. There are two reasons for this:

1. Having an hour "gap" in the apparent data time, or a repeated hour in the apparent data time would cause data analysis problems.
2. The logger does not know where it is. Thus, it is not able to automatically enter or leave daylight savings time.

If the RTC is set to local time where daylight savings time is in use, the clock will accept the entry and will continue at that time. If the measurement interval does not extend to the end of daylight savings time, then you only need to remember that the clock time was based on daylight savings time. If the measurement interval extends past the end of daylight savings time, then part of the record will be different than the local time (usually by one hour).

C. Accuracy

Accuracy can be a concern for two reasons:

1. Synchronization of data from multiple loggers after the measurements are complete.
2. Calibration of the sample rate for accurate frequency determination of signal components in the data.

There are two factors that effect both of these concerns. These factors are:

1. Initial accuracy
2. Temperature coefficient

The initial accuracy of the watch crystals used in the AL101 is rated at 10ppm at 25C. This is equivalent to about +/-0.86 seconds per day. Other circuit components can also effect the basic accuracy, making a worst-case accuracy of 25ppm (about +/-2.2 sec/day) at 25C. Thus, any two loggers COULD differ at a rate at high as 4.4 sec/day (one 2.2 sec/day fast and the other 2.2 sec/day slow). This extreme is unlikely, but possible.

Over the span of 10C to 40C, watch crystals can change as much as 10ppm. This is shown in Figure 6-5. In most experiments involving multiple loggers, temperate differences between loggers will usually be small; one exception is if one logger is in direct sunlight and the other is in shade. Thus, if any temperature dependent changes do occur, they will usually be similar in all of the loggers in the experiment.

IF temperature is expected to be an issue, the temperature reading from inside the sensor IC, and included in the data record, can be used as a first-order correction to the clock.

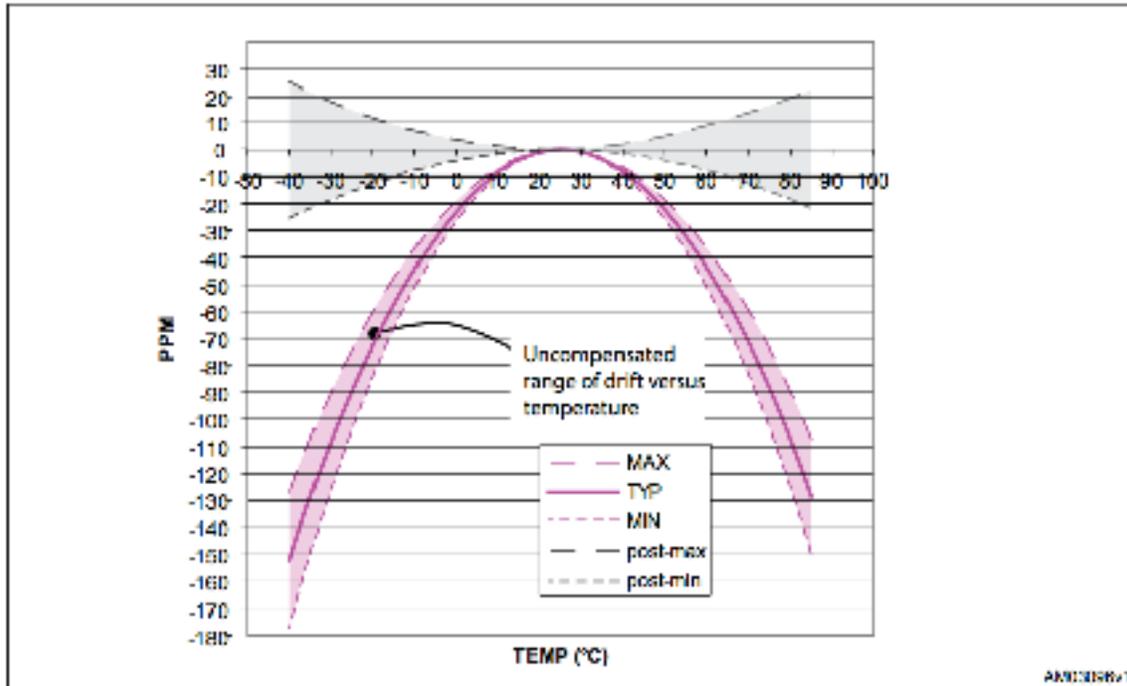


Figure 6-5 Clock crystal Frequency Variation with Temperature
(Courtesy STMicroelectronics)

D. Time Stamps for Frequency Calibration

If the data is going to be analyzed for frequency components using something like an FFT, then the clock-based time stamps can be used to improve the frequency accuracy from the data.

An FFT directly ties the sample interval of the data to the frequency scale of the output data. Thus, if the sample interval is not what you expect, then the frequency scale will be in error. The accelerometer sets the sample rate, and there is no sample rate specification for this device. Thus, we simply do not know how accurate it is or how much it may vary.

To improve this situation, time stamps can be used to determine the sample rate to within 25ppm at 25C. The method is simple: simply count the number of samples in some interval (long compared to the sample time).

For example, suppose that you have a nominal sample rate of 2Hz (2 samples per second, 0.5 seconds per sample). Then, in a 100 second interval (101 time stamps), we find that there 203 samples. From this, we know that the actual mean sample rate over that interval is 203 samples / 100 seconds = 2.03 Hz. More accuracy is obtained as the measurement interval increases.

PART 6F: Enclosure

The enclosure of the AL101 is rated at "IP65". This means that it will not allow any dust entry (the "6") and that it will withstand a moderate water spray for 3 minutes (the "5"). The specified water spray is probably equivalent to rain from a major tropical storm, though a tropical storm probably lasts longer than 3 minutes. The box is NOT weather resistant when open for a USB connection! To achieve this weather resistance, several things need to be done and some precautions have to be taken.

A. Securing the Lid

Before securing the lid to the box, you need to verify that the gasket is properly seated. The gasket must be in a groove in the underside of the lid. No part of the gasket can protrude from the groove.



Figure 6-6 Enclosure Lid

There is a ridge along the top edge of the base of the box. This ridge presses against the gasket to provide the seal. There must not be any damage to this ridge and it must be free of debris. This ridge is highlighted in the next image.

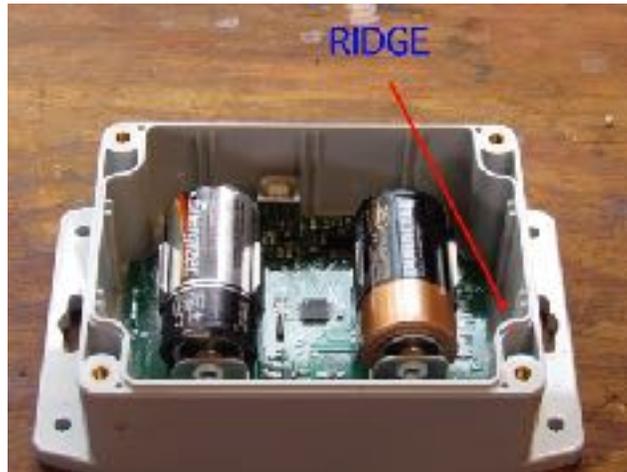


Figure 6-7 Enclosure Edge Ridge

When the screws are tightened, do not tighten them to the point where they are difficult to unscrew. If the screws are tightened more than this, the lid or the box can be warped, leading to a loss of seal. Sequentially tighten all 4 screws lightly, then finish tightening all 4 evenly. ORE cannot be responsible for damage due to an improperly installed cover.

The lid is symmetrical. Be careful to install it with the label opening for the LEDs actually over the LEDs.

B. Removing the Lid

There are four cavities in the base of the box, one near each screw. Over time and with significant rain, these cavities can fill with water. When you remove the lid, water from these cavities CAN spill into the interior of the box.



Figure 6-8 Water Retaining Cavities

The recommended way to deal with this is to only open the box when it is laying flat on a surface. Remove most of the water with absorbent material. Finally, quickly turn the box over and shake it to remove any remaining water.

C. Enclosure Reliability

The enclosure is made of UV-resistant polycarbonate. It should last a long time in normal environments. The life may be shorter at high altitudes where UV levels are higher.

If it becomes necessary to clean the enclosure because of dirt, sap or pitch, care must be used in selecting a cleaning agent. Never use something abrasive. Never scrape the surface. Never clean in the hot sun.

Polycarbonate is generally susceptible to hydrocarbon exposure. The surface of the enclosure can begin to “craze” or crack, leading to eventual failure. The only remedy is to keep the box away from hydrocarbons. ORE is not responsible for chemical damage to the enclosure.

Safe cleaners:

Methyl Alcohol

Ethyl Alcohol

Butyl Alcohol

Isopropyl Alcohol

Heptane

Hexane

Formula 409

Joy dish soap

Palmolive liquid soap

Windex with Ammonia

VM&P grade Naphtha

Unsafe cleaners:

Lysol	Pinesol	High Alkaline cleaners
Benzene	Acetone	Gasoline
Carbon tetrachloride	kerosene/paraffin	Solvents not listed as safe, above

PART 6G: Mounting

The enclosure can be attached to many surfaces with screws, nails, and the like. Care is required, however, to avoid damaging or breaking the enclosure. One simple way is to wrap a bungee cord twice around the object to be observed. The cord can be arranged over the “flanges” at the top and bottom of the enclosure as shown in the next figure; this will usually secure it so that it will not shift position in when the object moves.



Figure 6-9 Bungee-Secured Accelerometer

PART 7: TROUBLESHOOTING

PART 7A: LED Flashes

D. Symbol Key



The LED, X, Y, or Z, is indicated. If a flashing LED flashes a specific number of flashes, that is shown.

E. On Startup

On startup (batteries just installed), the following sequence of LED flashes should be observed:

 X 1	 Y	 Z	LED test
 X	 Y 1	 Z	LED test
 X	 Y	 Z 1	LED test
 X 1	 Y	 Z	LED test
 X	 Y 1	 Z	LED test
 X	 Y	 Z 1	LED test

This will be followed by ONE of the next two patterns:

 X	 Y 1	 Z	Successful accel sensor init
 X	 Y 1	 Z	Failed accel sensor init; will NOT proceed

If accelerometer sensor init is successful, this, in turn, will be followed by one of the next two patterns:

X 4 Y Z uSD card successfully opened

X 100 Y Z uSD card missing or fail to open

If uSD card fails to open, for any reason, it simply idles, waiting for a valid card to be inserted. While waiting, it will not accept a request to start sampling.

F. Removing and Inserting uSD Card

Whenever the uSD card is removed, the “uSD card missing or fail to open” indicator is shown. Then, it simply idles, waiting for a valid card to be inserted. While waiting, it will not accept a request to start sampling. USB connection is allowed, however.

X 4 Y Z uSD card successfully opened

X 100 Y Z uSD card missing or fail to open

When a valid uSD card is reinserted, the “successfully opened” indicator is shown. Autostart, if enabled, begins. Record start requests are accepted. Test mode is available.

G. Starting and Stopping Recording

If you activate the SS switch with the magnetic wand for more than 2 seconds, while the unit is NOT recording, the following pattern appears:

X Y Z not recording, then after 2 seconds

X Y Z recording, or ...

X Y Z battery low - does not start recording

If you do the same when it IS recording, the pattern changes to:

- | | | | |
|-------------------------|-------------------------|------------------------------------|--|
| <input type="radio"/> X | <input type="radio"/> Y | <input checked="" type="radio"/> Z | recording, then after 2 seconds |
| <input type="radio"/> X | <input type="radio"/> Y | <input checked="" type="radio"/> Z | not recording, or ... |
| <input type="radio"/> X | <input type="radio"/> Y | <input type="radio"/> Z | battery low, recording already stopped |

If you attempt to start or stop recording and a fatal memory write has occurred, the Z LED will alternate red and green:

- | | | | |
|-------------------------|-------------------------|--|--------------------|
| <input type="radio"/> X | <input type="radio"/> Y | <input checked="" type="radio"/> Z (alt) | fatal memory error |
|-------------------------|-------------------------|--|--------------------|

Batteries must be removed to clear this. Recommend new or reformatted memory card.

H. Automatic Start

If AutoStart is enabled (AutoStart Delay greater than zero), then immediately after the Startup pattern, the following will appear:

- | | | | |
|-------------------------|-------------------------|--|-------------------------|
| <input type="radio"/> X | <input type="radio"/> Y | <input checked="" type="radio"/> Z (very slow flash) | AutoStart delay running |
|-------------------------|-------------------------|--|-------------------------|

The LED flashes much slower than other displays to help reduce the amount of battery power used. The purpose of this flash is to remind you that AutoStart IS running. When it stops, you then know that recording has begun.

I. Connecting USB

- | | | | |
|-------------------------|------------------------------------|-------------------------|--|
| <input type="radio"/> X | <input checked="" type="radio"/> Y | <input type="radio"/> Z | electrically connected but not "logged in" |
| <input type="radio"/> X | <input checked="" type="radio"/> Y | <input type="radio"/> Z | "logged in" |

J. Low Battery on startup

When flashing on startup, will not complete initialization.

- | | | | |
|-------------------------|-------------------------|---|-------------|
| <input type="radio"/> X | <input type="radio"/> Y | <input checked="" type="radio"/> Z (double flash) | battery low |
|-------------------------|-------------------------|---|-------------|

PART 7B: Test Mode

Test mode is designed to verify operation of the acceleration sensor. This should rarely be an issue but it can give you confidence in correct operation.!



Figure 7-1 Activating Test Mode

The Test LEDs are enabled by activating the TST switch, on the left side, near the lower-left corner, of the enclosure with the magnet wand. See image above for the location; note the label on the side of the enclosure. The magnet in the wand must be parallel to the base of the enclosure; the faces of the magnet are visible on each side of the wand. All three XYZ LEDs will come on, alternating RED & GREEN. Once the alternating flash begins, you can remove the wand. TEST Mode is now in operation.

In Test Mode, unless over-ridden by an error display, the LEDs show the tilt status of each axis. The rules are the same for all three axes and can be stated as follows:

- If any axis indicates an acceleration greater than +0.5g, the corresponding GREEN LED flashes about 5 times per second. On and off times are equal.

- If any axis indicates an acceleration between +0.5g and -0.5g, the corresponding LED is off.
- If any axis indicates an acceleration more negative than -0.5g, the corresponding RED LED flashes about 5 times per second. On and off times are equal.

Test Mode can only be entered from the non-sampling condition with no USB connection.

The accelerometer can be systematically checked by following these steps:

1. Turn on TEST mode using the magnetic wand. Hold it next to the TST label on the left side of the enclosure. Keep it in place until the XYZ LEDs flash red/green, alternately. If the unit is laying on a flat surface, the Z LED will show green since the positive Z axis is downward, parallel to the gravity vector.
2. Hold the accelerometer so that the long axis is approximately vertical and the top edge of the box (the end with the XYZ LEDs) is UP
3. The X LED should flash bright green about once per second and the other two should be off.
4. Turn the accelerometer over, so that it is vertical but the top end is downward. The X LED should flash bright red and the other two LEDs should be off.
5. Lay the accelerometer on its back on a table. The Z LED should flash bright green and the other two should be off.
6. Turn the accelerometer over, so that its top is on a table. Position the enclosure so that the LEDs can be seen by looking upward into the enclosure. The Z LED should flash bright red and the other two should be off.

7. Lay the enclosure so that its left side is on a table surface. The Y LED should flash bright red and the other two should be off.
8. Lay the enclosure so that the right side is on a table surface. The Y LED should flash bright green and the other two should be off.
9. Turn TEST off using the magnetic wand. Hold it at the TST label until all 3 LEDs change to alternating red & green. Then, remove the wand, and the AL101 will be back in idle state.

Test Mode can be turned off by holding the magnetic wand at the TST label on the left side of the enclosure. The three XYZ LEDs will all change to alternating red & green; when you then remove the wand, it will be back in idle state. Test Mode is also timed (4 minutes) and will turn off, on its own, if accidentally left on. Test Mode uses a lot of battery power, so use it sparingly or replace the batteries after using TEST.

PART 7C: Other Trouble Indicators

There are other indications of unit trouble. Some of these indicators are listed, next:

- No LED comes on when you install a battery. Possible causes are: (1) discharged battery; (2) battery inserted in holder backwards. Try a new battery and check battery orientation (see Figure 6-4). Both batteries must be oriented the same way.
- Valid accelerometer LED (Y) shows red after XYZ sequential LED flash on startup. This is a fatal error. Please contact ORE immediately for repair or replacement.
- Memory card LED (X) flashes red after valid accelerometer display on startup. Memory card is (1) missing, (2) installed incorrectly, or (3) not

readable. The socket may also be damaged. See Part 6c for memory card information.

- Z LED double flashes red at a very slow rate. Battery is nearly discharged. Replace all batteries.
- No LED comes on when you try to start or stop recording. This indicates a low battery. Replace all batteries.
- Alternating red and green Z LED flashes when trying to start or stop recording. This indicates that a fatal write error has occurred with the current memory card. Remove the batteries and reinstall to clear the error indication. Try a different memory card or reformat the one you have. See Part 6C, Section 3.
- Data recording stopped earlier than expected. There could be several possible causes: (1) the AL101 was not able to open a new file when it attempted to change files, (2) low battery.
- No data file in memory card. This indicates that sampling has not started. If set to autostart, wait for that to complete, or manually start sampling with the wand: see Part 6A, section A.
- Data file is empty. This indicates that the memory card was removed from the unit without stopping the sampling. The file is “closed” only when sampling stops or at an automatic file change. Use the wand to terminate sampling: see Part 6A, section A.
- One or more of the TEST LED indications are incorrect: see Part 7B. This is potentially a fatal error. Please contact ORE immediately.

PART 8: RELEASE INFORMATION

PART 8A: Revision Log

The Revision Log includes both hardware and firmware (software) changes. The newest change appears at the top of the list, with revision age increasing down the list.

Hardware includes the circuit board, components on the circuit board, and mounting details (enclosure). The board has a version number marked on it; other hardware revisions can be tracked by the factory serial number (readable by USB).

Software version number is indicated in the "USB Boot Message" and the "Software Version" which is readable by USB.

May, 2019

Software: Version 4.0

Circuit Board: Version 1.1

Serial Numbers: "11000" & "11001"

May, 2019

Software: Version 4.1

Circuit Board: Version 1.1

Serial Numbers: start at "11002"

Corrects factory settings for Burst Period and Burst Duration.

PART 8B: Errata & "Work-Arounds"

Errata: Version 4.0 Factory settings for Burst Period and Burst Duration are incorrectly set to 60 minutes and 300 seconds, respectively. These values can both be set to zero via the terminal, but choosing "Reset to System Defaults"

returns the incorrect values. These, also, should be changed via terminal to 0 and 0. Corrected in firmware version 4.1.

Errata: Manual Version 4.1, June 18, 2019

1. **Updated battery life specs:** Typical 45 days with two batteries, 10Hz sample rate, and nominal 25C temperature. Battery will keep clock alive about 10 days additional after sampling ends. These values MAY depend on the memory card used.
2. **Warning:** Do not allow the memory card to stay in the unit until the batteries loose their charge. If you do, you may loose ALL of the data on the card!

Update: Manual Version 4.2, November 8, 2019

1. **Clarification:** 24 hour file rollover time commences with recording start. This is unlike the AL100 where the roll-over happens at midnight. Text references are at [here](#), and [here](#).
2. **Information:** Some spreadsheets, notably Apple "Numbers" version 5.x, will open only a limited number of data records from a CSV file, and will NOT tell you that some are omitted! See the reference [here](#).
3. **Data Loss:** When recording is stopped with the wand, a small amount of data may be lost. For details, see [here](#).

Update: Manual Version 4.3, November 16, 2019

1. **Correct manual formatting errors**

Bug Fix: Manual Version 4.4. December 26, 2019

1. **Correct a software bug.** The error resulted in incorrect temperature reports within data records written to the microSD memory card. Other temperature displays were correct. The firmware version number now displayed in each file header and when logging into the menu system is **4.2**. There are no operational changes.
2. **f.** Many larger microSD card sizes are displaying markedly higher operating currents; this means shorter battery life. Also, there is evidence of write

failures at the fastest sample rates, even with 16GB cards. At this point, it is impossible to tell whether these are related to manufacturer differences or if it is something attributable to size, alone.

Manual Version 4.5. November 11, 2020

- 1. Manual Addition.** Add recommendation to register products purchased from places other than ORE (page 3).
- 2. Firmware Revision.** Firmware has been revised to correct mismatch between firmware version reported in the menu login header and in the data file header compared to the version reported in the body of the menu. The reported version number in all locations is now **4.3**. There are no operational changes.
- 3. Operation.** Add recommendation that a minimum sample recording time of 30 seconds be observed. Shorter times may result in no data. in the data file. This will most commonly occur while testing.
- 4. Memory Card.** Add strong recommendation to use Bridgetek “Strontium” memory cards (page 36). Tests have shown much lower than expected battery life with other memory cards.

APPENDIX I

Effect of Sample Rate, Burst Duration and Burst Period

The sample rate governs the Nyquist Frequency for the recorded data. According to the Nyquist Theorem, the highest resolvable frequency is one-half the sample rate. Practically, it is probably closer to one-quarter the sample rate.

In other words, if you set the sample rate to be $100\text{Hz}/10 = 10\text{Hz}$, the highest resolvable frequency in the acceleration frequency spectrum will be 5Hz. Practically, it is safer to expect the maximum useable frequency to be 2.5Hz.

Burst duration effects the minimum observable frequency and the frequency resolution, which have the same value. That frequency is simply $1/\text{duration}$. A 1 min = 60 second burst duration will allow you to resolve frequencies that are $(1/60)\text{Hz}$ apart, or 0.0166..Hz.

The ratio of the burst duration to the burst period gives you the odds of capturing an event that is shorter than the duration. For example, the odds of capturing a random 1 second long event when the burst duration is 10 seconds and the burst period is 60 seconds is $10/60 = 0.166..$

Thus, the duration and period should be consistent with the physical phenomenon you are trying to observe. As an example, if you are trying to observe tree sway and typical wind events at the observing location last 2.5 hours, then 10 seconds every 10 minutes might be fully adequate. On the average, there will be 15 burst observations during the typical wind event.

Burst period also establishes a kind of second Nyquist consideration. In effect, bursts ARE samples that occur once every period. This sets the upper frequency limit for very low frequency phenomena, such as diurnal processes.