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LPR-200 Ultra low power seismic recorder

Instruction Manual

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1. Introduction

The LPR-200 Seismic Recorder is a three channel unit with an ultra-low power consumption of typically <200mW during continuous recording for extended record life. The unit is also designed to be run off safe $LiFePO_4$[1] rechargeable battery technology and can run in excess of 3 months off a single charge. The addition of a small 5 or 10W solar panel can also extend this time significantly. The device also incorporates a 3.5" screen and 4 button interface for simple setup and fast deployment.

The low powered Sigma-Delta ADCs used provide a SNR of at least 124dB with a 24 bit output resolution. Sample periods are selectable over a range of 1 – 1000 samples per second with the 1sps range featuring a shutdown mode allowing a power consumption of just 125mW.

A GPS unit is incorporated to accurately synchronise on board clocks to UTC time and to provide an accurate clock error reading down to 1µs precision during recording. The GPS module also boasts cold start-up times of less than a minute allowing for quick deployment.

Data is recorded to a standard miniSEED Format with 32 bit data storage. The device also records a data-only SEED metadata record at the start and end of each record to provide more specific location and channel details. In addition to the SEED data a log file is also created to record extra information about the location, temperature, clock error and battery charge. This data is recorded to a standard FAT32 formatted SD card which will allow storage up to 2TB as the technology becomes available.

[1] Lithium Iron Phosphate

2. Specifications

Mechanical	
Dimensions	40.6*33*17.4cm (16*13*6.85”)
Weight	12Kgs
IP rating	IP67 when closed And Connectors Mated
External Connectors	
Seismometer	MIL-C-26482 10 Way Size 12 Socket
GPS	BNC
External Power	MIL-C-26482 2 Way Size 10 Plug
Battery Connector	MIL-C-5015 Bayonet 6 Way Size 14 Plug
Power	
Input Voltage	5-14V
Power Consumption	125mW (1Hz Sample Rate) 195mW (100Hz Sample rate) 205mW (1000Hz Sample Rate)
A/D Converter	
Type	∆-Σ 24 Bit Output Resolution
Channels	3
Dynamic Range	124dB at 1kHz and 40Hz 127dB at 100Hz 130dB at 1,10,25,50 and 250Hz
Time Base	
Time Reference	UTC
GPS Accuracy	50ns RMS
Onboard Clock Drift	1ppm over -40 - 85°C
Clock Error Handling	Log file record error to 1µs Mini-Seed record error to 100µs
Sample Rates	1,10,25,40,50,100,250,1000 Hz
Storage Media	
Type	FAT32 Formatted SD Card
Data Format	
Seismic Data	MiniSEED, with dataless SEED Metadata Files
Log File Data	Custom Binary File
GPS Antenna	
Antenna Bias Voltage	3.3V
Antenna Supply Current	3-30mA
Seismometer	
Supply Voltage	12V
Input Signal	Selectable: ±5V,±10V,±20V
Battery	
Cell Type	Lithium Iron Phosphate ($LiFePO_4$)
Output Voltage	5 – 7.2V
Capacity	140Ah
Charge Voltage	9 - 15V
Dimensions	22.8*16.8*14.8cm (9*6.6*5.8”)

Table 2.1 - Specifications

3. Layout

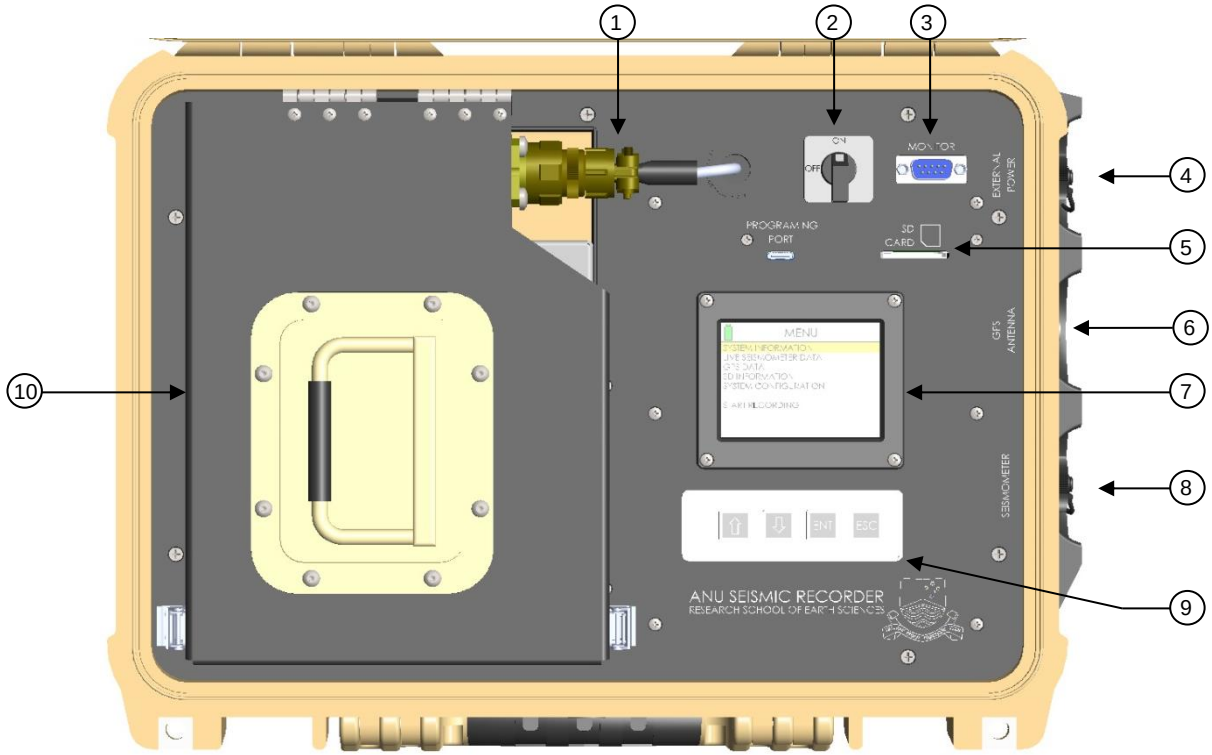

Figure 3.1 - Box Layout

1. Battery Connector[1] – Connects to the Seismic Recorder Battery Pack to supply power to the unit. The connector also provides the trickle charge voltage for the battery pack when an external power source is provided.
2. On/Off switch.
3. Monitor Port – An RS232 port with a 9600 baud rate which can be used to control the unit or check diagnostics if the display interface has failed. The monitor port requires a null modem for correct operation.
4. External Power Connector – Can be connected to a solar cell or external supply to trickle charge the battery pack or power the unit with optional attachment. **NOTE** This input is to trickle charge the battery pack and should not be connected to a supply capable of supplying more than 2 amps.
5. SD Card Slot – Standard size SD card slot. Push to insert and push to extract operation.
6. GPS Antenna Connector – Active GPS antenna connector. The unit is capable of supplying a 3.3V bias at up to 30mA.
7. 3.5" Display – Main interface for controlling and monitoring the unit.
8. Seismometer Connector – Seismometer connection with 12V seismometer supply voltage.
9. Interface Buttons – Buttons to control interface.
↑/↓**:** Scroll Selection **ENT:** Confirm current selection. **ESC:** Return to pervious screen
10. Battery Compartment – Positioning slot and battery latch to secure battery in place during transit.

[1] Refer to 7.1 External Connections and Pin Outs

4. Operation

4.1. System Precautions

- Take care never to drop the unit as this may cause damage
- Take care not to drop the battery pack as this will deform the unit and cause damage to the batteries
- Take care in opening the unit in bad weather as exposing the inside of the box to excess moisture may damage the unit
- Only ever trickle charge the battery pack (limit the current to less than 2 amps if using a power supply) via the external power connector on the unit
- Always refer to connector pin outs before making or connecting new cables
- Ensure the battery compartment is free of any cables when inserting the battery pack
- Take care to limit dirt and dust getting into the SD card slot
- Take care when reattaching dust caps not to fill the connector with any dirt or mud
- Whilst charging the side of the battery pack will heat up significantly. It is recommended to avoid touching the unit whilst charging
- Take care when removing SD card. It has a push to insert and push to release locking mechanism. Removing the card without using this action may cause damage to the connector

4.2. Hardware Connections

- Insert an ANU Seismic Recorder Battery Pack into the battery compartment. Attach the battery connector and secure the batteries in place with the compression latches.

- Connect an active antenna to the GPS antenna. For optimal performance place the antenna so that it has a clear line of site unrestricted by any trees and overhanging ledges.

- Connect a compatible seismometer via the seismometer input. Deploy seismometer as advised by manufacturer documentation.

- Remove any inserted SD card by pushing down on the card until it clicks and pops out. Insert a new FAT32 pre-formatted SD card by pushing the card into the slot until it clicks into place. A SD card may be inserted at any stage prior to recording and will automatically initialise. ***It is recommended that a freshly formatted card be used for each recording.***

- Connect a solar panel (optional) to the external power connector to trickle charge the battery pack. For optimal performance place the solar panel so that it is unrestricted by any trees and overhanging ledges.

4.3. Interface

When the device is powered on there will be a slight delay of about 10 seconds before the screen will respond whilst the CPU initialises. The following is a guide to the user interface screens in logical order.

4.3.1. Initialisation

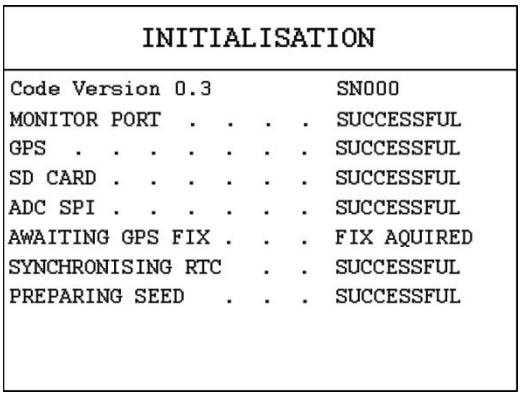

Figure 4.1 - Initialisation Screen

The first screen that will be displayed after the unit is turned on is the initialisation screen.
When the unit it powered up the CPU must initialise various functional blocks for the unit to operate correctly. The initialisation screen is a visual representation of the processes that are being undertaken and indicates whether the operation was successful or if it has failed.
The following are brief descriptions of the processes occurring during the initialisation screen.

- *Code Version and Serial Number* - Displays the current firmware version and the serial number of the unit.
- *Monitor Port* – Reports the status of the RS232 monitor port.
- *GPS* – Reports the status of communications to the GPS module
- *SD Card* – Reports the status of the SD card. The initialisation will fail if the SD card is not inserted or if the SD card does not meet standard SD specifications. This will also see the SD dialogue displayed which can be seen in *Figure 4.2 - SD Dialogue Screen*. At this point the system will also search for a setup file and set the parameters accordingly. Please Refer to *7.2 ANU Seismic Setup Software* for information regarding setup file creation.

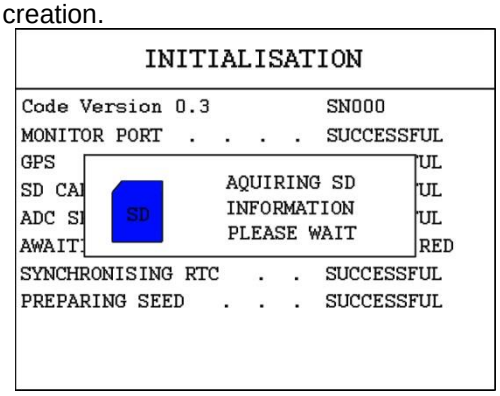

Figure 4.2 - SD Dialogue Screen

- *ADC SPI* – Reports the status of communication to the ADCs.
- *AWAITING GPS FIX* – The screen will stay on this line until either a valid GPS fix is aquired or until a 5 minute timeout. In the instance where the GPS antenna is not connected fix will fail immediately.
- *SYNCHRONISING RTC* – Indicates that the on-board clock is being synchronised to the GPS clock.
- *PREPARING SEED* – Initialises seed information to default values.

4.3.2. Menu Screen

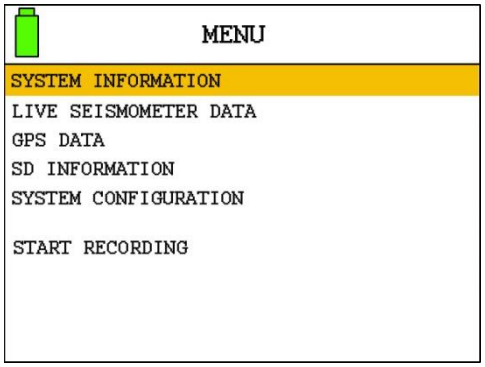

Figure 4.3 - Menu Screen

After initialisation is complete the menu screen is displayed. From here the user can access all of the sub menus to setup or view the recorder's status. The following is a guide to each of these submenus.

- *System Information* – Contains general information about the state of health of the unit.
- *Live Seismometer data* – Displays a live trace from the seismometer.
- *GPS Data* – Displays current GPS data like time, location etc…
- *SD Information* - Displays the statistics of the currently inserted SD Card.
- *System Configuration* – The screen to setup any recording parameters such as sample period, GPS interval and network code.
- *Start Recording* – Selected when you are ready to commence recording.

4.3.3. System Information

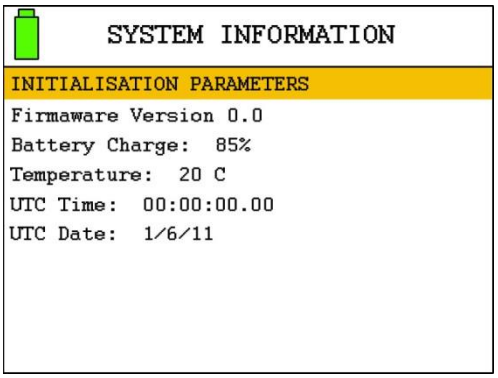

Figure 4.4 - System Information Screen

The system information screen allows the user to view up to date information about how the system is currently operating. This includes the current battery charge and box temperature as well as the current UTC time and date as set by the on board clock.
You can also select initialisation parameters to review how the system initialised from start up. This screen will look similar to Figure 4.1 - Initialisation Screen.

4.3.4. Live Seismometer Data

The live seismometer data screen is a visual representation of the signals coming from the seismometer. It has 3 different display modes, three channels around the same axis, three channels offset and each individual channel, which can be accessed by using the ↑/↓ interface buttons. As can be seen from the figures below, the signal level for each axis is displayed above the graph with the scale being in DC volts. Each axis will auto scale when a new maximum value is acquired or the old value scrolls off the screen.
There is a selectable high pass filter option used to remove any large broadband signals that may effect the scaling whilst trying to test seismometers. This function may be toggled on or off by pressing the ENT key and is displayed at the bottom right of the screen with a "HPF: ON" or "HPF: OFF" indication. The filter has a corner frequency of 0.5Hz and will remove any offset incurred by the broadband signals allowing the display to scale solely around the faster response signals.

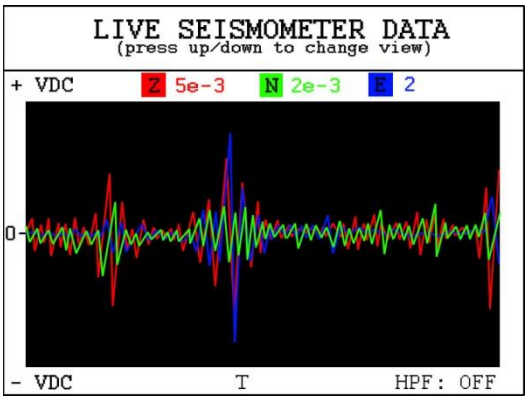

Figure 4.5 - Live Data Screen

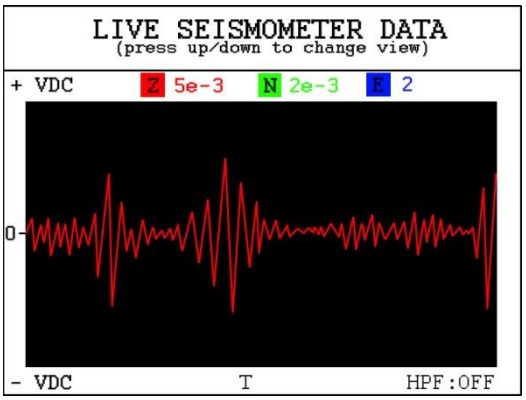

Figure 4.6 - Live Data Single Axis

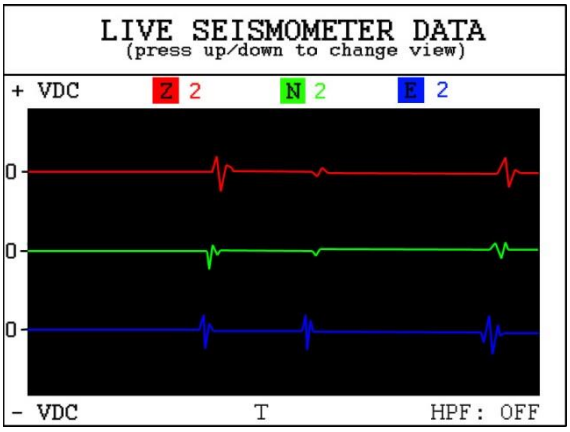

Figure 4.7 - Live Data Offset Axis

4.3.5. GPS Data

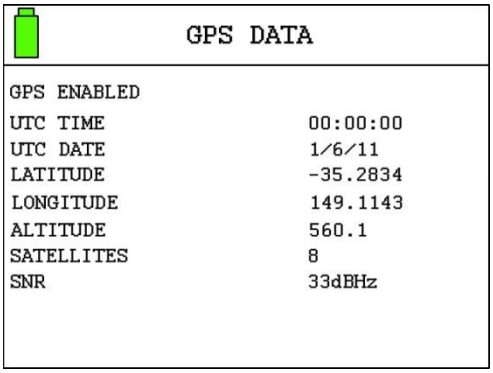

Figure 4.8 - GPS Data

The GPS data screen allows the user to view up to date GPS information. The screen first gives an indication to whether the GPS is currently active. If there were any GPS errors they will also be displayed on this line. In the instance that the GPS is disabled all values are set to either default or are the last known GPS values.

The data displayed on the screen includes the GPS UTC time and date, the position of the unit, the number of satellites currently in view and the average signal to noise ratio of these satellites.

4.3.6. SD Information Screen

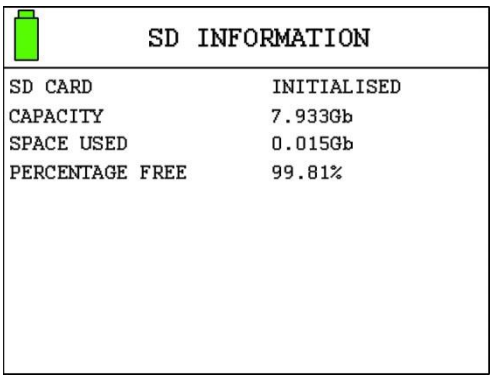

Figure 4.9 - SD Information Screen

The SD information screen provides a brief insight into the currently inserted SD card. The first line is a report on the state of the SD Card (not detected, error or initialised). If the card was successfully initialised the SD capacity, space used and percentage of space free will then be displayed, otherwise these fields will be left blank.

4.3.7. System Configuration Screen

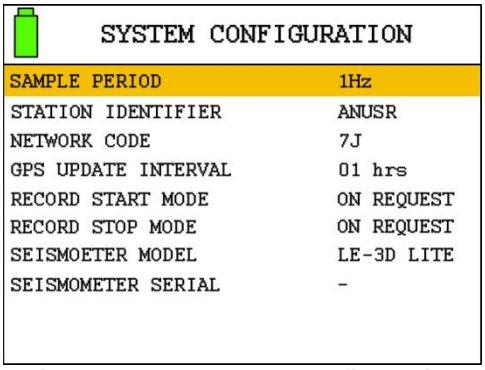

Figure 4.10 - System Configuration Screen

The system configuration screen provides an interface for the user to change any of the major recorder settings.
If a valid setup file was found during initialisation then all values on this screen will have been updated accordingly and allow the user to review or alter any setup values. If there wasn't a setup file these values will be defaults and will need to be altered from this screen prior to commencing recording. Below you will find an in-depth description of each field found on this screen.

- *Sample Period* – The sample period is selected with the ↑/↓ keys. Selectable values are 1, 10, 25, 40, 50, 100, 250 and 1000 sps. To confirm current value press the ENT key otherwise press ESC to cancel and maintain last known sample period. The default value is 50 sps.
- *Station Identifier* – The station identifier is the 5 character station code that will be used in the SEED records. Characters can be selected with ↑/↓ keys and pressing ENT will move onto the next character. At any point you press the ESC key the station identifier will revert back to the last known state. Please make sure to set all 5 characters padded with spaces. Default value is LPR-200 but may revert to 00000 if an SD error has occurred.
- *Network Code* – The network code is the 2 character code that will be used in the SEED records. Characters can be selected with ↑/↓ keys and pressing ENT will move onto the next character. At any point you press the ESC key the station identifier will revert back to the last known state. Please make sure any unused characters are padded with spaces. The default value is two spaces but may revert to 00 if an SD error has occurred.
- *GPS Interval* – The GPS interval is the frequency at which a GPS update occurs. Selectable values are 1, 2, 4, 6, 12 and 24 hours. The ↑/↓ keys are used to select the desired value and either ENT or ESC will confirm the change. The default value is 1 hour, this is also the recommended value as it provides more up to date logfile entries and clock drift comparisons. This value should only be altered where increased efficiency is required.

- *Record Start Mode* – This field is used to set the start mode for the next recording. Upon selecting this field you will be taken to a new screen where you can select between two options, on request and on time.
    - *On Request* - In this mode the device will commencing recording to the nearest minute once the 'Start Recording' field is selected form the main menu.
    - *On Time* – In this mode the device will start on a set time once the 'Start Recording' field is selected form the main menu.

  If the on time start mode is selected a field for the time and date will appear on the screen. These fields will be pre-set to the current UTC time and date. The interface buttons can then be used to set the desired start time. Whilst changing the time or date value the ENT key must be used to set all of the digits otherwise there will be errors upon commencing recording. The ESC key will cancel the current request but will not reset the time if it was changed.
- *Record Stop Mode* – This field is used to set the stop mode for the next recording. Upon selecting this field you will be taken to a new screen where you can select between three options, on request, on samples and on time.
    - *On request* – In this mode the device will continue to record until prompted by the user to stop.
    - *On Samples* – In this mode the user will set the number of samples they want to record. This is set by using the ↑/↓ keys and will increment depending on the sample period so that the data will fit the miniSEED fixed header precisely.
    - *On Time* – In this mode the device will stop on a set time.

  If the on time stop mode is selected a field for the time and date will appear on the screen. These fields will be preset to the current UTC time and date. The interface buttons can then be used to set the desired stop time. Whilst changing the time or date value the ENT key must be used to set all of the digits otherwise there will be errors upon commencing recording. The ESC key will cancel the current request but will not reset the time if it was changed.
- *Seismometer Model* – This field is used to select the model of seismometer being used for the recording. The ↑/↓ keys can be used to select one of the following models, Lennartz LE-3Dlite, Guralp CMG-40T, Guralp CMG-3ESP and Trillium Compact. Pressing ENT will confirm the change whilst pressing ESC will revert to the last known selection.
- *Seismometer Serial* – This field is the serial number of the seismometer being used for the record. This field allows up to a 10 character serial number which is padded with spaces. Use the ↑/↓ keys to scroll characters, the ENT key confirm the current character and move onto the next and the ESC key to confirm current serial number and return with out cycling all 10 characters.

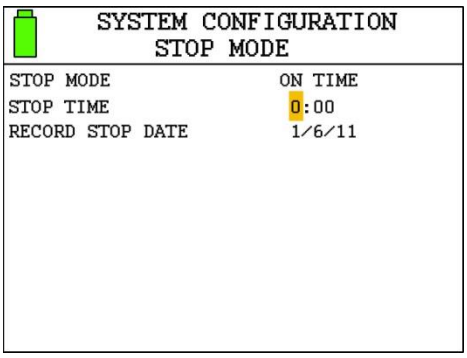

Figure 4.11 - On Time Mode

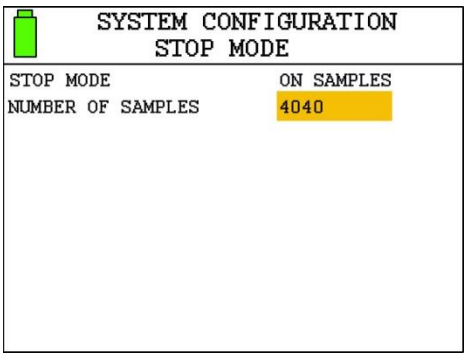

Figure 4.12 - On Samples Mode

4.3.8. Start Record

When start record is selected from the menu the system will first check that the system meets the minimum requirements for recording[1]. If there have been no errors registered the system will proceed through its record initialisation process. During this process several different screens will be displayed as described below.

- RTC Resynchronisation – At this point the on board clock is resynchronised with the GPS to ensure that there is no clock errors upon commencing recording.
- SEED Metadata – The dataless SEED file is written to disk.
- Record Commencing – The screen provides a countdown to when the record is going to commence. The record can be cancelled at this point by following the prompts (see section 4.2.9 During Recording, for further information) otherwise the screen will continue to countdown until recording is commenced. If the start mode is set to on time the unit will switch off the display shortly after entering this screen otherwise the screen will not shutdown to the record has begun.

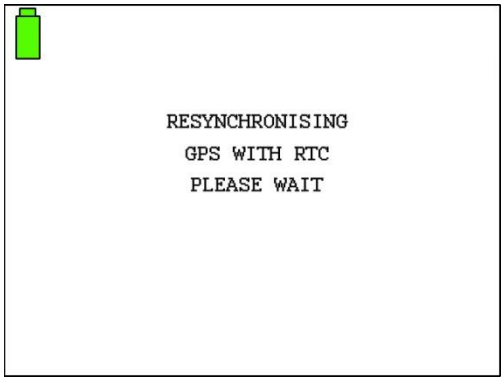

Figure 4.13 - Desynchronising RTC Screen

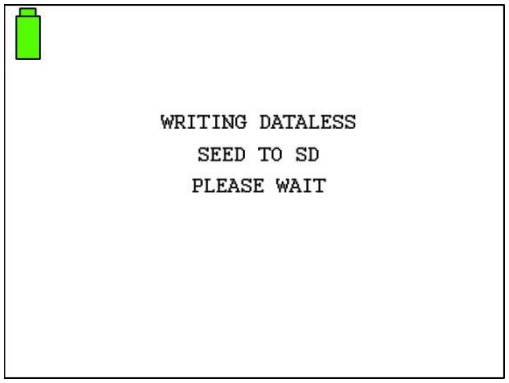

Figure 4.14 - Writing Metadata Screen

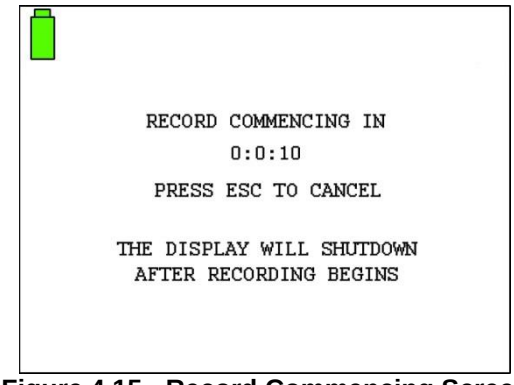

Figure 4.15 - Record Commencing Screen

[1] Refer to 4.3.11Error Screen for details

4.3.9. During Recording

Figure 4.16 - Currently Recording Screen

When the record has commenced the currently recording screen will be displayed for about 10 seconds before the screen will automatically shutdown. To wakeup the screen either the ↑/↓ or ENT buttons can be pressed. In the instance the screen does not turn on straight away the device is writing data to disc and cannot be interrupted. A 30 second pause is recommended before trying again.
As the screen advises there are two options from this point, pressing ESC to end record or ENT for system status.

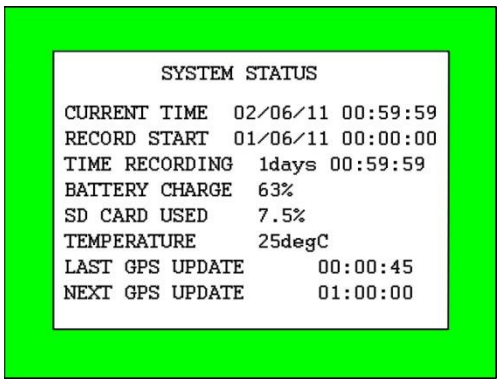

Figure 4.17 - Recording Status Screen

The system status screen allows the user to view some of the system information while recording as the user does not have access to the main menu.
You can select from a range of menu options to review what the setup was prior to recording as well as viewing up to date information about the unit.
Pressing ESC will return the user back to the currently recording screen.

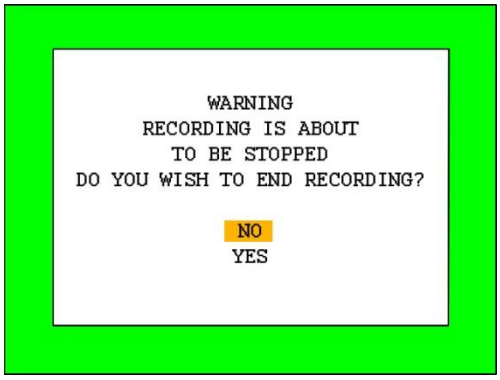

Figure 4.18 - End Record Screen

If escape was pressed in the currently recording screen then the end recording screen will be displayed. The user is to then select yes/no using the ↑/↓ keys and then press ENT to confirm selection or alternatively press ESC to return to the currently recording screen. If no is selected you will also return to the currently recording screen and yes will end the current record.

4.3.10. Finished Recording

When the record has finished either by request, reaching the set number of samples or set end time the unit will briefly display a screen stating it is writing data to SD followed by the writing metadata screen (Figure 4.2.14) before returning to the main menu. At this point the recording cycle is complete and a new record may be commenced after a brief wait until the GPS reinitialises, however it is recommended to restart the unit between runs and if possible use a freshly formatted SD card.

4.3.11. Error Screen

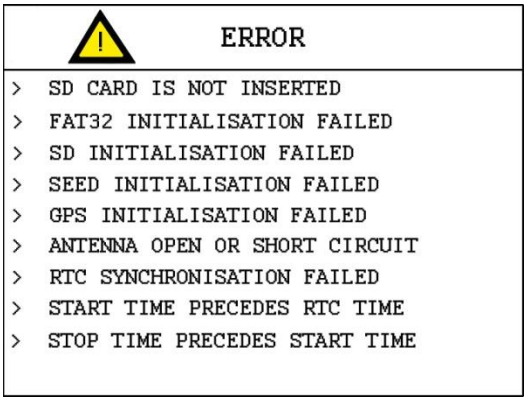

Figure 4.19 Error Screen

The error screen will appear if an attempt to start recording has been made but a system error has occurred. The most likely cause of errors are elements of the recorder failing initialisation. For a full list of errors and troubleshooting guide please refer to section 6. Troubleshooting later in the manual.

5. Data Format and Storage

The storage of the unit occurs on a FAT32 formatted SD card. The unit will communicate to the SD Card at a rate of 1MHz. It is recommended that prior to each use the data on the SD Card is backed up and the card is reformatted. This will provide optimal performance from the unit and ensure that previous data is not overwritten.

There are four main files used or produced by the unit, a setup file, a log file, miniSEED files and dataless SEED metadata files. The following section describes each file and how the device will handle them.

5.1. Setup File

The setup file is created by the ANU Seismic Setup Java Program[1] which will produce LPR-200Setup.txt. This file is to be stored in the root directory of the SD card and will be read upon SD initialisation.
The file contains all of the parameters from the system configuration menu and if used will increase both the ease and speed of deployment. Review and changes to any parameters in the setup file can be made from the system configuration menu.

5.2. Log File

The log file produced by the unit is a custom binary file and will require the file to be converted by the LPR-200 Logfile Converter software[2] to make it legible. Once converted the file will be a standard text file that can be easily read.
Each log file created will use the station identifier for that record and concatenate LOGFILE to it to create the file name. For example if the station identifier was TEST1 the log files produced would be TEST1LOGFILE.dat for the binary file and TEST1LOGFILE.txt for the converted text file. If the same station identifier is used for multiple recordings then the file will be appended to and all log information will be contained in the one file. All binary log files are created in the root directory of the SD card.
Below you will find a guide to the information found in a standard log file.

- *Unit Serial Number* – Upon commencing each record the unit serial number is logged e.g. “Recorded on Unit Serial Number: SN000”.
- *Seismometer Model* – Upon commencing each record the unit will log the seismometer model used for the current record e.g. “Seismometer Model: Lennartz LE-3Dlite”.
- *Seismometer Serial Number* – Upon commencing each record the seismometer serial number will be logged e.g. “Seismometer Serial: F-0365”.
- *Start Time* – The time at which the record is going to begin e.g. “Record commencing at 2011,152,00:00:00”. The time format is a standard SEED format that is yyyy,ddd,hh:mm:ss where ddd is the days since Jan 1.
- *GPS Update* – GPS updates occur at a frequency set by the GPS interval parameter. A standard GPS update appears as follows:

  GPS Update Details:
  Time: 01/06/2011 00:00:00
  Latitude: -35.283412
  Longitude: 149.11423
  Altitude: 593.1
  Time Error: 0us
  Battery Charge: 95%
  Temperature: 25degC

[1] Please refer to 7.2 ANU Seismic Setup Software for operation
[2] Please refer to 7.3 LPR-200 Logfile Converter Software for operation

- *GPS Error* – The GPS error is logged when a scheduled GPS update is not acquired due to poor signal or antenna error e.g. “GPS update failed at 2011/06/01 01:00:05”.
- *End Record* – The time and date that the record was stopped. It is essentially the time when the next miniSEED update was to occur e.g. “Record ended at: 2011,152,02:00:00.3400”. The time format is a standard SEED format that is yyyy,ddd,hh:mm:ss.uuuu where ddd is the days since Jan 1 and uuuu is units to 100us.

5.3. Metadata Files

The unit produces metadata files that conform to dataless SEED standards[1]. Two metadata files are produced per recording, one at the start and one at the end, which will have slightly different data. The file at the start of the record is a snapshot at that particular point in time while the one at the end will include averages of location based over the entire life of the record.
The file created can be read and altered using IRIS PDCC software[2]. All metadata files are stored in their own subdirectory. The directory name will have the station identifier concatenated with “METADATA”, so a station identifier of TEST1 would produce a sub directory of “TEST1METADATA”. Any records that share a station identifier will be stored in the same subdirectory.
The metadata files themselves also have a similar naming arrangement. The station identifier is used once again, followed by the start date and if applicable the end date and have a .dataless extension. For example if a record was recorded on station TEST1 and began at 00:00:00 on the 01/06/11 and finished at 02:00:00 on the 02/06/11 the filenames would be as follows:

First File: TEST1-2011,151,00_00_00.dataless
End File: TEST1-2011,151,00_00_00-2011,152,02_00_00.dataless

5.4. MiniSEED Files

All of the samples during the recording are recorded to miniSEED[1] (data-only SEED) files. These files conform to IRIS standards and hence will be readable or configurable with any miniSEED handling software.
As with the metadata the files are stored in their own subdirectory with the name being derived from the station identifier, so a station identifier of TEST1 would produce a miniSEED subdirectory of TEST1miniSEED. Separate files are created for each axis with a new file being created the first complete SEED after midnight. The creation of files will continue in this fashion until the record is ended, so it is possible to end up with a sub directory with hundreds of separate files.
Filenames once again use the station identifier, this time followed by the date of the first sample and an extension that represents each specific channel. The complete filename will take the following format:

TEST1	11	06	01	00	00	00	.BHZ
Station	Year	Month	Day	Hour	Min	Sec	Channel

[1] A reference manual can be found at http://www.iris.edu/manuals/SEEDManual_V2.4.pdf
[2] Software and documentation can be downloaded at http://www.iris.edu/software/pdcc/

To demonstrate the example of a record on station TEST1 that began at 00:00:00 on the 01/06/11 and finished at 02:00:00 on the 02/06/11 would produce six files as follows:

Files for the first day:	TEST1110601000000.BHZ TEST1110601000000.BHE TEST1110601000000.BHN
Files for the second day:	TEST1110602000254.BHZ TEST1110602000254.BHE TEST1110602000254.BHN

The time in the second filename relies purely on when the previous miniSEED entry is complete and will alter depending on the sample period and the start time.

5.5. File sizes

Below is a list of the file sizes that may be used to calculate the appropriate SD card size.

Sample Period (Hz)	File Size Per Day
1	1.065Mb
10	10.6Mb
25	26.3Mb
40	41.8Mb
50	52.25Mb
100	104.5Mb
250	260Mb
1000	1.015Gb

Table 5.1 - File size per day

6. Troubleshooting

The following section outlines some of the faults that may occur with the system and provides a guide to why the error may have occurred and possible solutions to fix the problem. This guide only provides a troubleshooting guide to minor system and user errors, if this guide fails to identify the issue it is recommended you contact a technical service person.

Error Screen Warnings	
Error	**Solution**
Antenna open or short circuit	▪ Check antenna connection ▪ Replace antenna if faulty
GPS initialisation failed	▪ A GPS communications issue has occurred ▪ Restart the unit
Failed to acquire GPS fix	▪ Reposition the antenna so that it is not obstructed ▪ Either monitor the GPS info screen or restart the system to monitor if a fix is now acquired
SD card is not inserted	▪ Insert a FAT32 formatted SD card ▪ Check SD slot is free of debris
FAT32 Initialisation failed	▪ Ensure the SD card is FAT32 formatted ▪ Reinsert card to reinitialise or replace
SD card initialisation failed	▪ Ensure the SD card is FAT32 formatted ▪ Reinsert card to reinitialise or replace
RTC synchronisation failed	▪ Ensure GPS is operating correctly ▪ Else communications to RTC failed, restart the unit
Start time precedes RTC time	▪ Alter the start time noting the current time
End time precedes the start time	▪ Alter either the start or stop time
Record start time is not set	▪ Record start mode is set to On Time but the start values have not been set ▪ Set the start time and date fields ensuring the ENT key is used to set each digit
Record end time not set	▪ Record end mode is set to On Time but the end values have not been set ▪ Set the end time and date fields ensuring the ENT key is used to set each digit
SEED initialisation failed	▪ Ensure GPS, RTC and SD card have all initialised correctly
Write error	▪ The SD card may have run out of room during recording ▪ Ensure the SD card is adequately sized for the intended use[1] ▪ Alternatively the SD card may be faulty and need to be replaced
General System Errors	
Error	**Solution**
The unit does not start	▪ Ensure the battery pack being used is fully charged and replace if necessary ▪ Disconnect external connections to see whether they are blowing the internal fuse[2] ▪ Else use an alternative unit

[1] Refer to 5.5 File sizes for more information
[2] You must wait a couple of minutes to allow the fuse time to reset

The screen does not respond to wakeup during recording	▪ Wait 30-45 seconds before reattempting as the display will not respond while the unit is writing data to disc ▪ The battery may have gone flat during recording and the unit will not respond
There is no response from the seismometer	▪ Ensure the seismometer is connected correctly ▪ Ensure the appropriate seismometer model is selected in the system configuration screen ▪ Try an alternative seismometer ▪ Restart the unit to reinitialise the ADCs ▪ Try an alternative unit
The display does not respond to commands	▪ The buttons may be faulty or the unit may have frozen ▪ Restart or try an alternative unit
Battery Errors	
Error	**Solution**
The unit never fully charges	▪ There may be an issue with one or more cells ▪ Cease charging immediately and use an alternative battery pack
The unit does not live up to expected life cycle	▪ There is a damaged cell ▪ Use an alternative battery pack
The unit does not charge at all (none of the indicators light up)	▪ Check charging voltage and current ▪ Check connections
The unit does not appear to trickle charge via the external connector	▪ Check external power connections ▪ Ensure solar panel is not obstructed and receiving direct sunlight ▪ The seismic recorder may be damaged from a pervious overvoltage/ current state on the external power line, try an alternative unit
The charging indicator lights up but the power indicator does not	▪ The power indicator is controlled by a single charging chip and will light up when sufficient power is applied to fully charge the batteries ▪ This feedback is normal whilst trickle charging ▪ May indicate that one or more of the charging circuits is faulty
Power Light is on but both charged and charging light is off	▪ Can be caused by the unit being above 40°C and surpassed the recommended charging temperature of the batteries ▪ One or more of the cells could be damaged and need to be replaced

Table 6.1 - Troubleshooting

7. Appendices

7.1. External Connections and Pin Outs

7.1.1. Seismometer Connector

Pin	Description
A	Ch1 + (Z Axis)
B	Ch1 - (Z Axis)
C	Ch2 + (N Axis)
D	Ch2 - (N Axis)
E	Ch3 + (E Axis)
F	Ch3 - (E Axis)
G	NC
H	NC
J	V +
K	PGND/AGND/SHIELD

Table 7.1 - Seismometer Connector

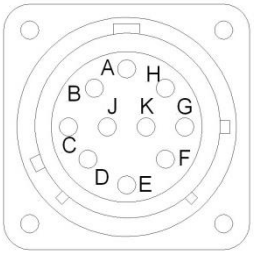

Figure 7.1 - Seismometer Connector

7.1.2. External Power Connector

Pin	Description
A	V+
B	GND

Table 7.2 - External Power Connector

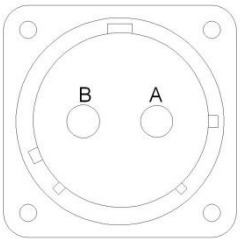

Figure 7.2 - External Power Connector

7.1.3. Battery Connector

Pin	Description
A	Charge +
B	Charge +
C	Charge -
D	Charge -
E	Out +
F	Out -

Table 7.3 - Battery Connector

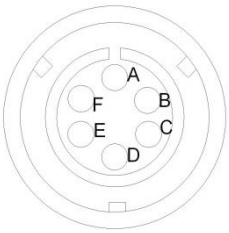

Figure 7.3 - Battery Connector

7.2. ANU Seismic Setup Software

To increase speed and efficiency of deployment it is recommended that setup files be used. The setup file is read in when initialising the SD card and will set any desired system parameters avoiding the need to set them manually via the interface.
To create the setup file a java program[1], ANU Seismic Setup.jar, is used. Below you will find a step-by-step guide to operating the software.

- Open ANU Seismic Setup.jar. (See Figure 7.4 - ANU Seismic Recorder Setup File Software)

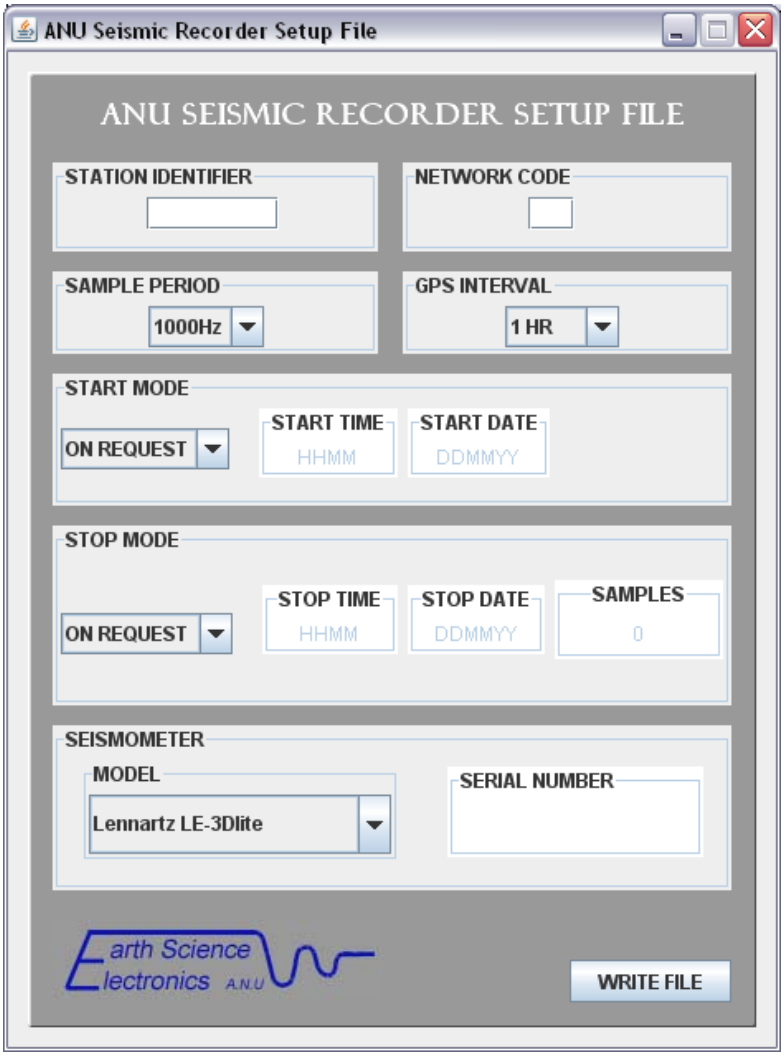

Figure 7.4 - ANU Seismic Recorder Setup File Software

- Enter the station identifier into the field provided. The station identifier is a 5 character alphanumeric code unique to each station. This code is used in identifying the unit in the SEED records. If your identifier is less than five characters enter what you have and the program will automatically pad the spaces. Alternatively if deciding not to use a specific station identifier leave the field blank and the program will pad with spaces.

[1] Java is pre-installed on most modern systems but may be downloaded here: http://www.java.com/en/download/index.jsp

- Enter the network code in the field provided. The network code is a 2 character alphanumeric code for identifying the user network and is used in maintaining the SEED records. As with the station identifier if the field is not being used or is less than two characters enter what you have and the program will pad with spaces.

- Next select the sample period from the drop down box (see Figure 7.5 - Sample Period Selection). This will select the speed at which the unit records. The higher the frequency the more resolution however this is a trade off with the efficiency of the unit as at lower frequencies the power draw is reduced, extending the battery life and overall time of recording. With this in mind the sample period should be chosen to suit the nature of that particular record.

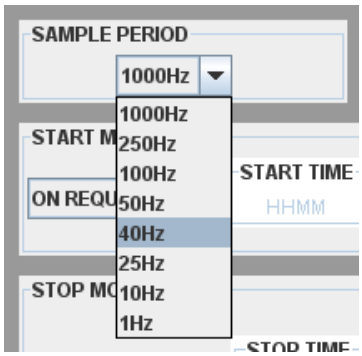

Figure 7.5 - Sample Period Selection

- Then select the GPS interval from the dropdown box provided (see Figure 7.6 - GPS Interval Selection). The GPS interval is the frequency that the unit will turn on the GPS module to get clock errors and record the current system information. Once again this parameter is a trade-off to data resolution and the overall efficiency of the unit. For shorter periods you will get a more accurate reading of the clock error and more frequent system information. However the GPS module consumes a large percentage of the overall device efficiency and longer update intervals can once again extend battery life. It is however recommended that the GPS interval be left at 1 hour unless extended run times are absolutely necessary.

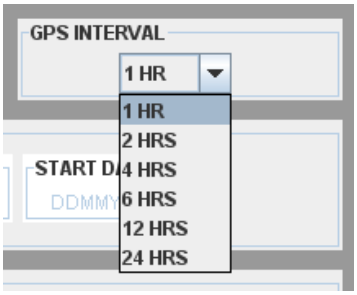

Figure 7.6 - GPS Interval Selection

- Next the start mode is selected via the dropdown box between two options, on request or on time.
  - *On Request* – In this mode the unit will commence recording only when commanded via the on-board interface. The unit will then begin recording to the closest minute. If this option is selected no further fields in the start mode are required.

- *On Time* – In this mode the unit will commence recording on a set time. Once selected the start time and date fields will become available (see Figure 7.7 - Start Mode Selection) at which point you enter each one in the specified format. If an incorrect date or time is entered you will get an error dialogue upon trying to create the file (see Figure 7.8 - Start Mode Error), which means you will have to amend the specified field to a correct value.

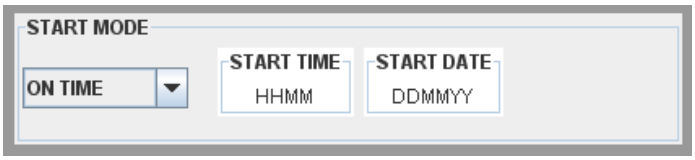

Figure 7.7 - Start Mode Selection

Figure 7.8 - Start Mode Error

- Next the stop mode is selected from its dropdown box between three different options, on request, on time and on samples.
  - *On Request* – Similar to the start mode on request only this time the record is ended when requested via the on-board interface. If this option is selected no further fields in the stop mode are required.
  - *On Time* – In this mode the record will end at a specified time. The program functions essentially the same as the start mode, once it is selected the appropriate fields will become available and values are entered as per the specified formats. Similarly if there is any issues with the specified times a dialogue will appear stating what amendments should be made.
  - *On Samples* – In this mode the record is ended when a specified amount of samples are reached. Once the mode is selected the samples field becomes available (see Figure 7.9 - Stop Mode Selection) and a value up to 2,147,483,647 is entered. Upon attempting to write the file you may experience a dialogue stating that the number of samples has been altered, this is just saying that the samples has been altered to fit the nearest seed data size and no further action is required regarding this field.

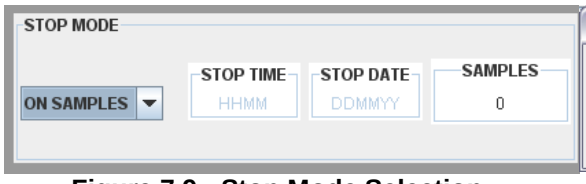

Figure 7.9 - Stop Mode Selection

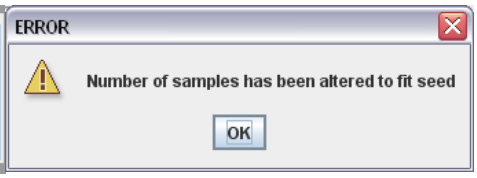

Figure 7.10 - Altering Number of Samples Dialogue

- Then the seismometer model is selected from the dropdown box (see Figure 7.11 - Seismometer Model Selection). Currently there are four options for seismometers, Lennartz LE-3Dlite, Guralp CMG-40T, Guralp CMG-3ESP and Trillium Compact. The main function of this is to set the gain to allow for different output voltages on the seismometers. If a seismometer that is required is not present in the list then it is possible to compare the output signal of the above seismometers and the one planned for use and select a matching model.

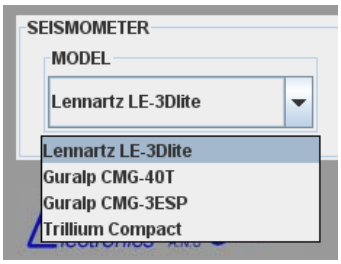

Figure 7.11 - Seismometer Model Selection

- The final parameter to set is the seismometer serial number via its specified text field. The serial number is recorded in the log file as a means to streamline all post processing of data should it be found that any unit may have been underperforming. The serial number has a limit of 10 characters and should be entered to match the specific seismometer being used.

- The final process is to click the write file button to create the file. If any parameters have been set incorrectly a dialogue will appear for each error. These errors should be amended before attempting to create the file again. If successful (see Figure 7.12 - Write File Successful) then a file entitled LPR-200 Setup.txt will be created in the same path as the software. If there is already a setup file at this path that file will be overwritten so care is to be taken when file handling.

Figure 7.12 - Write File Successful

- The file is then placed in the root directory of the SD being used for that record.

7.3. LPR-200 Logfile Converter Software

The ANU short period seismic recorder produces a binary log file that contains information specific to that record. As the file is a custom binary file it is not legible and must be converted to a text file before the data is useable. A java program[1], LPR-200 Logfile Converter.jar, has been created to interpret the binary file and convert it to a text file for processing. Below is a guide to using this software.

- Open LPR-200 Logfile Converter.jar. (See Figure 7.13 - LPR-200 Logfile Converter Software)

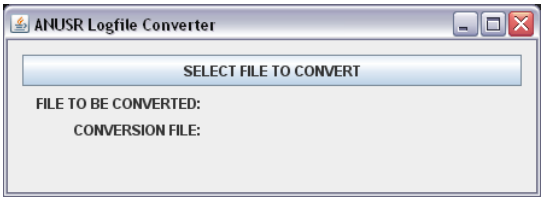

Figure 7.13 - LPR-200 Logfile Converter Software

- Click the “Select File to Convert Button”. This will result in a file chooser dialogue opening (see Figure 7.14 - File Chooser Window).

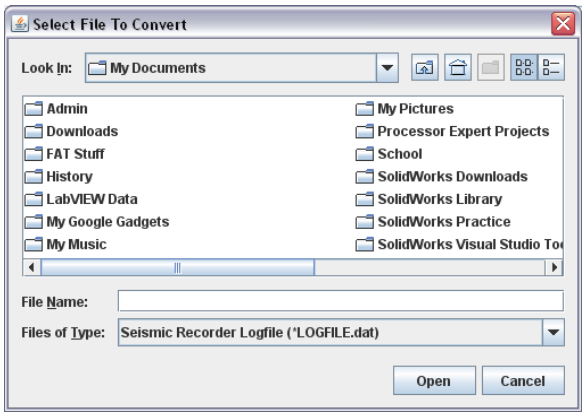

Figure 7.14 - File Chooser Window

- Use the file chooser to navigate to, select and open the desired file.

- Once the file has been selected the program will automatically create the file in the same location as the file being converted (see Figure 7.15 - Successful File Conversion).

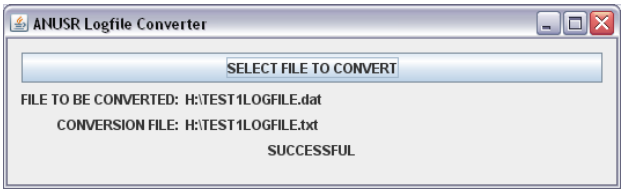

Figure 7.15 - Successful File Conversion

[1] Java is pre-installed on most modern systems but may be downloaded here: http://www.java.com/en/download/index.jsp

7.4. Battery Pack and Charging

The Seismic Recorder is designed to be used with a custom rechargeable battery pack that is designed to provide high power density whilst also being safe to charge and transport. The pack incorporates 14 LiFePO4 battery cells to achieve a nominal output of 6.4V with a capacity of 140Ah. The battery pack has all of the charging and protection circuitry on board meaning all that is required to charge each unit is a 9-15V 100W supply. The following section will provide a brief insight to the battery pack and how to charge it.

7.4.1. Battery Pack Layout

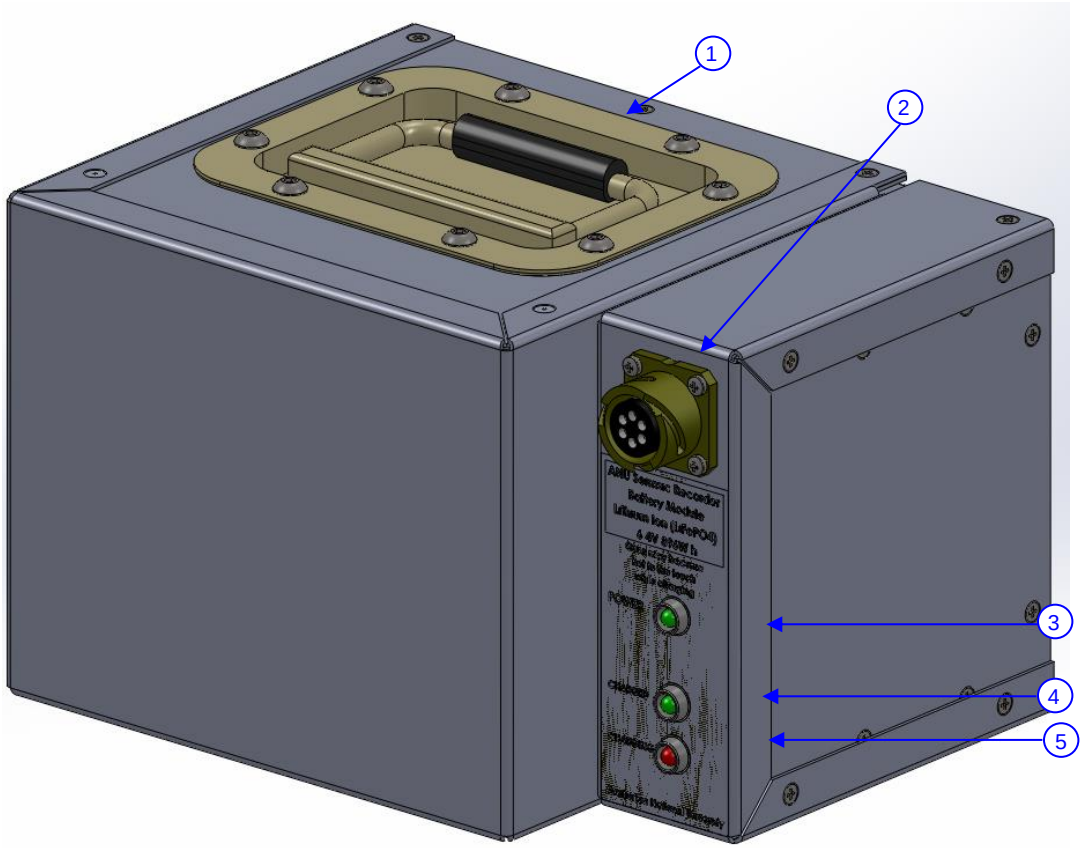

Figure 7.16 - Battery Pack Layout

1. **Handle:** Carrying handle for ease of inserting or removing the pack from the battery compartment in the seismic unit.
2. **Battery Connector:** Output and charging connector for the unit[1].
3. **Power Indicator:** A green LED to indicate when the unit has sufficient input to fully charge the battery pack.
4. **Charged Indicator:** A green LED to indicate when the unit is fully charged.
5. **Charging Indicator:** A red LED to indicate when the unit is being charged.

[1] Refer to 7.1.3 Battery Connector for the MATING connector pin out

7.4.2. Seismic Battery Charger Layout Front

Figure 7.17 - Seismic Battery Charger Front

1. ***Output Connector:*** 6 output connectors to connect directly to each battery pack

7.4.3. Seismic Battery Charger Layout Rear

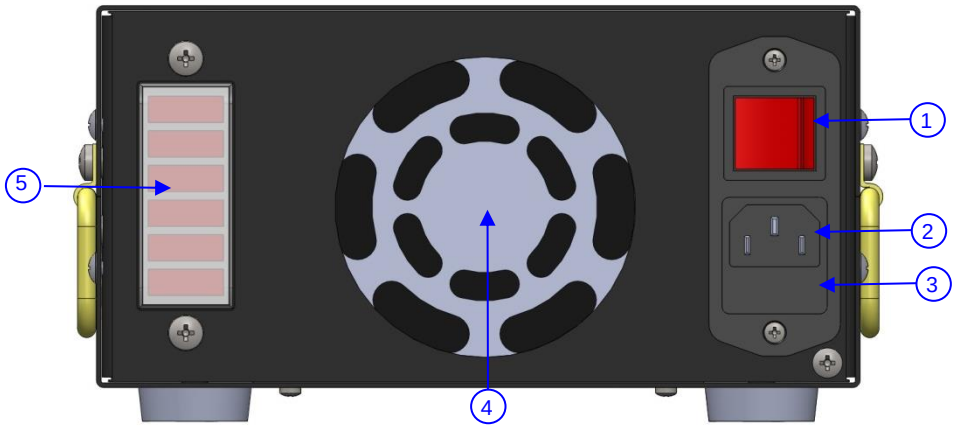

Figure 7.18 - Seismic Battery Charger Rear

1. ***On/Off Switch:*** The power switch for the unit
2. ***IEC Connector:*** Mains power input connector
3. ***Fuse Holder:*** Fuse holder, slide out for replacement
4. ***Fan:*** Fan ventilation slots, DO NOT OBSTRUCT
5. ***Output Fuse:*** 10A automotive fuses for each output channel

7.4.4. Seismic Battery Charger Operation

- Ensure the battery charger is placed to allow adequate airflow around the unit.
- Ensure that charging will take place in a cool environment as the batteries must not exceed 40°C as charging will stop.
- Connect up to six battery packs to the output connectors of the battery charger with the cables provided.
- Connect an IEC lead to the rear of the unit.
- Use the switch at the rear to start/stop charging.

Note the side compartment of the battery pack will heat up quite dramatically. It is recommended to avoid touching it during charging.

7.4.5. Using a power supply to charge battery pack

Equipment required to charge a battery pack from a power supply:

- Minimum 100W 9-16V power supply
- Length of dual core 10A cable
- Battery Pack mating connector[1]

Follow the following steps to make cable and charge the battery pack:

- Strip back the cable and solder wire to the connector as per pin out 7.1.3 Battery Connector, ensuring correct colours are used (+ RED or BROWN, - BLACK or BLUE)
- Ensure there is adequate ventilation around the supply
- Ensure that charging will take place in a cool environment as the batteries must not exceed 40°C as charging will stop.
- Connect the exposed ends of the cable to appropriate terminals on the supply (+ = RED, - = BLACK)
- Turn on the supply and set the output voltage to 12V
- Set the current limit to allow a minimum 9A current flow
- Finally connect the battery and allow to charge

Note the side compartment of the battery pack will heat up quite dramatically. It is recommended to avoid touching it during charging.

7.4.6. Trickle charging with solar panel via external power connector

An external power connector is provided on the unit to allow the battery to trickle charge with the use of a solar panel while recording. This connector is designed to trickle charge the battery only and should never be connected to a supply capable of supply more than 2 amps as this would cause irreparable damage to the on-board circuitry. A maximum 40W panel can be connected directly to the connector[2] as per pin out 7.1.2 External Power Connector to greatly increase the units run time. This will cause the charging indicator on the battery to light up as well as indicating the unit is charging with a lightning bolt being displayed in the battery charge gauge.

[1] Battery connector available from RS Components. Connector: 442-2173 Coupling: 475-943
[2] External Power Mating connector available from RS Components: 189-156

7.4.7. Powering the unit from the external connector

As mentioned previously the external power connector is designed primarily for in circuit trickle charging of the battery. However with the use of an optional attachment it is possible to run the device of an external 5-12V supply. To do this connect the attachment to the unit's battery connector and then connect to the power source to the external power connector[1] conforming to the pin out outlined in section 7.1.2. The battery gauge will indicate a charge based on the supply voltage but will always indicate the unit is charging.

[1] External Power Mating connector available from RS Components: 189-156