CMG-EDU
Educational Seismometer System

Technical Manual

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1 Preliminary Notes

1.1 Proprietary Notice

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1.2 Warnings, Cautions and Notes

Warnings, cautions and notes are displayed and defined as follows:



Warning: A black cross indicates a chance of injury or death if the warning is not heeded.



Caution: A yellow triangle indicates a chance of damage to or failure of the equipment if the caution is not heeded.



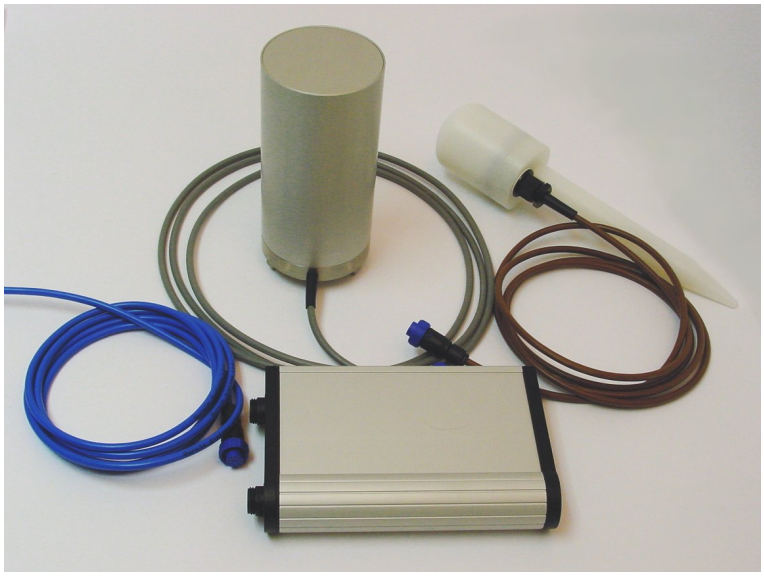
Note: A blue circle indicates indicates a procedural or advisory note.

1.3 Manuals and Software

All manuals and software referred to in this document are available from the Güralp Systems website: https://www.guralp.com/ unless otherwise stated.

2 Introduction

The CMG-EDU is an ultra-compact single-axis broadband seismometer designed specifically for educational uses. It is available in either vertical or horizontal form.



The CMG-EDU is ready to record ground movements as soon as you provide it with power. It does not have to be unlocked or centred as long as its base is within 3 ° of horizontal. For the best results, however, you should install where possible on a hard, near-horizontal surface, preferably underground. See section 3.1 on page 3.1 for recommendations. Also supplied is a Güralp Systems CD24E1 compact single-component digitizer, and a GPS unit.

Each package is delivered with a detailed calibration sheet showing its serial number, measured frequency response in both the long period and the short period sections of the seismic spectrum, sensor DC calibration levels, and the transfer function in poles/zeros notation.

2.1 Unpacking and handling

The CMG-EDU instrument is delivered in a single case, with specially designed packaging. You should reuse this case whenever you need to transport the sensor. Please note any damage to the packaging when you receive the equipment, and unpack on a safe, clean surface. The package should contain:

- the seismometer with attached signal cable;
- the digitizer;
- the GPS unit with attached data cable;
- a blue power/data cable;

- a calibration and installation sheet, and
- this manual.

You will need to provide your own 12–24 V DC power supply, and a Windows or Linux PC for recording the data.

2.1.1 Handling notes

Although the CMG-EDU is relatively rugged, it can be damaged if mishandled.

- Do not bump, kick or drop the sensor.
- Do not kink or walk on the data cable, nor allow it to bear the weight of the sensor.
- Do not ground either of the signal lines from the instrument.

If any component is missing or appears damaged, contact Güralp Systems immediately (see chapter 3.1 on page 3.1).

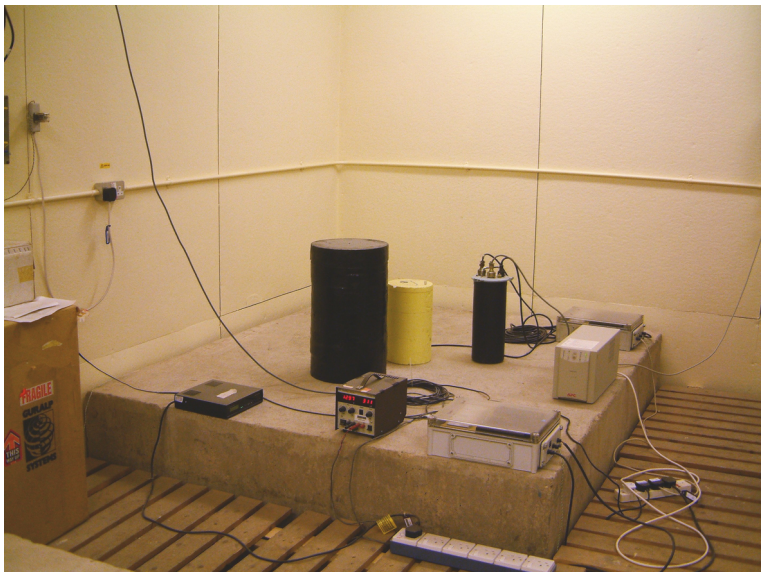
3 Installing the CMG-EDU

3.1 Installing in vaults

The CMG-EDU is a sensitive instrument designed to measure extremely small movements of the ground. These movements are the sum of all the vibrations arriving at the instrument: as well as distant earthquakes and nearby tremors, the ground responds to surf on nearby beaches, quarry blasts, heavy machinery, traffic, and even people moving around the building. Temperature changes and air currents in the same room as the sensor can also affect its output.

3.1.1 Choosing a location

When studying natural earth movements, any other effects introduce unwanted noise into the system. It is therefore important to choose an appropriate site for the instrument, ideally in an underground vault with the sensor installed on a concrete pier that is in direct contact with the bedrock.



This setup has a number of advantages:

- It is installed below ground. Most man-made noise tends to travel along the surface, and natural microseisms (tiny natural flexings of the Earth's crust) also occur near the surface.
- Good contact with bedrock means that the signals accurately reflect earth motions; seismic waves do not have to travel through layers of soft soil and sediment.
- If the vault is inside a larger structure, its foundations are separated from the pier, so that nearby vibrations are not transmitted to the sensor.

A high-quality seismic vault can be incorporated into the construction plans of a new building at relatively low cost. However, if you are not in a position to build a dedicated vault, you can still reduce noise to a satisfactory level by

- installing below ground, in the basement or sub-basement of an existing building;
- placing the sensor directly on a cement floor to improve contact; and
- locating the sensor in a quiet corner away from people and machinery (*e.g.* air-conditioning and heating systems, elevators, *etc.*)

Installation on higher floors is not recommended, especially for horizontal sensors, since any "give" in the floor near the sensor will cause it to tilt slightly and register a signal.

3.1.2 Temperature stability

The CMG-EDU can operate over a wide temperature range (–10 °C to +75 °C). However, the sensor mass is sensitive to fluctuations in local temperature. This affects the response of the instrument at long periods. Sunlight and other bright lights can also cause small mechanical stresses that will be detected by the sensor. You can minimise these effects by

- installing in a basement, where the temperature is normally more stable than above ground;
- locating the sensor in a dark, protected corner, and
- enclosing it in an insulated box (expanded polystyrene works very well). This also helps protect the sensor from air currents.



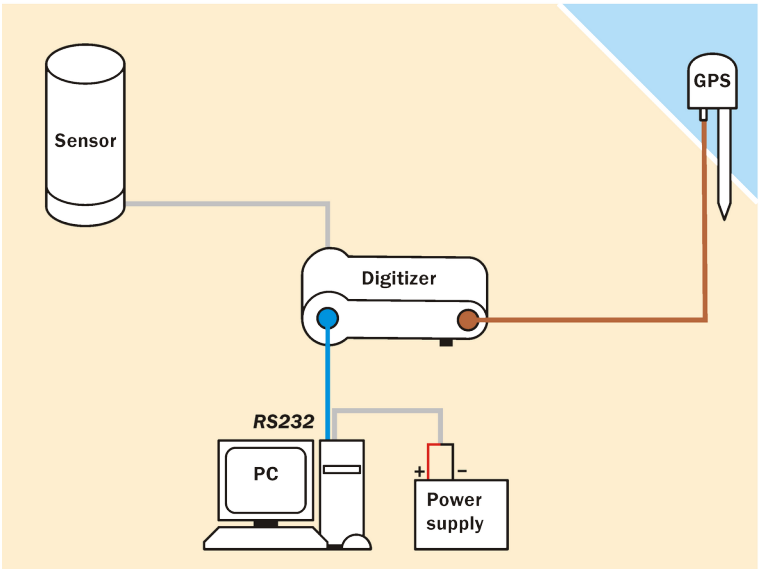
3.1.3 Other considerations

- The sensor and cables should be situated well away from other electical cables and appliances. Stray radiation from these sources may interfere with the sensor's electronics.
- The sensor should be placed on a smooth, level surface free from cracks. Small cracks tend to open and close slightly with changes in humidity and temperature, causing the surface to move slightly.
- All three of the sensor's metal feet must make good contact with the floor.
- The signal cable from the sensor should rest loosely on the ground nearby, so that vibrations are not transmitted along it.
- If your recording or digitizing equipment has front-panel indicators or connectors, make sure it can be reached without disturbing the sensor.
- The GPS unit needs to be in a location where it can see as many satellites as possible. A location with a good view of the sky, preferably down to the horizon, is recommended. If you are in the Northern Hemisphere, make sure as much of the southern sky as possible is visible. Conversely, in the Southern Hemisphere, make sure the GPS can see a large area of sky to the north.

  The GPS unit is supplied with a 15 m cable to the digitizer.

3.2 Setting up

Once you have chosen suitable locations for the sensor, digitizer and GPS, you need only connect the various components and supply them with power. The digitizer and sensor will begin working immediately.



- Connect the grey cable attached to the sensor to the *SENSOR* socket on the digitizer.
- Connect the brown cable attached to the GPS unit to the *GPS* socket on the digitizer.
- The remaining blue and grey cables are joined together at a 9-pin RS232 socket. Connect this socket to your PC's serial connector.
- The grey cable from the RS232 connector ends in red and black wires. Connect the black wire to the negative (–) terminal of the power supply, and the red wire to the positive (+) terminal.
- The blue cable from the RS232 connector ends at a blue socket. Connect this to the *DATA* plug on the digitizer. *Do this step last* – an intermittent power supply can damage the digitizer, so it is best to make sure the wires to the power supply terminals are securely connected before you connect the digitizer.
- When everything is connected, the digitizer should be drawing around 50 mA from the power supply. You can measure this either directly from the power supply unit (if it has the facility) or by connecting a 5 W-rated, 1 Ω resistor in series with the positive terminal and measuring the voltage drop across it: 50 mA through a 1 Ω resistor should consume 50 mV.

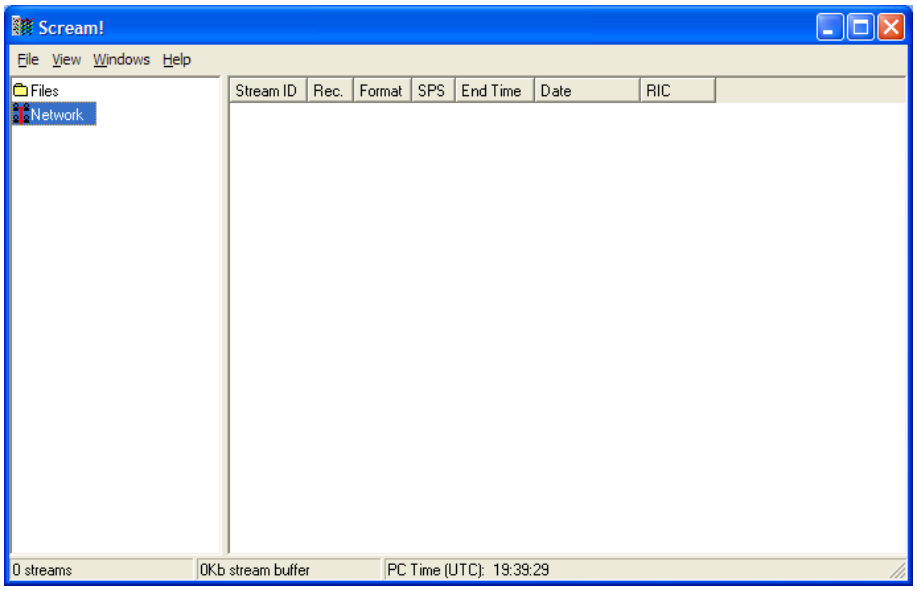
  If the digitizer draws significantly more or less than 50 mA, switch it off immediately and contact Güralp Systems.

4 Viewing data with Scream!

You can use Güralp Systems' Scream! software to view incoming seismic data, record it, and play events back later. Windows and Linux versions of Scream! are freely available from Güralp Systems.

4.1 The main window

When you start Scream!, you will be shown an empty main window:

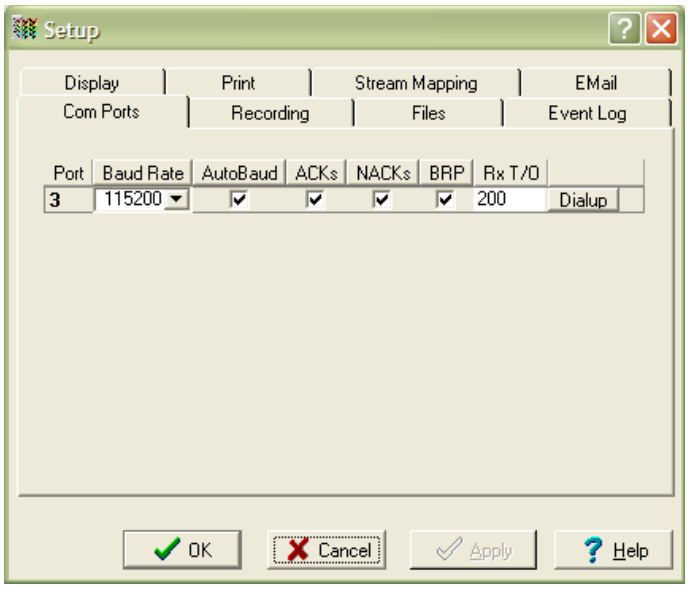


Scream! is now ready for you to start adding data sources.

4.2 Serial ports

1. Select **File → Setup...**. If the *Com Ports* tab is not visible, bring it to the front.

   If you are running Scream! for the first time, it will automatically bring up this window, together with a short tutorial.



   You can also configure a serial port by right-clicking on its entry in the streams list (the left-hand panel in the main window) and selecting **Configure...** However, you can only do this if data has already arrived through the port, making it appear in the streams list.

2. The serial ports available to Scream! are listed in the table. Identify each port, and the instrument connected to it.

   If you are using Microsoft Windows, the *Port* number corresponds to the COM*n* number of the serial port.

   If you are using Linux, *Port* numbers 1 – 64 refer to the built-in serial ports `/dev/ttyS0` – `/dev/ttyS63`, and 65 and above to USB-connected serial ports beginning `/dev/ttyUSB0`.

   A port may not be listed if it is not installed, or suitable drivers are not available, or if another program is using it. Scream! scans your computer for new ports each time you open the *Setup* window. To make Scream! scan the ports again, click the **Port** column heading.

3. Configure each port according to the settings of the instruments connected to them:

   Baud Rate: The speed of the serial link to the instrument. If you do not know the baud rate of your digitizer's output port, select *Auto-Detect* from the drop-

down menu to have Scream! attempt to detect it for you. The instrument must be producing data for this to work.

You can set all ports to the same baud rate by clicking on the column heading and choosing a suitable value from the drop-down menu.

Under normal conditions, you will not need to change any of the remaining settings.

4. Click **OK**.

Streams from connected instruments should now begin appearing in the right-hand portion of Scream's main window.

Scream! will remember all the data sources you have specified on exit. When you next open the program, it will automatically try to re-establish all the connections.

4.3 The stream buffer

Scream! works by recording incoming streams into a fixed area of memory, called the *stream buffer*. All of Scream!'s operations work with the data in this buffer.

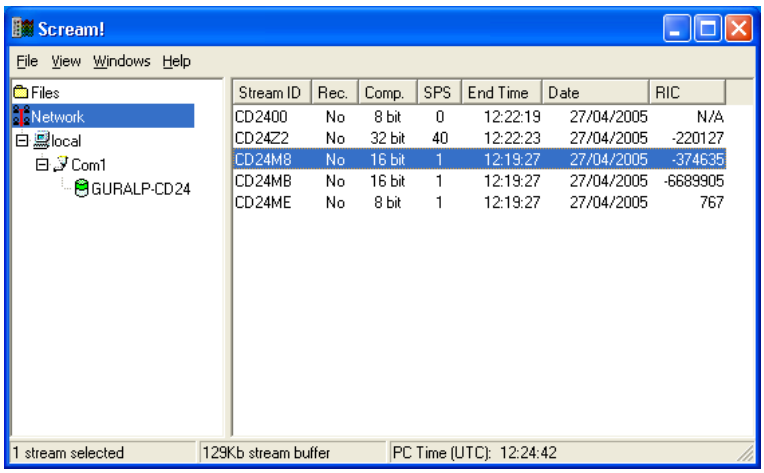
When you start Scream! for the first time, this buffer is empty. You can add data to it either by receiving it from local serial ports, connecting to Scream! network servers, or replaying GCF files.

Once the stream buffer is full, Scream! will start discarding the oldest data. If you have not told Scream! to record the incoming streams (see chapter 5 on page 5), then you will not be able to get discarded data back.

If you have enabled GCF recording, Scream! keeps track of the files which contain data in the stream buffer, and saves this information in a `.lst` file in the current recording directory. When Scream! is restarted, it reads this file and tries to rebuild the stream buffer as it was when it was shut down. Otherwise, the buffer starts off empty as before.

4.4 The source tree

The tree in the left panel of the main window shows all the data sources currently connected to Scream!.



Scream!'s source tree has two main parts: *Files*, which contains all the files you have replayed (including automatic replay: see section 5.3 on page 27), and *Network*, which represents your seismic network.

Beneath *Network* is a list of all the network servers Scream! is connected to, plus the entry *Local* for your computer's own serial ports.

The next layer contains the serial ports themselves. These icons are provided to help you identify the instruments, as well as providing direct terminal access.

You can tell Scream! to ignore a particular instrument by right-clicking on its icon and selecting **Ignore**. When you do this, Scream! will discard any blocks it receives from the instrument. They will not appear in the stream buffer or be recorded to disk. Select **Ignore** again to stop ignoring the instrument.

4.4.1 Icons

Instrument icons change colour to provide you with a quick overview of the instrument's timing and mass position status:

If both halves of the instrument icon are clear , Scream! has not received any information from the instrument since the program started.

If the top half is green , the instrument has reported a satisfactory timing fix.

If the top half is yellow , the instrument has reported a gap in the timing stream. This will occur if the GPS signal deteriorates to the point where the receiver cannot keep a lock on the satellites.

If the top half is red , the instrument has not reported a satisfactory timing fix for over an hour. This will happen if the instrument has reported failures (as above), but also if it has not reported anything. If you have set the GPS system to power down for intervals longer than an hour, the icon will turn red even if the system is working normally.

If the bottom half is red , the instrument (or one of its components) is running with a mass position over 15000 counts—roughly 50% of its travel. You should re-centre the component if possible, to avoid clipping after large ground movements.

If the instrument appears as a green box , the instrument has sent status blocks to Scream!, but no data. The box represents a Güralp CRM/SAM; these modules store or forward data from other instruments, but occasionally produce status blocks themselves. If a digitizer produces a status block before any data, perhaps because you have configured very slow data rates, it will temporarily appear with this icon.

4.5 The stream list

If *Network* is selected in the source tree, the right-hand panel will list all the data streams which Scream! receives (and is not ignoring). If an entry in the source tree is selected, the stream list will only show the streams beneath that entry—selecting a serial port will only show streams from instruments connected to that port, and so on.

The columns in the table provide useful information about each stream.

Stream ID : A unique name for the data stream, being a combination of six letters A – Z and numbers 0 – 9. Streams ending in `00` carry status information about the internal digitizer, whilst other streams contain data coming from connected instruments. The slow-rate environmental channels (Mux channels) generally have Stream IDs ending in `Mx` where *x* is a hexadecimal digit (0 – 9 or A – F), whilst other *Stream ID*s are used for seismic data from attached instruments.

The last number in the *Stream ID* gives the tap number of the stream: in order of decreasing sample rate, 0, 2, 4, or 6. If you are using a 6-channel digitizer, tap numbers 1, 3, 5 and 7 are used for the second 3 channels.

Rec. : Whether Scream! is currently recording the data stream to the laptop's onboard hard disk. If another device on your network is recording the data stream independently of Scream!, the entry in this column will still be `No`.

Comp. : The compression factor of the data in the stream, expressed as the number of bits occupied by each record (8, 16 or 32 bits.)

SPS : The sampling rate of the data stream, in samples per second. Status streams, ending in `00`, do not constantly output data and have an *SPS* of 0. By default, the stream list is sorted in order of sample rate, with the status streams at the bottom.

End time and *Date* : the date and time of the most recent data, as measured by the data's own timestamp. This is *not* necessarily the latest data to arrive.

RIC : The 'Reverse Integrating Constant'. In effect this is the value of the last sample received. This is most useful for reading mass positions or other environmental streams. Status streams have a RIC of zero.

You can hide the extended information about each stream by selecting **View → List** from the menu. To return to the full view, select **View → Details**.

4.5.1 Sorting options

Sorting options are available from the **View → Sort By** → menu:

Alphabetical : Strict alphabetical order, 0 – 9 then A(a) – Z(z).

Component : Vertical components (ending `Zx`), followed by `Nx` and `Ex` components, then Mux channels `Mx`. Within a component type, sort by the first four characters of the *Stream ID*.

Instrument : Sort by the first four characters of the *Stream ID*. Within an instrument, sort by tap, then by component.

Sample Rate : Sort by sample rate, highest to lowest. Within a sample rate, sort as *Instrument*.

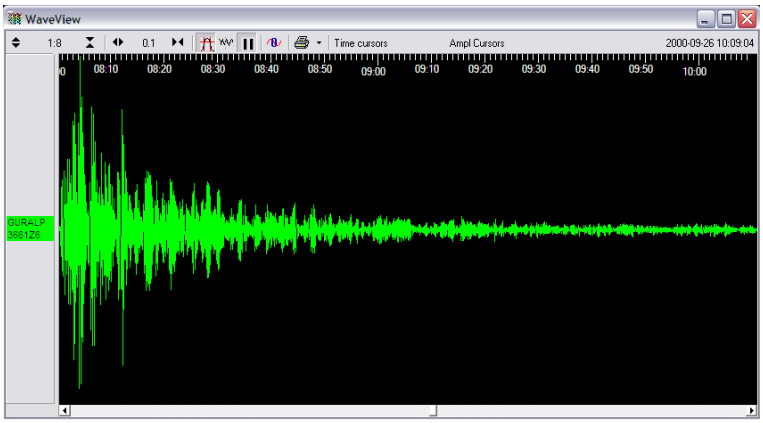
Tap : Sort by tap (the last character of the *Stream ID*). Within a tap, sort by instrument, then by component.

Select the **Reversed** option to reverse any of these sort orders.

You can also sort the list by *Stream ID* or *SPS* by clicking on the relevant heading; click again to reverse the sort order.

4.6 Waveview windows

The most commonly used features of Scream! are accessed through *Waveview* windows. You can open as many *Waveview* windows as you like, on any combination of streams; the same stream can be part of several *Waveview* windows at once, at several different scales.



To open a *Waveview* window from Scream!'s main window:

- select **Window → New Waveview Window...** from the main menu;
- double-click on a stream ID in the streams list;
- right-click on a stream in the list and select **View**; or
- make a selection of streams and double-click the selection (or press `ENTER`.)

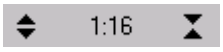
You can add further streams to the *Waveview* window by selecting them from the streams list and dragging the selection into the *Waveview* window, or by dragging them from other *Waveview* windows. Dragging with `Ctrl` held down will copy the stream from one window to another; otherwise, the stream will be moved to the new window.

You can also drag streams within a *Waveview* window to reorder them. (If you have paused a *Waveview* window with the  icon, you will need to drag from the panel on the left, since dragging across the window will zoom in; see below.)

To the left of the stream display is a panel identifying the stream by its *System ID* and *Stream ID*. If the label is too long to read, you can resize the panel by dragging its edge across the *Waveview* window. You can also hide the panel this way.

Above the stream display is a toolbar, containing icons which act on all of the streams within the window.

4.6.1 Zooming in and out

To zoom in and out vertically, click the vertical scale icons 

at the top left of the window, or use your mouse wheel. The current zoom factor is shown between the icons, as a ratio of pixels to counts. Zooming in and out affects every stream in the window.

To zoom in and out horizontally, click the horizontal scale icons 

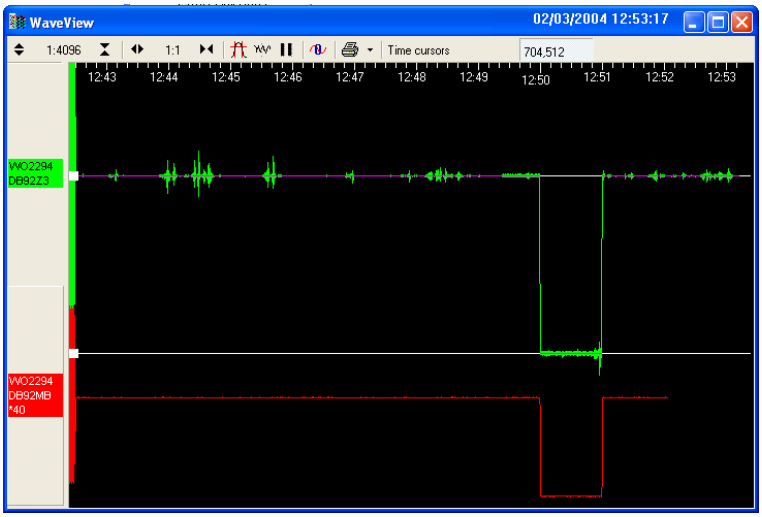
, or hold down SHIFT whilst turning your mouse wheel. The current zoom factor is shown between the icons, in pixels per second. To convert to pixels per sample, divide the zoom factor by the sample rate for the stream.

If you have a large window which takes some time to scroll, especially at a high horizontal zoom factor, Scream! may not be able to finish drawing new data before it needs to scroll again. If this happens, Scream! will delay scrolling until it can display in real time once more. To prevent this, decrease the time scale.

If you have paused the window with the  icon, you can zoom into an area of interest by dragging a rectangle across the streams. Scream! displays the time span in the top right corner of the rectangle, and the number of counts in the bottom left corner. When you zoom this way, Scream! will always keep the edges of the window at 1-second boundaries. You can drag across one stream, or several; the resulting window will still include all streams.

4.6.2 Making measurements

Click the **Time Cursors** or **Ampl Cursors** button to display a pair of vertical or horizontal cursors. Each cursor has a white square at one end, which can be dragged across the *Waveview* window to measure features. If two cursors coincide, you will only be able to see the squares.



The distance between the cursors is given in the text of the **Time Cursors** or **Ampl Cursors** icon, in seconds and Hz or counts. You can have both vertical and horizontal cursors active at the same time. Because the limit of accuracy of the cursors is one pixel, you should zoom in to the range of interest before measuring.

The **Ampl Cursors** measure distances in counts according to the current zoom settings. However, if you have applied a scaling factor to an individual stream (see below), the **Ampl Cursors** do *not* take this scaling into account. If you set a stream's scale factor to the combined sensitivities of the sensor and digitizer, you can set up the window so that one pixel corresponds to a useful value in physical units.

To obtain the true value in counts, divide the value displayed in the **Ampl Cursors** icon by the scale factor for that stream, as displayed beneath its ID on the left-hand panel.

4.6.3 Printing

To print the data currently being displayed in the *Waveview* window, click on the **Print** icon . Scream! will use the current printer settings to print a full page view of the window, using the current amplitude and time scaling, filtering and other display options. You can print at any time, in either real-time or paused mode.

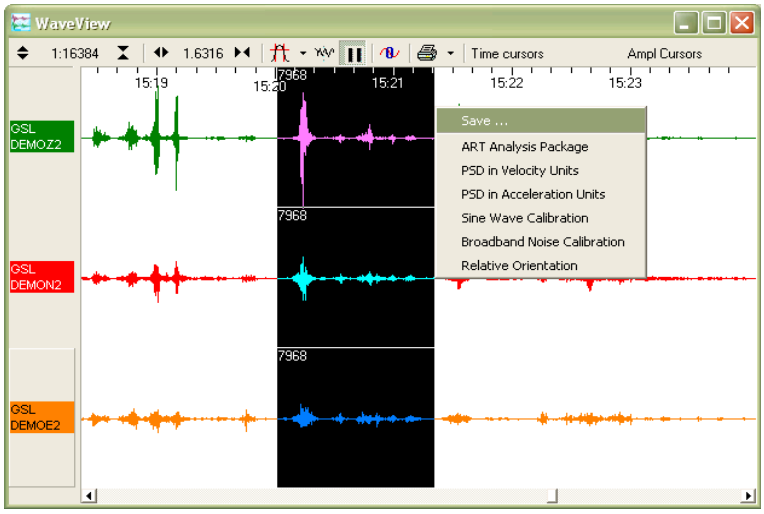
To print the same data in black and white (on a colour or greyscale printer), click on the arrow beside the **Print** icon and select **Page Print (monochrome)** from the drop-down menu. Black and white output is more suitable for copying or faxing.

4.6.4 Paused mode

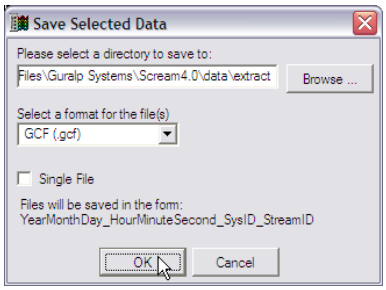
Click the **Pause** icon  to stop the window scrolling. If new blocks arrive which contain data from the time period displayed, Scream! will add them to the window.

Whilst a window is paused, you can:

- Scroll the waveform to left and right to view all the data that Scream! has in memory. *Alternatively*, hold down `CTRL` whilst turning your mouse wheel to scroll through the data. Because new data is still being added to the memory buffer, the scroll bar will move slowly to the left as long as the display is paused.
- Zoom in and out to examine features in the data.
- Select data from several streams by holding down `SHIFT` and dragging:



You can save this data to a file by clicking **Save...**:



Select the directory and format for the file, and click **OK** to save the data with one file for each stream (using the format shown.)

Some formats support multiple streams per file. For these formats, you can select **Single File** to combine the streams.

The number at the top left of the selection (here, 2940) is the number of samples from each stream that you have selected.

Click the **Pause** icon again to return to real-time mode. If you have changed the zoom settings, the window will return to its previous state, with the window once more following the real-time data.

4.6.5 Other icons

Click the **Block Boundaries** icon  to display a dotted line at the end of every GCF block displayed in the window.

The number beside each line is the number of bits used to store each sample in the block. A fixed-length GCF block with 8-bit samples (largest difference –128 to 127 counts) can store 4 times as many samples as a block using 32 bits for each one (largest difference –4 294 967 296 to 4 294 967 295 counts). Clicking the icon again removes the block markers.

Click the **Bandpass Filter** icon to make Scream! apply a band-pass filter to each of the displayed streams. This is most useful when long-period signals are causing the baseline to vary. The pass band is set as follows:

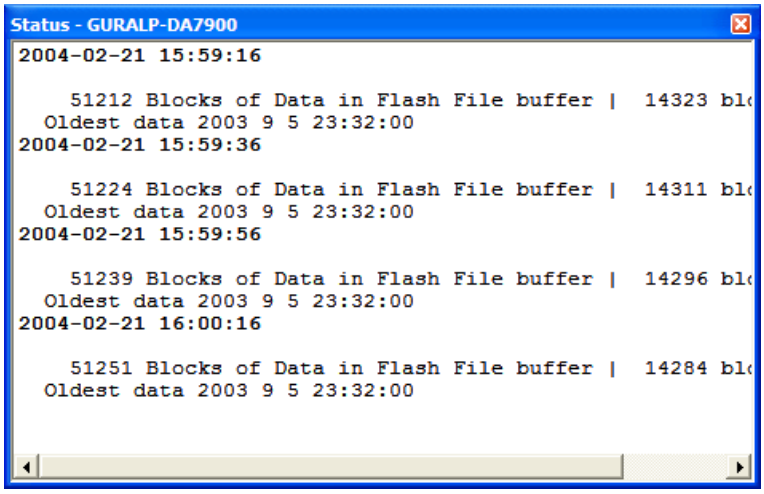
- Data at 1 or 2 samples/s is filtered with a 10 – 30 s pass band.
- Data at other sample rates is filtered with corner frequencies at 0.1 and 0.9 times the Nyquist frequency of the stream; for example, the pass band for the filter applied to a stream at 100 samples/s will be 5 – 45 Hz.

Click again to remove the filter.

Click the **Zero Streams** icon to set the offset of each stream in its "lane" so as to centre its mean value over the time period displayed. If you do not want a particular stream to be zeroed when you click this icon, right-click on the stream beforehand and select **Locked Offset**. This option is particularly useful when first setting up an instrument, since its output is often offset by a constant DC voltage.

4.7 Viewing status streams

Status streams (ending `00`) consist of plain text. Double-clicking on a status stream produces the *Status* window:



The first blocks will give the boot message from the digitizer, including its software revision and the data streams selected for downloading and triggering. Later blocks give information on visible GPS satellites, the location of the GPS antenna and time synchronization status. Also displayed are the baud rates currently used for each channel and for the data link.

If you **View** a selection which includes both status and data streams, the status streams will be collected together and displayed in a tabbed *Status* window, whilst the data streams will appear in a single *Waveview* window.

5 Recording and playback

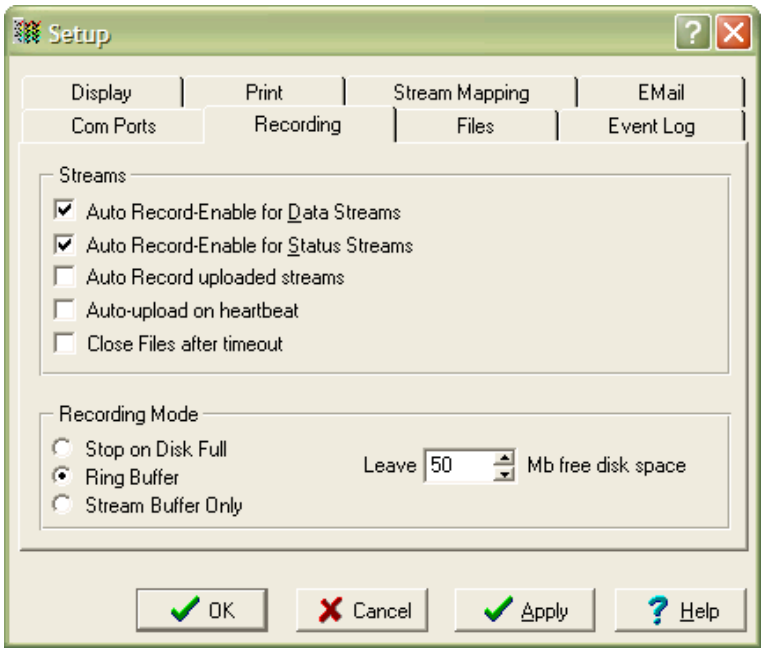
Scream! allows you to record all incoming data and store it on the local hard disk. To do this, you should select the streams you want to record from Scream!'s main window, right-click, and choose **Start recording** from the pop-up menu. The streams will display `Yes` in the *Rec.* column to indicate that they are recording.

When Scream! starts recording, it starts at the earliest point in the current stream buffer, and immediately records all it can. For continuous streams, the recorder will soon catch up with the real-time data.

By default, recorded data is placed in a `data` directory within the Scream 4 installation, in GCF format. Scream! records files for each stream separately, which it puts in that stream's own directory. This directory may contain one or several GCF files.

Scream! has a number of options which allow you to change the way data is recorded and filed. From the main window, select S**etup...** from the **File** menu to open the *Setup* window. Click on the **Recording** tab. (Scream!'s setup window also provides a number of other kinds of options. Consult Scream!'s documentation or online help for more details.)

5.1 Recording



The upper part of this pane allows you to instruct Scream! to record various streams automatically. Scream! will start recording all relevant streams immediately, but will also remember the settings for the next time it is started up.

Auto Record—Enable for Data Streams causes all local data streams to be saved automatically, whilst **Auto Record—Enable for Status Streams** does the same for digitizer status streams (those ending in 00.)

Auto-upload on heartbeat : If a digitizer has been configured to record data into its own Flash memory only *(FILING* mode), it transmits heartbeat status messages. With this box checked, Scream! will listen for heartbeat messages, and ask the digitizer to send filed data whenever it receives one.

Auto-record uploaded streams : If you have selected **Auto-upload on heartbeat**, you can check this box to instruct Scream! to automatically record to the local hard disk any data that it receives. These are not normally counted with the streams above, since they may come from another Scream! which is already recording.

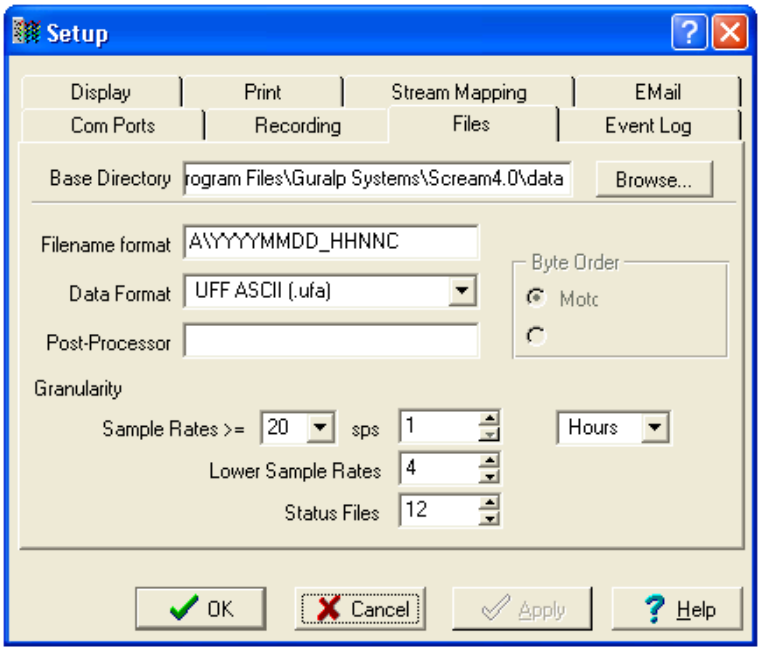
The lower section tells Scream! how to use its hard disk space:

- If **Stop on Disk Full** is selected, then Scream! will stop recording data once it runs out of space in its directory. This way, the data recorded will have a known starting point.
- If you select **Ring Buffer**, then Scream! will start deleting the oldest files in the data directory in order to make space for new data, so that you will always have access to the most recent recorded measurements. Scream! does *not* check whether it created the files itself. If you put your own files in Scream!'s data directory, then they are at risk of being deleted.
- If **Stream Buffer Only** is selected, Scream! will delete any file which no longer appears in the stream buffer. This is useful if you are only recording to preserve data in the stream buffer through restarts of Scream!.

If there is very little space on the disk, the PC's operating system can become slow or unstable. By default, Scream! will consider the disk “full” when only 50 Mb of space remains on it. You can change this amount by altering the value at bottom right.

5.2 Files

Another part of the *Setup* window allows you to alter the way Scream! files the data it receives. Click on the **Files** tab to open the following pane:



The options you can change are:

Base Directory: This specifies the root directory in which data files will be saved. Files for each stream are stored in sub-directories off this root. The sub-directory structure depends on the filename format.

Filename format: This allows you to describe how you want files to be named by entering a *format specifier*. The string you enter is used to construct the file names for all files. Among the specifiers you can use are:

YYYY the year number (*e.g.* 2003),

M the month number (1 – 12),

D the day of the month (1 – 31),

H the hour (0 – 23),

N the minute (0 – 59),

S the second (0 – 59),

R or **J** the day in the year (0 – 366),

X the date represented as an 8-digit hexadecimal number (this allows a complete date to fit in the DOS 8.3 format, for compatibility),

I the *System ID*,

T the *Stream ID* (e.g. `DM24Z2`),

C the component identifier (`Z`,`N`,`E`,`M`, *etc.*),

P the sample rate, in samples per second;

A the name of the stream, if you have set a mapping, otherwise the same as **T**.

The specifiers **MM, DD, HH, NN, SS, RRR, JJJ, IIIIII** and **TTTTTT** are the same as their single-letter counterparts, but they are padded with zeros or underscores to a constant length. **YY** can also be used for a 2-digit abbreviation of the year (*e.g.* `03` for 2003), and **MMM** for a 3-letter month name (`jan`, `feb`, *etc.*)

Any other letters (including small letters) in the filename will be left as they are, so you can add constant descriptions or field separators as you wish. Owing to operating system limitations, you cannot use any of the punctuation marks `* ? " : < > |` in filenames. You can create directory structures by using the **** character.

For example:

T\YYYY_MM_DD;HHhNNmSSs will give filenames like `dmz2\1997_10_05;07h35m20s`.

You should always ensure that files are given unique names. Scream! writes each stream separately. If it finds that it cannot write to a file because it is already open for another stream, the write will fail and data will not be recorded.

Data Format: Selects the format of the recorded data files. Options are GCF, SAC, MiniSEED, P-SEGy, PEPP, SUDs, GSE, UFF (ufa and ufb; see below), and CSS. A single Scream! can only record in one format at a time.

Byte Order: For SAC, SEG-y, UFB and CSS files, the byte order of the files can be specified. This can be used to match the byte order with the native order of the platform where you are going to perform analysis. GCF and MiniSEED are defined to be in “Motorola or SPARC” byte order. PEPP and SUDs data is defined to be in “Intel” byte order. Byte order is not applicable to the ASCII-like GSE or UFA formats.

Granularity: Allows you to decide how large files are allowed to become before a new one is started, for three different types of stream (high sample rates, low sample rates and status streams). The distinction between high and low sample rates is set by the number in the **Sample Rates >=** box; the remaining boxes give the number of hours of data that Scream! should combine into a single file for each type of stream. In the example above, streams with a sample rate of 20 samples/sec or above will be recorded in files with up to 1 hour's data per file; lower-rate streams will be recorded in 4-hour files, whilst a new status file will be started every 12 hours. You will need to choose a **Filename format** (see above) which gives each file a unique name.

If you prefer to set a limit on a file's size, rather than its duration, choose **Kilobytes** from the drop-down menu (instead of **Hours** or **Minutes**) and set as appropriate.

Post-processor: This option allows you to specify a program which Scream! will run every time it closes a file. The name of the file is passed as a parameter. You can use this feature to interface to other analysis or archival systems, for example:

- FTP or emailing files to remote data centres,
- format conversion using a third party utility,
- post-processing of file data headers to add site-specific information.

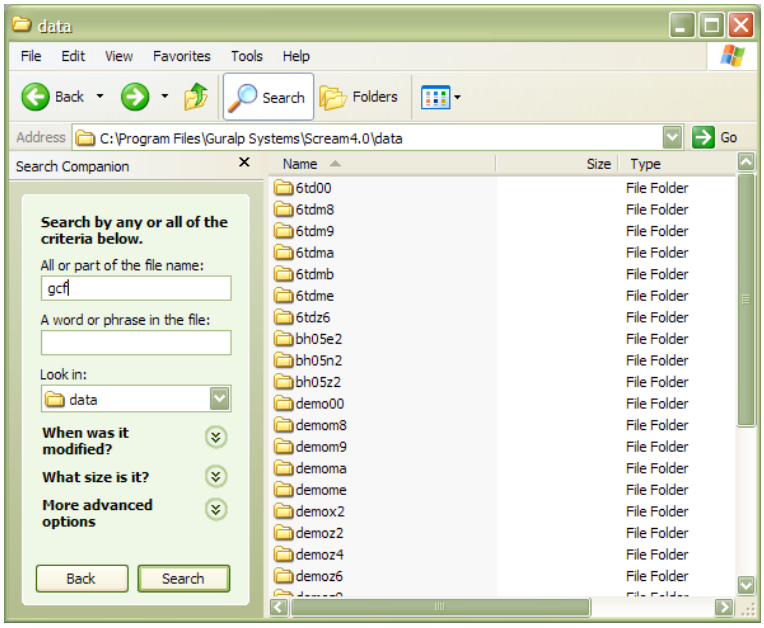
5.3 Playback

5.3.1 GCF files

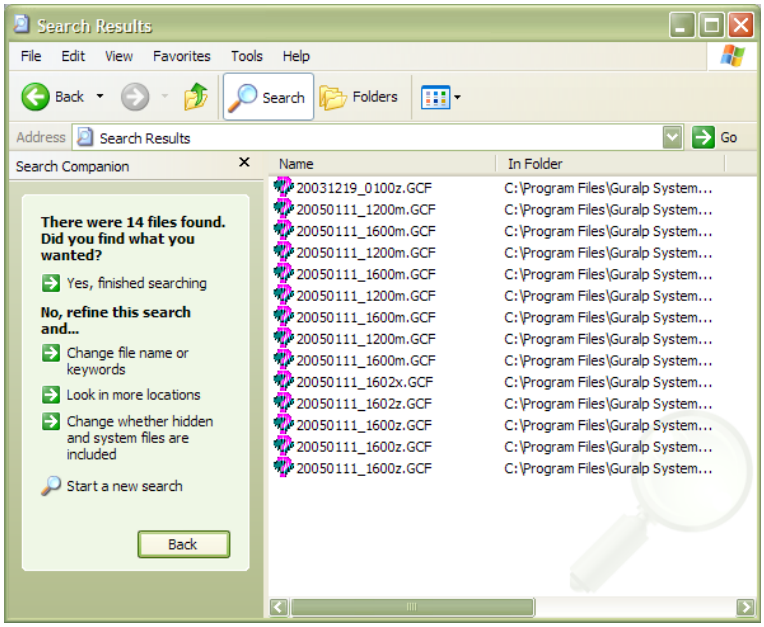
To replay a stored GCF file or files:

1. Select **File → Replay Files...** from Scream!'s main menu and select the data you want to replay, or drag GCF files from a Windows Explorer window into Scream!'s main window.

   Using Microsoft Windows, you cannot select files from more than one window at the same time. However, you can use the *Search* tool to select files from more than one directory. Open a window on the topmost data directory and click **Search**, or press `F3`:

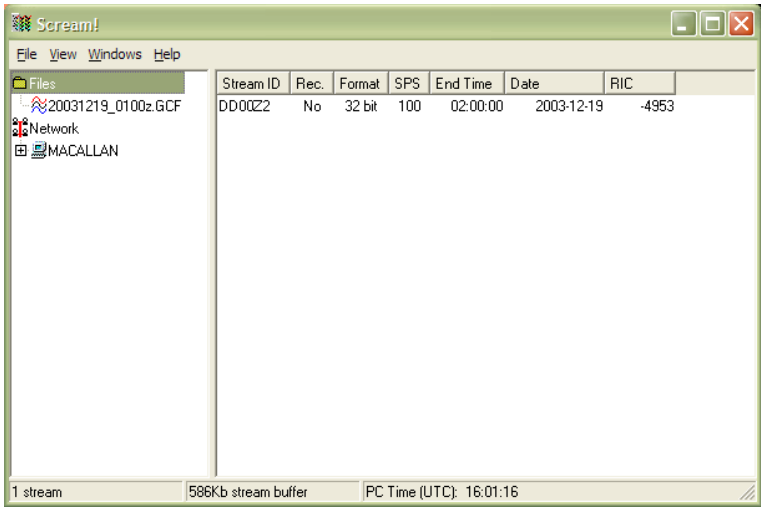


   Fill in your search criteria (*e.g.* *n*ame contains `gcf`), and click **Search**.



You can now select these files and drag them together into Scream!.

2. The main window will change to include the file(s) you selected:



3. Select streams from the files in Scream's main window, and view them in a *Waveview* window.

4. The *Replay Control* window contains controls for moving through the files.



To begin with, the replay is set to the beginning of all files, and the **Pause** button is active.

5. Use the **Slower** and **Faster** icons to set the speed at which you wish to replay the file(s). You cannot choose a negative speed.

Scream! will replay data into the stream buffer, which has a limited length. If your file is longer than the buffer, Scream! will eventually begin overwriting old data. To see this data, you will have to begin the replay again.

If your file is shorter than the memory buffer, you can safely choose the highest speed and play the entire file into memory.

You can read files into memory one at a time by selecting them in the drop-down box. If you select *All files*, the files are replayed together at the same rate.

6. When you are ready to play the file, unpause the replay by clicking on the **Pause** button .

   Alternatively, click the **Block step** button  to replay the files one block at a time.

7. Open *Waveview* windows as required on the data streams. *Waveview* windows begin in continuous mode, starting at the last data "received" (*i.e.* played back). All the normal functions of *Waveview* windows are available to you (see section 4.6 on page 18).

   If you want to pause the *Waveview* window to examine or measure signals, it is recommended that you pause the replay beforehand, so that the data you are viewing stays in Scream!'s memory buffer. If you leave the replay running, the data you are viewing may be replaced with newer blocks.

8. When all files have finished playing back, the *Replay Control* window will disappear. You can continue to work with the data that remains in Scream!'s memory buffer.

6 Advanced usage

You can connect to the internal software of the CMG-EDU over its output serial port and communicate with it.

To enter command mode from Scream!, right-click on the digitizer's icon and select **Terminal...** from the menu that pops up. A window will open, and once the digitizer and computer are communicating properly you will see the prompt

```
ok
```

If you prefer, you can use a terminal program on your computer (such as `minicom` on Linux, or `hypertrm` on Microsoft Windows) to connect to the CMG-EDU.

Whilst you are in terminal mode, data transfer will be interrupted. Some commands, such as `SET-TAPS`, require a reboot to take effect.

If you have problems connecting to the console, you should check that the serial port's options and baud rate are set correctly in Scream! or your terminal program. As supplied, the CMG-EDU expects connections at 19200 baud, with 8 data bits, no parity bit and 1 stop bit. No flow control is used.

6.1 Using the command interpreter

The CMG-EDU uses a FORTH-like interpreter to implement its features. To issue a command in FORTH, you must supply the arguments *before* the command, for example:

```
3 SENSOR-TYPE
```

In FORTH, anything you enter is termed a *word*. New words (case insensitive) are placed on a stack. Some words are known to the system, and may represent commands; if a command finds itself at the top of the stack (*e.g.* because it is the last thing you typed), they will execute, remove themselves from the stack, and then remove further items from the stack to use as arguments. Thus, in the command

```
3 SENSOR-TYPE
```

the 3 has no immediate effect, so stays on the stack; `SENSOR-TYPE` takes itself and the previous item (here `3`) off the stack, then performs its action on the `3` .

If a command completes with nothing remaining on the stack, the digitizer will show the prompt `ok`. Otherwise, the prompt will remind you that the digitizer is waiting for you to complete the command. Some commands, such as `SAMPLES/SEC`, clear the stack automatically after they execute.

Some commands are *interactive*, and will ask you to provide extra information after you execute them. In the following sections, interactive commands are shown as

example sessions, where information you enter is given in `medium` and messages returning from the CMG-EDU are given in **`bold`**.

Some seldom-used commands are in the *extended dictionary*. To access these commands, you need to enable this dictionary with the command `ok-1`. The standard commands will still be available. To return to normal operation, issue the command `[seal]`. While the extended dictionary is active, be very careful to type commands exactly as they are shown here. Mistyping a command with the dictionary unprotected can damage the internal code of the digitizer.

To close the terminal session and return to sending data, type

```
go
```

6.2 General configuration

6.2.1 SET-ID

Syntax: `SET-ID` (interactive)

Sets the system identifier and serial number of the CD24E1 to values you supply.

```
SET-ID
System Identifier ? (e.g. ALPHA,) DM24ID, Serial # ? (e.g. 1234,00)
4507,00
```

The system identifier you supply may contain up to 6 alphanumeric (0–9,A–Z) characters, and must have a comma after it. 6-character strings later than `ZIK0ZJ` are not permitted. The CD24E1 will pad any remaining space on the right with zeroes. If you want to use a system identifier less than 6 characters long, you should insert zeroes on the *left* to make it up to 6 characters. (Because of this, you cannot have a system identifier that begins with a zero.)

The serial number you supply must contain exactly 4 alphanumeric (0–9,A–Z) characters, followed by `,00` as shown.

You will need to `RE-BOOT` after issuing this command for it to take effect.

6.2.2 .IDS

Syntax: `.IDS`

Displays the System ID and stream IDs which are used to stamp all outgoing data packets, in the form

`system-id` *`stream-id`* *`sensor-type`* `ok`

where *`system-id`* is the name of the instrument (as reported in Scream!'s instrument list) and *`stream-id`* is the string which begins every data stream.

This command is in the extended dictionary; to use it, first issue the command `ok-1` and finish with `[seal]`.

6.2.3 BAUD

Syntax: `0` *`baud-rate`* `BAUD`

Sets the baud rate for the serial port on the CD24E1, in bytes per second. The CD24E1 has a single port, numbered 0. For example,

```
0 19200 BAUD
```

This will reset a standard CD24E1 to its default configuration.

The allowable values for *`baud-rate`* are 4800, 7200, 9600, 14400, 19200, 38400, 57600 and 1152 (*n.b.*), representing 115200.

You will need to `RE-BOOT` after issuing this command for it to take effect.

6.2.4 GO

Syntax: `GO`

Exits the terminal session and begins sending data. In Scream!, closing the terminal window has the same effect as this command.

If you have made configuration changes, you may need to `RE-BOOT` the digitizer instead of using this command.

6.2.5 RE-BOOT

Syntax: `RE-BOOT`

Causes the CD24E1 to reset.

```
RE-BOOT
Confirm with 'y' ? y
```

Responding to the confirmation message with anything other than `y` will abort the reset.

This command automatically closes Scream!'s terminal window.

6.3 GPS and timing systems

6.3.1 XGPS

Syntax: *on/off* XGPS

Switches on or off the GPS system. To save power consumption under normal operation, the CD24E1 only powers on the GPS occasionally to update timing information. You can override this with the XGPS command, where *on/off* is 0 to switch off the relay, and 1 to switch it on. Once switched on, the system will check the GPS, update the fix, and switch off for the period set by the HR-CYCLE command (see below).

6.3.2 HR-CYCLE

Syntax: *interval* HR-CYCLE

Sets the interval between GPS fixes. The system will power on the GPS system every *interval* hours and synchronize its internal clock with GPS timing signals. Once the internal clock is sufficiently close to GPS time, the GPS system will be automatically powered down for another *interval* hours.

Setting *interval* to 0 will make the CD24E1 leave the GPS on continuously. This is recommended if your installation has access to mains power.

6.3.3 SET-RTC

Syntax: *year month day hour minute second centisecond* SET-RTC

Sets the system's real time clock. This time will be used from power-up until it is corrected by an attached GPS. If you are not using GPS but are synchronizing from some other time source, you will need to re-issue this command regularly to ensure the CD24E1 does not drift.

You will need to RE-BOOT after issuing this command for it to take effect.

6.3.4 TIME?

Syntax: TIME?

Displays the current time as held in the system's real time clock. If a GPS is attached, this will be synchronized to it. The output is given in the form

year month day hour minute second centisecond ok

6.3.5 .FIX

Syntax: `.FIX`

Displays the current GPS timing fix. The GPS must be attached *and powered up* for this command to be valid; if it is not, you will see an error message. You can power up the GPS manually with the command `XGPS`.

The CD24E1 will reply in the form

```
.fix year month day hour:minute:second =>> Auto fix-mode SV#'s
satellites ( number-of-satellites ) ok
```

where *fix-mode* is the fix type (either `2-D` or `3-D`) and *satellites* is a list of the satellites currently visible. The CD24E1 will carry out clock trimming only if a `3-D` fix is available, which requires at least 3 satellites to be visible.

6.3.6 .POSITION

Syntax: `.POSITION`

Displays the current reported GPS position, in the form

```
.position Lat latitude Long longitude ok
```

where *latitude* and *longitude* are displayed in degrees, minutes and seconds.

This command is in the extended dictionary; to use it, first issue the command `ok-1` and finish with `[seal]`.

6.4 Calibration

6.4.1 SINEWAVE

Syntax: `Z` *freq-or-period* *unit* `SINEWAVE`

Instructs the CD24E1 to inject a sine-wave calibration signal, starting on the zero crossing.

`Z` denotes the Z channel of the digitizer. This is used for the CMG-EDU's single component (whether vertical or horizontal.)

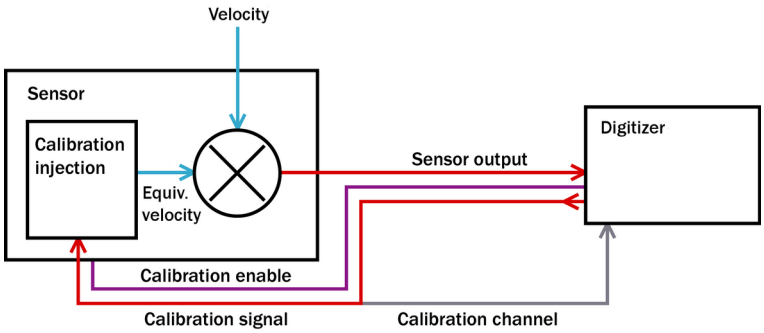
freq-or-period and *unit* together determine the frequency of the calibration signal. If *unit* is `HZ`, then *freq-or-period* is taken as a frequency, in Hz; if `SECOND`, then it is interpreted as a period, in s. For example:

```
Z 4 HZ SINEWAVE
```

freq-or-period must be an integer; if you want to specify a period of, for example, 0.5 s, you should specify it as `2 HZ` instead.

The calibration signal will be automatically disconnected after 2 minutes if you have not altered the setting using the `MINUTE` command, described below.

Whilst the calibration signal is being generated, it is output on the channel `MB` as well as being fed into the sensor. Calibration is done by comparing the data from the `MB` channel with the sensor's normal data stream.



Note that the `MB` channel is a 16-bit channel whilst the signal is digitized at 24 bit resolution. If using Scream! to measure signal strengths, you will have to multiply values from the `MB` channel by 256 before comparing them with the normal signals.

6.4.2 SQUAREWAVE

Syntax: `Z SQUAREWAVE`

Instructs the CD24E1 to inject a square-wave (step function) calibration signal, consisting of a positive step on the start of the next clock minute, followed by a negative step some minutes later (by default, 2). The calibration is disconnected the same number of minutes after the negative edge.

`Z` denotes the Z channel of the digitizer. This is used for the CMG-EDU's single component (whether vertical or horizontal.)

You can alter the duration of each step using the `MINUTE` command, described below.

6.4.3 MINUTE

Syntax: *duration* `MINUTE`

Sets for how long the next `SINEWAVE` calibration signal will be injected, or the period of the next `SQUAREWAVE` calibration signal.

duration is the desired interval, in minutes. If you now issue a `SINEWAVE` command, the calibration will last *duration* minutes; if the next calibration command is `SQUAREWAVE`, a positive step of *duration* minutes will be generated, followed by a negative step of a further *duration* minutes.

If you do not issue `MINUTE`, calibration signals will default to 2 minutes. This is to avoid the sensor and digitizer inadvertently being left in calibration mode. Issuing, *e.g.*, `5 MINUTE` will cause the next calibration signal to last 5 minutes, but later calibration signals will revert to a duration of 2 minutes. You will need to issue a `MINUTE` command before each injection.

Because of the way FORTH works, you can insert `MINUTE` commands into `SQUAREWAVE` or `SINEWAVE` commands, for example:

```
N/S 4 HZ 5 MINUTE SINEWAVE
E/W 10 MINUTE SQUAREWAVE
```

6.4.4 MINUTES ?

Syntax: `MINUTES ?` (note the space before `?`)

Displays the current setting of the `MINUTES` variable, *i.e.* how long the next calibration signal will last.

6.4.5 %AMPLITUDE

Syntax: *`percentage`* `%AMPLITUDE`

Sets the calibration amplitude to the given percentage of the full-scale signal.

6.4.6 AMPLITUDE ?

Syntax: `AMPLITUDE ?` (note the space before `?`)

Displays the current setting of the `AMPLITUDE` variable, *i.e.* the amplitude of the next calibration signal, as a percentage of the full-scale signal.

6.4.7 RESP

Syntax: *`value`* `RESP`

Switches the CMG-EDU between response modes according to *`value`*:

`0` : broadband mode (standard);
`1` : 1 second response mode (for monitoring mass positions.)

6.4.8 MASSES?

Syntax: `MASSES?`

Displays the current, instantaneous position of the three sensor masses, in counts (range ±8 000 000):

```
masses? z-position n/s-position e/w-position ok
```

7 Troubleshooting and help

7.1 Troubleshooting

The installation is connected, but Scream! is not receiving any data.

- Choose *File* → *Setup...* from the main menu and open the *Com Ports* tab. Check that the baud rate for the serial port attached to the digitizer is set to 19200, and that all the boxes are checked.
- Check that the power supply to the sensor and digitizer is switched on and providing a consistent voltage of 12 – 30 V.
- Check all connectors and cabling.

The observed signal contains a lot of noise above 1 Hz (1 s).

You are observing "cultural noise" due to human activity. This can be reduced by choosing a more suitable environment for the sensor.

- Move the sensor away from noise sources such as machinery (elevators, air-conditioning units, heating systems, pumps, *etc.*) and traffic (pedestrian or motorized.)
- Mount the sensor below ground level.
- Enclose the sensor in an insulated box, to reduce the effect of draughts and temperature fluctuations.

The observed signal contains a lot of noise around 0.2 Hz (5 s).

You are observing natural vibrations in the Earth, known as *microseisms*. These are an inescapable fact of life in most locations. Microseisms can be caused by local storms, rough surf, or large standing waves in the deep ocean. A large proportion of microseismic vibrations travel along the surface.

- To minimise the effect of microseisms, install directly on bedrock if possible, or underground in a seismic vault.

The observed signal drifts significantly over a long period of time.

This drift is most likely due to temperature fluctuations in the sensor, caused by changing conditions through the day.

- Isolate the sensor from temperature changes and draughts by enclosing it in an insulated box.
- Keep the sensor away from strong sources of light and heat (direct sunlight, light bulbs, *etc.*)

You should give a newly-installed sensor time to reach thermal equilibrium with its surroundings (at least overnight). If drift persists, keeping a record of the times of day when the drift is most prominent can help you track down its origin.

7.2 Limited warranty

The CMG-EDU system has been thoroughly tested and calibrated before leaving the factory. It should provide years of continuous, problem-free operation.

Güralp Systems guarantee that your CMG-EDU will be free from defects in workmanship and materials for a period of 12 months from the date of purchase (as shown on the purchase invoice). This warranty does not apply in the event of misuse or abuse of the product, or as a result of unauthorized alterations or repairs.

7.3 Contacting Güralp Systems

If you have any questions about any aspect of the installation or operation of the CMG-EDU, you should contact Güralp Systems Technical Support at *support@guralp.com* or by telephone at +44 (0) 118 981 9056 (2 pm – 5 pm GMT)

You should also contact us if the CMG-EDU requires service, either during or after the warranty period. When you call, be ready to quote the serial number of the instrument. This number is stamped into the side of the sensor base, and can also be found on the label on the top face.

Updates to this manual, as well as other technical information about this and other Güralp Systems products, can be found on our website at *https://www.guralp.com/*

7.4 Resources for teachers and students

A complete list of available books and resources on seismology is beyond the scope of this manual. However, some useful starting points may be found on the Web. These links are prone to change.

http://www.indiana.edu/~pepp/ – The Princeton Earth Physics Project, now completed and being run from Indiana University, continues to maintain a web site with extensive information for teachers interested in bringing earth science to the high school classroom.

https://www.seismosoc.org/education/education.html – The Seismological Society of America maintains a good bibliography of material useful to teachers and students of seismology.

8 Connector Pinouts

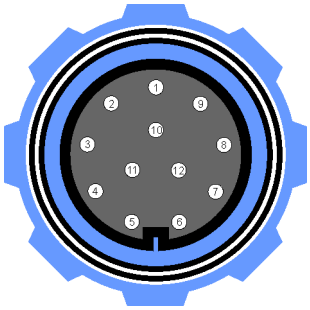
8.1 Sensor Connectors

These are Bulgin Buccaneer 400-series 12-pin connectors.

The chassis socket, as fitted to the CD24E1, is part-number PX0412/12S and the free plug, as fitted to the CMG-EDU sensor, is part-number PX0410/12P/5560.



Pin	Function
1	Velocity signal -ve
2	Signal ground
3	Screen
4	Mass position
5	Calibration signal
6	Supply ground
7	Supply -ve
8	Supply +ve
9	Velocity signal +ve
10	*not connected*
11	Calibration enable
12	One second mode enable



Wiring details for the free plug, PX0410/12P/5560, as seen from the cable end.

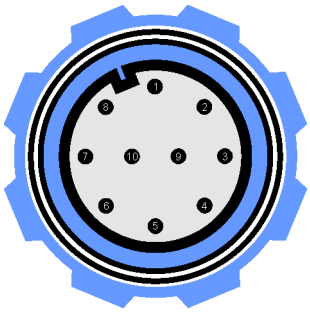
8.2 Power/Data Connectors

These are Bulgin Buccaneer 400-series 10-pin connectors.

The chassis plug, as fitted to the CD24E1, is part-number PX0412/10P and the free socket, as fitted to the power/data cable, is part-number PX0410/10S/5560.



Pin	Function
1	*not connected*
2	Received data (RxD)
3	Transmitted data (TxD)
4	*not connected*
5	Ground
6	Supply voltage +ve
7	*not connected*
8	*not connected*
9	Supply voltage -ve
10	*not connected*



Wiring details for the free socket, PX0410/10S/5560, as seen from the cable end.

Note: Some units were fitted with 12-pin connectors with exactly the same pin-out.

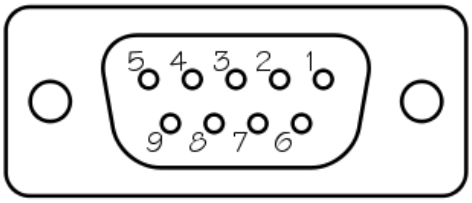
8.3 Data Connectors

These are standard DE9 “subminiature” connectors conforming to DIN 41652 and MIL-DTL-42308.

They are widely available from a variety of electronics and I.T. suppliers.



Pin	Function
1	*not connected*
2	Received data (RxD)
3	Transmitted data (TxD)
4	*not connected*
5	Ground
6	*not connected*
7	*not connected*
8	*not connected*
9	*not connected*
10	*not connected*



Wiring details for the compatible plug, as seen from the cable end.

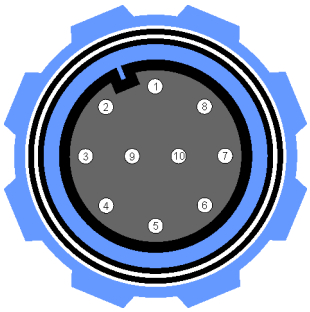
8.4 GPS Connectors

These are Bulgin Buccaneer 400-series 10-pin connectors. Full details of this range are available from the Bulgin web-site at http://www.bulgin.co.uk/Products/Buccaneer/Buccaneer.html

The chassis socket, as fitted to the CD24E1, is part-number PX0412/10S and the free plug, as fitted to the CMG-EDU sensor, is part-number PX0410/10P/5560.



Pin	Function
1	*not connected*
2	GPS received data (Rx)
3	GPS transmitted data (Tx)
4	*not connected*
5	Signal ground
6	+ve supply voltage
7	*not connected*
8	Pulse-per-second (PPS)
9	Supply ground
10	*not connected*



Wiring details for the free plug, PX0410/12P/5560, as seen from the cable end.

9 Revision History

A	6 Dec 2005	New Document
B	23 Oct 2009	Added connector pin-outs and revision history.
C	16 Nov 2021	Added note about 12-pin power/data connectors
D	1 June 2022	Fixed broken links, reformatted with current branding