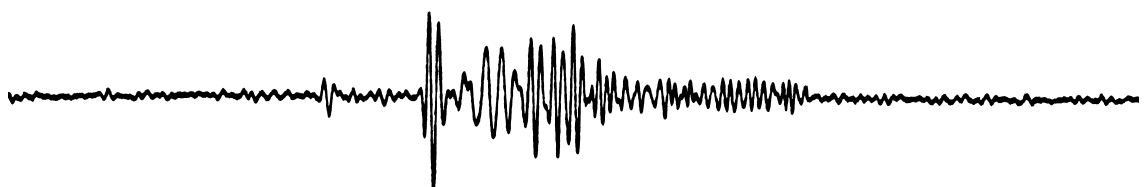




CMG DM24 DIGITISER

OPERATOR'S GUIDE



DESIGNED AND MANUFACTURED BY:

**GÜRALP SYSTEMS LIMITED
3 MIDAS HOUSE
CALLEVA PARK
ALDERMASTON
READING
BERKS, RG7 8EA
ENGLAND**

Telephone: +44 (0) 118 9819056 Fax: +44 (0) 118 9819943

PROPRIETARY NOTICE

The information in this Manual is proprietary to Gralp Systems Limited and may **not** be copied or distributed outside the approved recipient's organisation without the approval of Gralp Systems Limited.

Gralp Systems Limited shall not be liable for technical or editorial errors or omissions made herein; nor for incidental or consequential damages resulting from the furnishing, performance, or use of this material.

CONTENTS

	page
1. Introduction	5
2. Operating Instructions	9
2.1 Stand-Alone CMG-DM24 Front Panel Connectors	9
2.2 CMG-DM24 Sensor Module Connectors	11
2.3 Quick Start	12
2.4 FLASH Memory Upgrade	16
3. Digitiser Configuration and Control Mode	19
3.1 Digitiser Configuration:- <u>Using SCREAM</u>	20
Digitiser Configuration	20
Digitiser Output Control Programming	22
Programming Trigger Parameters	25
Setting Digitiser Communication Parameters	27
Sensor Calibration	28
Sensor Mass Control	29
Auxiliary (Mux) Channels	30
Buffering – Data Storage	31
Buffering – FLASH Data Storage	31
3.2 Digitiser Configuration:- <u>Using Terminal</u>	33
Digitiser Configuration	33
Digitiser Output Control Programming	34
Programming Trigger Parameters	36
Setting Digitiser Communication Parameters	37
Sensor Calibration	38
Sensor Mass Control	39
Auxiliary (Mux) Channels	39
4. Status Information	41
5. Digitiser Data Acquisition and Telemetry	47
6. Adding a Digitiser Module onto a Broadband Sensor	49
7. System Power Requirements	51
8. Description of the Broadband Digitiser	53
9. Data Transmission Protocol & Data Block Structure	57
10. STA/LTA Trigger Options	61
11. GPS Receiver	69
12. Connector Pin outs	71
13. CMG-DM24S12, 12 Channel Digitiser.	77

1. INTRODUCTION

The Guralp CMG-DM24 24-bit digitiser can be supplied in many different formats. The main internal features are common to them all, but they can be interfaced in different forms depending upon customer requirements. The two main types are the *module*, which is fixed to, and becomes a physical part of a Guralp seismometer; and the *stand-alone* digitiser, both pictured below. A 12 Channel version, the CMG-DM 24S12 Digitiser is introduced in the last section of this document.



The CMG-DM24 digitiser module can be supplied with, or to retro-fit to any of the Guralp Broadband Seismometers (CMG-1T, CMG-3T, CMG-3ESP, CMG-40T or CMG-5T). The clean, isolated and stable sensor environment is ideal for the precision low-noise requirements of a wide range digitiser. Once converted to digital form the

output of the sensor cannot be contaminated and is easily processed, stored and transmitted over long data links.

The stand-alone configuration with (differential) analogue inputs can interface with other sensor systems.

There are two different types of housings used for the stand-alone DM24 digitiser. The water proof housing introduced in 2003 is shown below. The operation of the digitiser is identical to those digitisers used prior to 2003. The housing of the digitiser is from high impact copolymer polypropylene with external inputs mil.spec connectors fitted on to a metal plate. The digitiser housing also has internal cable storage facility.



Stand-alone configurations are supplied within a portable waterproof housing as shown in the photograph above or optionally in a 19" rack mounted enclosure. In both cases the digitiser units are fitted with high impedance low noise differential input pre-amplifier modules.

The stand-alone CMG-DM24 unit input connections are identical to the output connections of the Guralp CMG-1T, CMG-3T, CMG-3ESP and CMG-40T. Indeed other sensors can also be wired to the CMG-DM24.

The purpose of creating a compatible connection between the CMG-DM24 and CMG sensors is to ensure that all the broadband seismometer commands can be initiated through the CMG-DM24 module.

Generally the CMG-DM24 module has 1 to 3 analogue to digital converters with 24-bit resolution. However, the CMG-DM24 stand-alone units can have 3 or 6 digitiser channels with 24-bit resolution. There are no operational differences between the 3 channel and 6 channel CMG-DM24 systems.

ENVIRONMENTAL CHANNELS

An optional 16 channel 16 bit digitiser module can be included in the main digitiser unit to provide low sample rate data (4 s/s) primarily used for 'State of Health' monitoring e.g. sensor mass position, temperature, pressure, battery voltage etc. This data is packaged and processed in exactly the same fashion as the primary digitiser channels.

CMG-DM24 FEATURES:

- built-in Digital Signal Processor (Motorola 56002) provides simultaneous multiple sample rate data streams at user selectable rates. Up to 4 streams of data for each component are available at sample rates from 200 samples/second down to 1 sps.
- precision microprocessor controlled time-base synchronises Analogue to Digital Converters, and DSP and time-stamps data blocks.
- time synchronisation to external GPS or serial time code.
- control microprocessor (Hitachi H8) formats and buffers data in on-board 512k RAM ring buffer.
- compressed data format (Güralp Compressed Format) for efficient storage and transmission.
- serial data output (RS232) at user selectable baud-rates - options of RS422, DPSK or fibre-optic.
- built-in microprocessor system configuration and sensor control such as locking, unlocking, centring and calibration.
- very low system power consumption, less than 1.5W.
- Flash EEPROM for program code and filter coefficients.
- FLASH memory data storage (16 Mb standard) upto 1 Gb options available.

There are six housing configurations in which the CMG-DM24 can be provided. These are:

- a) CMG-DM24 module which plugs straight onto an existing CMG-1T, CMG-3T, CMG-3ESP or CMG-40T broadband sensor.
- b) CMG-DM24 unit in a stand-alone waterproof portable housing with differential high impedance pre-amplifier unit.
- c) CMG-DM24 unit with a differential high input impedance pre-amplifier module which is housed inside a 19 inch rack with isolated BNC type input plugs.
- d) CMG-DM24 unit with very low noise pre-amplifier module to be interfaced to an electromagnetic seismic sensor.
- e) CMG-DM24 unit housed inside the pressure casing of a broadband borehole seismometer.
- f) CMG-DM24 unit housed within the pressure housing of an ocean bottom seismometer.

All the configurations described above are based on the same CMG-DM24 system design. Variations between different configurations are due to the application of the CMG-DM24 digitiser rather than a complete system design change, for example the surface CMG-DM24 unit. Also, the borehole CMG-DM24 unit is equipped with 16 additional 16-bit slow sampled ADC channels to digitise sensor mass position outputs, inclinometer and other related analogue signals.

This operator's guide is applicable to both the CMG-DM24 digitiser module, which fits onto the top of CMG-broadband sensors and the stand-alone portable CMG-DM24

broadband digitiser. The operational features of both systems are identical with identical command and control functions.

The CMG-DM24 units manufactured for borehole applications are described in the borehole sensor operator's manual.

2. OPERATING INSTRUCTIONS

2.1 STAND-ALONE CMG-DM24 FRONT PANEL CONNECTORS



TOP PANEL & CONNECTORS ON STAND-ALONE DIGITISER
(DM24-S6 SHOWN)



PANEL & CONNECTORS ON STAND-ALONE DIGITISER
(DM24-S6 SHOWN)

Sensor A (Sensor B):- CMG-DM24-S3 has one 26 way Mil-Spec sensor input plug, while the CMG-DM24-S6 has two (sensor A and sensor B as shown in the diagram at the front of this section). Each sensor input (as with the 19inch rack mount model) have high impedance differential inputs. The sensor inputs carry sensor power and three channels of differential velocity, mass and calibration signals (see pin-out table in the Appendices).

Data:- 10 pin Mil-Spec plug for digitiser power, receive and transmit digital data

GPS:- 10pin Mil-Spec plug. Carries power supply to the GPS, receive and transmit data, and 1 pulse per second reference signal.

Auxiliary:- Optional eight 16 bit, 4 samples per second channels primarily for 'state of health' monitoring, e.g. sensor mass position, external temperature, pressure, battery voltage.

POWER SUPPLY REQUIREMENTS

The CMG-DM24 unit operates from a wide input voltage range of 10 to 36 Volts DC. The power consumption for the portable surface unit is:

CMG-DM24 - 3 Channel-115mA from 12 Volts

CMG-DM24 - 6 Channel-145mA from 12 Volts

CMG-GPS1-190mA from 12 Volts

CMG-GPS2-75mA from 12 Volts

The given power supply current requirements are a guideline. There are many factors which can influence the power consumption of the sensor system, for this reason it is recommended that the user should budget more generously when choosing power supplies than the given typical values.

The listed power supply consumptions should be checked against the supply requirements given in the calibration documents.

NOTE

A dc-dc converter is used within each module of the system (sometimes more than one dc-dc converter is used within a module) and it is generally recognised that the start up current of such dc-dc converters can be a factor of 5 to 8 times larger than the quiescent currents given above.

2.2 CMG-DM24 SENSOR MODULE CONNECTORS



The diagram above shows the lids for the digitiser module that is fixed to a Guralp sensor (CMG-1T, CMG-3T, CMG-3ESP, CMG-40T or CMG-5T).

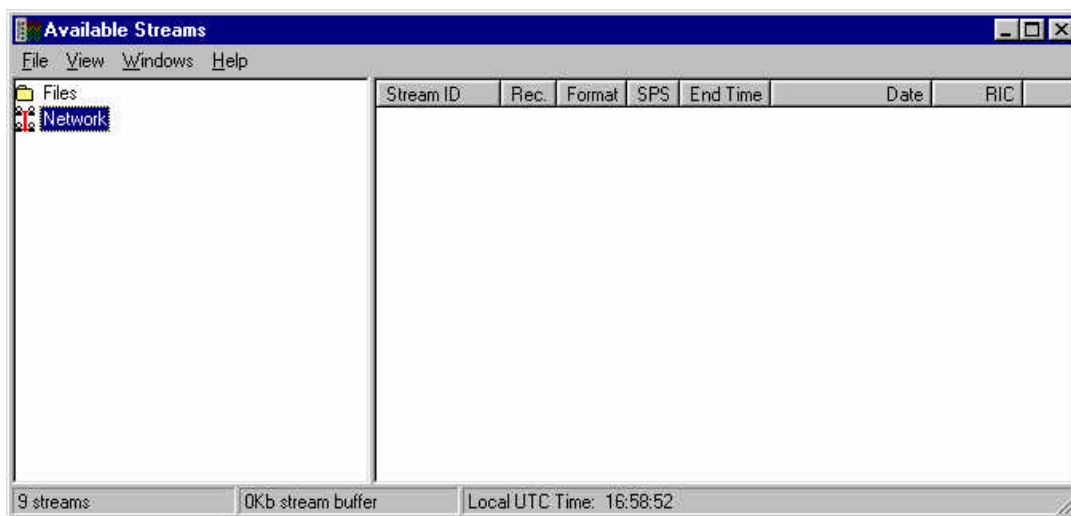
Data:- 10 pin Mil-Spec plug for power supply to the digitiser and sensor, digital transmit and receive data.

GPS:- 10 pin Mil-Spec plug. Carries power supply to the GPS, receive and transmit data, and 1 pulse per second reference signal.

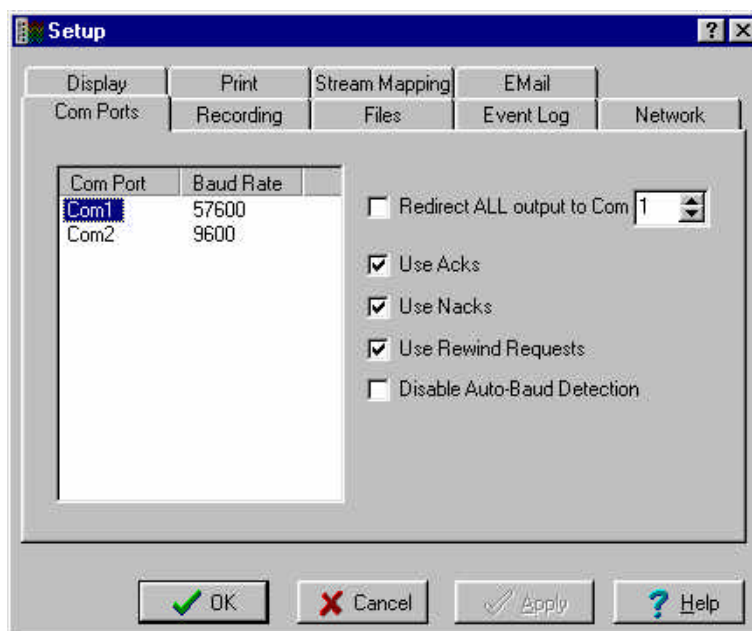
Analogue:- This is a customer requested option. The 26 pin Mil-Spec plug carries the analogue signals directly from the attached sensor below and is the analogue input for the optional eight 16 bit digitiser channels.

2.3 QUICK START

1. Connect the GPS cable to the digitiser's plug marked '**GPS**' (GPS is not essential for initial test set-up).
2. The other cable supplied with the module or stand-alone digitiser has one 10 pin Mil-Spec socket at one end to connect to the digitiser connector marked '**Data**'. This cable splits into two; one part has a 9 pin 'D'-type socket to connect to the COM port of a PC, the other part of the cable is connected to a 11-36V power supply.
3. Install **SCREAM** software (see later chapter) on your PC and run.
4. To configure the COM port connected to the digitiser, start from the main window in **SCREAM**:-

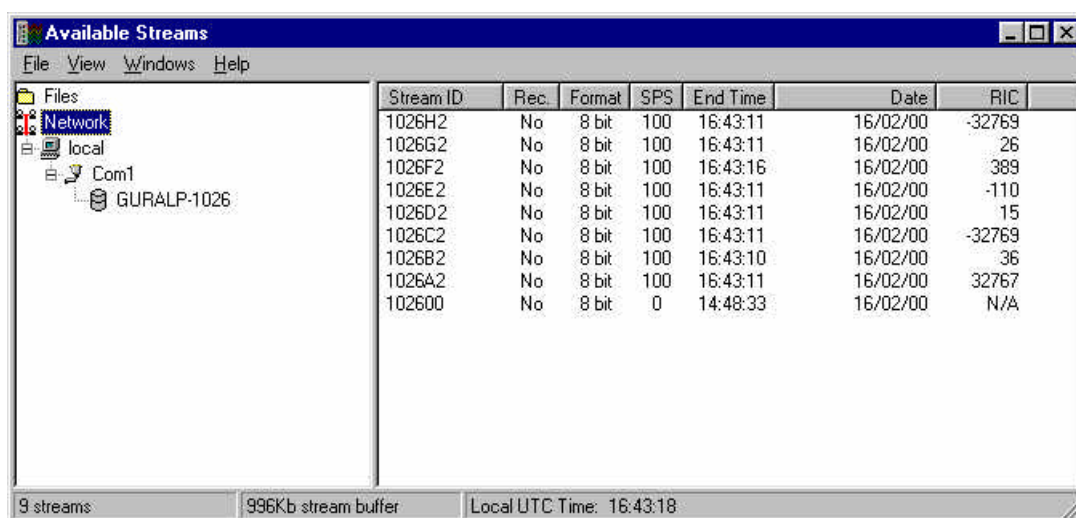


6. Click on the '**File**' button, select '**Setup**'

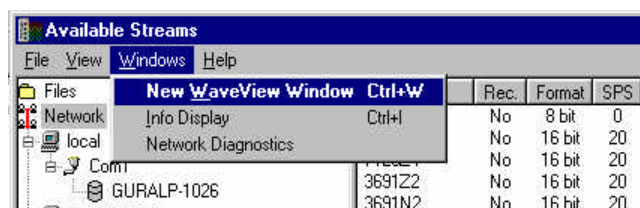


7. Select the '**Com Ports**' tab
8. Click on the COM port to which the Digitiser is connected.

9. Select '**Autodetect**'
SCREAM will detect, then display the baud rate that the digitisers output is currently set at.
10. Click on the '**OK**' button to return to the main **Available Streams** window.
11. In the **Available Streams** window the identifier of the digitiser will appear in the left hand frame (which appears similar to the tree type format of Windows Explorer) under:-
Network >
Local >
Com1' (if Com1 is used)
12. The data streams will appear in the right-hand frame.

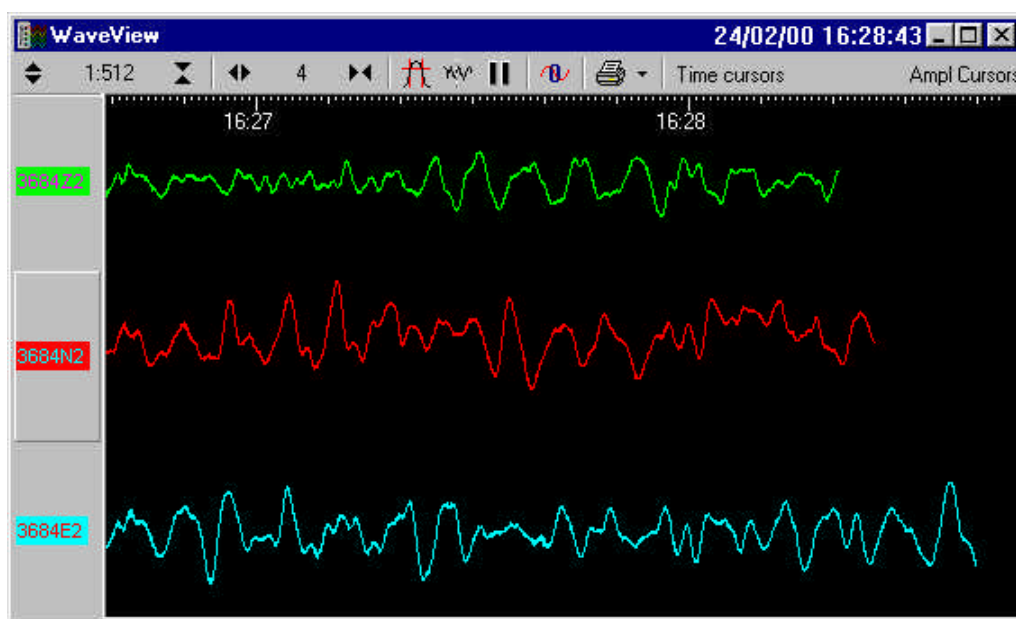


13. The **Stream ID's** are six character strings uniquely identifying each instrument, component and sample rate. (There may be up-to four different sample rates per channel)
The stream ending in '00' contains status information from the digitiser.
Depending upon the selected sample rate, then the streams with the higher sample rates will appear in the display sooner than the slower sample rates.
14. If a digitiser module is running then the format will most likely be 16 or 32 bit format as indicated in the **Available Streams** window, due to the seismic data.
15. If a Stand-Alone digitiser is running, then an analogue seismic instrument can now be connected to a **Sensor Input** port.
16. From the main '**Available Streams**' window,
click on the '**Windows**' button,
choose '**New WaveView Window**' to create a WaveView window for displaying the data.



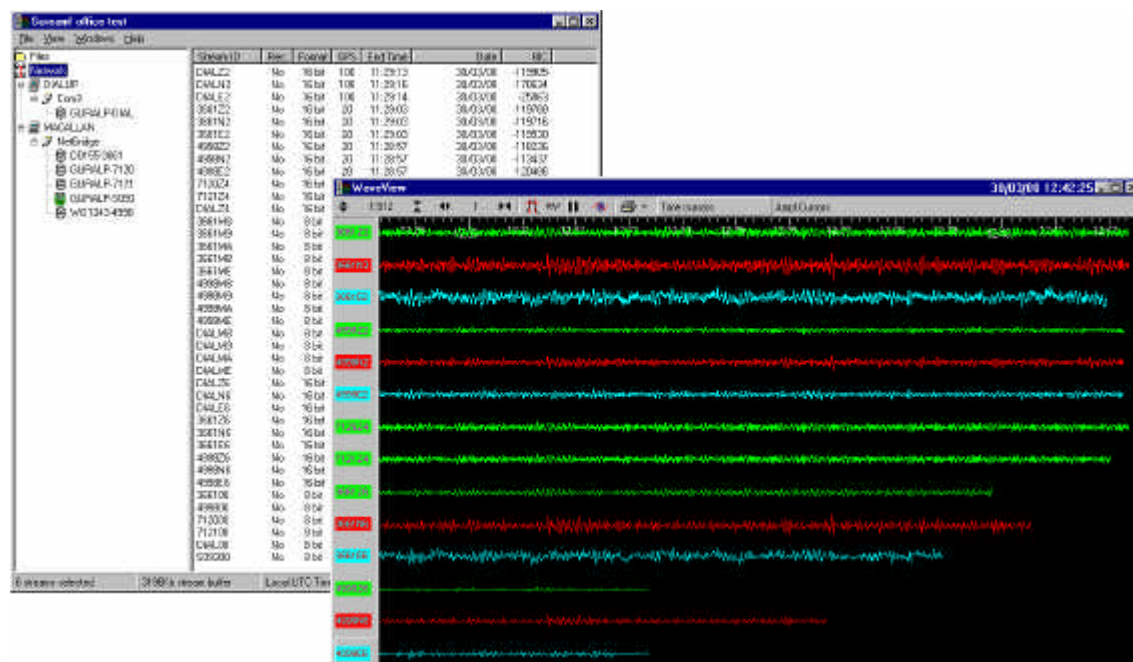
17. Select the data streams in the right side of the window and drag them into a '**Waveview**' window.

18. **SCREAM** will now display digitised data in the '**Waveview**' window.

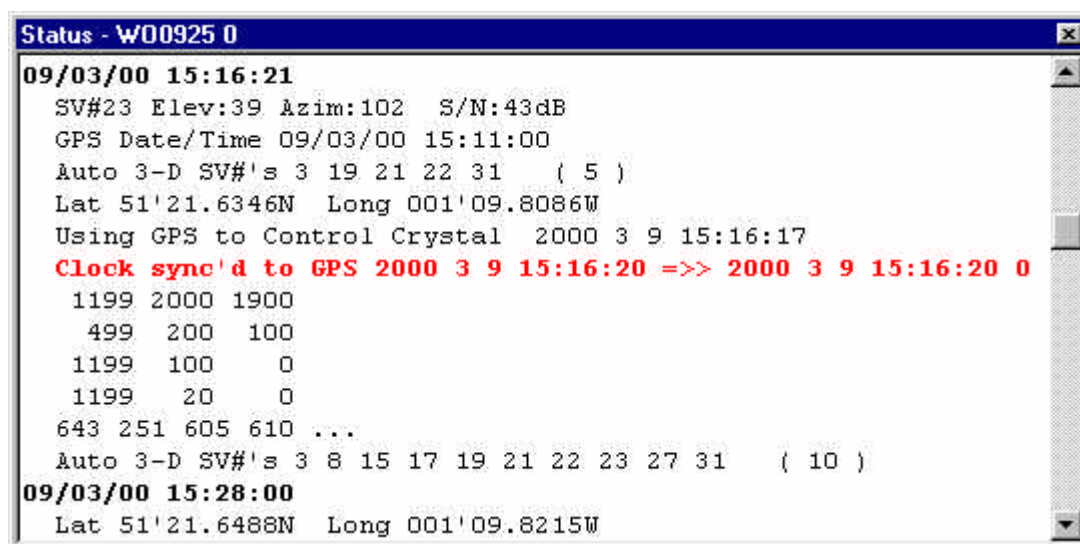


Above is shown a basic **WaveView** window showing one 3 component instrument.

The screenshot below shows more of the power and flexibility of **SCREAM**. Some networked instruments can be seen in the **Available Streams** window with some of their output traces shown in the **WaveView**.



19. To see status information coming from the digitiser, right click on the status stream, from the pop-up menu select '**View**'. A new window, '**Status**' should open containing text. The first blocks will give the boot message from the DM, including its software revision and the data streams selected for down-loading and triggering. Later blocks give information on the expected GPS satellites, the location of the GPS antenna, time synchronization status and transmit and receive baud rates for each channel and the data link.



The screenshot shows a window titled "Status - W00925 0". The text inside the window is as follows:

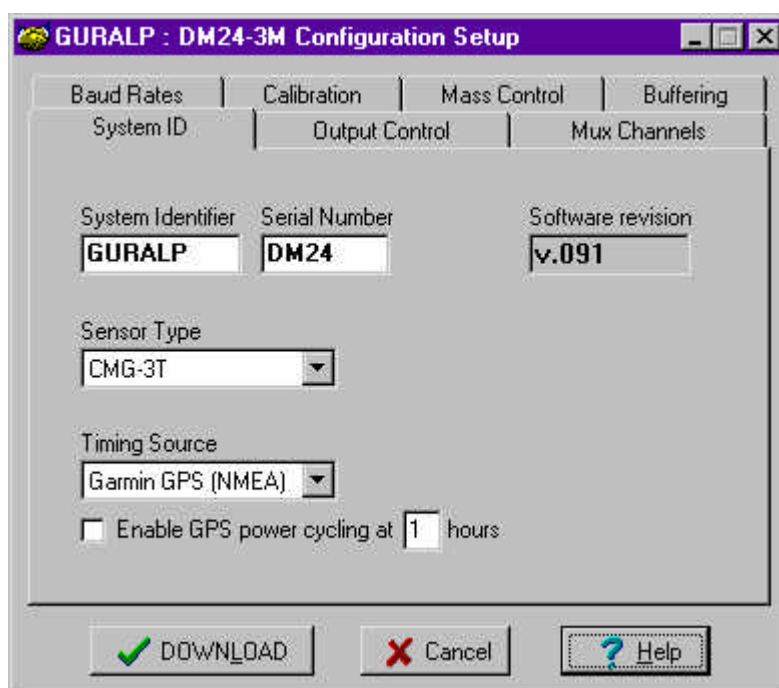
```
09/03/00 15:16:21
SV#23 Elev:39 Azim:102 S/N:43dB
GPS Date/Time 09/03/00 15:11:00
Auto 3-D SV#'s 3 19 21 22 31 ( 5 )
Lat 51'21.6346N Long 001'09.8086W
Using GPS to Control Crystal 2000 3 9 15:16:17
Clock sync'd to GPS 2000 3 9 15:16:20 ==>> 2000 3 9 15:16:20 0
1199 2000 1900
499 200 100
1199 100 0
1199 20 0
643 251 605 610 ...
Auto 3-D SV#'s 3 8 15 17 19 21 22 23 27 31 ( 10 )
09/03/00 15:28:00
Lat 51'21.6488N Long 001'09.8215W
```

2.4 FLASH MEMORY UPGRADE

For the later models with Flash memory it is possible for the user to upgrade the digitiser software.

Guralp Systems have a mailing list to keep Scream users up to date. To subscribe, send an email to listserver@guralp.com with a single line in the body containing "subscribe screamusers" (without the quotes). This will keep the users informed of latest upgrades available.

To find out what the users current software version is, either double click on the digitiser icon in the main Start-up window and the **Configuration Setup** window will open up, or right click on the icon and select Configure from the pop-up menu for the same **Configuration Setup** window. The picture below shows "*Software revision v.091*".

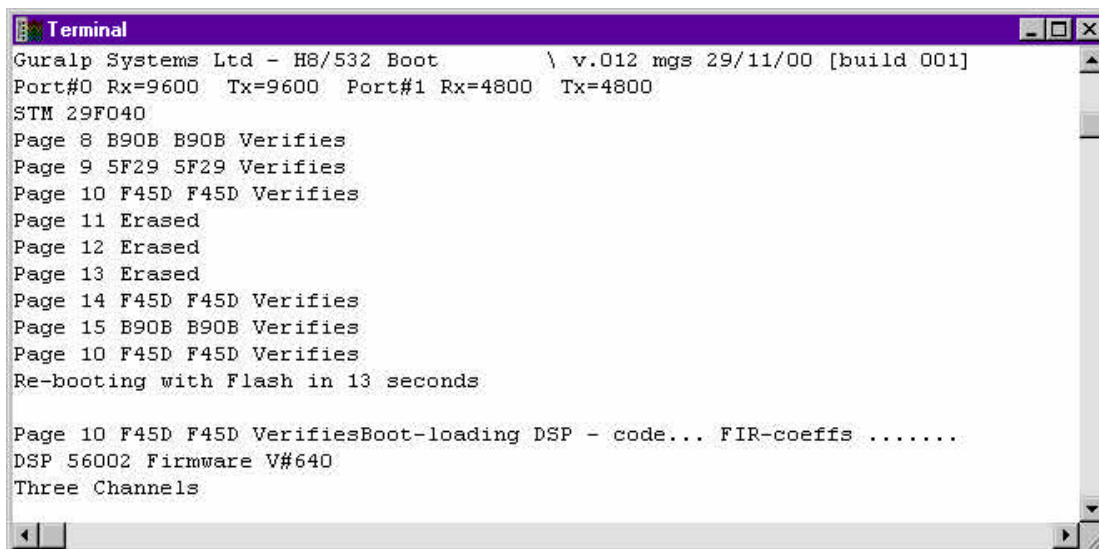


First obtain the latest software, then proceed as the following instructions.

- 1) In SCREAM's main startup window, right click on the digitiser icon and select **Terminal** from the pop-up menu. This will open as shown



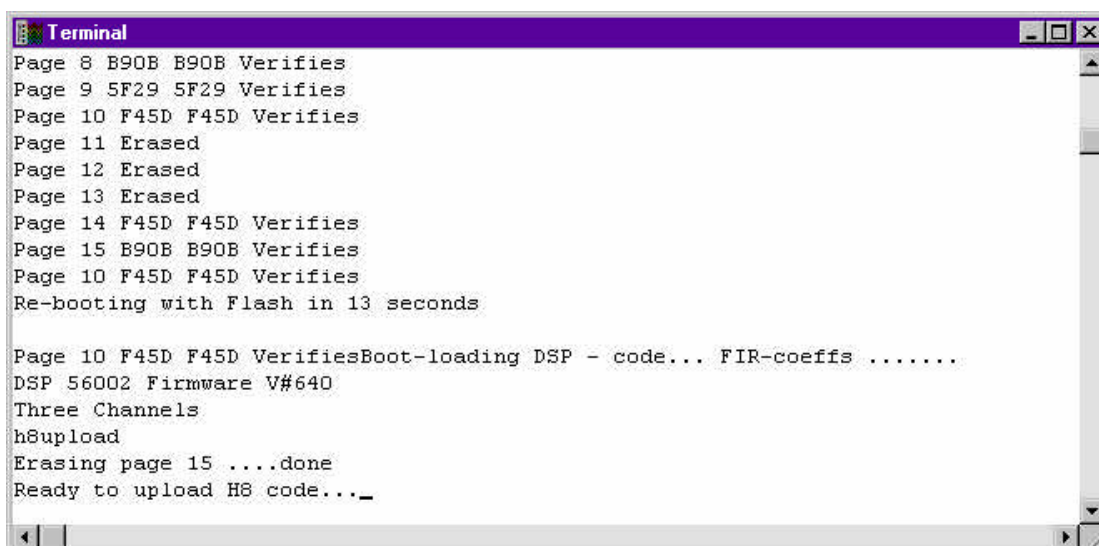
- 2) If the user presses the **Enter** key “ok” will appear on a new line, signifying that there is two-way communication with the digitiser.
- 3) Re-boot the digitiser by turning the power off then on again and the initial boot-up information will be displayed similar to that shown in the picture below.



```
Terminal
Guralp Systems Ltd - H8/532 Boot      \ v.012 mgs 29/11/00 [build 001]
Port#0 Rx=9600 Tx=9600 Port#1 Rx=4800 Tx=4800
STM 29F040
Page 8 B90B B90B Verifies
Page 9 5F29 5F29 Verifies
Page 10 F45D F45D Verifies
Page 11 Erased
Page 12 Erased
Page 13 Erased
Page 14 F45D F45D Verifies
Page 15 B90B B90B Verifies
Page 10 F45D F45D Verifies
Re-booting with Flash in 13 seconds

Page 10 F45D F45D VerifiesBoot-loading DSP - code... FIR-coeffs .....
DSP 56002 Firmware V#640
Three Channels
```

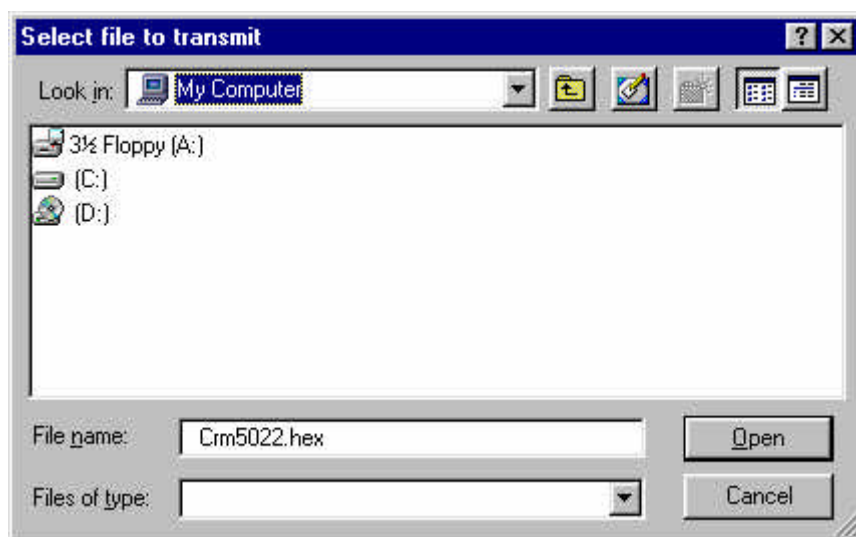
- 4) In the instance shown above, the user then has 13 seconds to type “h8upload” then press enter. After the next message “Ready to upload” appears, as shown below, right click anywhere on the terminal window and select **send file** from the pop-up menu.



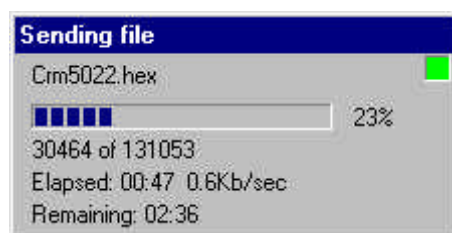
```
Terminal
Page 8 B90B B90B Verifies
Page 9 5F29 5F29 Verifies
Page 10 F45D F45D Verifies
Page 11 Erased
Page 12 Erased
Page 13 Erased
Page 14 F45D F45D Verifies
Page 15 B90B B90B Verifies
Page 10 F45D F45D Verifies
Re-booting with Flash in 13 seconds

Page 10 F45D F45D VerifiesBoot-loading DSP - code... FIR-coeffs .....
DSP 56002 Firmware V#640
Three Channels
h8upload
Erasing page 15 ....done
Ready to upload H8 code..._
```

- 5) Through your computer's directories find the file to be uploaded and click on it, or type in the full path and file name to display it in the **File name** edit box, then click on the **Open** button.



Whilst the file is loading a countdown window as shown below will be on display.



- 6) Re-boot the digitiser by switching off and on, for the new program to install.
- 7) Finally, once the instrument has finished automatically backing-up the old and new firmware, reboot the unit and the firmware will be installed.

3. DIGITISER CONFIGURATION AND CONTROL MODE

A digitiser may be reprogrammed using the **SCREAM** configuration setup interface. For any given digitiser, this interface module may be accessed by double-clicking with the right mouse button on the digitisers icon in the **Available Streams** window. If you single-click on the digitisers icon with the left mouse button, you must select **Configure** from the pop-up menu. Using this module of **SCREAM**, you may interactively set the digitisers system characteristics, control the output of streams at different digitisation rates, turn on or off the output from the low digitisation rate multiplex channels (Mux Channels), set output baud rates and digitiser buffering parameters, as well as invoke seismometer calibration.

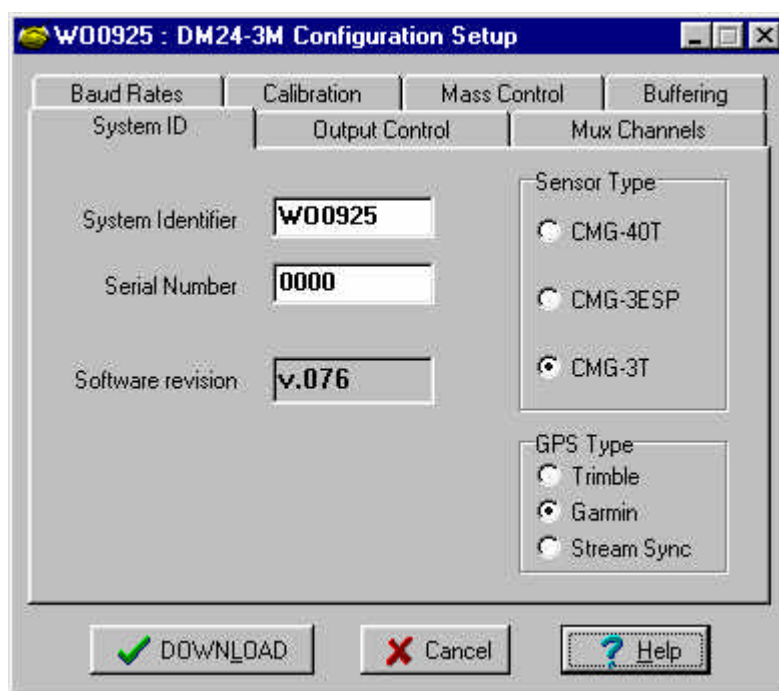
Using any standard terminal program such as *Hyperterm* or *Kermit*, these parameters may also be changed by sending text commands to the digitiser. This mode may also be invoked from **SCREAM** by single-clicking on the digitisers icon with the right mouse button and selecting **Terminal** from the pop-up menu. When using standard terminal programs, you must initiate command mode by typing **Control-S** when in the text mode. This is done automatically by **SCREAM** when a terminal window is opened to a digitiser. If you use the **SCREAM** configuration set-up interface, data collection will continue while you are setting digitiser parameters. If you use **SCREAM**'s terminal mode or another standard terminal program, data collection will be interrupted until you exit terminal mode by issuing a re-boot command.

Parameters from most of the commands are stored to the battery-backed CMOS and only take effect when the digitiser is rebooted. Some seismometer control commands, such as unlocking and calibration take place immediately. When you click the **Download** button from the digitiser configuration set-up interface, the parameters you have chosen are transferred to the digitiser and it is automatically rebooted. You will notice a data gap in the **Waveview window** corresponding to the digitiser you have rebooted. This occurs because the reboot automatically clears the data buffer and resets the output block counter.

3.1 DIGITISER CONFIGURATION:-USING 'SCREAM'

To access the digitiser configuration setup from **SCREAM**, double-click with the left mouse button on the digitisers icon in the **Available Streams** window (**NOT** the **Local** or **COM** port icons). Alternatively, you can single-click on the digitisers icon with the right mouse button, then select **Configure** from the pop-up menu.

DIGITISER CONFIGURATION



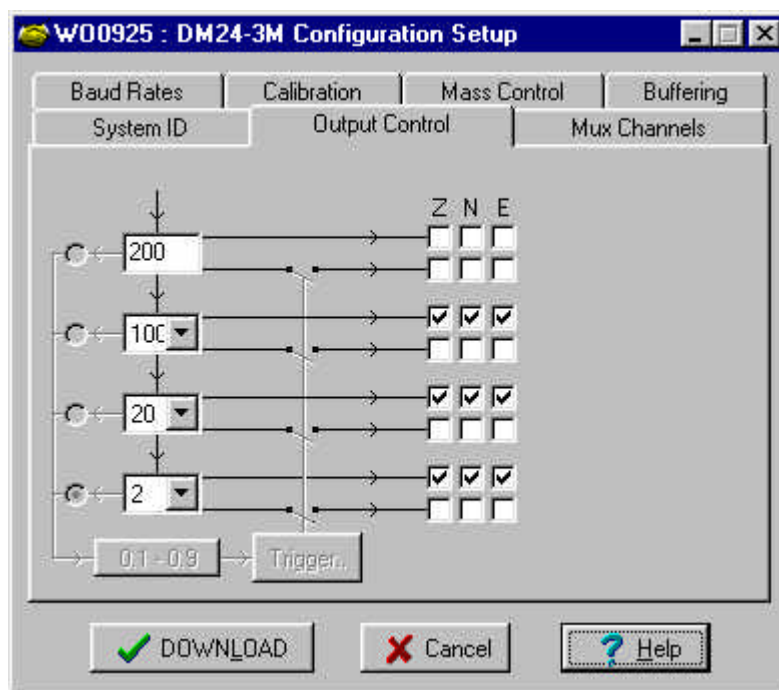
System Identifier and Serial Number: The digitiser type is identified by its system identifier and serial number. These two parameters are stored as the first two 32-bit fields in the header of each data and status block generated by the digitiser to indicate the blocks origin. Each of these parameters consists of 6 alphanumeric characters encoded as base 36 numbers. On delivery from the factory, the system identifier and the serial number are, respectively, set to the GSL works order number and the DM serial number, or if bonded to a seismometer, the seismometer's serial number. The **System-ID** can be reset to any convenient combination of letters and numbers, such as an abbreviation of your institution.

Sensor Type: If the sensor attached to the digitiser is a Guralp velocity sensor, several seismometer functions, such as sensor locking, centering and calibration, may be controlled through the digitiser. The type of sensor programmed with this option determines which functions will be available through the **SCREAM** digitiser configuration set-up interface or through interactive commands. If the digitiser is bonded to a sensor, it will arrive from the factory programmed to the proper sensor type.

GPS Type: The digitiser can utilize time signals from different sources. Options available from GSL are Trimble GPS units (now obsolete), Garmin GPS units or stream synchronization. In stream synchronization, time signals from a GPS antenna or one of the radio time standards are sent via telemetry from a central site to the digitiser. In order to synchronize with the time standard, the correct option must be selected.

DIGITISER OUTPUT CONTROL PROGRAMMING

The screen shot below shows the **Output Control** window for a CMG-DM24-S3 standalone digitiser. The digitiser module set-up will appear the same. The CMG-DM24-S6 will display an extra 3 columns (Z, N and E) on the right –hand side, corresponding to the extra three channels available on that model.



Sampling rate: The output of the digitiser's analogue-to-digital converters (ADC) is data sampled at 2000 Hz. These data are filtered and reduced to lower rates using a digital signal processor (DSP). The DSP has 4 cascaded filter/decimation stages each of which can be programmed for decimation factors of 2, 4, 5, 8 or 10. The output of each stage is called a "tap". The first filter stage, tap 0, is preset to reduce the data by a factor of 10 to 200 samples/second, but each of the subsequent stages may be configured for a different decimation factor.

The four windows on the left of the **Output Control** screen (shown above) allow you to select the sampling rates for three of the four digitiser taps. The upper window corresponds to tap 0 and has a fixed sampling rate of 200 Hz. Each of the other taps may have a sampling rate lower than its predecessor above, if the rate can be achieved by decimation by 2, 4, 5, 8 or 10. Clicking on the window shows a list of the rates that are permitted, given the sampling rate in the window above it.

If some of the outputs are not required then leave the buttons 'unticked' to save communications capacity.

Stream selection: The CMG-DM24-S3 has three channels or *streams*. These are depicted by the three columns of small windows labelled Z, N and E in the **Output Control** window shown above.

A tick in a box will give an output for the corresponding channel (column) at the corresponding sample rate (row). For each sample rate there are two possible rows to tick. The upper row for each sample rate will give a continuous output at that sample rate; the lower row, shown diagrammatically as passing through a switch, will only output data when its trigger criteria are met (see below).

The **Stream IDs** displayed in the main **Available Streams** window has six-character ID's. The first four characters identify the digitiser, the last two characters identify the stream from the digitiser. The first of these two characters identify the channel, the second defines the 'tap', or digitiser output (see Data Transmission Protocol & Data Block Structure later).

For example; for the **Output Control** configuration shown above, at the beginning of this sub-section, there will be three data streams, Z, N and E, outputting data at 100sps, 20sps and 2sps. This is shown below, where the digitiser '1123' has the following streams:-

- Z2, N2, E2 are input channels Z, N, E output through the second tap '2';
- Z4, N4, E4 are input channels Z, N, E output through the third tap '4',
- Z6, N6, E6 are input channels Z, N, E output through the fourth tap '6',
- 00 is the digitiser status stream (notice no sample rate),
- M8, M9, MA are sensor mass positions for Z, N, E channels
- MB, ME, MF are three of the optional eight 16bit channels available

Stream ID	Rec.	Format	SPS	End Time	Date	RIC
1123Z2	No	8 bit	100	11:16:04	13/03/00	-120916
1123N2	No	8 bit	100	11:16:04	13/03/00	-121887
1123E2	No	8 bit	100	11:15:54	13/03/00	-120424
1123Z4	No	8 bit	20	11:15:18	13/03/00	-120917
1123N4	No	8 bit	20	11:15:18	13/03/00	-121884
1123E4	No	8 bit	20	11:15:18	13/03/00	-120424
1123M8	No	8 bit	4	11:13:20	13/03/00	-1
1123M9	No	8 bit	4	11:13:20	13/03/00	0
1123MA	No	8 bit	4	11:13:20	13/03/00	0
1123MB	No	8 bit	4	11:13:20	13/03/00	0
1123ME	No	8 bit	4	11:15:25	13/03/00	23235
1123MF	No	8 bit	4	11:13:20	13/03/00	1
1123Z6	No	8 bit	2	11:06:41	13/03/00	-120919
1123N6	No	8 bit	2	11:06:41	13/03/00	-121887
1123E6	No	8 bit	2	11:06:41	13/03/00	-120427
112300	No	8 bit	0	11:10:32	13/03/00	N/A

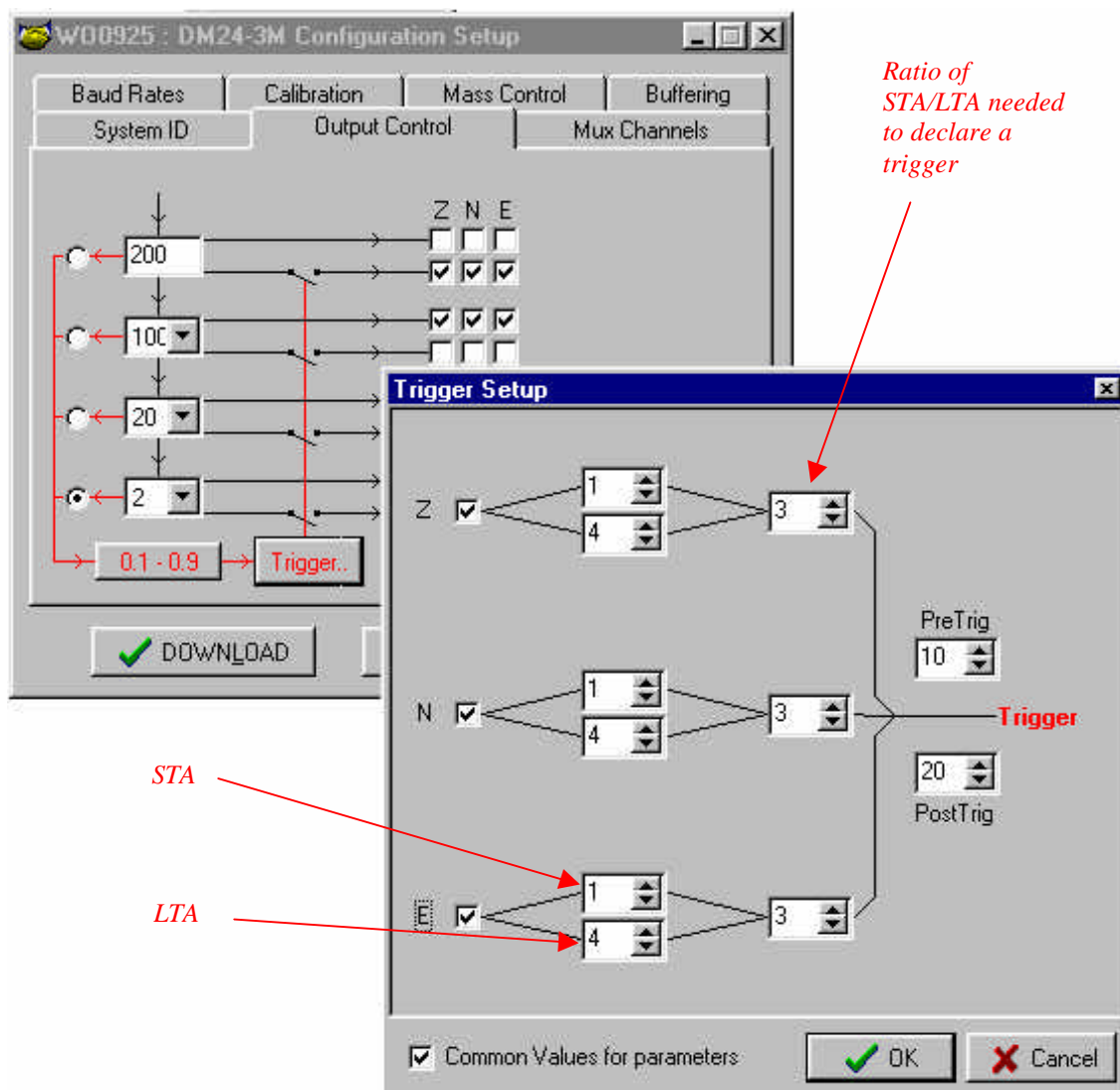
16 streams 468Kb stream buffer Local UTC Time: 11:16:05

Triggered output stream selection: For each tap there are two rows of boxes where the user can tick either triggered or continuous data outputs. The digitiser applies a simple short term average (STA) - long term average (LTA) algorithm to a selected stream or set of streams to determine whether the trigger condition is met. These streams may be bandpass filtered before evaluation using standard bandpass parameters. The data transmitted due to the trigger may be from different streams than those used to determine the trigger.

For this to function properly, triggering streams must be selected and trigger criteria must be set by clicking on the **Trigger** button. When at least one stream is selected for triggered output, selection of triggering streams and trigger criteria are enabled. It is possible to trigger off of one tap but record data from one or several different taps. (TRIGGERED)

Triggering streams selection: The triggering tap is selected by marking the circle next to the tap. This tap need not be the tap from which streams are transmitted when a trigger occurs. If you set triggering, you must also set the parameters for the trigger criteria. (TRIGGERS)

PROGRAMMING TRIGGER PARAMETERS



In general, it is not advisable to trigger from broadband data. The button near the bottom of the **Configuration Setup** window therefore allows the user to select from a set of standard bandpass filters from a pull-down menu (a full list of options is given later in the STA/LTA chapter). The chosen filter will be applied to the streams from the triggering components before they are tested for the trigger condition. The corner frequencies of the pass band of the filter are determined by the Nyquist frequency, which is given by the sampling rate of the triggering data. The three filter options have pass bands between 10 % and 90 %, between 20 % and 90 % and between 50% and 90% of the data's Nyquist frequency, respectively.

Trigger criteria: Trigger criteria for the simple short term average/long term average (STA/LTA) trigger function may be set in the **Trigger Setup** window, accessed by clicking on the **Trigger** button near the bottom of the **Output Control** window.

The three tick boxes down the left side of the **Trigger Setup** window (Z, N, E) allows the user to choose the channels which will be tested for a trigger condition.

The second column of boxes, the user must set the averaging intervals for the short and long term averages (STA and LTA). Typically, the time interval for the short term average should be about as long as the signals you want to trigger on, while the long term average should be taken over a much longer interval. Both the STA and LTA values are recalculated continually, even during a trigger.

The third column of boxes are for defining the STA/LTA ratio which will constitute a trigger for each of the components selected for triggering. The system declares a trigger when any one of the triggering components exceeds this value. The trigger ratio is continuously recalculated for all components and the system will dettrigger when all the components selected for triggering have fallen below their respective ratio values.

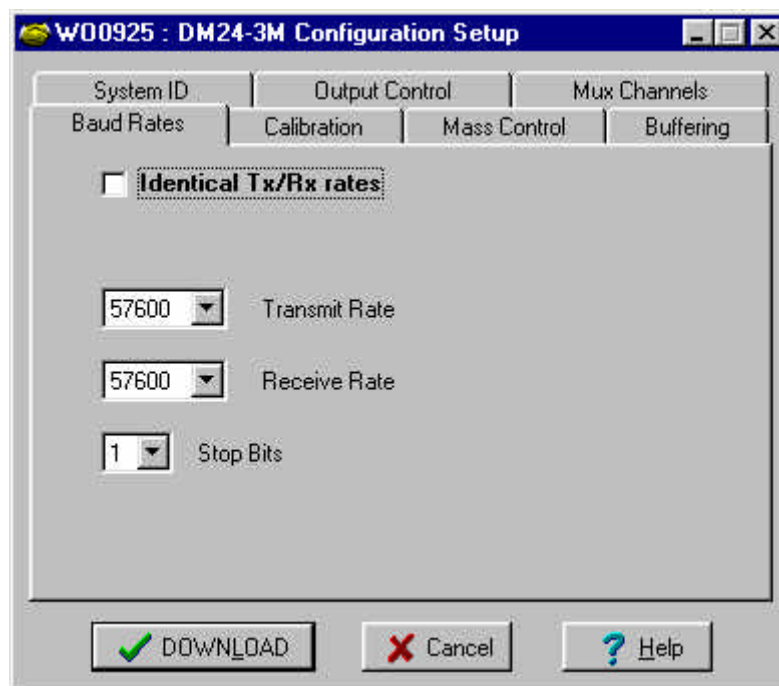
The final column of two boxes on the right-hand side allows the user to select the pre-trigger and post-trigger data intervals. These values determine the minimum length of data that will be saved prior to the trigger condition, and how much data will be saved after the trigger condition has lapsed. Regardless of the intervals chosen, the data for the triggered streams will begin on an even second.

If the box **Common Values for parameters** is ticked, a trigger parameter entered for one component will be used for all selected components. (BANDPASS, STA, LTA, RATIO, PRE-TRIG, POST-TRIG)

More details are given later in Chapter 7. **DIGITISER STA/LTA TRIGGER OPTIONS.**

SETTING DIGITISER COMMUNICATION PARAMETERS

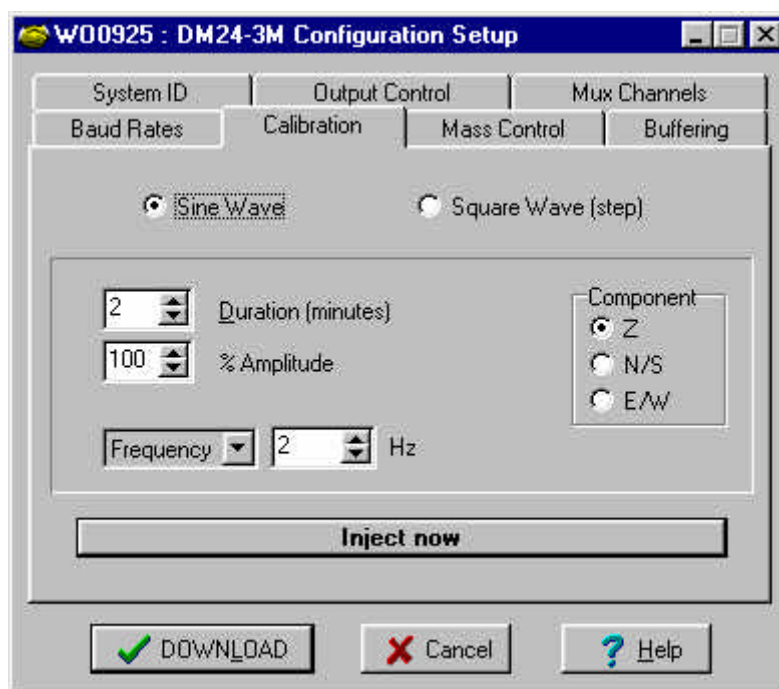
If the digitiser has a duplex link for *handshake* communications with a seismic instrument and a GPS, its COM ports must be configured to match the communications parameters of the attached devices or computers. If the digitiser is connected directly to a computer running **SCREAM**, **SCREAM** can auto-detect the communication baud rate under most conditions. If data from the digitiser must pass through a telemetry link or into a Guralp Storage and Acquisition Module (**SAM**), it is very important that the baud rate and other COM port parameters for the digitiser match that of the telemetry device, whether it be a modem, a radio or the **SAM**.



Data Port Baud Rate. The **Baud Rates** window of the digitiser configuration set-up allows you to program the baud rate and stop bits for the digitisers COM port. The baud rate you choose must satisfy two conditions. It must be high enough to allow all the transmission of all data generated by the digitiser at the sampling rates you have chosen. For three streams of data at 100 Hz, for example, 9600 baud will usually be sufficient. If you wish to transmit 200 Hz data, however, the baud rate must be at least 19200. The second condition for the baud rate, is that it matches that of the telemetry equipment. While modern modems often offer transfer rates up to 56 kbaud, the telephone or transmission lines may not support these rates. The same holds true for radio telemetry. Usually, transmit and receive rates of the data port will be the same. If not, you may select different data rates by removing the check in the box marked **Identical TX/RX rates**. Make sure that the COM port in **SCREAM**, the **SAM** or the communications device is also configured accordingly.

Stop Bits In most circumstances this can be left set at 1. The **Stop Bit** option gives the user the choice of setting the serial transmitted data stop bits to 2 if required over 'difficult' transmission lines. Whilst it can be an aid with say, a radio link, it will add an overhead to the data of $\frac{1}{10}$.

SENSOR CALIBRATION



The digitiser can generate either sinewave or step signals to calibrate the attached seismometer.

Sinewave frequency can be from 10 Hz to 0.1 Hz (0.1 to 10 second period) and can be applied to a particular component (via the built-in relay).

The step (squarewave) calibration is specified in minutes between changes in state.

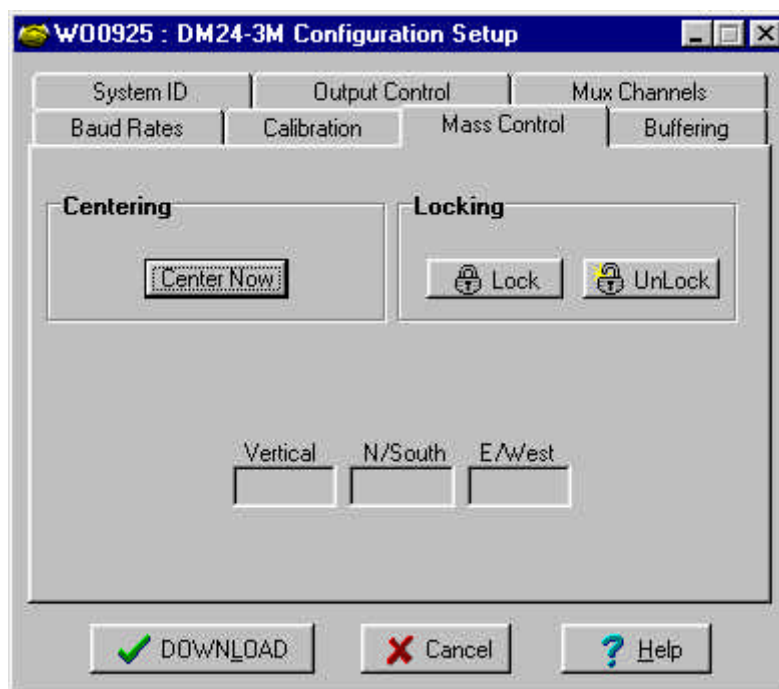
The component to be calibrated is specified by **Z**, **N/S**, **E/W** and the frequency or period by **Hz** or **Seconds** respectively. Note that only integers can be specified for frequency/period, so to generate a 0.5 Hz signal use '**2 Seconds**' or for a 0.25 second period use '**4 Hz**'. e.g. **N/S 4 Hz SineWave** will generate this signal in the calibration coil of the north/south component.

The calibration signal will be automatically disconnected after the specified time. This avoids the system being inadvertently left in the calibration mode. If the signal is required for longer this can be specified, e.g. '**5 Minutes**' will set the timer so that the calibration is disconnected after 5 minutes - this timer is then reset to its default value of 2 minutes.

NOTE: Sinewave calibration signal starts and stops on the zero crossing.

Step calibration is specified by the **Squarewave** button, which generates a positive step on the start of the next minute (of the internal clock) and a negative step the specified number of minutes later (default 2 minutes). This calibration is also disconnected after the same (specified) number of minutes after the negative edge.

SENSOR MASS CONTROL



When the digitiser is installed directly to a Guralp seismometer the mass locking and centring can be controlled if the seismometer supports these operations. The digitiser needs to be configured for the correct sensor type so that the appropriate commands are available (see options under the **System ID** tab).

Four different sensor types are currently supported:-

- CMG-40T- no mass lock or centring
- CMG-3ESP- manual mass lock and remote centring
- CMG-3T- upgraded 'analogue' instrument
- CMG-3TD- fully digital borehole instrument (extra button available when borehole instrument is switched on)

The three buttons **Lock**, **Unlock**, and **Centre** will lock and unlock the sensor mass for transportation then re-centre the mass for operation when installed. While they are executing, the system displays the mass positions for the 3 components, updated once per second per component (3 seconds to cycle through the 3 components). The mass positions are measured to 16 bits. When the masses are locked therefore, the displayed readings will be in the region of 32k or -32k. When the masses are correctly centred the readings should be less than 1000 counts.

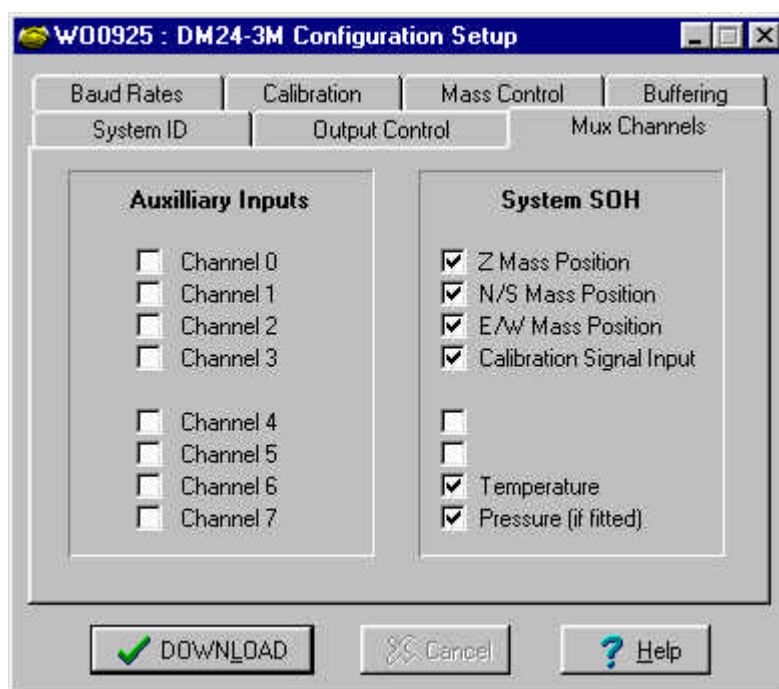
AUXILIARY (MUX) CHANNELS

All the CMG-DM24 digitisers have as standard, five 16bit, 4 samples per second channels. Three of these report the sensor mass positions, one is for inputting calibration signals and the final one for reporting the internal temperature of the digitiser.

In addition to these five channels, there are a further three channels available at the time of manufacture for user specified options (pressure monitor, borehole orientation, etc).

Further to the above eight channels, there can be an additional eight 16bit auxiliary channels which are standard on the stand-alone units, or can be ordered as an extra with the digitiser modules. These can be used for the users own purposes, which can be accessed as they require.

The additional eight channels are accessed via the **Auxiliary** port on the stand-alone units, or, when ordered as an extra with the digitiser module, they are accessed via the **Analogue** connector on the lid



Collection and transmission of the environmental channels is controlled using the **Mux Channels** window. If a tick is placed in the box next to a channel, its data will be collected and transmitted as a data stream in GCF format, just as with the normal data channels. To indicate that the data comes from a Mux channel, the **Stream ID** will be in the format ******Mn**, where M stands for **Mux** and *n* is a hexadecimal integer. The integers between 0 and 15 are indicated by 0 - 9 and A - F, for 10 through 15. If a Guralp seismometer is attached to the digitiser input (module or stand-alone), Mux channels M8, M9 and MA will produce mass position for the vertical, north/south and east/west components respectively. Channel ME monitors the internal temperature of the digitiser.

BUFFERING – DATA STORAGE



If fitted, the digitiser can contain silicon memory modules, the size of which would appear in the window. Data would then be stored in the digitiser rather than being continually transmitted. The '**Heartbeat**' function is then be set to periodically register to the user that the instrument is still functioning.

BUFFERING – FLASH DATA STORAGE

There are 3 modes available to the user with the digitisers that have the flash memory fitted (standard of 16Mb) with other options available up to 512Mb. These include normal, adaptive and filing. To change between these modes, open the terminal connection to the digitiser and type either *direct*, *adaptive* or *filing*; the unit does not need to be re-booted.

Normal Mode is where the digitiser ignores the flash file installed and continues operation as normal.

Adaptive Mode will result in the unacknowledged data (i.e. the interruption of the serial output) being recorded by the flash file. When the connection is restored, both the real-time and recorded data are transmitted.

Filing Mode causes the digitiser to record all the data to the flash in a circular buffer. When in this mode, the unit transmits only 'heartbeats' which are just status messages informing the user that it is recording data. When in this mode, and it is required that all the recorded data be transmitted, right click on the digitiser icon and click download.

There are more commands for when using the digitiser in filing mode through the terminal connection. These allow the user to define more accurately what data the digitiser sends from the flash. The parameters should be set before downloading.

<i>Status-only</i>	Replay only the status blocks.
<i>all-data</i> (DEFAULT)	Replay all sample rates.
<i>all-times</i> (DEFAULT)	Replay all data regardless of time stamp.
<i>Stream xxxxxx</i>	Only data with stream-id xxxxxx
<i>nn s/s</i> specified	i.e. <i>04 s/s</i> , Replay any streams with sample rate (overrides stream selection).
<i>yyyy mm dd hh mm from-time</i>	Specifies start time of the selection.
<i>yyyy mm dd hh to-time</i>	Specifies end time of the selection.
<i>download</i> parameters.	Starts the operation with the set
<i>reset-flash</i>	Deletes all the data in the flash file.

3.2 DIGITISER CONFIGURATION:– USING 'TERMINAL'

DIGITISER CONFIGURATION

Command	Syntax	Comments
SET-ID	<i>interactive</i>	Both sets of characters must include the comma in the location shown
System Identifier ? (e.g. ALPHA,) Serial # ? (e.g. 1234,00)	NUNAME, 4339,00	
SENSOR-TYPE	n SENSOR-TYPE n=1CMG-40T n=2CMG-3ESP n=3CMG-3T n=4CMG-3TD	
GPS-TYPE	n GPS-TYPE n = 0 no time signal n = 1Trimble n = 2 Garmin n = 3 stream-sync	Not all versions support all combinations

NOTE: The last two digits of the serial number should set to 00 (two zeros) as the system replaces these with the characters to identify the component (Z, N, E etc) and digitiser 'tap' (0 to F) to form the '**stream-id**'.

DIGITISER OUTPUT PROGRAMMING

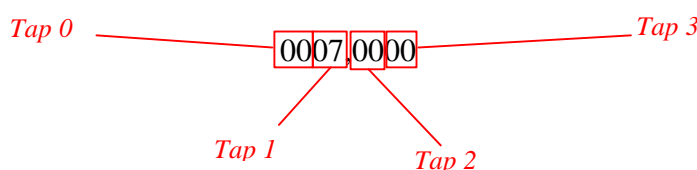
Command	Syntax	Comments
SAMPLES/SEC	tap0 tap1 tap2 tap3 SAMPLES/SEC example: 200 100 50 10 samples/sec	The tapN's are integers. If an illegal combination of sampling rates is specified, the system is automatically set to the default.
SET_CONFIG	SET-CONFIG <i>Interactive</i> 0007,0000 0307	See text below
TRIGGERS	n TRIGGERS Example: 5 TRIGGERS (Trigger on Z and E/W components)	To disable triggering, set: 0 TRIGGERS <i>The binary bits that make up n (an integer less than 8) indicate the components to which the trigger algorithm will be applied.</i> 001 = trigger on Z 010 = trigger on N/S 100 = trigger on E/W
TRIGGERED	tap components TRIGGERED Example: 0 7 TRIGGERED (In case of a trigger, save all three components from tap 0)	tap: 0-3 indicates the tap number from which data should be transmitted in case of a trigger components: like the triggers command.

Explanation_ SET-CONFIG

The 'registers' are set-up by simply defining an 8 digit 'hex' code corresponding to the required contents, the most significant byte (2 hex digits) corresponding to the first tap (#0) and the least significant byte the last tap (#3).

When setting the configuration all 8 digits should be entered with the , [comma] as shown.

For example, to select all 3 components of a standard CMG-DM24 output at 100s/s the code is 0007,0000



For tap1: 07 in hex = 0111 in binary = channels 0,1,2

The environmental channels can be selected (when the hardware is fitted) in a similar fashion, but in this case only 4 hex digits are required to set the appropriate bits - msbit=channel#15, lsbit=channel#0.

For example:

Channel 9
Channel 2
Channel 0
 0307 in hex = 0000 0011 0000 0111 in binary
Channel 8
Channel 1

Therefore the whole **SET-CONFIG** example will look like this:-

Enter	<i>set-config</i>
Displayed	Hex code to select DSP#1 'taps' { 0070,0000} <u> </u>
Enter	<i>0007,0000</i>
Displayed	Hex code to select DSP#1 'taps' { 0070,0000} <i>0007,0000</i> Hex code to select mux channels { 00ff} <u> </u>
Enter	<i>0307</i> <i>Current settings</i>
Displayed	Hex code to select DSP#1 'taps' { 0070,0000} <i>0007,0000</i> Hex code to select mux channels { 00ff} <i>0307</i> DSP1 Tap 0 200s/s 00(<i>TAP#0 'register' setting</i>) Tap 1 100s/s 07 = Chans 0 1 2(<i>TAP#1 setting decoded</i>) Tap 2 20s/s 00 Tap 3 4s/s 00 Mux = 0307 = Chans 0 1 2 8 9(<i>Mux selection decoded</i>) Port#0 9600 Port#1 9600 ok

PROGRAMMING TRIGGER PARAMETERS

Command	Syntax	Comments
BANDPASS	tap# filter BANDPASS Example: 1 5 BANDPASS This command will select data from tap 1 (maximum sampling rate 100 Hz) and bandpass filter 5	Bandpass filter parameters Filter Limits* 0 0% - 100% 1 10% - 90% 2 20% - 90% 5 50% - 90% * Given in percentage of the Nyquist frequency.
STA	n1 n2 n3 STA Example: 1 1 2 STA	Calculate short term averages for 1 s of the Z component, 1 s of the N/S component and 2 s of the E/W component.
LTA	n1 n2 n3 LTA Example: 15 20 20 LTA	Calculate long term averages for 15 s of the Z component, 20 s of the N/S component and 20 s of the E/W component.
RATIOS	n1 n2 n3 RATIOS Example: 4 6 10 RATIOS	Declare a trigger if the STA/LTA ratio is 4 for the Z component OR if it is 6 for the N/S component OR 10 for the E/W component.
PRE-TRIG	n PRE-TRIG Example: 20 PRE-TRIG	n is in seconds. When a trigger is declared, include 20 s of data prior to the trigger time.
POST-TRIG	n POST-TRIG Example: 60 POST-TRIG	n is in seconds. When a trigger is declared, include 60 s of data after the trigger ends.

SETTING DIGITISER COMMUNICATON PARAMETERS

Command	Syntax	Comments
BAUD	port# baud-rate BAUD 0 19200 BAUD 1 4800 BAUD	The DM's port 0 is assigned to data output and communication. Port 1 is used for GPS input and should remain set at 4800 baud. Port 0 may be set to one of the following baud rates: 4800, 7200, 9600, 14400, 19200, 38400, 57600 or 115200.

SENSOR CALIBRATION

Command	Syntax	Comments
SENSOR-TYPE	n SENSOR TYPE	Where 'n' is the number 1 to 4 1. CMG-40T no mass lock or centring 2. CMG-3ESP manual lock, remote centring 3. CMG-3T upgraded analogue instrument 4. CMG-3TD digital borehole instrument
SINEWAVE	SINEWAVE	See text below
SQUAREWAVE	SQUAREWAVE	See text below

The digitiser can generate either sinewave or step signals to calibrate the attached seismometer.

Sinewave frequency can be from 10 Hz to 0.1 Hz (0.1 to 10 second period) and can be applied to a particular component (via the built-in relay).

The step (squarewave) calibration is specified in minutes between changes in state.

The component to be calibrated is specified by **Z**, **N/S**, or **E/W** and the frequency or period by **HZ** or **SECOND** respectively. Note that only integers can be specified for frequency/period, so to generate a 0.5 Hz signal use **'2 SECOND'** or for a 0.25 second period use **'4 HZ'**.

e.g. **N/S 4 HZ SINEWAVE** will generate this signal in the calibration coil of the north/south component.

The calibration signal will be automatically disconnected after the specified time. This avoids the system being inadvertently left in the calibration mode. If the signal is required for longer this can be specified by using the **MINUTE** command, e.g. **'5 MINUTE'** will set the timer so that the calibration is disconnected after 5 minutes - this timer is then reset to its default value of 2 minutes.

NOTE: Sinewave calibration signal start and stops on the zero crossing.

Step calibration is specified by the command **SQUAREWAVE**, which generates a positive step on the start of the next minute (of the internal clock) and a negative step the specified number of minutes later (default 2 minutes). This calibration is also disconnected after the same (specified) number of minutes after the negative edge.

e.g. **E/W 10 MINUTE SQUAREWAVE** would be used to generate a long period step function suitable for calibrating a 360 second response instrument.

SENSOR MASS CONTROL

Command	Syntax	Comments
LOCK	LOCK	The 3 commands LOCK , UNLOCK , and CENTRE are simply entered at the command line. While they are executing the system displays the mass positions for the 3 components updated once per second (3 seconds to cycle through the 3 components). The mass positions are measured to 16 bits so when the masses are locked the displayed readings will be in the region of 32k or -32k. When the masses are correctly centred the readings should be less than 1000 counts.
UNLOCK	UNLOCK	
CENTRE	CENTRE	

AUXILIARY (MUX) CHANNELS

Command	Syntax	Comments
SET-CONFIG	SET-CONFIG	See digitiser output programming earlier

If you are programming the digitiser using the **SCREAM** terminal window or a standard terminal program, you must issue the RE-BOOT command to restart the DM.

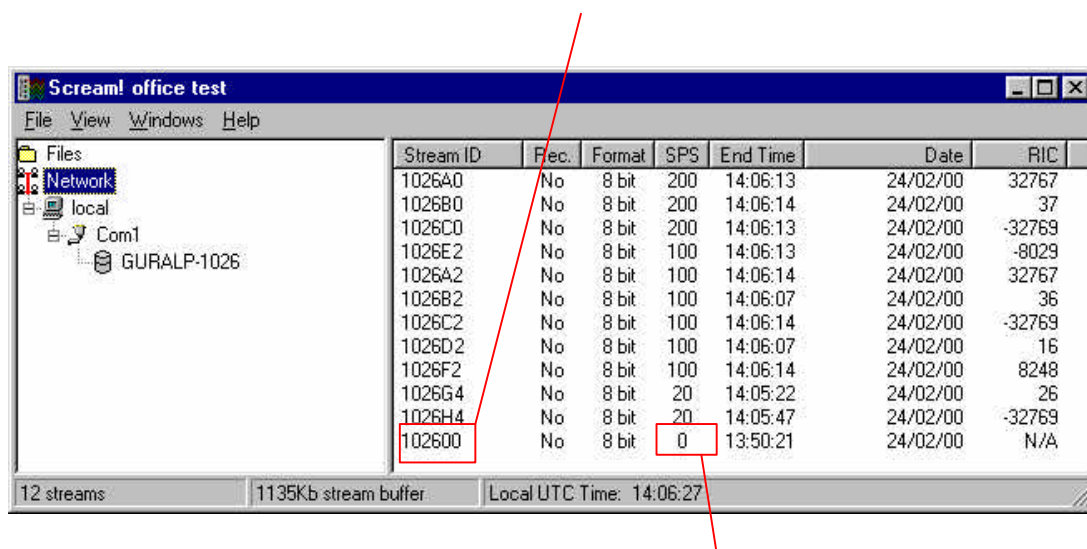
Command	Syntax	Comments
RE-BOOT	RE-BOOT <i>no parameters</i>	The command prompts the operator to confirm this operation with 'y'. The system will then automatically reset after a delay of about 2 s.

4. STATUS INFORMATION

DIGITISER STATUS INFORMATION

Various status information is output from the digitiser to report the system operation such as GPS and time synchronisation status. This status information is in plain ASCII text packaged in the same block structure as the channel data. There are usually 12 lines of information in a block.

To access a **Status** window right click on the **Stream ID '****00'**, (where **** is the digitiser). In the example below this is **102600**



Stream ID	Rec.	Format	SPS	End Time	Date	RIC
1026A0	No	8 bit	200	14:06:13	24/02/00	32767
1026B0	No	8 bit	200	14:06:14	24/02/00	37
1026C0	No	8 bit	200	14:06:13	24/02/00	-32769
1026E2	No	8 bit	100	14:06:13	24/02/00	-8029
1026A2	No	8 bit	100	14:06:14	24/02/00	32767
1026B2	No	8 bit	100	14:06:07	24/02/00	36
1026C2	No	8 bit	100	14:06:14	24/02/00	-32769
1026D2	No	8 bit	100	14:06:07	24/02/00	16
1026F2	No	8 bit	100	14:06:14	24/02/00	8248
1026G4	No	8 bit	20	14:05:22	24/02/00	26
1026H4	No	8 bit	20	14:05:47	24/02/00	-32769
102600	No	8 bit	0	13:50:21	24/02/00	N/A

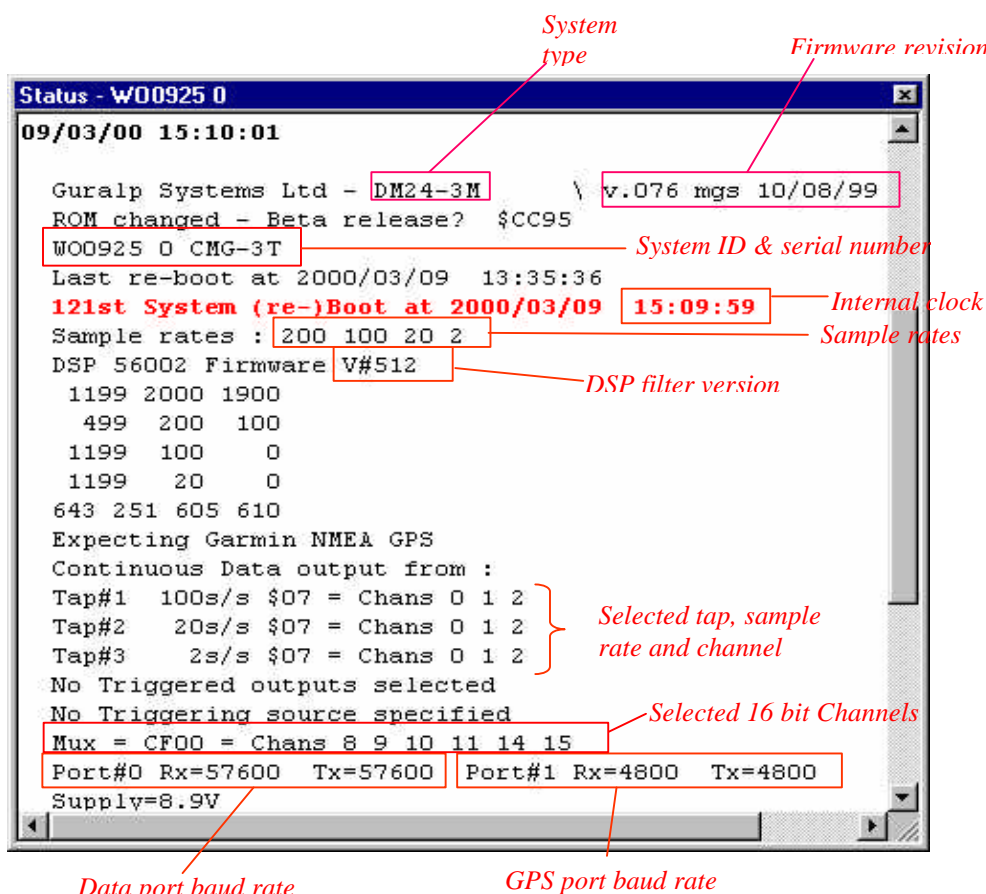
12 streams 1135Kb stream buffer Local UTC Time: 14:06:27

Notice this is the only stream with '0' samples per second

DIGITISER STATUS

During boot-up the units report their model type, firmware revision number, the system-ID and serial number. This information is followed by the count of resets that have occurred and the time of this re-boot from the internal back-up clock. The following lines report the configuration of the unit sample rates, output taps selected, and the baud-rates of the serial ports.

Typical digitiser re-boot status message:



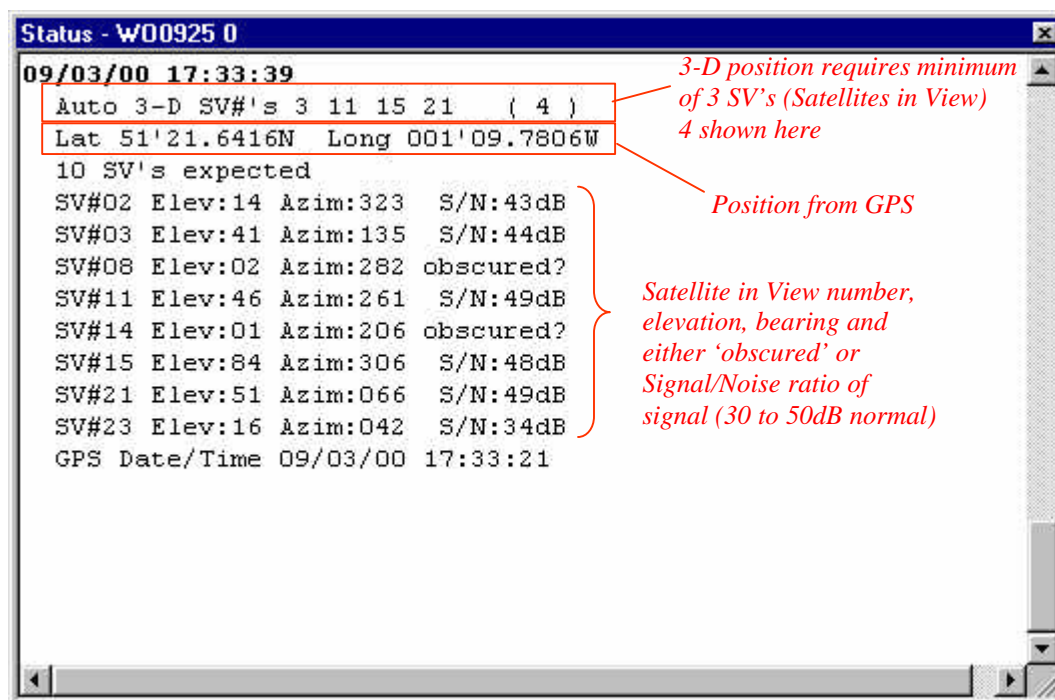
The system will produce this status message whenever it is powered up. If this status is reported at other times it indicates that the system has been reset by the built-in 'watchdog' monitor. This will occur if the system has suffered a corruption due to external noise or power dips.

If the digitiser does not have a GPS unit connected for time synchronisation no further status reports are produced.

When a GPS unit is fitted its operational status is reported and the behaviour of the time synchronisation software will also be shown.

From a 'cold' start GPS will initially report 'No GPS time' and its last position from the internally backed up status. All messages from the GPS that involve a *change* of its status are *automatically* reported, repeated status messages are not shown to avoid unnecessary accumulation of repeated information.

Initial GPS status report will be like this:



If GPS is having difficulty in acquiring satellites there can be a delay of several minutes before a new message is displayed, but normally if the system has not been moved from its previous location it should report acquisition of 1 or more satellites and GPS time in a very short time. The report will also show the satellite numbers and their corresponding signal strengths.

The internal time synchronisation and control software will wait for the GPS unit to report a good position fix (requires 3 satellites) before starting operation. The system actually waits 6 consecutive 'good' messages, which normally occur every 10 to 20 seconds.

If GPS maintains a good fix from the satellites available, the system will then switch on the control process and set the internal clock as shown by the status messages over the page.

The system jam-sets its internal clock at this point to be synchronised to GPS time and will also re-synchronise the Analogue to Digital Converters so that the data is accurately time-stamped to this new reference. The data transmitted up-to this point will be stamped with the time from the internal back-up 'Real-Time Clock' ; this is also now reset to this accurate time. Re-synchronisation will also result in the received data showing a discontinuity.

The control process will now attempt to keep the internal time-base synchronised to the GPS 1 pulse per second output by adjusting the voltage controlled crystal oscillator. The control algorithm has two stages - initially it compares its internal 1 Hz time-base with the GPS 1pps and adjusts the voltage control to minimise the error. Once this has been achieved it then controls the crystal to minimise both the 'phase error' (offset between its internal 1 Hz and GPS) and the drift (frequency error) relative to GPS. During the

control process the system reports the measured errors and the control signal applied, as a 'pwm' value - Pulse Width Modulation - digital to analogue conversion.

```

Status - W00925 0
09/03/00 15:16:21
SV#23 Elev:39 Azim:102 S/N:43dB
GPS Date/Time 09/03/00 15:11:00
Auto 3-D SV#'s 3 19 21 22 31 ( 5 )
Lat 51'21.6346N Long 001'09.8086W
Using GPS to Control Crystal 2000 3 9 15:16:17
Clock sync'd to GPS 2000 3 9 15:16:20 ==>> 2000 3 9 15:16:20 0
1199 2000 1900
499 200 100
1199 100 0
1199 20 0
643 251 605 610 ...
Auto 3-D SV#'s 3 8 15 17 19 21 22 23 27 31 ( 10 )
09/03/00 15:28:00
Lat 51'21.6488N Long 001'09.8215W
  
```

Synchronisation process commenced

*Internal clock synchronised to GPS. Notice the date and time are repeated.
The first is the internal clock, the second is the GPS time the clock will change to, if there is a difference.*

During the initial 'coarse' adjustment only the coarse voltage control is used and no 'drift' calculation is made (drift is initially shown as '0'). If the system is operating in a similar environment to that when the system was last powered (i.e. same temperature) the saved control parameters will be appropriate and the system should rapidly switch to the 'fine' control mode.

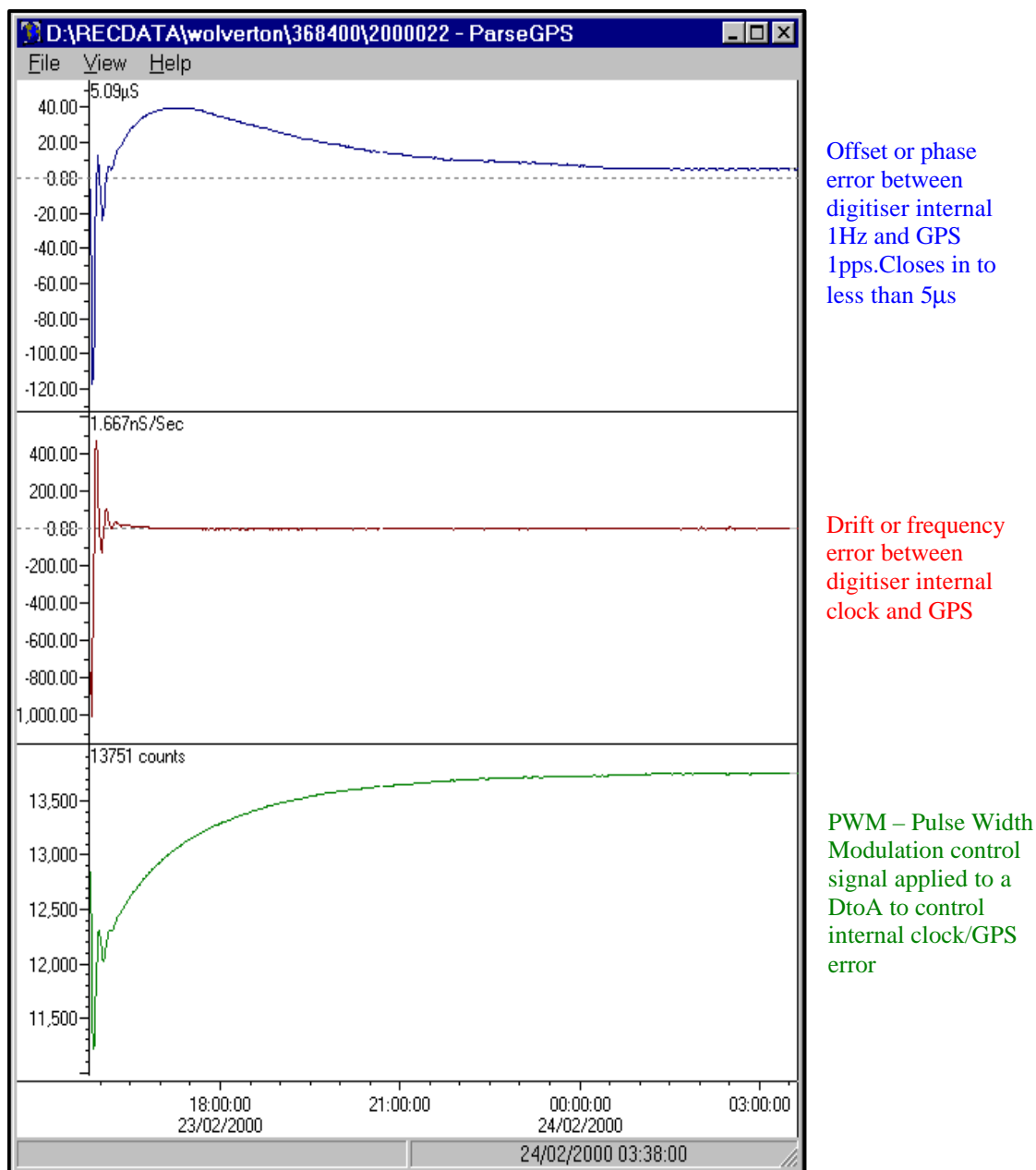
The system reports its control status and parameters each minute as shown below:

```

Status - W00925 0
Supply=8.9V
Auto 3-D SV#'s 3 8 15 19 21 22 23 27 31 ( 9 )
Lat 51'21.6608N Long 001'09.8136W
GPS Date/Time 09/03/00 16:00:01
Auto 3-D SV#'s 3 8 15 19 21 22 23 27 31 ( 9 )
Lat 51'21.6609N Long 001'09.8136W
GPS Date/Time 09/03/00 16:00:02
09/03/00 16:13:00
2000 3 9 16:01:00 o/s= 14404 drift= -421 pwm= 12508
2000 3 9 16:02:00 o/s= 14254 drift= -285 pwm= 12502
2000 3 9 16:03:00 o/s= 14164 drift= -187 pwm= 12506
2000 3 9 16:04:00 o/s= 14034 drift= -158 pwm= 12513
2000 3 9 16:05:00 o/s= 13840 drift= -176 pwm= 12518
2000 3 9 16:06:00 o/s= 13735 drift= -140 pwm= 12526
2000 3 9 16:07:00 o/s= 13748 drift= -63 pwm= 12541
2000 3 9 16:08:00 o/s= 13935 drift= 62 pwm= 12570
2000 3 9 16:09:00 o/s= 14069 drift= 98 pwm= 12602
2000 3 9 16:10:00 o/s= 14068 drift= 48 pwm= 12629
2000 3 9 16:11:00 o/s= 13850 drift= -85 pwm= 12643
2000 3 9 16:12:00 o/s= 13390 drift= -272 pwm= 12637
  
```

The offset and drift figures are the total accumulated error measurements during the previous minute in time-base units (nominally $0.5 \mu\text{sec}$). To convert the figures to time, divide by 120 ($60 * 2$) to give micro-seconds. In a stable temperature environment the system should soon settle down showing an offset error of only a few thousand (average error $< 100 \mu\text{sec}$) and a drift rate under 100 counts (< 1 in 10^{-6}).

The screen shot below shows, from the top graph down, the offset, drift and pwm of a digitiser internal clock tracking and homing-in on a GPS clock pulse over approximately a twelve hour period.



The above graphical image was printed from a Guralp plot module to demonstrate the effectiveness of digitiser clock synchronisation and subsequently time stamped data.

5. DIGITISER DATA ACQUISITION & TELEMETRY

Guralp Systems provides complete broadband seismological data acquisition solutions. All of the equipment is modular in connectivity. The equipment comprises of broadband sensors with a choice of digitisers, SAM units for data Storage and Acquisition and the CRM for data Combining and Repeating.

Due to the modular nature of the equipment and the power offered to the user from Guralp Systems' SCREAM! Software, complete system set-ups are highly flexible, allowing rapid deployment of equipment tailored to the customers requirements.

Over the page is a diagram of some of the combinations possible of data acquisition, transmission over a desired medium and collection for subsequent analysis. Shown below are two examples of typical arrangements.

Example 1:

Two 3 channel analogue sensors could be connected to a CMG-DM24, then via a direct cable link to an acquisition computer. This could then retransmit via telephone modems or the internet.

Example 2:

Up-to seven sensor arrays could be connected to a Guralp SAM (Storage and Acquisition Module) or CRM(Combiner/Repeater Module) unit. These units can combine several serial input channels into one serial stream for transmission via a radio modem, cable or, using a serial server, directly over the internet. A GPS can be used on the CRM or SAM, instead of each digitiser, to synchronise and time stamp all the data streams.

The CRM is designed specifically as a telemetry repeater station. Incoming RS232 data streams from Guralp digitisers will be at 9600, 19200 or 38400 baud depending upon sample rates, number of channels and compression factor.

The CRM combines the asynchronous incoming data streams and outputs at an appropriate baud rate (up to 115200 baud output). For example four incoming streams at 9600 baud will be output at 38400 (assuming the transmission medium can sustain this baud rate; ie some radio modems may have lower baud capacity).

The SAM unit functions in a similar manner to the CRM, except it has a SCSI hard drive to store data. If, for instance, the transmission link is less than 100% effective or in danger of being disrupted, the SAM continuously records all the data in a ring buffer. Should the transmission link then be lost, this ensures no data is also lost.

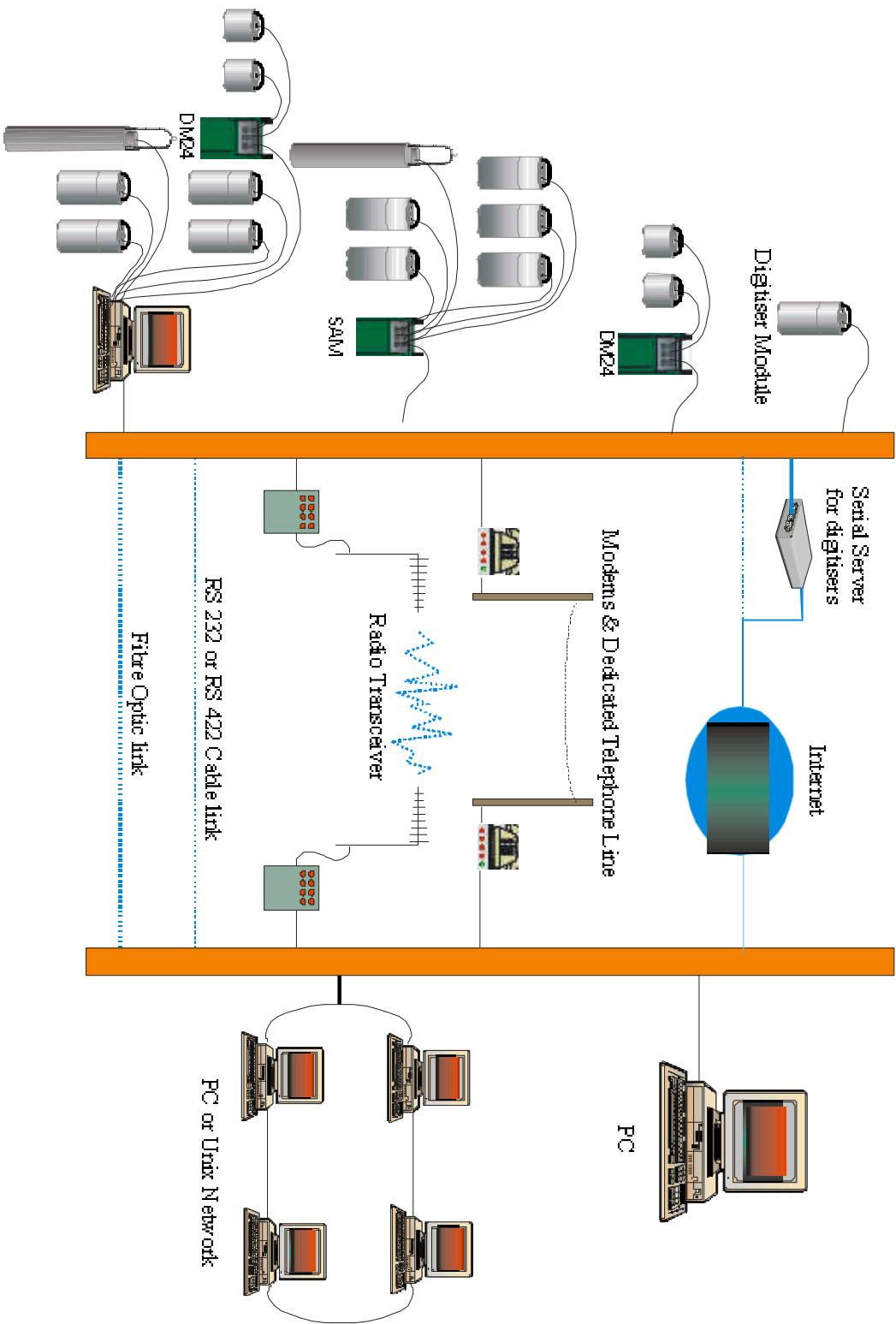
The main design purpose of the SAM though, is where there is no means of transmitting data from a remote or difficult site, where it can store data over long periods, depending upon the quantity of data and disc size (9 Gb standard, other options are available).

DIGITISER ACQUISITION AND TELEMETRY

Data Source

Data Transmission

Data Collection



6. ADDING A DIGITISER MODULE ONTO A BROADBAND SENSOR

The CMG-DM24 module is connected onto a Guralp sensor by a ribbon cable. A ribbon is used as the cable length is only 150mm. The input stage of the CMG-DM24 module is single ended to save power and component count (see pin connections in the Pin-out section).

In order to fit a digitiser module onto the top of a standard Guralp analogue output instrument it is necessary to follow the following procedure.

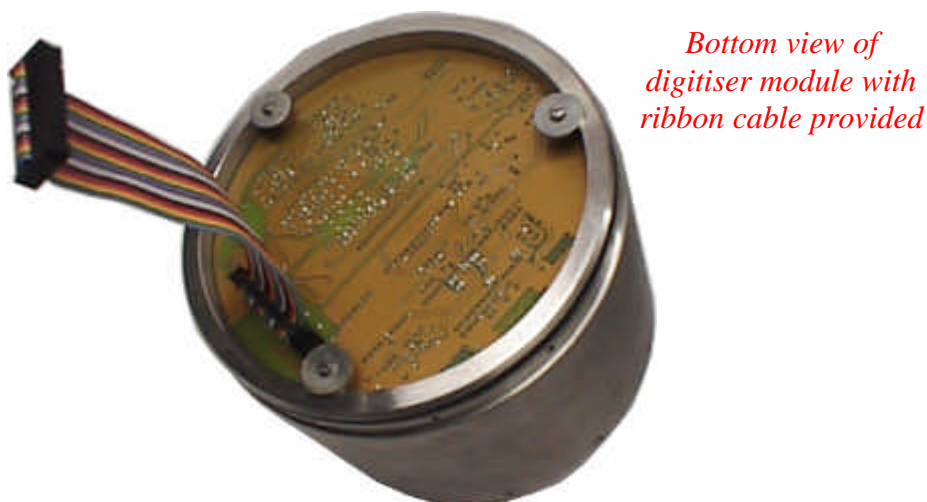
NOTE

It is essential that all the sensors are in a locked state (if applicable) throughout this procedure.

1. Unscrew 12 sets (can be 6 sets) of M3 x 6 cap head screws retaining the top lid of the sensor.



2. Remove the pressure relief valve before gently pulling the top lid off the sensor pressure housing tube.
3. Under the lid there is a short ribbon cable assembly. Unplug the cable assembly from the top circuit board in the sensor.
4. Remove the air pressure relief screw from the digitiser.
5. Use the ribbon cabling provided with the digitiser, to connect the digitiser module onto the broadband sensor.



6. Slide the digitiser module onto the top of the sensor housing tube, ensuring that there is sufficient silicon lubricant (Type: Corning 111) on the 'O' ring applied onto the 'O' ring groove.
7. Screw the 12 (can be 6 sets) x M3 x 6 cap head screws back through the pressure housing onto the digitiser module. Refit pressure relief sealing screw.

NOTE

Before powering the system up it is essential to check the supply rating of the sensor and the digitiser module.

A digital output sensor system can be converted back to an analogue sensor output by following the above procedure in reverse order. It is possible to obtain the top lid by specifying the assembly part number ASM-030-0014 for CMG-3T and CMG-3ESP or ASM-040-0014 for CMG-40T.

7. SYSTEM POWER REQUIREMENTS

Any part of the sensor system can be operated from a 10 to 36 Volts DC power supply. Power reversal protection is provided in all the sensors, digitizer modules and SAM units.

The typical power supply current requirement at 12 Volts is:

CMG-3T	75mAmps (400 mAmps locking/unlocking/centring)
CMG-3ESP	75 mAmps (400 mAmps centring)
CMG-40T	50 mAmps
CMG-DM24	125 mAmps
CMG-GPS	80 mAmps
CMG-SAM	200 mAmps continuous (no disk power surge due to power management)

The given power supply current requirements are a guideline. There are many factors which can influence the power consumption of the sensor system, for this reason it is recommended that the user should budget more generously when choosing power supplies than the given typical values.

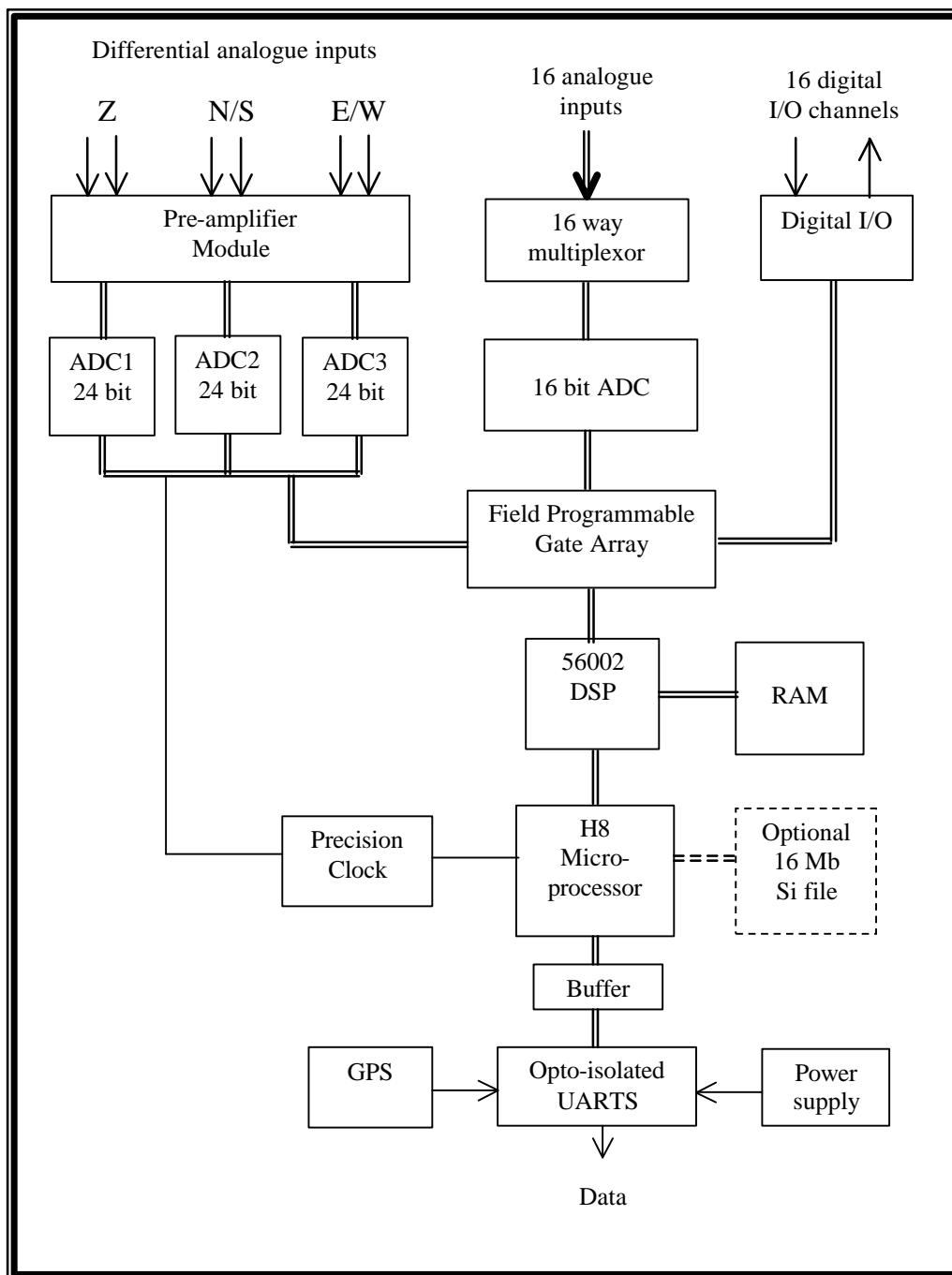
The listed power supply consumptions should be checked against the supply requirements given in the calibration documents.

NOTE

A dc-dc converter is used within each module of the system (sometimes more than one dc-dc converter is used within a module) and it is generally recognised that the start up current of such dc-dc converters can be a factor of 5 to 8 times larger than the quiescent currents given above.

8. DESCRIPTION OF THE BROADBAND DIGITISER

The DM24 system design block diagram is given below. Each section of the block diagram represents a separate printed circuit board. Depending on the CMG-DM24 configuration, the printed circuit boards are stacked up either as circular PCB, square circuit boards or long and slim PCBs for the borehole digitiser.



The high resolution digitiser utilises the Crystal Semiconductor CS5321/2 chipset and Motorola 56002 DSP. The CS5321/2 provides data at 2,000 samples per second,

triggered by the H8 timing system, to the 56001 DSP. The DSP can control from 1 to 3 ADCs and process the data.

The system is designed around a low power, high performance 16bit microprocessor (Hitachi H8/500 series). This features a large address space (1Mb - 16 *64k pages) for data storage and manipulation and many integrated functions such as multiple timers and serial I/O ports.

The modular (paged) structure of the processor architecture is used to advantage in the modular design of the system, each module being assigned to a separate 'page'. Each module is associated with an 'I/O' function and can simply be added to the system at an available page. Every module includes 32k of RAM which is used for data buffering and workspace for the module's software.

An important feature of the system design is its ability to synchronise the sampling of the analogue to digital converter to an external time reference so that data samples are accurately time stamped (at the source). The microprocessor time-base serves as the system time reference and can be synchronised and tuned to an external reference such as GPS to maintain sampling accurately synchronised to UTC. To avoid the cost and power consumption of multiple GPS receivers in larger arrays the systems can also be synchronised to a centrally transmitted time reference using a scheme similar to that employed by the National Radio Time Standards (WWV, MSF and DCF77). As this only involves sending 2 characters per second it can utilise a low band-width, even half-duplex link.

To achieve the high degree of timing precision required for a 24 bit digitiser system the microprocessor time-base is run from a precision voltage controlled oscillator which is software controlled from the external reference so that its frequency is accurately set and maintained with temperature and ageing. The control is sufficiently accurate to maintain precision sampling for long periods (several hours) in the absence of an external reference once the system has stabilised.

All the timing functions are derived via the internal timer/counter channels from the precisely set processor frequency so that sampling and time-stamping are accurately maintained with reference to UTC. The system also automatically compensates for the pure time delay introduced by the digital filtering/decimation of the DSP which provides data output at different sample rates simultaneously.

The main microprocessor board incorporates a battery-backed Real-Time Clock and RAM which is used to set the systems internal software clock at start-up independent of the availability of the external time reference. The RAM is used to store system parameters such as the optimum control voltage setting for the system time-base and the system configuration.

The microprocessor module includes the (multi-tasking) system operating software in 64K EPROM. This module also has 512k of static RAM for system workspace and data buffering depending on the system requirements (number of data channels and sample rates).

The microprocessor serial port (19,200 Baud) provides an interactive interface for system setup and configuration. This port is known as the terminal port. Unlike the

GPS serial port or the data port, the terminal port is not optically coupled to the outside world. Care should be taken not to run a terminal over very long RS232 cables.

The DSP software consists of 4 cascaded programmable filter/decimation stages allowing multiple data output rates to be simultaneously selected. The first stage is set to decimate the data by 10 resulting in a data output rate of 200 samples/sec. The following 3 stages can be set individually for decimation factors of 2, 4, 5, 8, and 10 allowing data to be output at lower rates requiring less storage and transmission bandwidth. For example, a system can be configured to provide data at 200, 50, and 10 samples/sec covering the whole of the seismological broad band range.

The configuration of the DSP is programmable (in the field) via the host H8 microprocessor. The H8 communicates with the DSP via its high speed 8-bit 'host port', which allows the operating mode/configuration to be altered and the resulting processed/filtered data to be acquired.

The primary digital interface for the systems is the multiple serial port card. Each card can contain 1 or 2 dual UARTs (Universal Asynchronous Receiver Transmitters) and upto 2 cards can be fitted to a SAM/DM unit. This allows a system with upto 8 serial ports to be configured.

On a DM unit with analogue inputs a serial port is usually configured to send the data packets to a (local) SAM unit for storage/acquisition or via a modem or radio link to the central recording station. The second serial port is available for use with a local GPS receiver for time synchronisation, or alternatively the first (data) port is used for time synchronisation from the central station.

The multiple serial port card is usually configured as several data inputs for a SAM unit allowing it to collect data from upto 8 other SAM or DM units located locally, using RS232 or RS422 links, or more remotely using radio links or telephone modems.

Each of the serial ports on a module can be configured for a wide range of standard baud rates (with different settings available for transmit and receive channels), allowing a wide range of data links to be used depending on the required data rates.

The first dual UART supports full modem interface on one port and hardware handshake on the second. The second dual UART is configured for data line interface only, supporting software handshake. Each dual UART is optically isolated to avoid ground loops that could degrade the performance of the ADC's.

The serial port module includes 32k RAM for data buffering and formatting by the transmission/reception process.

9. DATA TRANSMISSION PROTOCOL & DATA BLOCK STRUCTURE

The block structure of the SAM/DM data format (which does NOT use BDTS format) lends itself to a simple block transmission/acknowledge protocol for transmission of the data between multiple SAM/DM units and central data acquisition systems.

To send blocks of data from one system to another each block is packaged in a 'transport' layer, which consists of a short block header and a checksum tail. The header consists of 4 bytes. The first is always an ASCII 'G' and the second is an incrementing block number (modulo 256). The other 2 bytes contain the length of the data block (binary, Motorola byte order). The checksum is also a 'word' (16 bit) being the sum of all the **bytes** in the data block **and** the 4 header bytes.

To optimise the use of available transmitter bandwidth the transmitted data block is truncated to the actual data length. As the systems currently only have 24 bit resolution the redundant most significant byte in 32 bit data blocks is also not included in these blocks i.e. 24 bit (3 byte) records are transmitted. This reduction is only applied to the *difference* records - the first and last *absolute* values are still transmitted as 32 bit values.

The transmission header consists of 4 bytes

Fixed identifier	ASCII 'G' (hex 47)
Block sequence number	0 - 255
Block size in bytes (excludes header and checksum)	Most significant byte Least significant byte

The digitiser units transmit data as complete blocks become available without any flow control except that provided by a simple positive/negative acknowledge (**ack/nak**).

Acknowledgement of received packets is not necessary as the transmitter only waits for a nominal 100 mSec before moving onto the next block, if ready. To acknowledge correct reception of a block the receiver should reply with an '**ack**' character (here defined as hex 01) and the least significant byte of the block's 'stream-id'. This allows for a system which has a simple broadcast acknowledgement via a common link (radio band) to many systems that are part of an array, each system is able to identify its own **ack/nak** by matching the identifier byte. Reception of a positive acknowledgement will enable the transmitter to terminate its wait timer and immediately proceed to the next block.

When the receiver detects a transmission error it should reply with a '**nak**' (here defined as hex 02) and the identifier byte. This will cause the transmitter to re-send the block of data.

DATA BLOCK STRUCTURE

Block Header

All elements of the GCF data block can be considered as long words (4 bytes or 32 bits).

The GCF block header consists of 4 elements (16 bytes) as shown

System-ID	32 bit number (base 36) - see below		
Stream-ID	32 bit number (base 36) - see below		
Date/Time	15 bit Day number	17 bit Second number	
Format	R.F.U.	s/sec	compression block size

The first element contains the unique identifier for the system from which the data came. This is usually a six character string encoded in base 36 i.e. each character can be extracted by taking the number modulo 36 and converting to the characters 0 - 9 and A - Z. Only positive integers are allowed (most significant bit=0) limiting the range of values to 0 - 7FFF,FFFF in hex (2,147,483,654 decimal) or ZIK0ZJ in base 36. This field can be set to any convenient unique identification number by the user, but units are shipped from the factory with this set to the factory Works Order number e.g. WO1234.

The second element identifies the stream of data i.e. source as horizontal or vertical sensor and its origin from the digitiser. This again uses base 36 encoding, but this field should not be changed as it is dynamically set according to the configuration of the digitiser.

This is best viewed in its base 36 form i.e. as 6 alphanumerics. The 4 most significant characters are the instrument serial number (decimal) and the 2 least significant characters encode the sensor component and digitiser output.

Stream-ID	digit 4	digit 3	digit 2	digit 1	Z,N or E	see text
	serial number				comp	source

The Guralp CMG-DM24 digitisers can output upto 4 data rates per component simultaneously.

The third header element contains the date/time information as a 15 bit day number packed with a 17 bit second number. The second number is the time since midnight - maximum 86,399 normally but possibly 86,400 in the case of a 'leap second'. The day number increments on the roll-over of the seconds count at midnight. The origin of the day number (day zero) was 17th November 1989. Thus the date/time can be uniquely decoded for the next 80 years.

The final header element defines the format of the data in the block, i.e. compression, sample rate, size etc.

The most significant (first) byte is currently unused and is set to zero.

The next byte contains the sample rate (s/sec in binary). If this field is zero this indicates that the block contains status (text) information.

The third byte is used to specify the compression format for all the data in the block. The 3 least significant bits are used to indicate whether the data elements (32 bits) contain 1, 2 or 4 sample points - i.e. a value 4 indicates that the data records should be treated as 4 8 bit differences, a value 2 means the data are 2 16 bit differences and the value 1 the data are a single 32 bit difference.

The fourth byte contains the count of the number of data records (32 bits). The product of these last 2 bytes can be used to calculate the total number of sample points in the block.

Block Data.

First absolute value	32 bits
First 1, 2 or 4 differences	1*32bit, 2*16bit or 4*8bit values

Final 1, 2 or 4 differences	same format 1, 2 or 4 differences
Final absolute value	32 bits

The first data record in the block, following this format record, is the initial 32 bit absolute value (forward integration constant). The last record is the final 32 bit absolute value (reverse integration constant). Between these are the specified number of data records. Each data record contains the specified number of 8, 16 or 32 bit differences from the previous value. The first difference is always zero as it corresponds to the first sample.

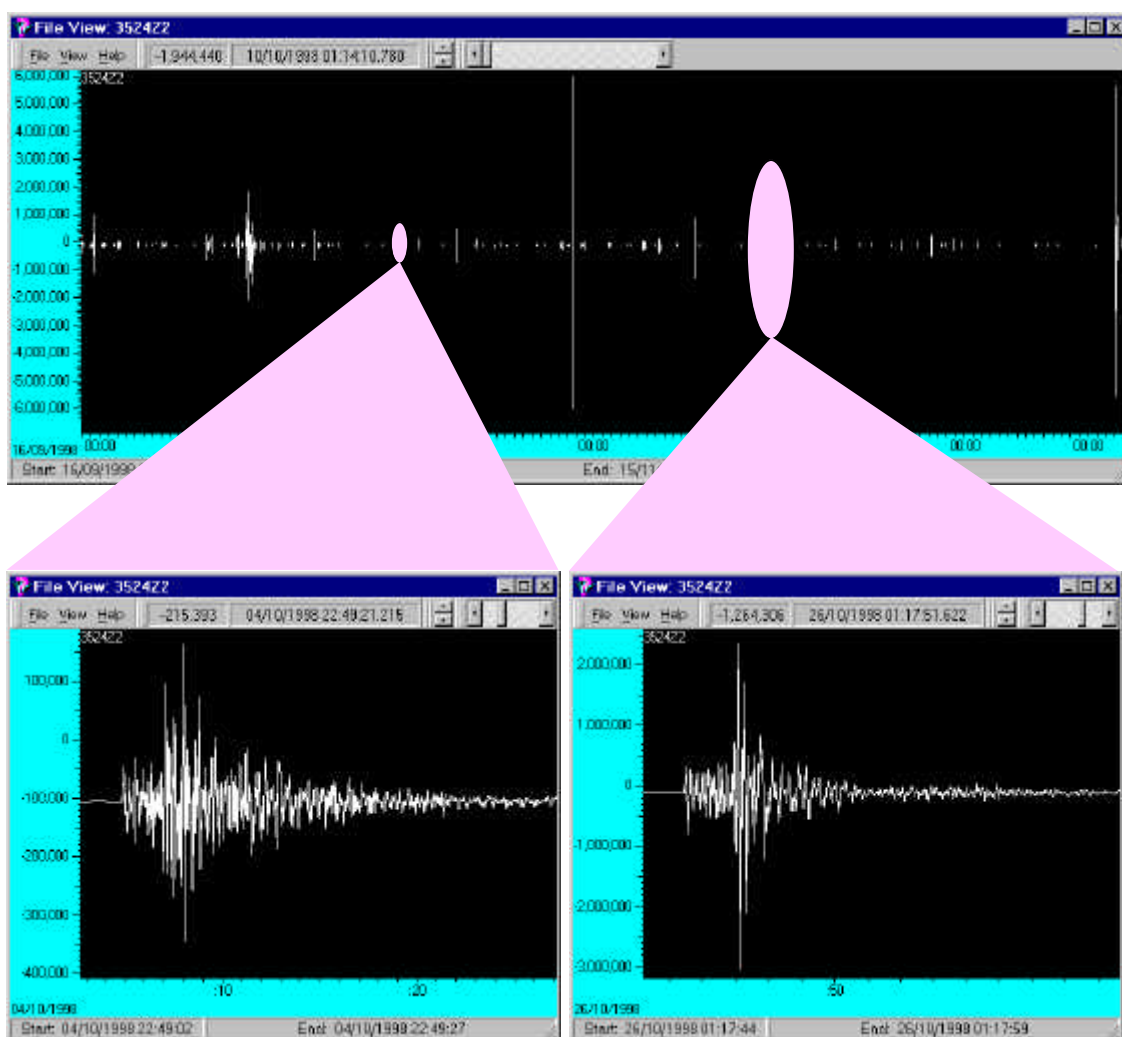
By definition each data block starts on an integral second and contains an integral number of seconds of data. The data block has a *maximum* size of 1024 bytes (16 byte header + 8 bytes for start and end value leaves 1000 bytes for data differences e.g. at 8 bit compression the block will contain 1000 sample points i.e. 10 seconds of data at 100 s/s - using minimum compression (32 bit) only 2 complete seconds of data can be fitted in a block at this sample rate - $2 \times 100 \times 4 = 800$ bytes). Changes in signal level will result in the compression algorithm having to change the format so blocks are not necessarily filled to the maximum specified capacity, when the next second of data requires more dynamic range.

The data has this format when processed and stored in the DM and SAM units (maintaining data values on word boundaries in the processor), but when data blocks are transmitted via the serial ports, blocks of 32 bit differences have the redundant most significant byte (of the difference values) omitted to optimise the efficiency of the serial transmission.

10. STA/LTA TRIGGER OPTIONS

In it's standard configuration the digitiser outputs continuous data at a user-selectable sample rate. An additional powerful feature of the digitiser is the ability to simultaneously run a STA/LTA event triggering algorithm in parallel with the continuous acquisition. This permits the system to record continuously at a relatively low sample rate, and record at a much higher sample rate during short periods when triggered. Parameters controlling the triggering algorithm, and controlling the data output once the system is triggered, are all selectable by the user, permitting the maximum flexibility of operation and the most efficient use of available storage space.

Shown below in the upper window, is an example of a data stream recording over a two month period. Two seismic events are shown highlighted in the two lower windows which, given suitable triggering parameters, can be recorded in greater detail at a higher sampling rate of upto 200 samples per second.



Triggering of all three components from vertical channel 100Hz tap, filter from 5 to 45 Hz
 Sta = 1, Lta = 50, Sta/Lta = 10, pre-trigger = 40, post-trigger = 70

This section describes the triggering algorithm and gives several examples of typical system configurations that may be used. It is intended to be read along with the Digitiser Configuration Section of the Operator's Guide.

USING THE TRIGGERED SYSTEM -- OVERVIEW

The Digitiser Configuration Section of the Operator's Guide describes in detail how to configure the system to output continuously at up to 3 different sample rates, selectable within certain constraints by the user. Typically, you may only wish to record one sample rate as continuous data, but it may be useful to record selected time periods at a higher sample rate

The triggering algorithm used is a standard STA/LTA ratio test on a bandpass filtered signal. An individual channel, corresponding to an individual seismometer component can be defined as the trigger channel, or triggers can be permitted on any channel. Details of the various parameters related to the triggering process are given in the following sections.

PRETRIGGER BANDPASS FILTERING

As the digitiser is normally used with a Güralp Systems Limited broadband seismometer the raw data is very broadband. To enhance the performance of the triggering algorithm, the raw input data is bandpass filtered prior to running it through the triggering system. This filtering serves to maximise sensitivity within a specific frequency band of interest, and to reject noise outside this band, for example from oceanic microseisms. The system is provided with a choice of 3 inbuilt generic bandpass filters (wide, medium and narrow) which are slaved to the defined tap output sample rates defined using the samples/sec command. The filters all have a low pass corner at 90% of the Nyquist frequency of the selected tap, and the wide, medium and narrow filters have high pass corner frequencies at 10%, 20% and 50% of the Nyquist frequency respectively. For example, if we consider the 100 samples/sec tap defined above (Tap#1) the low pass corner for each filter will be at 45Hz, and the high pass corners will be at 5Hz, 10Hz and 25Hz.

The possible filter configurations are shown in the following table:

Tap#	Samples/sec	Bandwidth 1 Hz	Bandwidth 2 Hz	Bandwidth 5 Hz
0	200	10 - 90	20 - 90	50 - 90
1	100	5 - 45	10 - 45	25 - 45
	50	2.5- 22.5	5- 22.5	12.5- 22.5
	40	2 - 18	4 - 18	10 - 18
	25	1.25- 11.25	2.5- 11.25	6.25- 11.25
	20	1- 9	2- 9	5- 9
2	50	2.5 - 22.5	5 - 22.5	12.5 - 22.5
	25	1.25- 11.25	2.5- 11.25	6.25- 11.25
	20	1 - 9	2 - 9	5 - 9
	10	0.5- 4.5	1- 4.5	2.5- 4.5
	8	0.4- 3.6	0.8- 3.6	2- 3.6
	5	0.25- 2.25	0.5- 2.25	1.25- 2.25
	4	0.2- 1.8	0.4- 1.8	1- 1.8
	2	0.1- 0.9	0.2- 0.9	0.5- 0.9
3	25	1.25- 11.25	2.5- 11.25	6.25- 11.25
	10	0.5- 4.5	1- 4.5	2.5- 4.5
	5	0.25- 2.25	0.5- 2.25	1.25- 2.25
	4	0.2- 1.8	0.4- 1.8	1- 1.8
	2	0.1- 0.9	0.2- 0.9	0.5- 0.9
	1	0.05- 0.45	0.1- 0.45	0.25- 0.45

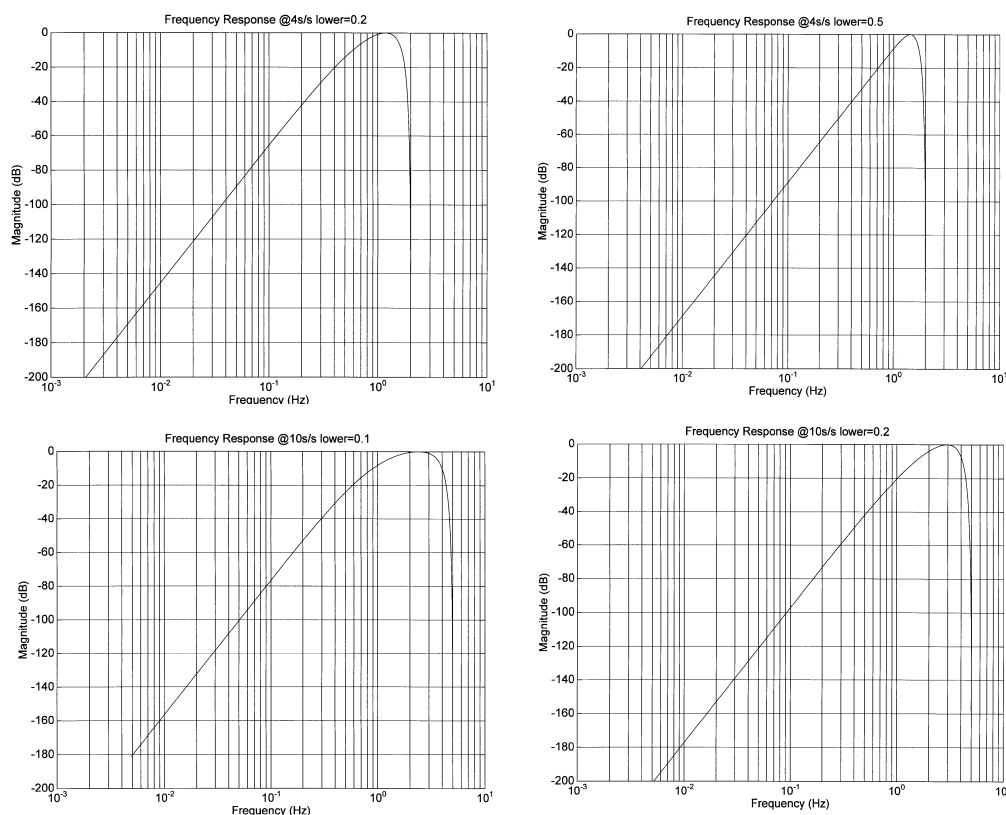
As can be seen from the list the choice of required filter will tend to define the set of permissible sample rates required. The filter combination is set using the bandpass command, which takes the tap number (0-2) and bandwidth factor (1, 2 or 5) as arguments. For example:

2 5 bandpass

defines the narrowest filter on the output from tap #2, the 20 samples/sec tap in our example, corresponding to a filter with corners at 5.0Hz (50% Nyquist) and 9.0Hz (90% Nyquist). The system response to the above command would be:

Tap#2 20 s/s Bandpass: 5.0->9.0Hz

The spectral amplitudes for the various frequency responses available are shown in the figures below.



TRIGGERING ALGORITHM

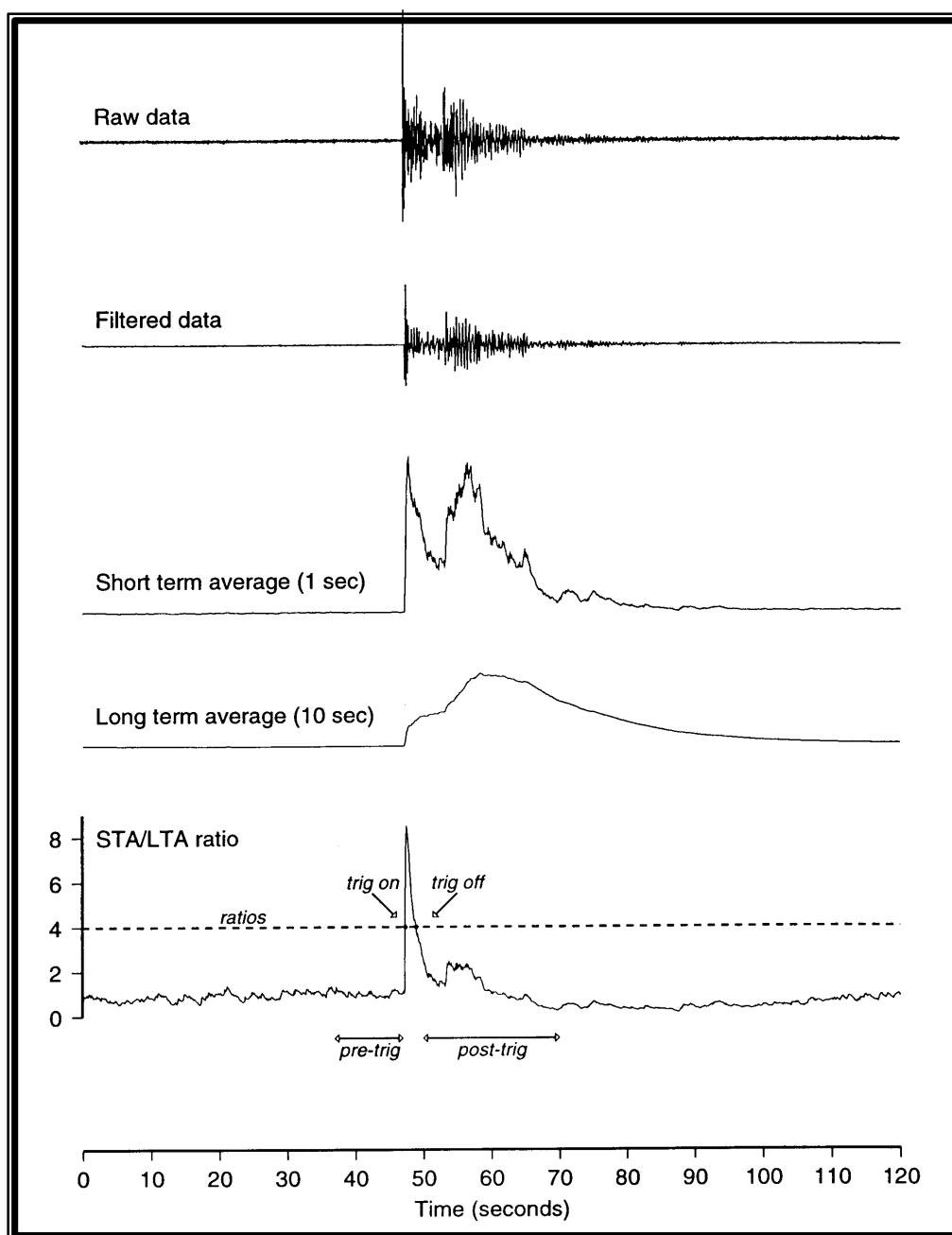
The triggering algorithm applied to the bandpass filtered data is a standard STA/LTA ratio test. Averages of the modulus of signal amplitude are computed over two user defined time periods, a short time average (STA) and a long time average (LTA), and the ratio of the two at each sample point is computed (STA/LTA). If this ratio exceeds a user-defined threshold, then a trigger is declared, and the system remains in a triggered state until the ratio falls below the defined threshold. The trigger works by identifying sections of an incoming data stream when the signal amplitude increases. The purpose of taking a short term average, rather than triggering on signal amplitude directly, is to reduce the probability of triggering on spurious spikes or short duration transients, and to introduce some element of frequency selectivity into the triggering process. As a rule of thumb, the short term average should be set to the dominant frequency of the events the trigger is designed to catch. The purpose of the long term average is to provide a measure of the variation in the background seismic noise, so it should be set to some value longer than the period of the lowest frequency seismic signal of interest. Obviously there is some element of trade-off in setting a value for the trigger ratio. Too high a value will result in events being missed, while too low a value will result in spurious non-seismic noise triggering the system producing false alarms. Determining an appropriate value in any given situation which maximises the number of seismic events detected while minimising the number of false alarms is a matter of experiment.

In order to capture all of a seismic event, some seconds of buffered data from before the trigger is declared are recorded. This facility is particularly useful for emergent type signals where the system triggers on a phase after the first arrival. Furthermore, some seconds of data after the system stops triggering are also recorded to ensure the coda of an event is not missed.

There are 5 parameters directly associated with the STA/LTA trigger algorithm:

- sta** defines the length of the Short Term Average window in seconds. Takes 3 arguments which are the values to use for each of the three seismometer components (Z, N/S, E/W)
Example: 1 1 1 sta
- lta** defines the length of the Long Term Average window in seconds. Takes 3 arguments which are the values to use for each of the three seismometer components (Z, N/S, E/W)
Example: 1 1 1 lta
- ratios** defines the STA/LTA ratio above which the system will declare an event. Takes 3 arguments which are the values to use for each of the three seismometer components (Z, N/S, E/W)
Example: 4 4 4 ratios
- pre-trig** specifies the amount of time in seconds for which data prior to the trigger will be retrieved from the buffer and output with the triggered data. Because of the block nature of the data format and compression algorithm this time is only approximate.
Example: 20 pre-trig
- post-trig** defines the amount of time in seconds after the trigger has ceased during which triggered data will continue to be output. Because of the block nature of the data format and compression algorithm this time is only approximate.
Example: 40 post-trig

An example illustrating the various trigger parameters is shown overleaf.



DEFINING CHANNELS RUNNING TRIGGER ALGORITHM

The filtering and triggering can be carried out on 1, 2 or 3 channels, usually corresponding to the 3 components of a seismometer. The channels to be used are specified using the command **TRIGGERS**. A trigger on any defined channel will cause the system as a whole to declare a trigger. The argument for the **TRIGGERS** command is an integer specifying with its binary bits which components to enable: 1 (001) for the first component (channel 0, vertical), 2 (010) for the second component (channel 1, N/S) and 4 (100) for the third component (channel 2, E/W). So, for example, to enable triggering on all three components:

$$001+010+100 = 111 = 7$$

The command is:

7 triggers

This returns the configuration report:

Triggering on Data from:
Tap#2 20s/s 70 = Chans 4 5 6
Tap#2 20 s/s BandPass: 2.0->9.0Hz

(Note: Channels 4, 5 and 6 correspond to the bandpassed versions of data on Channels 0, 1 and 2)

The trigger operating mode can be disabled simply by sending the command:

0 triggers

DEFINING CHANNELS FOR OUTPUT ON TRIGGER

When a trigger is declared, the channels to be output are defined using the **TRIGGERED** command. This takes 2 arguments, the tap number (0-3) and the components (an integer defined from the bit values as for **TRIGGERS** defined above). For example:

0 7 triggered

will cause all three components to be output at 200 s/s on triggering. The configuration report will be:

Output Triggered Data from:
Tap#0 200s/s 07 = Chans 0 1 2

11. GPS RECEIVER



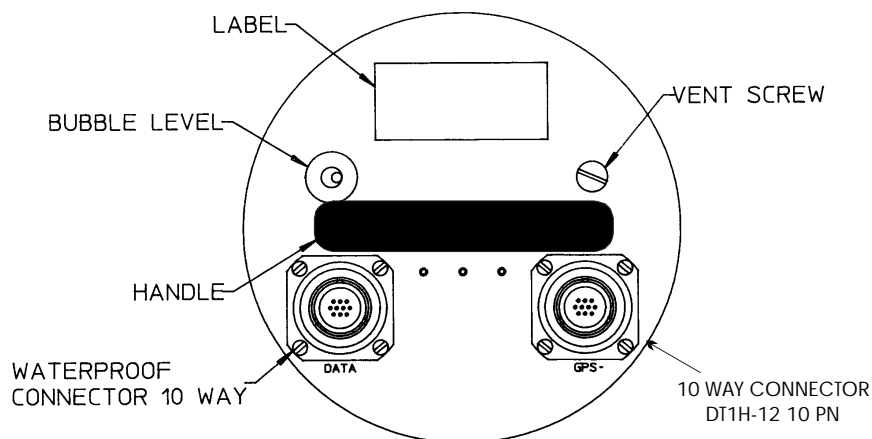
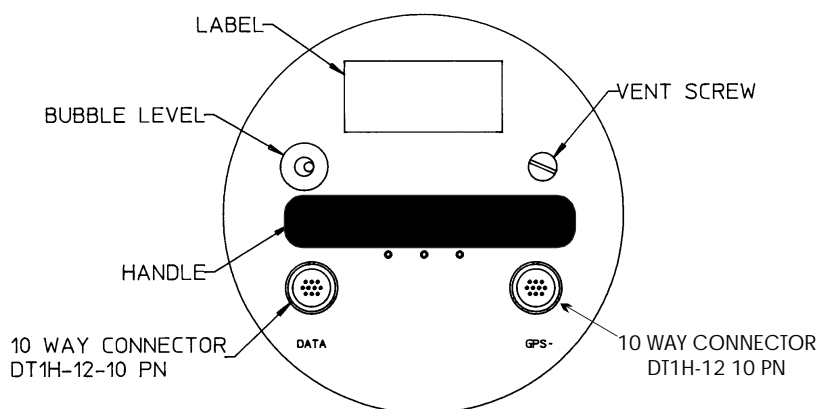
The GPS2 Receiver Unit comprises an antenna, the GPS receiver electronics, wide range input isolated dc power supply and output line drivers.

The antenna and all the associated electronics above, are all combined and housed inside a specially designed enclosure. The enclosure is sealed with 'O' rings and manufactured from a hard rigid resin. It is a stand-alone unit that is powered from the digitiser it is connected to.

GPS data (position, date/time and status) is output in NMEA format at 4800 baud once per second. Time synchronisation pulse (100 ms duration) is output at 1 pps. Both outputs use RS232 (or RS422 option) line drivers allowing use of long cables (up to 100 metres or more).

For further information on time stamping and clock synchronization, see chapter 3
Status Information

12. CONNECTOR PINOUTS



DATA PORT (RS232) Module and Standalone

<u>FUNCTION</u>	<u>CONNECTOR</u>
+ Vin (Digitizer and Sensor Power 10 to 36 Volts)	<u>02E-12-10P</u> B
0 Vin (Digitizer and Sensor Power 0 Volts)	A
COM1 Tx (Transmit data)	K
COM1 GND	G
COM1 Rx (Receive Command etc.)	J
COM1 CTS	C
COM1 RTS	D

All the COM port outputs are optically isolated.

DATA PORT (RS422) Module and Standalone

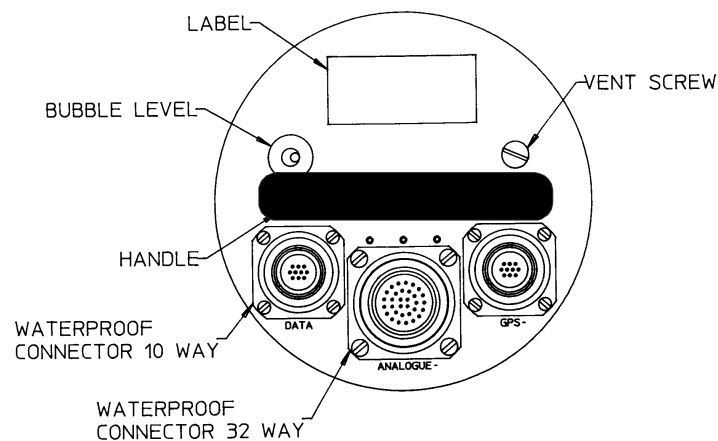
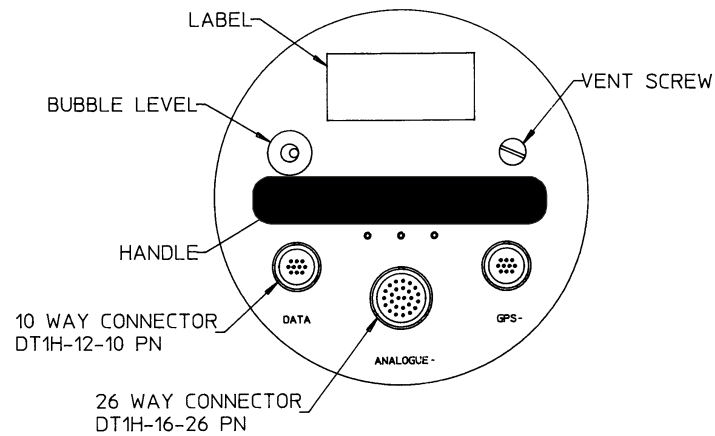
<u>FUNCTION</u>	<u>CONNECTOR</u> <u>02E-12-10P</u>
+ Vin (Digitizer and Sensor Power 10 to 36 Volts)	B
0 Vin (Digitizer and Sensor Power 0 Volts)	A
COM1 +Tx	K
COM1 -Tx	C
COM1 +Rx	J
COM1 -Rx	D
COM1 GROUND	G

GPS PORT Module and Standalone

<u>FUNCTION</u>	<u>CONNECTOR</u> <u>02E-12-10P</u>
Terminal Tx (Transmit to the terminal)	E
Terminal Rx (Receive from terminal)	F
+V Supply to GPS from sensor	B
0V Supply to GPS	A
COM2 Tx (Transmit to GPS)	J
COM2 GROUND	G
COM2 Rx (Receive data from GPS)	K
1Hz Reference, RS232 Level Isolated	C
Terminal GND	H

Terminal connections are not isolated. COM2 connections to GPS are all optically isolated.

**CMG-DM24 DIGITISER MODULE
OPTIONAL ANALOGUE SENSOR THROUGH-PUT
& 16-BIT AUXILIARY INPUTS**



**CMG-DM24 DIGITISER MODULE
OPTIONAL ANALOGUE SENSOR THROUGH-PUT
& 16-BIT AUXILIARY INPUTS**

<u>FUNCTION</u>	<u>CONNECTOR ON DM</u> <u>851-02E-16-26P</u>
Cal Signal	P
Centre	U
Signal Ground	N
LED (busy indicator)	K
VERTICAL	
+ Velocity	A
- Velocity	B
Mass Position	G
Cal Enable	R
NORTH/SOUTH	
+ Velocity	C
- Velocity	D
Mass Position	J
Cal Enable	S
EAST/WEST	
+ Velocity	E
- Velocity	F
Mass Position	L
Cal Enable	T
Unlock	W
Lock	X
Auxiliary 0	H
Auxiliary 1	M
Auxiliary 2	V
Auxiliary 3	Z
Auxiliary 4	a
Auxiliary 5	b
Auxiliary 6	c
Auxiliary 7	Y

**STAND-ALONE CMG-DM24-S3 OR S6
ANALOGUE SENSOR INPUTS**

<u>FUNCTION</u>	<u>CONNECTOR</u> <u>851-02E-16-26P</u>
Analogue Power +V	c
Analogue Power Ground	b
Cal Signal	P
Centre	U
Signal Ground	N
Logic Signal Ground	Y
LED (busy indicator)	K
VERTICAL	
+ Velocity	A
- Velocity	B
Mass Position	G
Cal Enable	R
NORTH/SOUTH	
+ Velocity	C
- Velocity	D
Mass Position	J
Cal Enable	S
EAST/WEST	
+ Velocity	E
- Velocity	F
Mass Position	L
Cal Enable	T
Unlock	W
Lock	X

STAND-ALONE CMG-DM24-S3 OR S6 AUXILIARY 16 BIT INPUTS

<u>FUNCTION</u>	<u>CONNECTOR</u> <u>SCPT 02E14 19P</u>
Ground	N
Auxiliary 0	A
Auxiliary 1	B
Auxiliary 2	C
Auxiliary 3	D
Auxiliary 4	E
Auxiliary 5	F
Auxiliary 6	G
Auxiliary 7	H

DIGITISER MODULE RIBBON-CONNECTOR TO SENSOR

<u>FUNCTION</u>	<u>CONNECTOR</u> <u>26 WAY IDC</u>
Signal Ground	8
Digital Ground	4
+V Sensor	17
0 V Sensor	13
Busy	3
Hole-lock (Optional)	26
SDA (do not connect)	7
SCL (do not connect)	9
Lock	2
Unlock	24
Centre	19
Cal Signal	10
V Cal Enable	12
N Cal Enable	11
E Cal Enable	15
V Mass Position	25
N Mass Position	1
E Mass Position	5
V +Velocity	14
V-Velocity	16
N +Velocity	18
N-Velocity	20
E +Velocity	22
E-Velocity	23

13. CMG-DM24S12, 12 Channel Digitiser.

The 12-channel 24-bit digitiser unit has been configured to operate single component CMG-5U strong motion accelerometers. The housing of the digitiser is from high impact copolymer polypropylene with external inputs mil.spec connectors fitted on to a metal plate. The digitiser housing also has limited internal cable pocket to store cables or documentation.

The operation of the 12 channel digitiser is identical to that of the CMG-DM24 units, for quick start please see section 2.3. This section will cover the operation of the digitiser unit using the RS232 outputs of the digitiser. There are two separate RS232 outputs each operating 6 channels of the digitiser.

The 12 channel digitiser has the following inputs and outputs:



- 12 Channel differential inputs
- For each CMG-5U sensor, power is provided; this is 12 Volts, same as the digitiser power supply.
- Each sensor attached to the digitiser can be calibrated with the digitiser calibration signal.



The CMG-DM24/12 digitiser output can be connected either via USB bus or RS232 to any PC. There are two RS232 outputs; each RS232 output is for a 6-channel digitiser within the DM24/12 digitiser enclosure.

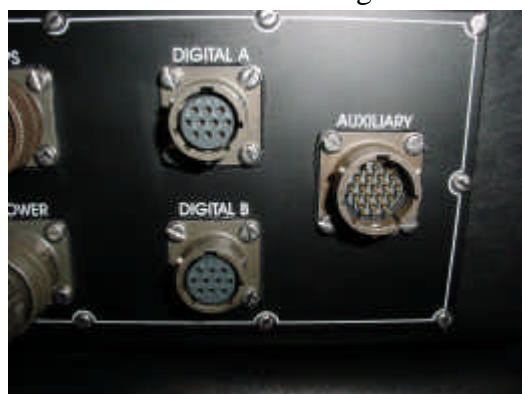
A single GPS for timing is used for the digitiser units.

The power to the digitiser is through the power connector. The power to the digitiser should not exceed 13.5 volts.



As well as the analogue inputs for the 24-bit digitiser, there are additional 16 slow rate 16-bit resolution analogue inputs. The inputs to the slow rate channels are through the connector marked 'AUXILIARY'. These inputs are all single ended and have a fixed sample rate of 4 s/s.

Güralp Systems digital output seismometers, such as CMG-3TD or accelerometers CMG-5TD, can be connected to the digital inputs of the 12 Channel recorders. These connectors are marked as 'DIGITAL A' and 'DIGITAL B'. The digital sensors can also be powered from this connector.



The cabling in between the sensor and the digitiser units should be twisted pair with overall shielding. A typical cabling to use is BELDEN 1510C (Belden Audio cable high/flex multi-pair snake cable). The CMG-5U sensor systems are suitable to operate over 50 meters of cabling in between the sensor and the digitiser.

CMG-DM 24S12 with CMG-5U sensors

