CMG-DM24

Mk3 Digitizer

Operator's guide

Part No. MAN-D24-0004

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1 Introduction

The Güralp CMG-DM24 multi-channel digitizer is a state-of-the-art digital module for seismic data. It can be supplied in several different formats:

A *stand-alone* DM24 (below) can be installed with existing or new analogue sensors.

Conversely, a *modular* digitizer is fixed to, and becomes a physical part of, a Güralp seismometer. These can be supplied with new instruments, or retrofitted to CMG-1T, 3T, 3ESP or 40T seismometers at the factory. A modular digitizer benefits from the sensor's isolated, clean and stable environment, and allows it to operate at optimum noise levels and precision

The DM24 can also be supplied in borehole sonde form, with optional strain relief accessories. All these units operate identically, although the connector for the borehole unit is necessarily more compact.
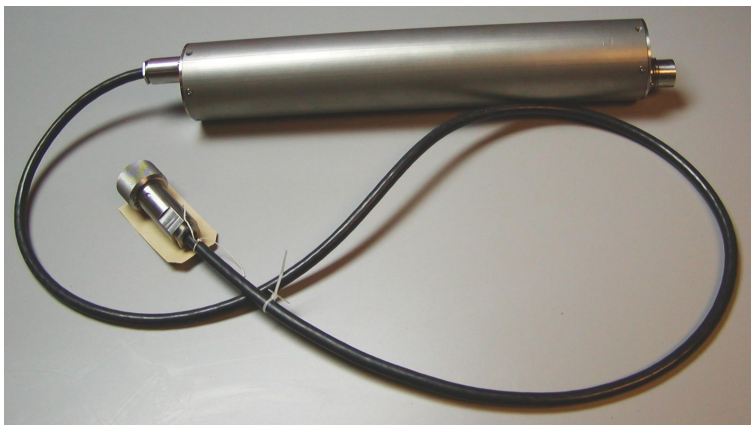
A DM24 is especially powerful when operated in conjunction with a Güralp data module such as the CMG-DCM or AM. All three types, sensor, digitizer, and data module, can be customized to meet your installation requirements.

1.1 Features

- A built-in Digital Signal Processor (DSP), which can provide simultaneous multiple sample rate data streams at user selectable rates. Up to 6 streams of data for each component are available at sample rates from 1 to 1000 samples/s.

- A precision microprocessor-controlled time base synchronizes Analogue to Digital Converters, and DSP, and time-stamps data

blocks.

- Time synchronization to an attached GPS receiver or from a remote time source.

- An ARM microprocessor, which formats and buffers data in an on-board 256k RAM ring buffer.

- Efficient data storage and transmission using the Güralp Compressed Format.

- RS232 serial data output at user selectable baud rates, with automatic modem dial-out facility.

- Built-in microprocessor system configuration and sensor control, including locking and unlocking, centring and calibration.

- Low system power consumption.

- Flash EEPROM for program code and filter coefficients.

- High-impedance, low-noise, differential input pre-amplifier modules with adjustable gain.

- Internal electronic thermometer provides temperature measurements at an accuracy up to ± 0.33 °C, with a linearity of ± 0.5 °C.

- Optional Flash memory storage.

- Optional Firewire interface, allowing you to download GCF data directly onto a compatible disk by simply plugging the disk into the Firewire connector inside the casing, and monitoring progress on the built-in LCD screen.

- Optional USB interface, enabling fast data transfer direct to a PC or other recording device.

The DM24 can be connected to two Güralp analogue sensors, or up to 6 conventional single-axis seismometers, through its *SENSOR A* and *SENSOR B* connectors. (Single-sensor and integrated DM24 units have only *SENSOR A* connectors.) Signals from these sensors are digitized to 32-bit precision, initially at 2000 Hz. Data is output through the *DATA OUT* serial port of the digitizer in the flexible GCF format, either to a PC or a Güralp data module. Timing signals are gathered from a GPS unit connected to the single *GPS* port.

2 Installing the CMG-DM24

2.1 Power supplies

The DM24 accepts power from lines in its *DATA OUT* port. This is a Güralp standard 10-pin combined serial/power interface, a cable for which can be obtained from Güralp Systems. A standard 12 V DC power supply is recommended.

2.2 Connecting sensors

The DM24 is configured for use with Güralp Systems feedback sensors, which can be connected directly to the *SENSOR A* and *SENSOR B* ports. No further configuration of the sensor is necessary; the input ports carry sensor power, four channels of differential velocity, mass position and calibration signals. The *AUXILIARY* port allows you to measure and digitize environmental parameters, *e.g.* local temperature, pressure, or signals from other scientific instruments.

In addition, two pins on the *AUXILIARY* port allow you to input signals for a fourth, full-rate 24-bit data channel. This channel is digitized continuously, but is interrupted when you calibrate the instrument, so that the DM24 can return the calibration signal on a stream with a different name. When calibration is over, the fourth channel returns to digitizing the external source.

If you prefer, you can attach any seismometer with balanced differential output to the signal inputs of the DM24. You will need to make up a cable to connect the relevant pins of the *SENSOR A* or *B* port to your instrument(s). See Section 8.1, page 107, for details of the connector used.

If you have only one sensor, you should attach it to the *SENSOR A* port, since only this port can be used to send control signals to it (*e.g.* mass locking and unlocking.) The *SENSOR B* port can therefore only be used for sensors which do not require remote control signals, such as Güralp accelerometers or the CMG-6 series of medium noise instruments. The 4-channel model of the DM24 does not have a *SENSOR B* port.

2.3 Connecting external hardware

On a stand-alone DM24, the digital ports are located on the other side from the analogue ports:

The DM24 outputs data through its *DATA OUT* port. This is a standard serial link, outputting data in GCF format according to the particular configuration of the instrument. The DM24 has a default baud rate of 38400. You can change this later using the `BAUD` command or from Scream!.

A *GPS* connector is also provided on the front panel for attaching to a GPS receiver. GPS signals are sent to both digitizers simultaneously, but only the one to which it is directly attached can control the GPS system.

The *DATA IN* port can be used to access the digitizer's console over a direct serial link, or for inputting additional data streams for transmission in GCF format.

Finally, the DM24 can be supplied with an optional USB client interface for connecting to a PC. When this is present, the *USB* port acts as a direct replacement for the *DATA OUT* or console port, and appears as an additional serial port to your computer. You can configure which port is replaced from the digitizer console (see chapter 5.)

FireWire disks

The optional IEEE.1394 ("FireWire") ports on the DM24 may be used to download data onto a compatible hard disk. The unit can be supplied either with standard FireWire connectors or with robust mil-spec plugs (see Section 8.5, page 109, for pinout details.)

Before you can use the disk, you will need to reset it. The DM24 saves data on the hard disk in a special format, so you *cannot* use the PC's operating system to reset the disk.

You can use the DM24 itself, Scream!, or ReadSCSI software to reset the disk. For instructions on using Scream! and ReadSCSI, please see the documentation for these software packages, or their on-line help.

To reset a FireWire disk with the DM24:

1. Power up the DM24, and connect it to your computer's serial port.

2. Open its terminal console. To do this using Güralp Systems' Scream! software, right-click on the digitizer's icon (once it appears) and select **Terminal...**. From a Güralp DCM, issue the command `minicom -n` *`port-number`*.

3. Issue the command `DISKMENU`. You will see the message

   `Plug in FireWire cable`

4. Plug in your disk. The DM24 will output (on the console) information about the disk as soon as it is detected.

5. *Within the next 7 seconds*, press any key to bring up the disk menu.

6. Press `R` to reset the disk.

7. When the reset is complete, remove the disk.

You will now be able to download data onto the disk when required.

2.4 The DM24BH borehole digitizer

When the DM24 is ordered in borehole form, it is supplied with a surface interface unit for installation at the top of the borehole. This unit takes the single data cable from the downhole digitizer and provides standard connections for other equipment.

The connectors provided are:

- a *SENSOR* connector, a 10-way mil-spec socket carrying serial data, GPS and power to the sensor;

- a *GPS* connector for attaching to your GPS receiver; and

- a *POWER / HOLELOCK* connector which can either be connected to a source of 12 – 30 V power for supplying to the borehole instrumentation (including sensors), or to a Holelock Control Unit for driving the sensor's hole lock motors. It is not usual to power the sensor and hole lock simultaneously; once the hole lock is engaged, you should remove the Holelock Control Unit and cabling so that the sensor cannot be removed.

- On the reverse side, a standard 9-pin RS232 connector is provided, for attaching to a PC running Scream (you will need a straight-through serial cable for this).

- There is also a three-pin mains (outlet) plug, which can power the downhole instrumentation from 110 – 250 V AC as required.

3 Using the DM24

Once the DM24 is connected to your equipment, it will start producing data immediately. You can now start configuring it for your own needs. There are two ways you can do this:

- using the graphical interface provided by Scream!, or

- over a terminal connection (see Chapter , page .)

Both methods provide full access to the configuration options of the digitizer.

In most circumstances, you will use Scream! to operate the system. For information on how to use Scream! to configure and control your instrument, please refer to the Scream! user guide.

3.1 Taps

The DM24 converts analogue signals to digital data at a high sample rate, which is then reduced in steps. This process is known as *decimation*, and each output stage is called a *tap.*

The highest data rate you can choose is 1000 samples/s. This rate can only be produced by Tap 0, the first tap. Tap 0 can also produce data at 500, 400, 200 or 100 samples/s.

After Tap 0 there are three more taps. Each tap produces data at an integer sample rate, which must be 2, 4, 5, 8 or 10 times lower than the previous tap.

For example, the following is a possible sequence:

Tap 0 : 500 samples/s

Tap 1 : 50 samples/s (divide by 10)

Tap 2 : 10 samples/s (divide by 5)

Tap 3 : 5 samples/s (divide by 2)

The digitizer always generates all four sample rates, but it does not have to output them. You can configure any set of taps to output. You can also have different taps configured for different sensor components.

All of these configuration options are easily changed in Scream!, or you can use the terminal commands SET-TAPS and CONTINUOUS.

Triggering

The DM24 has a flexible triggering system. When the digitizer triggers, it outputs additional data. Any combination of tap and component can be output as the result of a trigger.

In the example above, you might configure the sensor to output Tap 2 data (at 10 samples/s) continuously, but when a trigger is declared, to output Tap 0 data (at 500 samples/s) as well.

Using triggering helps you to use limited storage capacity or bandwidth more effectively.

The digitizer can look at the data from any tap to decide if a trigger has occurred, including taps which it does not output. Which tap you choose depends on the frequencies you want the trigger system to be most sensitive to.

There are three types of trigger.

- A *LEVEL trigger* occurs when the absolute sample values exceed a configured value.

  The commands GTRIGGERS, MICROG, and HIGHPASS control *LEVEL* triggering.

- An *STA/LTA trigger* occurs when the ratio of a short-term average to a long-term average for recent data exceeds a configured value.

  The commands TRIGGERS, TRIGGERED, STA, LTA, RATIOS, and BANDPASS control *STA/LTA* triggering.

- A *software trigger* occurs when you issue the command S/WTRIGGER.

The DM24 can output data streams for a period of time before the trigger starts, and after the trigger ends. The commands PRE-TRIG and POST-TRIG set these time periods.

Triggering options can also be configured through Scream!.

3.2 Streams

The DM24 organizes the data it produces into streams. Each stream has a 6-character identifier. The first four characters are taken from the *System ID* of the digitizer. When you receive the instrument, the *System ID* is set to its serial number, but you can change it in Scream! or with a terminal command.

The next character denotes the component or output type:

- Z, N, and E denote the vertical, north/south, and east/west components respectively.

- X denotes the fourth full-rate data channel, which is provided for connection to your own monitoring equipment *via* the *AUXILIARY* connector (if present.)

- C denotes the calibration input channel, which replaces the X streams whilst calibration is in progress.

- M denotes one of the 16 slow-rate Mux (multiplex) channels. Three of these (M8, M9 and MA) are used to report the sensor mass positions. Channels MC and MD are connected to the X and Y axes of the downhole inclinometer.

- For Z, N, E, X, and C streams, the last character represents the output tap. Taps correspond to stages in the decimation process within the digitizer, allowing the DM24 to output several different data rates simultaneously. There are four taps, numbered 0 to 3; 0 has the highest data rate and 3 the lowest. Data streams end in 0, 2, 4 and 6 for taps 0, 1, 2 and 3 respectively.

  If you configure the DM24 to output triggered data, this will appear in separate streams ending with the letters G, I, K or M for taps 0, 1, 2 and 3 respectively.

The DM24 also generates a stream ending 00. This is a status stream containing useful diagnostic information, in plain text form (see Section 6.1, page 84.)

Digitizers for multiple instruments

The standard DM24 has 4 full-rate channels: one per component of a triaxial instrument, plus the auxiliary and calibration channel.

Some DM24 modules, known as "6-channel digitizers", are designed for use with two instruments simultaneously, connected to the ports *SENSOR A* and *SENSOR B*. These digitizers actually have 7 full rate data channels, including the auxiliary/calibration channel. When you enable calibration on these digitizers, the signal is passed to both instruments. All 7 channels share the same settings for the four output taps.

A 6-channel digitizer will output full-rate streams with the following final characters:

`Z/N/E0`	*SENSOR A* at tap 0	`Z/N/E1`	*SENSOR B* at tap 0
`Z/N/E0`	*SENSOR A* at tap 0	`Z/N/E3`	*SENSOR B* at tap 1
`Z/N/E0`	*SENSOR A* at tap 0	`Z/N/E5`	*SENSOR B* at tap 2
`Z/N/E0`	*SENSOR A* at tap 0	`Z/N/E7`	*SENSOR B* at tap 3
`Z/N/EG`	*SENSOR A* at tap 0, triggered	`Z/N/EH`	*SENSOR B* at tap 0, triggered
`Z/N/EI`	*SENSOR A* at tap 0, triggered	`Z/N/EJ`	*SENSOR B* at tap 0, triggered
`Z/N/EK`	*SENSOR A* at tap 0, triggered	`Z/N/EL`	*SENSOR B* at tap 0, triggered
`Z/N/EM`	*SENSOR A* at tap 0, triggered	`Z/N/EN`	*SENSOR B* at tap 0, triggered
`X/C0`	Auxiliary at tap 0	`X/C1`	Auxiliary at tap 1
`X/C2`	Auxiliary at tap 2	`X/C3`	Auxiliary at tap 3

Standard 6-channel digitizers have the same 8 Mux channels as their 3-channel counterparts: `M8`, `M9` and `MA` for the mass positions of *SENSOR A*, and `MB` to `MF` for your own equipment. These digitizers are designed for use with a strong-motion instrument or geophone attached to *SENSOR B*, and so do not expose the mass positions for this sensor. In addition, *SENSOR B* cannot be locked, unlocked, or centred.

Optionally, a digitizer can be supplied which provides 5 additional Mux channels `M3` to `M7` for external equipment (again exposed on the *AUXILIARY* connector.) 6-channel DM24 modules with this option also measure the mass positions of *SENSOR B*, if available, and output these on streams ending `M0`, `1` and `2`.

3.3 Filing modes

Filing modes are an important concept on the DM24. The current filing mode determines whether the unit stores data in its on-board Flash memory, sends it over the serial link in GCF format, or does some combination of these.

You can switch between filing modes with a console command, or through the Scream! configuration interface.

DIRECT

Command: DIRECT

Instructs the DM24 not to use Flash memory for storage. Instead, all data is transmitted directly to clients. An instrument in *DIRECT* mode still honours the GCF Block Recovery Protocol: a temporary RAM buffer always holds the last 256 blocks generated, and if a client fails to receive a block it can request its retransmission.

If you expect breaks in communication between the instrument and its client to last more than 256 blocks, or if you want the instrument to handle breaks in transmission (rather than relying on the client to request missed blocks), you should use

- *ADAPTIVE* mode, if you want data to stay as near to real time as possible (but do not mind if blocks are received out of order) or

- *FIFO* mode, if you need blocks to be received in strict order (but do not mind if the instrument takes a while to catch up to real time.)

FILING

Command: FILING
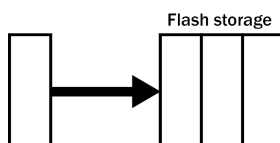
Instructs the DM24 not to transmit blocks to clients automatically, but to store all digitized data in the Flash memory. If you have chosen the

RECYCLE buffering mode (see below), the memory is used in circular fashion, *i.e.* if it becomes full, incoming blocks begin overwriting the oldest in memory. If the *WRITE-ONCE* mode is active, the instrument will switch to *DIRECT* mode (see above) when the memory becomes full.

You can retrieve blocks from an instrument in *FILING* mode by connecting to its terminal interface and issuing commands such as FLUSH, or through Scream! (see below).

Heartbeat messages

When in *FILING* mode, an instrument transmits "heartbeat" messages over its data port. These short messages take the place of data blocks, and ensure that programs such as Scream! know that an instrument is present.

You can change the frequency of heartbeat messages from Scream!'s *Control* window, or with the command HEARTBEAT.

DUPLICATE

Command: DUPLICATE
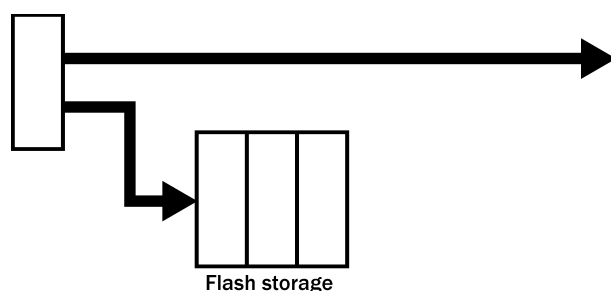
Flash storage

Instructs the DM24 to transmit streams directly to clients as for *DIRECT* mode, but also to store all data into Flash storage as for *FILING* mode.

If a client fails to acknowledge a block, the digitizer does not attempt to retransmit it.

DUAL

Commans: DUAL
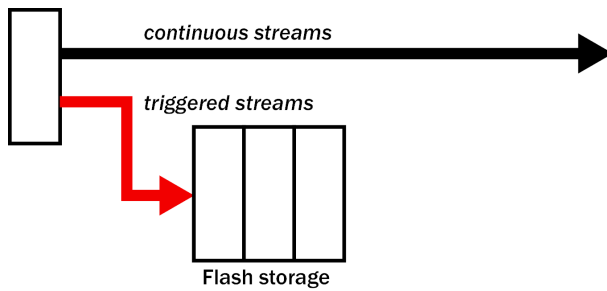
continuous streams

triggered streams

Flash storage

Instructs the DM24 to transmit any *continuous* streams directly to clients as for *DIRECT* mode, but to store *triggered* data into Flash storage as for *FILING* mode.

If you choose *DUAL* mode but do not select any continuous streams for output, the instrument will send heartbeat messages as for *FILING* mode. Scream! can pick these up and download new data as necessary.

FIFO (First In First Out)

Command: `FIFO`

Flash storage

not acknowledged
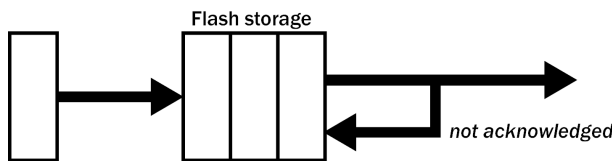
Instructs the DM24 to begin writing blocks to Flash memory as for *FILING* mode, but also to transmit data to clients. Data is transmitted in strict order, oldest first; the DM24 will only transmit the next block when it receives an explicit acknowledgement of the previous block.

If the communications link is only marginally faster than the data rate, it will take some time to catch up with the real-time data after an outage. If you want data to be transmitted in real-time where possible, but are worried about possible breaks in communication, you should use *ADAPTIVE* mode instead.

FIFO mode will consider a data block successfully transmitted once it has received an acknowledgement from the next device in the chain. If there are several devices between you and the instrument, you will need to set up the filing mode for each device (if applicable) to ensure that data flow works the way you expect.

Like all the filing modes, *FIFO* mode does not delete data once it has been transmitted. You can still request anything in the Flash memory using Scream! or over the command line. The only way data can be deleted is if it is overwritten (in the *RECYCLE* buffering mode, see below) or if you delete it manually.

ADAPTIVE

Command: `ADAPTIVE`
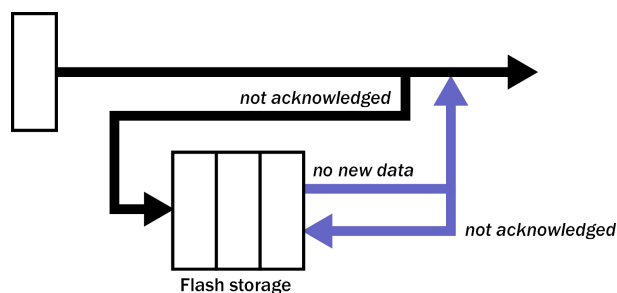
not acknowledged

no new data

not acknowledged

Flash storage

Instructs the DM24 to transmit current blocks to clients if possible, but to store all unacknowledged blocks in the Flash memory and re-send them, oldest first, when time allows. *ADAPTIVE* mode is best suited for "real-time" installations where the link between digitizer and client is intermittent or difficult of access.

If the communications link is only marginally faster than the data rate, it will usually be busy transmitting real-time data. Thus, it may take a while for the instrument to work through the missed blocks. In this case, and if your client supports it, you may prefer to use the Block Recovery Protocol to request missed blocks where possible.

Some software packages (most commonly Earthworm) cannot handle blocks being received out of time order. If you are using such a package, *ADAPTIVE* mode will not work, and may crash the software.

RE-USE / RECYCLE

Command: `RE-USE`

Instructs the DM24 to carry on using the current filing technique when the Flash memory becomes full, overwriting the oldest data held. This buffering mode is called *RECYCLE* in Scream! and on the DCM.

For example, in *DUAL* mode with *RECYCLE* buffering, the latest continuous data will be transmitted to you as normal, and the latest triggered data may be retrieved from the Flash memory using Scream! or the command line. However, if you do not download data regularly from the Flash memory, you may lose older blocks. This mode thus lets you define the end point of the data held by the instrument.

WRITE-ONCE

Command: `WRITE-ONCE`

Instructs the DM24 to stop writing data to the Flash memory when it is full, and to switch to *DIRECT* mode automatically.

For example, in *FIFO* mode with *WRITE-ONCE* buffering, the station will transmit data to you continuously, but also save it in the Flash memory until it is full. Once full, the instrument will switch to *DIRECT* mode and continue transmitting, though no further data will be saved. This mode thus lets you define the start point of the data held by the instrument.

3.4 Downloading stored data

If you choose a filing mode where some data is stored in Flash memory, you will need to recover this data at a later date. You can do this either over the serial link, or using the DM24's FireWire interface.

Downloading over FireWire

To download data over Firewire, plug the disk in and issue the command `DISKMENU` from the digitizer's console. The digitizer will reply with a list of download options.

If you have not used the disk before, you will need to reset it. Resetting the disk prepares it for the DM24 to use, and sets up the DFD filing system (see below.) Press `R` then `ENTER` to reset the disk. When the DM24 is ready, it will return to the menu.

You can also use ReadSCSI or Scream! to prepare a FireWire disk.

To download all the new data held by the DM24, press `N` then `ENTER`, or wait for 10 seconds. The DM24 will transfer any data it has recorded since you last downloaded, and mark this data as already transferred.

You can also download selections of data, or the entire contents of the data store, with the `DISKMENU` command. See Section 5.9, page 71, for more information.

The DM24 also looks for a FireWire disk when it boots up. If there is enough new data waiting to be transferred (by default 128 Mb), the DM24 will automatically transfer it onto the disk. The digitizer then updates its internal pointers to mark this data as already downloaded.

This feature is particularly useful for autonomous installations: after the digitizer has been retrieved from a field experiment, simply powering it up with a prepared disk attached will make it transfer all the data it has recorded during the experiment.

While the FireWire interface is active, it will consume about 200 mA of power (from a 12 V supply.) If you interrupt a transfer whilst in progress, the digitizer will re-boot, and will not mark data as downloaded. Because of this, next time you transfer data some will be duplicated. You will not lose any data.

Downloading over the serial link

To download data over the serial link:

1. Open the digitizer's console. To do this using Güralp Systems' Scream! software, right-click on the digitizer's icon (once it appears) and select **Terminal...**. From a Güralp DCM, issue the command `minicom -n` *port-number*.

2. If you want to download all data held in the Flash memory, issue the command

   `ALL-FLASH ALL-DATA DOWNLOAD`

3. Alternatively, select a particular set of streams, sample rates and times to download using the `STREAM`, `S/S`, `FROM-TIME` and `TO-TIME` commands, and finish with `DOWNLOAD`. See Section 5.9, page 71, for more details.

4. Close the terminal session. If you are using Scream! or a DCM, the DM24 should start transmitting immediately. Otherwise, you may need to issue the command `GO` to start transferring data.

3.5 Reading DM24 disks

When the DM24 saves data onto a FireWire disk, it uses a special format called DFD.

You can read this data into a PC using Scream! or the Windows `ReadSCSI` utility, which is freely available from the Güralp Systems

Web site. Linux and Solaris command line utilities are also available for reading data from a DFD disk.

The DFD format is *not* the same as that used by the Güralp Systems DCM data module, which uses a FAT32-compatible journalling file system.

Güralp Systems can provide fully-tested, formatted disks with FireWire and USB connectors. Alternatively, a third-party FireWire disk may be used (although compatibility is not guaranteed.)

To read a disk using `ReadSCSI`:

1. Attach the disk to your computer. You can use FireWire, USB, or any other interface supported by your computer and the disk.

2. Run `ReadSCSI`. The program will first search for non-DOS disks on all the interfaces it understands.
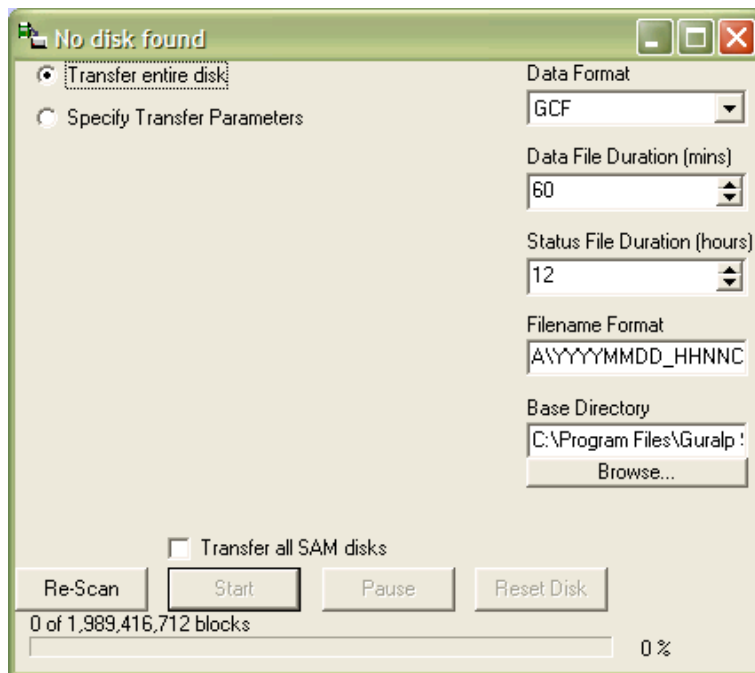
If it does not find your disk, check that it is properly connected and that the relevant drivers have been installed, and click **Re-Scan**.

3. `ReadSCSI` tries to find Scream!'s configuration file to discover where to put the recorded streams. These values are automatically entered into the *Data Format*, *Data File Duration*, *Status File Duration*, *Filename Format*, and *Base Directory* boxes. If you do not use Scream!, or you want to use different settings, fill them in here:

Data Format : `ReadSCSI` can automatically convert the GCF data on the disk to a variety of seismic data formats. Choose the format you require from the drop-down list.

Data File Duration : How many minutes long to make each saved file, before starting a new one. For file formats that do not support discontinuous data, `ReadSCSI` will also start a new file whenever there is a data gap.

Status File Duration : How many hours long to make files from status streams.

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

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

M the month number (1 – 12),

D the day of the month (1 – 31),

H the hour (0 – 23),

N the minute (0 – 59),

S the second (0 – 59),

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

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

I the *System ID*,

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

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

P the sample rate, in samples per second;

A a combination of **T**, **C** and **P** to give a standard, unique name for the stream (useful for directories).

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

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

For example:

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

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

Base Directory : The directory in which to place all the data files, and any subdirectories you have specified.

4. If you want to transfer the whole disk (including data that you may already have), click **Start** now.

5. To transfer specific streams or time periods, check **Specify Transfer Parameters**:
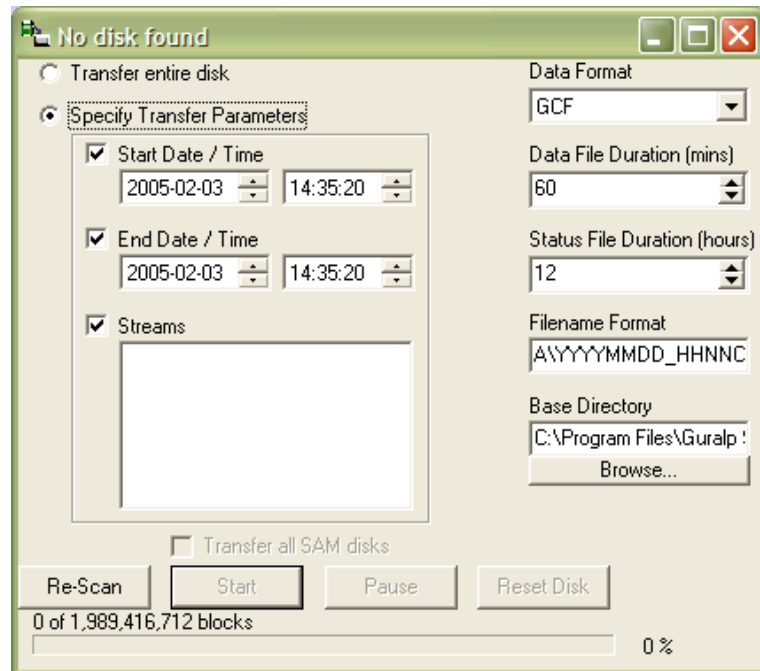
6. If you want to set the time period covered by the downloaded data, check **Start Date / Time**, **End Date / Time**, or both, and fill the date and time in the boxes.

7. If you want to record only specific streams, check **Streams** and select the streams of interest from the list.

8. Click **Start**. You can pause and resume a transfer that is in progress with the **Pause** button.

9. After you have downloaded all the data from the disk, and if you want to re-use it, click **Reset Disk**. This sets the flags on the disk so that the DM24 can overwrite the old data with new.

You can also read disks with Scream!. This allows you to view data in the process of being transferred, but is slightly slower, because Scream! does not read data in strict order. To read a disk with Scream!:

1. Attach the disk to your computer. You can use FireWire, USB, or any other interface supported by your computer and the disk.

2. Run Scream!, and select **File ➜ Setup...** from the main menu. Select the *Files* tab.

3. Set the *Base Directory*, *Filename Format* and *Data Format* as described above. Also, if required, set the *Post-processor* and *Granularity* options to your preference. Consult the Scream! documentation for details.

4. Select the *Recording* tab, and check **Auto Record—Enable for Data Streams** and **Auto Record—Enable for Status Streams**. Click **OK**.

   Scream! will remember the recording options you set in steps 3 and 4 for later occasions.

5. Select **File → Read SCSI disk...** from the main menu. Scream! will search for attached disks, and open a window with a list of all the streams it has found.

6. Select the streams you want to replay, and click **Open**. The disk will appear in the left-hand pane of Scream!'s main window, and the streams you have selected will start playing into the stream buffer, as well as being recorded.

7. When you have finished transferring the data, if you want to reset the disk, select **File → Reset SCSI disk...** from Scream!'s main menu. Select the disk you want to reset, and click **OK**.

4 Using Scream!

The DM24 can accept signals from up to 2 connected analogue sensors, and output digitized data to a computer running Scream! attached to its *DATA OUT* port. Scream! is a versatile seismic data visualisation program for Güralp instruments, and is available for free download from Güralp Systems, or may have been supplied with your equipment.

4.1 Configuring digitizers

Scream! 4 distinguishes between *configuration* and *control* of digitizers. The most important difference is that a digitizer may be *controlled* through Scream! at any time whilst it is acquiring data, whereas *configuration* options only take effect after a reboot (with consequent loss of data.)

To change the configuration of any connected digitizer:

1. Locate the digitizer you want to configure. All connected digitizers have an entry in the tree on the left of Scream!'s main window. If the digitizer is transmitting data through a remote server or DCM, you may need to "unroll" the entry for that server (by clicking on the ⊞ icon) to see the digitizers connected to it.

2. Right-click on the digitizer's entry (*not* the icon for the server or any **Comxx** icon). Digitizers are shown with icons depicting a coloured cylinder.

3. Click **Configure...**. Scream! will then contact the digitizer and retrieve its current configuration, a process which will take a few seconds. This done, the *Configuration setup* window will be displayed.

4. Once you are happy with any changes you have made in the *Configuration Setup* window, click **UPLOAD** to send them to the digitizer and reboot. This will take a short while.

To control a digitizer whilst it is running, either right-click on the digitizer's entry in the list and click **Control...**, or double-click the entry. In either case Scream! will contact the digitizer to retrieve control information and display the *Control* window. The options you can control immediately are:

- the type of sensor you are using,

- GPS power cycling options,

- the short-term and long-term average values for triggering (but *not* which streams perform the trigger, or which are output by it)

- the length of pre-trigger and post-trigger periods,

- calibration signal options, and

- mass control functions.

Some of these options can also be altered in the *Configuration setup* window. For more information on the *Control* window, see Section 4.2, page 40.

If you need a more powerful interface to the DM24, you can also issue commands to it directly using Scream!'s terminal mode. A terminal window is opened by right-clicking on the digitizer's entry in the list and selecting **Terminal...**. The digitizer will stop transmitting data while you have a terminal window open. Data collected whilst the terminal is active will be stored for transmission later, memory space permitting.

The remaining sections of this chapter describe in detail the configuration options available for the DM24.

System ID

The *System ID* pane gives information about the digitizer and its internal software, and allows you to change GPS timing parameters.
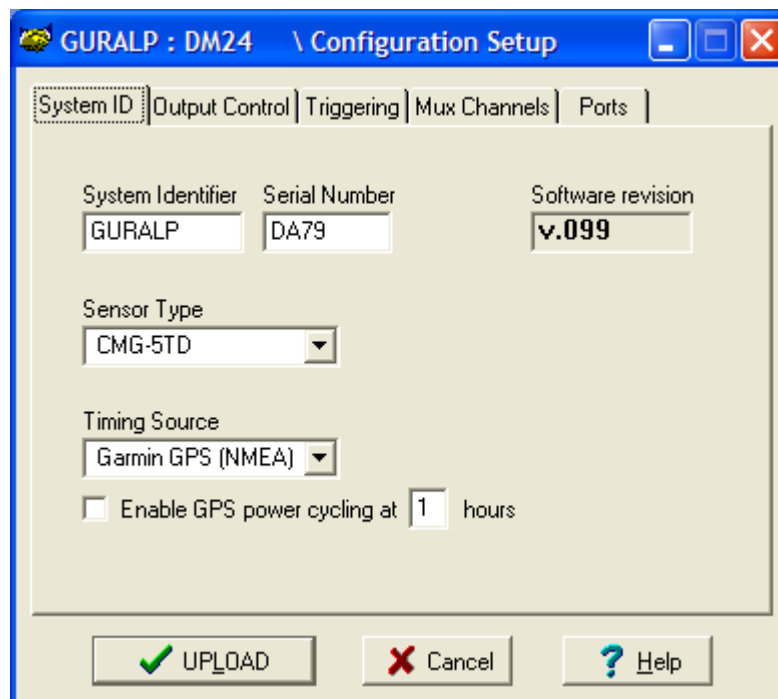
System Identifier and *Serial Number* : The digitizer type is identified by its system identifier and serial number. Every data and status block generated by the digitizer includes these two fields at the beginning, so that the block's origin can be identified. On delivery from the factory, the system identifier and the serial number are set to the GSL works order number and the digitizer's serial number, but any combination of letters A-Z and numbers can be used, such as an abbreviation of your institution's name, etc. The system identifier can be up to 5 characters long, whilst the serial number cannot be longer than 4.

Sensor Type : If the sensor attached to the digitizer is a Güralp velocity sensor, useful seismometer functions (such as sensor locking, centring, and calibration) may be controlled through the digitizer. The *Sensor Type* you set here determines which functions will be available through the Scream! digitizer configuration set-up interface or through interactive commands.

GPS Type : The digitizer needs to be able to time-stamp accurately all data that passes through it. It can set its clock either by receiving time signals from the GPS satellite network using an attached Garmin-compatible (NMEA output) unit, or by taking time information from a central site (*stream sync* mode). In *stream sync* mode, the digitizer

expects to receive two-byte packets from the central timing source, which may have its own GPS unit, or take signals from one of the radio time standards. Choose the mode you require from the drop-down menu.

Enable GPS power cycling : If you are using a GPS unit to receive time signals, but do not experience significant drift in the system's clock (for example, in a stable-temperature environment), you can save power by selecting **Enable GPS power cycling.** With this option in use, the GPS time is only checked at intervals of a specified number of hours. Disabling this option keeps the GPS unit running constantly; if you have ample power, this will give the most accurate results. You can choose any whole number of hours for the interval.

Output control

The *Output control* tab allows you to configure which data streams are sent to Scream! from the digitizer.
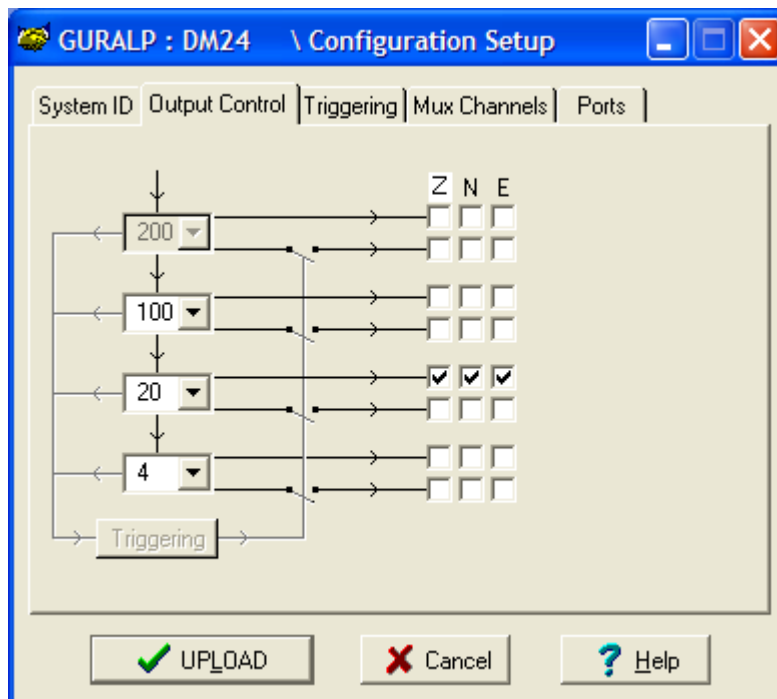
Güralp digitizers initially sample incoming data at a high rate (*e.g.* 2000 Hz for the DM24), which is then filtered and reduced to a lower rate (*decimated*) using an on-board digital signal processing unit, or DSP. The DSP has several filtering-decimation stages, which run one after the other. Stages which can produce output are called *taps*. The Güralp DM24 can output 4 taps simultaneously.

Each configurable tap can be set to a different decimation factor by choosing values from the drop-down menus on the left. Decimation factors of 2, 4, 5, 8, and 10 are available. The numbers visible in the drop-down menu of each tap are the data rates that each of the possible decimation factors will provide, given the settings of the taps above it. Only integer (Hz) data rates are allowed: thus, for example, if one tap emits data at 25 Hz, the only possible further decimation factor is 5.

To the right of each decimation factor menu is a grid of check-boxes. These boxes mark which streams of data to generate at each sample rate. The screenshot above shows a possible configuration for a triaxial instrument. Every channel of the digitizer may be output at any tap; currently, all three axes are being output at Tap 2 (20Hz). The DM24 mkIII has a fourth channel for external input and calibration, which can also be output at any tap.

If you want to change the names used for the channels, click in the white box containing a Z in the above picture, and type a letter or number. It will name the channels with a sequence of letters or numbers beginning with the one you choose *(e.g.* A, B, C; 2, 3, 4; 9, A, B)*,* unless you type Z in which case they will revert to Z, N, and E.

Each combination of channel and tap has two check-boxes.

- Checking the upper check-box of each pair makes that tap output data for that component continuously.

- Checking the lower check-box makes that tap output data only when a trigger is active.

In the example above, the digitizer will output data continuously for all three channels at Tap 2, but never for any other taps. If you do not need all the streams to output at all rates, you should leave boxes unchecked to save communications capacity.

You cannot check both continuous and triggered output for the same channel and tap.

When you enable a triggered stream, the digitizer will output data in that stream only when a particular set of trigger criteria are met. To remind you that the streams are not continuous, the window shows the data streams (lines) passing through a "switch".

In the example above, we might want the high-rate data from Tap 0 to be generated only when an event registers. To do this, the *lower* check-boxes of Tap 0 should be ticked:
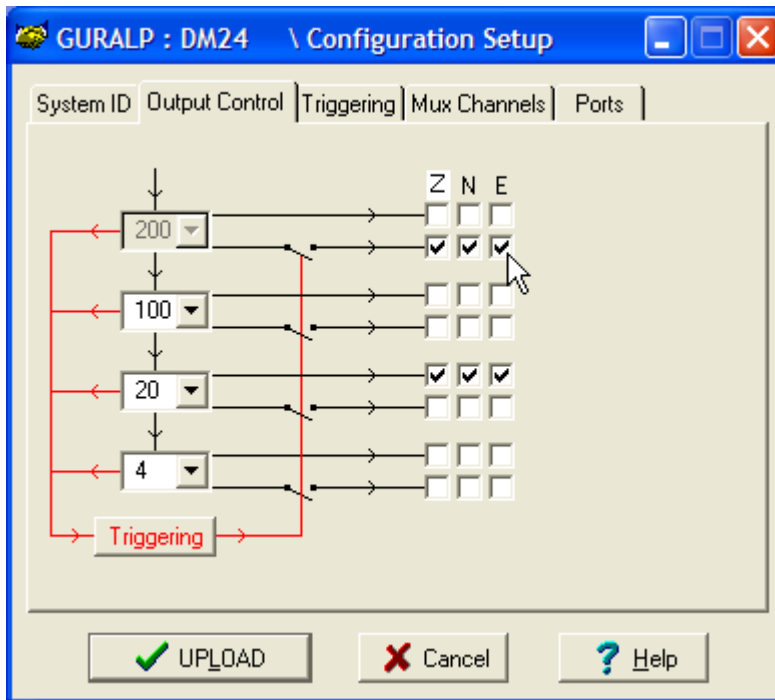
With this configuration uploaded, Tap 2 will continue to produce output at all times, but Tap 0 will also emit data whenever the trigger criteria are met. The *Triggering* button is now shown in red to remind you that the trigger is active.

When a trigger occurs, every checked box in this window will cause the digitizer to output a data stream. This stream will appear in Scream!'s main window when Scream! first receives some data from it.

Every stream is identified by a 6-character code, where the first four characters identify the digitizer, and the last two characters identify the individual stream. The first four characters are set by default to the serial number of the digitizer; you can change this on the *System ID* pane (see above) or from the digitizer's console.

Using the example above, there are three data streams, Z, N and E, which each output data at 20 samples/s (continuously) and 200 samples/s (occasionally).

In this example:

- DA79 is the serial number of the digitizer.

- Z0, N0, E0 correspond to input channels Z, N, and E, output through Tap 0.

- Z4, N4, E4 correspond to input channels Z, N, and E, output through Tap 2.

  Scream! can replace these designations with more helpful names if you wish: see the Scream! manual or online help for more details.

- 00 is the digitizer status stream (notice its zero sample rate).

Triggering

In its standard configuration, the DM24 outputs continuous data at a sample rate you specify. In addition to this, Güralp digitizers can run a triggering algorithm on the data they acquire. This allows you to record data continuously at a relatively low sample rate, but record at a much higher sample rate during short periods when the trigger is active. The parameters controlling the triggering algorithm, and controlling the data output once the system is triggered, are all selectable by the user, permitting maximum flexibility of operation and the most efficient use of available storage space.

The DM24 can be set up for triggered output, that is, to output certain

data streams only when a particular trigger criterion is met. The trigger criterion can be tested with data from the same or some other stream. For example, you could use a later tap (with a lower sample rate) as a trigger for output from an earlier, more detailed tap. Scream! 4 also allows you to configure each digitizer to receive triggers from other digitizers.

To create a new stream with a trigger, open Scream!'s *Digitizer configuration* window for the relevant digitizer, and click on the *Output control* tab. In the *Output control* pane, a tap which gives rise to a triggered stream has a tick in the *lower* row of its grid of check-boxes. You cannot configure the trigger criteria until you have selected at least one stream to be affected by the trigger.

Once you have decided which streams should be output when the trigger is activated, you will be able to click on the **Triggering** button to describe the trigger condition. Alternatively, click on the **Triggering** tab at the top of the window. Either action will open the *Triggering* pane:
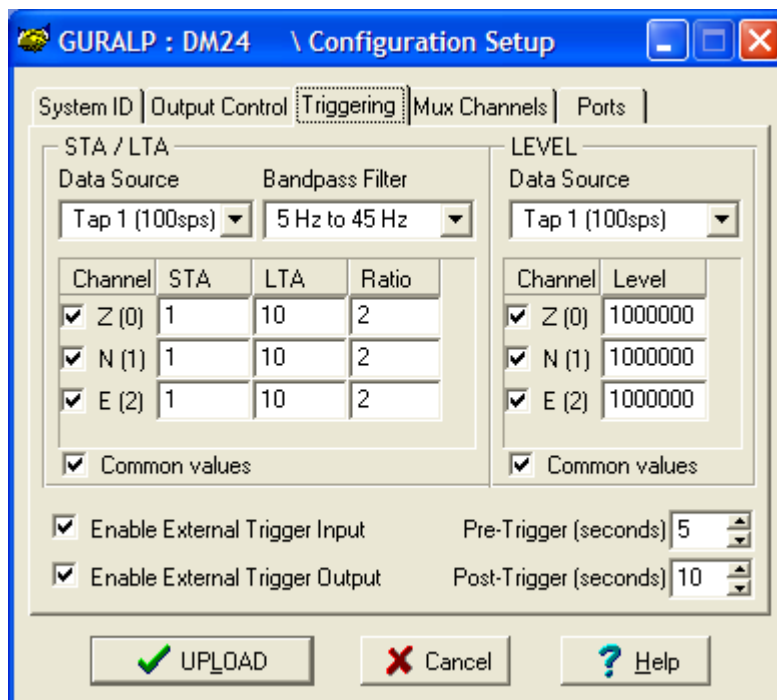
There are two triggering algorithms which Güralp digitizers can use. However, not all models can use both methods. Scream! will find out from the digitizer whether its on-board software supports each method.

In addition, some digitizers support external and software triggering.

STA/LTA

The *STA/LTA* algorithm applies a simple short-term average – long-term average calculation to the triggering stream. It 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 make it less likely that spurious spikes will trigger the device. Averaging also introduces an element of frequency selectivity into the triggering process.

You can select which tap is tested for the trigger from the **Data source** drop-down menu. The tap does not have to output data to Scream! for you to be able to use it here.

Any or all of the channels available at that tap may be used to determine a trigger. You can select which channels are considered by checking the boxes in the **Channel** column of the table. If *any* of the checked channels passes the trigger condition, the trigger will activate, and will not detrigger until *all* of the checked channels have fallen below their respective ratio values.

The **STA** and **LTA** columns allow you to set the intervals over which the two averages are calculated, in seconds. 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 **Ratio** column determines by what factor the STA and LTA must differ for the trigger to be passed. Finding the ratio most suited to your needs is best done by experiment. 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. Like the averages, their ratio is continuously recalculated for all components. Note that none of the boxes are allowed to be empty, and so you will need to enter the new value before removing the old one. Alternatively, you can use the up and down cursor keys to change the values.

For example, setting the **STA** to 1 second, the **LTA** to 10 seconds and the **Ratio** to 4 would give rise to the following trigger behaviour:
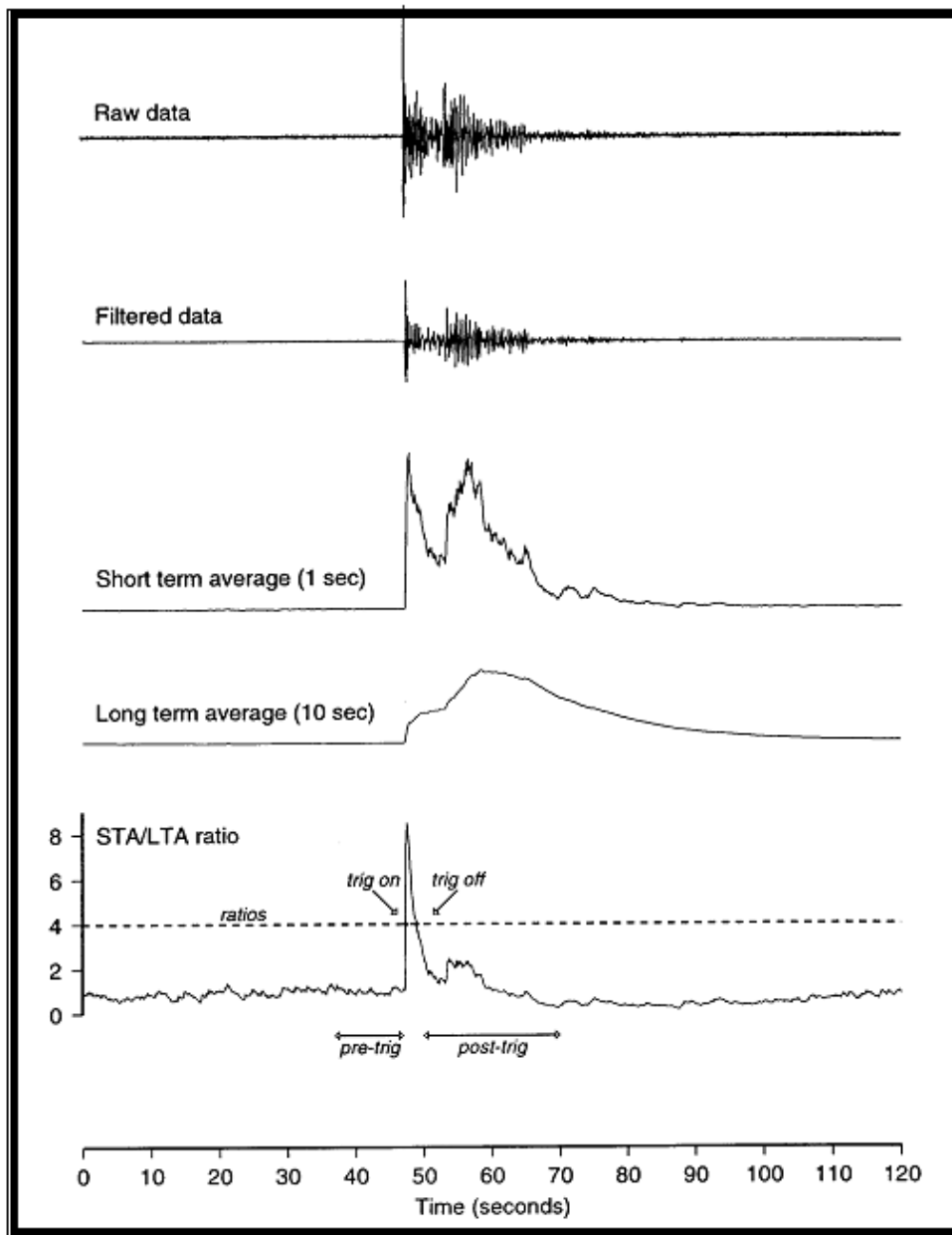
Usually, the values of the **STA** and **LTA** periods, and of the **Ratio**, will be the same for all checked channels. For convenience, Scream! will automatically fill in other values to match ones you enter. If you want to use different values for some channels, you should uncheck **Common values** before altering them.

Once you have enabled the *STA/LTA* triggering method on a particular channel, you can use the *Control* window to change the values of the **STA** and **LTA** periods, together with the **Ratio**, without restarting the digitizer (see Section 4.2, page 40.)

Since it is not generally advisable to trigger from broadband data, the

digitizer provides a set of standard bandpass filters to apply to the data streams before they are tested for the trigger condition. This filtering serves to maximise sensitivity within the frequency band of interest, and filter out noise outside this band. You can select which bandpass filter to use from the **Bandpass filter** drop-down menu. 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.

The possible filter configurations are shown in the following table:

Rate (samples/s)	Bandwidth 1 (Hz)	Bandwidth 2 (Hz)	Bandwidth 5 (Hz)
1000	50 – 450	100 – 450	250 – 450
500	25 – 225	50 – 225	125 – 225
400	20 – 180	40 – 180	100 – 180
250	12.5 – 112.5	25 – 112.5	62.5 – 112.5
200	10 – 90	20 – 90	50 – 90
125	6.25 – 56.25	12.5 – 56.25	31.25 – 56.25
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
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
1	0.05 – 0.45	0.1 – 0.45	0.25 – 0.45

As can be seen, the filter you choose defines the set of permissible sample rates.

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

Frequency Response @10s/s lower=0.1

Frequency Response @10s/s lower=0.2

Frequency Response @4s/s lower=0.2

Frequency Response @4s/s lower=0.5
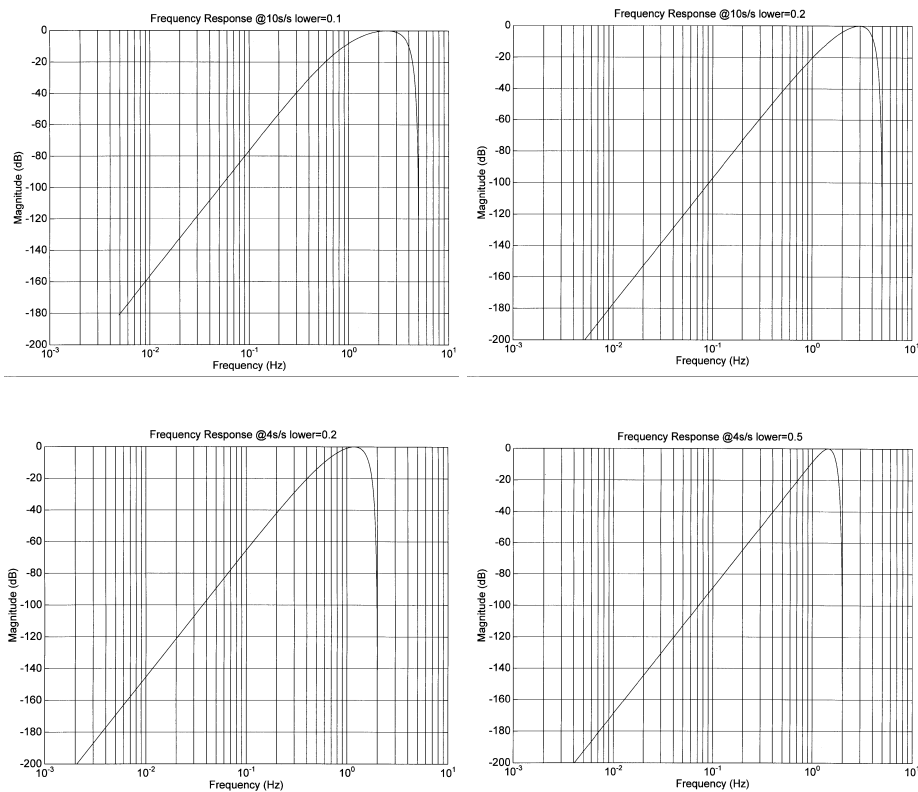
Level

Using the *Level* triggering method, a trigger is generated whenever one of the checked components reaches a certain level above the baseline. You can select which tap is monitored from the **Data source** drop-down menu, and the channel(s) to be considered from the **Channel** column of the table. The values in the **Level** column are the number of counts above the baseline that channel must reach before a trigger is generated.

As with the *STA/LTA* method, the values of the **Level** will often be the same for all checked channels. If you want to use different values for some channels, you should uncheck **Common values** before altering them.

Once you have enabled the *Level* triggering method on a particular channel, you can use the *Control* window to change the level at which the system triggers without restarting the digitizer.

External triggering

When a digitizer or digital sensor triggers, it sends the trigger itself to connected devices, as well as any extra data that it has been configured

to record. You can configure other digitizers to respond to this signal by triggering in turn. This is an option which you can specify at the time of manufacture. See Section 6.3, page 91, for details of how to set up an installation for external triggering.

As an example, to instruct a stand-alone digitizer with digital inputs to respond to triggers generated by an attached digital sensor:

1. Open the *Configuration setup* window for the digital sensor, and check **Enable External Trigger Output** to make it send triggers to connected devices.

2. **UPLOAD** the new configuration to the digital sensor.

3. Open the *Configuration setup* window for the digitizer, and check **Enable External Trigger Input** to make it listen for triggers coming from the digital instrument, and record data from attached analogue instruments when it receives one (depending on its *Output control* configuration.)

4. **UPLOAD** the new configuration to the digitizer,

If a digitizer has both **Enable External Trigger Output** and **Enable External Trigger Input** selected, it will record data when it receives an external trigger as if it had triggered itself, but it will *not* send that trigger on to other digitizers. It will only send a trigger message if its *own* triggering criteria are satisfied.

Pre-trigger and post-trigger recording

In order to capture all of a seismic event, it is often useful to be able to record data immediately preceding the trigger. Güralp digitizers have an internal buffer of some seconds which allows this data to be added to the triggered stream. Pre-trigger data is particularly useful for emergent-type signals, where the system does not trigger until one phase after the first arrival. In addition, to ensure that the coda of each event is included, some seconds of data are recorded after the system detriggers.

The two boxes at bottom right of the *Triggering* pane allow the user to set the pre-trigger and post-trigger data intervals, in seconds. These values determine the *minimum* length of time during which data will be saved before the trigger condition occurs, and after it has lapsed. Regardless of the intervals chosen, the data in the triggered streams will begin on a whole second.

Mux Channels

Güralp digitizers provide a range of slow-rate auxiliary channels for reporting the system's state of health and other diagnostic information, known as multiplexed ("Mux") channels. The number of Mux channels depends on the model and configuration of your digitizer. Generally, three channels are used to report the sensor mass position, and another measures the internal temperature of the digitizer. In addition to these, up to 12 Mux channels may be supplied for the user's own purposes. Some digitizers have a separate *AUXILIARY* port which can be used to access these channels.

The collection and transmission of Mux channels is controlled using the *Mux Channels* pane:
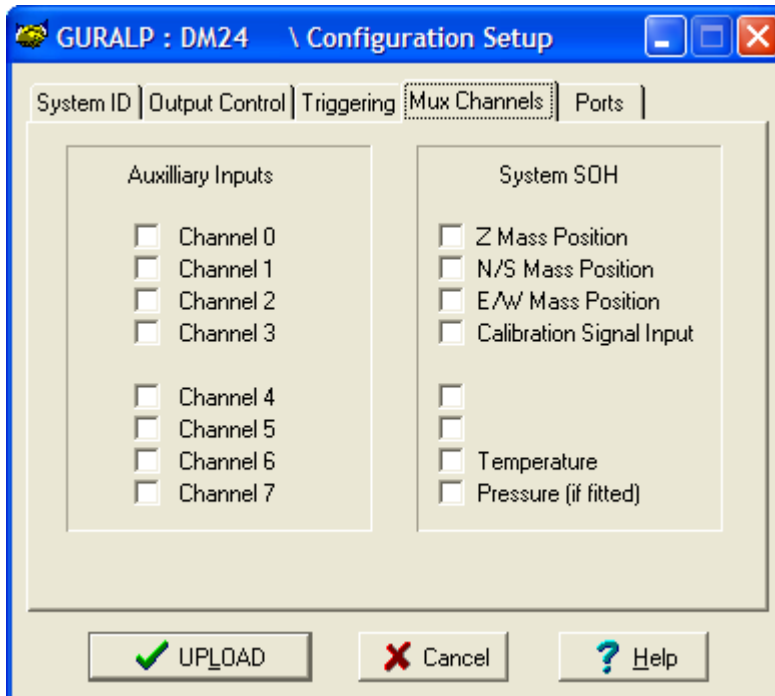
If a tick is placed in the box next to a channel, its data will be collected and transmitted as a data stream in GCF format, just as with the normal data channels. To indicate that the data comes from a Mux channel, the Stream ID will take the form *****M\underline{x}*, where M stands for Mux and \underline{x} is a hexadecimal integer (*i.e.* 0 – 9, and A – F for 10 through 15). **Z, N/S** and **E/W Mass Position** Mux channels appear as M8, M9 and MA respectively.

Ports

The *Baud Rates* pane of the *Configuration setup* window allows you to program the baud rate and stop bits for the DM24's output port.
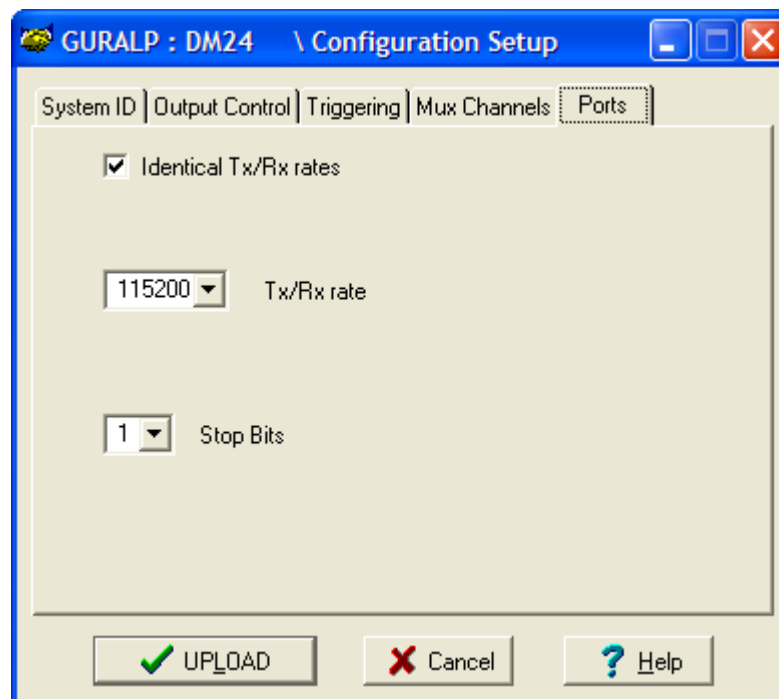
The baud rate you choose must satisfy two conditions:

- It must be high enough to allow all the transmission of all data generated by the digitizer 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.

- It must be low enough to fit within the operating range of the telemetry equipment you are using. 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, the 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**.

The **Stop Bits** option allows you to choose whether the serial link uses 1 or 2 stop bits. In most cases this can be left at 1, although 2 may be required if you are sending data over 'difficult' transmission lines (for example, some types of radio link.) Using 2 stop bits will add a 10% overhead to the data.

You will also need to set the data rate for Scream's local serial port, as well as for the SAM/DCM or other communications device (if you are using one). In Scream!, you can configure a serial port by right-clicking on its icon (*not* that of the digitizer) and selecting **Configure...** from the pop-up menu: for more details, consult the online help or user guide for Scream!. If you are using an additional communications device, you should consult its documentation to learn how to set its baud rate.

4.2 Controlling digitizers

To control a digitizer whilst it is running, either right-click on the digitizer's entry in the list to the left of Scream!'s main window (*not* the **Local** or **Com**xx icons) and click **Control...**, or simply double-click the entry. Scream! will then contact the digitizer and retrieve its current status, a process which will take a few seconds, after which the *Control* window will be displayed. Once you are happy with any changes you have made in the *Control* window, click **Apply** to send them to the digitizer, where they will take effect immediately.

This chapter describes the control options available to you for the DM24. Many of these options will also be available for other Güralp digitizers. For the most accurate information, you should consult the Operator's Guide for the digitizer or sensor you connect.

System

When the *Control* window is first opened, it will be showing the *System* pane.
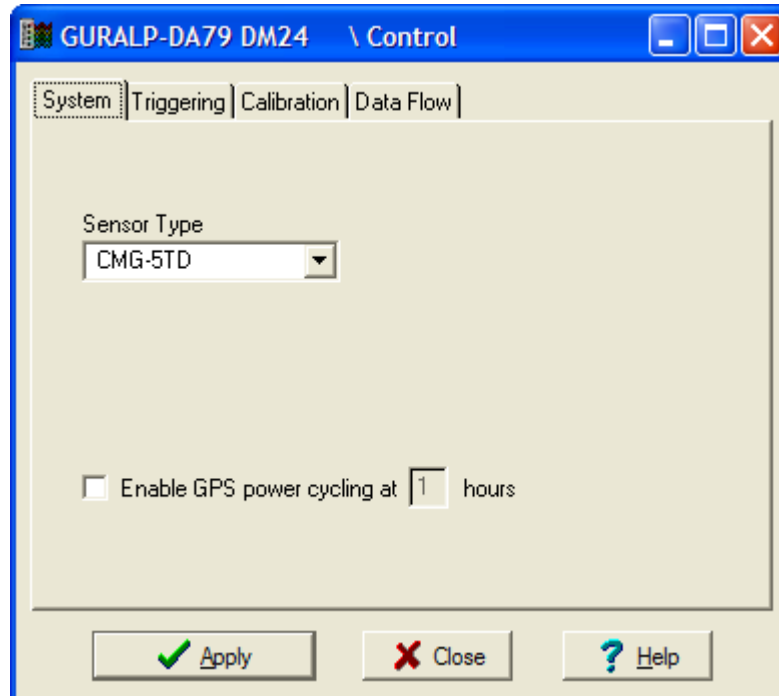
Sensor Type: If the sensor attached to the digitizer is a Güralp velocity sensor, you can send control commands to it from the *Mass Control* tab (see below.) Which functions are available on this tab depends on the *Sensor Type* you have set here.

If you change the **Sensor Type**, you may have to **Apply** the change, close the *Control* window, and open a new one to access the *Mass Control* options.

Enable GPS power cycling: If you are using a GPS unit to receive time signals, but do not experience significant drift in the system's clock (for example, in a stable-temperature environment), you can save power by selecting **Enable GPS power cycling.** With this option in use, the GPS time is only checked at intervals of a specified number of hours.

Triggering
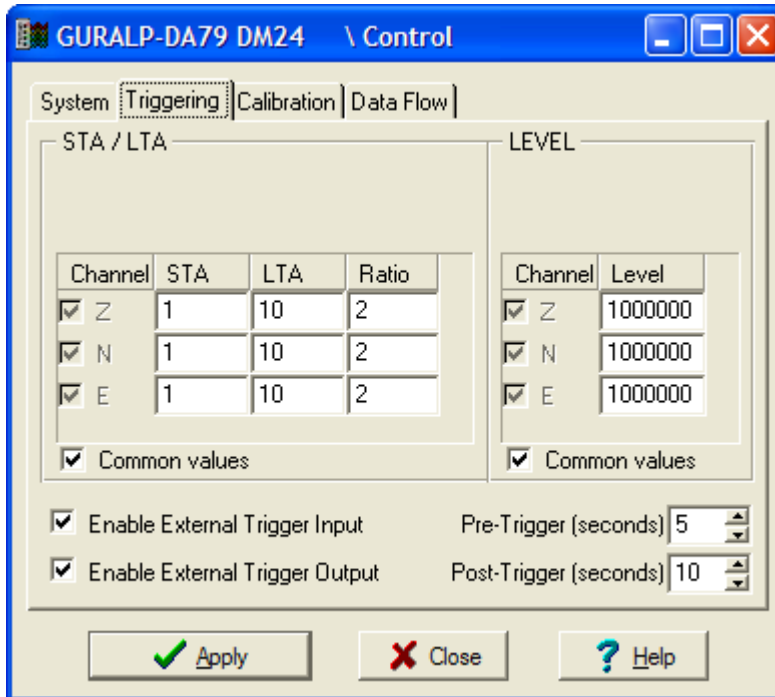
The *Triggering* pane is very similar to the corresponding pane of the *Configuration setup* window, although not all options are available since some require rebooting the digitizer.

Calibration

You can check that your instrumentation is correctly calibrated by injecting known signals into the sensor's feedback loop. The *Calibration* pane allows you to do this once the sensors are installed.
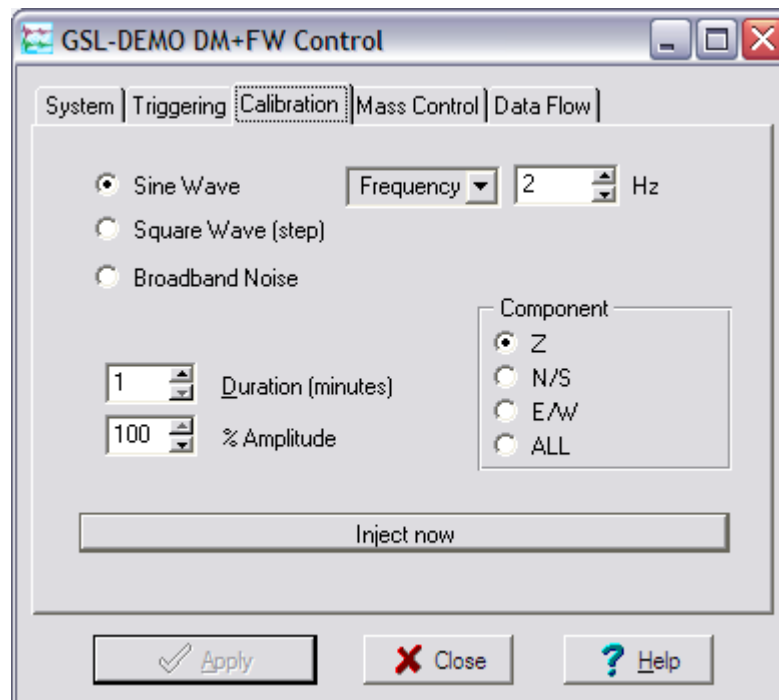
Each channel **Z, N/S** and **E/W** can be calibrated separately. For most triaxial digital instruments, each channel calibrates the corresponding axis of the instrument; simply select one of the **Z, N/S** and **E/W** check boxes to calibrate that axis. Some instruments use only one calibration loop, which is reproduced for all three components: if you have one of these instruments, you should select **Z** to calibrate the sensor.

The calibration signal is digitized at the same rate as the *highest-rate* data stream you have selected for either continuous or triggered output. It is returned on a channel ending Cn ($n = 0 - 7$.) The auxiliary analogue channel is interrupted whilst calibration is active.

The **Duration** box tells the digitizer how long to provide the calibration signal before disconnecting. This avoids the system being inadvertently left in calibration mode. The default is 2 minutes.

All Güralp digitizers can produce either sine-wave or square-wave (step) calibration signals; newer models can also carry out broadband noise calibration. The **Sine wave** calibration signal always starts and stops on the zero crossing. The frequency or period given by the boxes at bottom left. Only integers between 1 and 10 may be specified for either frequency or period, so to generate a 0.5 Hz signal you should select **Period** and set the time to 2 (seconds). Likewise, if you require a 0.25 second period you should select **Frequency** and set the rate to 4 (Hz). In this manner, you can select frequencies ranging from 0.1 to 10 Hz (10 to 0.1 s periods).

You can specify step calibration by selecting the **Square wave** button. The square wave consists of a positive step at the start of the next minute of the digitizer's internal clock, followed by a negative step after a specified number of minutes. After a further delay of the same number of minutes, the calibration signal is disconnected. The default is 2 minutes. The **Period** and **Frequency** are ignored.

The **Broadband Noise** calibration signal consists of a constant stream of white noise, which lasts for the specified number of minutes. The **Period** and **Frequency** are ignored.

Mass Control

Many Güralp instruments respond to control signals to centre, unlock, and lock the sensor masses. These signals are generated by the digitizer. You can tell the digitizer to send a signal using the **Center Now**, **Lock Now** and **Unlock Now** buttons on the *Mass Control* tab.
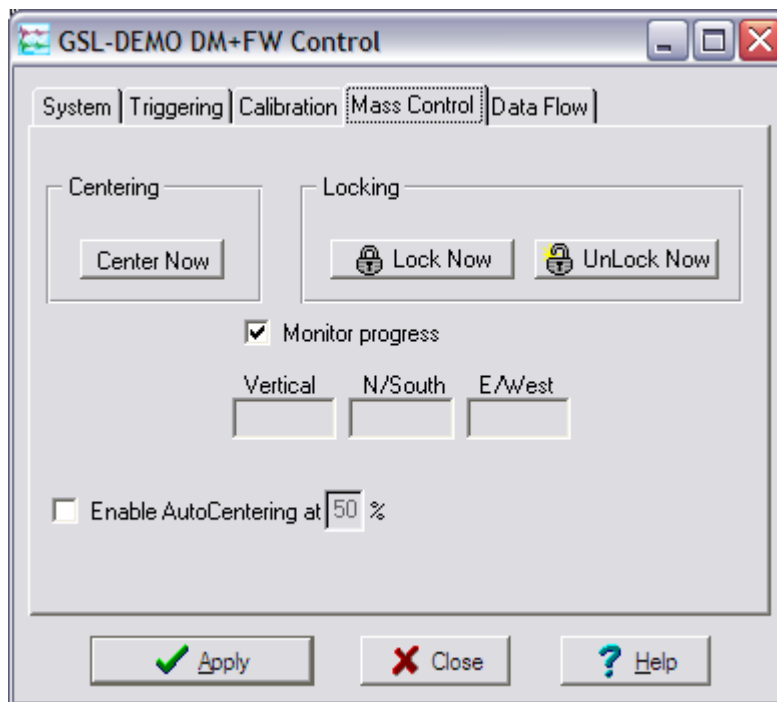
If you select **Monitor progress**, the window will remain open during the process, and the mass positions will be displayed in the *Vertical*, *N/South* and *E/West* boxes. If you leave **Monitor progress** unselected, the window will close. You can still monitor mass positions by selecting the appropriate streams and opening a *WaveView* window for them.

Depending on which *Sensor Type* you have chosen in the *System* tab (see above), not all the control signals will be available. For example, a

CMG-3ESP can be centred from Scream, but must be locked and unlocked manually, whilst a 3T has remote lock and unlock commands. Conversely, CMG-5T strong-motion instruments must be centred manually, and do not need locking or unlocking. If you have set the **Sensor Type** to *CMG-5T* or *CMG-5TD*, the *Mass Control* tab will not be available.

Data flow

The DM24 operates in one of several *filing modes*. These modes relate to how the unit uses its Flash memory:

- as a simple data store, from which you can request data (*FILING* and *DUAL* modes);

- as a buffer holding unacknowledged blocks, which are transmitted in preference to real-time data (*FIFO* mode);

- as a buffer holding unacknowledged blocks, which are transmitted whenever the channel is free but no real-time data blocks are ready (*ADAPTIVE* mode);

- not at all (*DIRECT* mode).

Separate from these modes are *buffering modes*, which tell the unit what to do when its Flash memory becomes full: either

- carry on, overwriting the oldest data held, or

- stop writing and switch the DM24 into *DIRECT* mode.

You can switch between filing modes in Scream! by right-clicking on the digitizer and clicking on **Control...**, then navigating to the **Data Flow** pane:
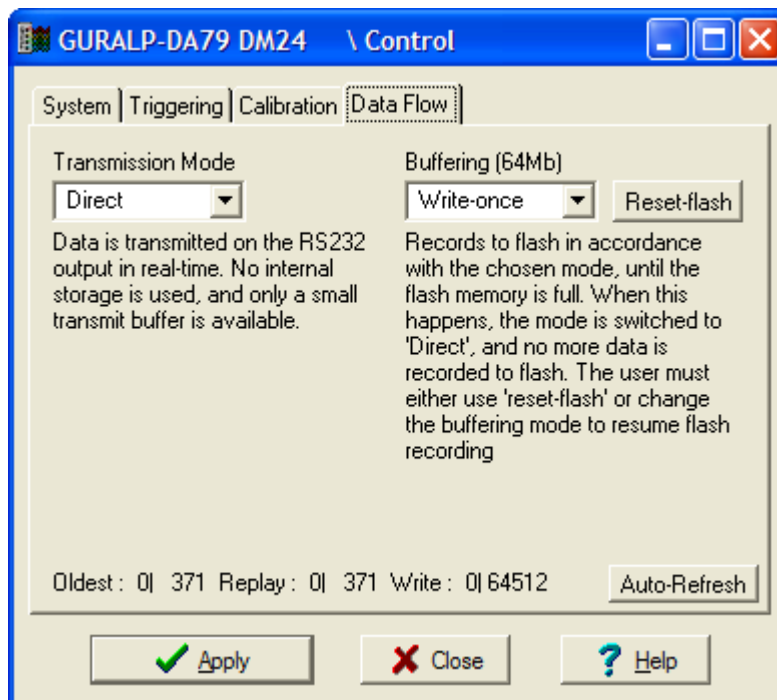
Clicking **Apply** in this window immediately activates the filing mode you have selected—there is no need to reboot.

If you prefer, you can use the DM24 terminal to switch between filing modes.

5 Command line interface

5.1 Introduction

You can connect to the internal software of the DM24 over its output serial port and communicate with it.

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

```
ok
```

If you prefer, you can use a terminal program on your computer (such as `minicom` on Linux, or `hypertrm` on Microsoft Windows) to connect to the DM24.

Whilst you are in terminal mode, data transfer will be interrupted; the digitizer may use any Flash memory as a temporary store, depending on how you have configured it. Some commands, such as `SET-TAPS`, require a reboot to take effect.

Güralp DCM and AM modules also allow you to send commands direct to the digitizer using the command-line tool `gcli`. For more information, please see the manual for your data module.

If you have problems connecting to the digitizer's console, you should check that the serial port's options and baud rate are set correctly in Scream! or your terminal program. As supplied, the DM24 expects connections at 19200 baud, with 8 data bits, no parity bit and 1 stop bit. No flow control is used.

FORTH

The DM24 uses FORTH to implement its features. To issue a command in FORTH, you must supply the arguments *before* the command, for example:

```
3 SENSOR-TYPE
```

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

execute, remove themselves from the stack, and then remove further items from the stack to use as arguments. Thus, in the command

```
3 SENSOR-TYPE
```

the 3 has no immediate effect, so stays on the stack; SENSOR-TYPE takes itself and the previous item (here 3) off the stack, then performs its action on the 3 (here, setting the configured sensor type to 3, representing a CMG-3T sensor.)

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

Some commands are *interactive*, and will ask you to provide extra information after you execute them. In the following sections, interactive commands are shown as example sessions, where information you enter is given in medium and messages returning from the DM24 are given in **bold**.

5.2 Getting help

The DM24 has an on-board help system which can be accessed with the commands HELP and EXPLAIN.

HELP

Syntax: HELP

Lists all the commands which are recognized by the digitizer.

If the command you want is not listed:

- The command may be in the extended dictionary. This dictionary contains certain advanced commands, as well as exposing internal digitizer functions and variables. To enable the extended dictionary, issue the command ok-1.

  When you have finished using the extended dictionary, close it with the command [seal], so you do not inadvertently change the internal settings with subsequent commands.

- *Alternatively*, the command may not be implemented in the firmware version you have installed. Check the Güralp Systems web site for updated firmware.

EXPLAIN

Syntax: EXPLAIN *command*

Displays a short message describing the syntax of *command* and its effect.

5.3 General configuration

SET-ID

Syntax: SET-ID (interactive)

Sets the system identifier and serial number of the DM24 to values you supply.

```
SET-ID
System Identifier ? (e.g. ALPHA,) DM24, Serial # ? (e.g. 1234,00)
4507,00
```

The system identifier you supply may contain up to 5 alphanumeric (0-9A-Z) characters, and must have a comma after it.

The serial number you supply must contain exactly 6 alphanumeric (0-9A-Z) characters, and must include a comma after the fourth character.

SENSOR-TYPE

Syntax: *type* SENSOR-TYPE

Tells the DM24 which kind of sensor is attached to it. This affects whether or not the digitizer exposes commands such as locking and centring.

type can be one of

- 1, for CMG-40T sensors,

- 2, for CMG-3ESP sensors,

- 3, for CMG-3T analogue sensors, or

- 4, for CMG-3TD sensors.

GPS-TYPE

Syntax: *type* GPS-TYPE

Tells the DM24 which kind of GPS is attached to it.

type can be one of

- 0, if no GPS is available, or

- 2, for attached GPS equipment using the NMEA protocol.

HR-CYCLE

Syntax: *interval* HR-CYCLE

Sets the time to wait between GPS synchronizations.

To save power, the DM24 can switch off the attached GPS receiver once its internal precision clock has been successfully synchronized. The GPS receiver is reactivated every *interval* hours to ensure that the clock remains correct, and shut down again once the clock error has stabilized.

Setting *interval* to zero disables this function, *i.e.* the GPS will be powered all the time. This is the best setting to use in installations with access to mains (outlet) power. The maximum allowed value for *interval* is 23.

SET-CLOCK

Syntax: SET-CLOCK (interactive)

Sets the internal clock.

```
SET-CLOCK
Enter Date & Time -
YYYY MM DD HH MM SS
2006 02 01 12 53 25  Clock set to 2006  2  1 12:53:27 ok_SBHY
```

The time should be entered in the form *year* *month* *day* *hour* *minute* *second*, padding each field with zeroes so that they line up with the guide above.

If the DM24 does not recognize the time format you have used, it will output the message Invalid Time Entry.

This setting will be overridden when the GPS system next synchronizes the clock.

TIME?

Syntax: `TIME?`

Displays the current date and time.

LEAPSECOND

Syntax: *yyyy* *mm* *dd* `LEAPSECOND`

Manually notify the digitizer of an upcoming leap second. This command is not normally necessary, since GPS already has support for leap seconds. However, some units do not properly interpret the GPS signals. See `SQPATCH`, below.

The leap second is taken to be at the end of the day *yyyy*-*mm*-*dd*.

SQPATCH

Syntax: `SQPATCH ENABLE` or `SQPATCH DISABLE`

Enables or disables the internal patch for older GPS receivers based on Trimble Lassen SQ units. These units misinterpret the GPS system's advance notification of a leap second, and consequently run one second slow until the leap second occurs.

With `SQPATCH` enabled, the time reported by the digitizer is offset by 1 second to counteract this problem. If you have set `LEAPSECOND`, above, `SQPATCH` will automatically be disabled when the leap second occurs, and the digitizer will then run normally.

GPS receivers with the latest firmware do not suffer from this problem.

To find out whether `SQPATCH` is currently enabled, issue the command

`.SQPATCH`

AZIMUTH

Syntax: *instrument* *angle* `AZIMUTH`

Some borehole digitizers can rotate incoming signals algorithmically as they are digitized. This feature allows you to compensate for an instrument being out of alignment with the North/South axis. To use it,

first measure the orientation of the sensor, then connect to the digitizer and issue an AZIMUTH command, giving the angle you have measured.

instrument tells the digitizer which instrument to apply the rotation to; 0 for a 4-channel digitizer.

angle is the measured angle of deviation from the North/South axis, in tenths of a degree. The angle of deviation is the *negative* of the angle by which you want incoming signals to be rotated. Like all other parameters, it must be an integer (*i.e.* a whole number of tenths of a degree.)

You can measure the orientation of a borehole sensor by placing a reference sensor nearby and carrying out coherence calculations. An extension to Scream! is available which can do this for you. For details, see the manual for your sensor or for Scream!.

The AZIMUTH command only alters the digitizer's CMOS settings. You will need to re-boot the digitizer to transfer them to the DSP.

CROSS

Syntax: *channel* CROSS

Alters the DSP's transformation matrix to invert one of the digitizer channels. *channel* is one of 0 (vertical), 1 (N/S), 2 (E/W) and 3 (auxiliary).

The CROSS command only alters the digitizer's CMOS settings. You will need to re-boot the digitizer to transfer them to the DSP.

If you need to set both AZIMUTH and CROSS, you must issue AZIMUTH first, since it overwrites the matrix.

5.4 Port configuration

BAUD

Syntax: *port* *baud-rate* BAUD

Sets the baud rate for one of the serial ports on the DM24, in bytes per second. *port* can be

- 0, for the *DATA OUT* port,

- 1, for the *GPS* port, or

- `2`, for the *DATA IN* port.

For example,

```
0 38400 BAUD
1 4800 BAUD
2 38400 BAUD
```

This will reset a standard single-sensor DM24 to its default configuration.

The allowable values for `baud-rate` are 4800, 7200, 9600, 14400, 19200, 38400, 57600, 115200 and 230400. For compatibility reasons, 1152 is also accepted, setting the baud rate to 115200.

GPS inputs should always be set to 4800 baud.

STOPBITS

Syntax: `port` `number-bits` STOPBITS

Sets the number of stop bits used for one of the serial ports on the DM24. `port` can be

- `0`, for the *DATA OUT* port,

- `1`, for the *GPS* port, or

- `2`, for the *DATA IN* port.

By default, the DM24 uses 1 stop bit on all ports.

+MODEM

Syntax: +MODEM (interactive)

Instructs the DM24 to use a modem connected to the *DATA OUT* port to contact a remote device and transmit data stored in the Flash memory.

The DM24 will dial out every time it generates a heartbeat message, and also whenever a trigger occurs. You can change the interval between heartbeat messages with the HEARTBEAT command, below.

When you issue +MODEM for the first time, the digitizer will prompt you to enter a telephone number:

```
+MODEM
Phone# is not set Enter phone# 00441189819056
Phone# 00441189819056 Flash FIFO : Circular  Configuration for
dial out  ok_DEMO00
```

If you have already configured a telephone number, the command will print out the current setting and ask if you want to change it.

```
+MODEM
Phone# 00441189819056 New number? y/n y
Enter phone# 00441189819943
Phone# 00441189819943 Flash FIFO : Circular  Configuration for
dial out  ok_DEMO00
```

+MODEM also changes the filing mode of the digitizer to FILING, so that all incoming data is stored in Flash memory ready to be downloaded. When the dial-out takes place, all new data in Flash memory is transmitted. By configuring the DM24 to transmit only triggered streams, you can create a system which "wakes up" on a trigger, connects to a data centre using the modem, and delivers the triggered data in close to real time.

–MODEM

Syntax: –MODEM

Disables automatic modem dial-out. This command does not change the current filing mode, so if you have previously issued +MODEM, the DM24 will be left in FILING mode.

If you issue –MODEM over a dial-out modem link, you should make sure you have arrangements already in place for contacting the DM24 by other means, since the command will cause the connection to close.

+GCFIN

Syntax: *input-port* +GCFIN

Instructs the digitizer to accept GCF input on either the *GPS* or the *DATA IN* port. *input-port* can be

- 1, for the *GPS* port, or

- 2, for the *DATA IN* port.

The GCF streams received will be combined with the DM24's own streams and output with them through the *DATA OUT* port or saved to Flash memory, according to the current filing mode.

Whilst GCF input is active, the normal function of each port (GPS or console access) is disabled.

−GCFIN

Syntax: *input-port* -GCFIN

Instructs the digitizer to stop accepting GCF input on *input-port*, and to return that port to normal operation.

OPEN

Syntax:OPEN *system-id* *stream-id-prefix* (*n.b.)*

Opens a terminal session with a connected digitizer.

The DM24 scans all the ports which are currently accepting GCF input (see +GCFIN, above) to find a digitizer which matches *system-id* and *stream-id-prefix*.

For *stream-id-prefix* you should use the first 4 characters of the Stream IDs produced by this digitizer, *i.e.* without the component and tap designations.

A terminal connection is then made to the second digitizer, allowing you to issue commands.

To finish the session and return to the first digitizer's terminal mode, use the command GO.

USBPORT

This command is only available on units with the optional USB interface.

Syntax: *port* USBPORT

Instructs the digitizer to redirect input or output from port *port* to the USB interface. You can then attach the *USB* port to your computer with a suitable cable, where it will appear as an additional serial port with a significantly faster data transfer rate. *port* can be

- 0, for the *DATA OUT* port,

- 1, for the *GPS* port, or

- 2, for the *DATA IN* port.

The USB interface is provided by an internal FTDI245 chip, which is compatible with Microsoft Windows, Linux and Apple Macintosh systems.

You can only use the USB port to connect to a computer, not directly to a peripheral (*e.g.* a hard disk.) If you want to download data to a hard disk, you should specify the Firewire interface instead.

5.5 Output configuration

SAMPLES/SEC

Syntax: *tap-0* *tap-1* *tap-2* *tap-3* samples/sec

The DSP software on the DM24 supports up to 7 cascaded filter/decimation stages. At each stage, the sample rate can be decimated by a factor of 2, 4 or 5. The ADC within the unit outputs data at 2000 samples/sec, so decimated data streams are available from 1,000, 500 and 400 samples/sec down to 1 sample/sec.

You can specify the sample rate to use at four of these stages, known as *taps*. You can also take output from any of these four stages. The DM24 will arrange the remaining stages according to your settings.

The arguments *tap-0* to *tap-3* are the sample rates at each tap in turn, starting with the highest. You must ensure that each rate is lower than the previous one by a factor of 2, 4, 5, 8 (= 2 then 4), 10 (= 2 then 5) or 16 (= 4 then 4). Non-integer values are not allowed.

For example:

```
1000   125   25    5    samples/sec
1000   500   100   10   samples/sec
500    100   20    4    samples/sec
400    40    10    5    samples/sec
```

As long as you specify the initial taps, you can omit later ones. The command fills in the value of the missing taps, using a decimation factor of 2 where possible. Thus, the following commands are equivalent:

```
400   40   20   10    samples/sec
400   40   samples/sec
```

Currently the DM software does not support the new GCF format for higher sample rates. It also does not properly support 250 samples/s, nor rates below 1 sample/s.

CONTINUOUS

Syntax: _tap_ _components_ CONTINUOUS

Sets which components are output under normal conditions, and at which tap(s).

tap is the tap number at which to output the triggered stream. You can set which taps output which sample rate using the SAMPLES/SEC command, described above.

components is an integer below 16, whose binary bits represent the Z (1), N (2), E (4) and auxiliary (8) components respectively. Thus, for example,

- 0 1 CONTINUOUS will output the Z component only (1) at the first tap;

- 0 2 CONTINUOUS will output the N component only (2);

- 0 4 CONTINUOUS will output the E component only (4);

- 0 7 CONTINUOUS will output all three directional components (1 + 2 + 4 = 7);

- 0 12 CONTINUOUS will output the E component and the auxiliary component (4 + 8 = 12);

- 0 0 CONTINUOUS will output nothing at this tap.

SET-TAPS

Syntax: _tap-0_ _tap-1_ _tap-2_ _tap-3_ SET-TAPS

This is an alternative to the CONTINUOUS command, which allows you to set the outputs for all taps simultaneously.

tap-0 to _tap-3_ are integers below 16, whose binary bits represent the Z (1), N (2), E (4) and auxiliary (8) components respectively. Each one sets which components are output at that tap under normal conditions.

For example, if you issue

9 7 0 15 SET-TAPS

- tap 1 will output Z and the auxiliary component (1 + 8 = 9);

- tap 2 will output all three directional components (1 + 2 + 4 = 7);

- tap 3 will not output anything; and

- tap 4 will output all four components (1 + 2 + 4 + 8 = 15).

To set triggered output streams, you should use the `TRIGGERED` command detailed below.

COMPRESSION

Syntax: *bits* *size* `COMPRESSION` or `NORMAL COMPRESSION`

Sets the maximum amount of compression to use. Greater compression means the digitizer outputs data more efficiently, so more can be transmitted over a link with a given bandwidth. However, compressing streams uses processor power and can increase data latency.

The digitizer compresses data without loss, so compression is most effective when the data contains relatively little information. In most cases, when a seismic event occurs, the digitizer will need to decrease the compression level.

bits can be one of `8BIT`, `16BIT` and `32BIT`. `8BIT` (the default) is the maximum amount of compression; `32BIT` denotes no compression.

size determines the maximum number of data samples in a GCF block. This must be between 20 and 250; the default is 250.

GCF blocks must be a whole number of seconds long. If you set *size* to a very small value, so that *size* samples is less than 1 second for some streams, the digitizer will output 1 block every second for those streams, ignoring the value of *size*.

Thus, if you issue `32BIT 20 COMPRESSION`, streams with a sample rate of 20 samples/s and higher will output one block per second, whilst lower rate streams will output 20-sample blocks: every 5 seconds for 4 samples/s data, etc.

The special value, `NORMAL COMPRESSION`, returns the setting to its default value, and is equivalent to `8BIT 250 COMPRESSION`.

LOWLATENCY

Syntax: `LOWLATENCY`

This is a special mode for applications requiring lower sample rate data in as close to real time as possible. In this mode, the digitizer takes a 200 samples/s stream and passes it through low-pass and decimation filters internally, before exposing it as a 20 samples/s stream at an increased rate of 1 block per second.

To enable low latency mode on all three components, first use `SAMPLES/SEC` to set Tap 0 to 200 samples/s, then issue the following commands:

```
NORMAL COMPRESSION
0 7 CONTINUOUS
0 1 BANDPASS
LOWLATENCY
7 TRIGGERS
```

If you want to enable low latency mode on some components only, replace the 7s above with another value (*e.g.* 1 = Z, 2 = N, 4 = E.)

To disable low latency mode, issue

```
0 1 BANDPASS
0 TRIGGERS
```

When `LOWLATENCY` is active, the `TRIGGERS` and `BANDPASS` commands have special meanings. Because of this, the STA/LTA triggering function is disabled. You can still use `LEVEL` triggering if you require (see below.)

SETDSS

Syntax: *output-spec* `SETDSS`

This command alters the way the DM24 outputs status streams.

In normal operation, the DM24 stores lines of status information until it has filled a 1K GCF block. For low latency applications, however, status information is required more frequently. In this mode, the DM24 will output a status block every minute. This mode is required by the DSS server distributed with Güralp Systems' CMG-DCM.

output-spec is an integer below 32, whose bits tell the digitizer which status lines to output.

- Setting bit 0 (1) produces lines like

```
2006  9  4 13:13:00 2 MicroSeconds Fast  Freq error 0 e-9
          Auto 3D [-4]
```

showing the current internal clock offset, frequency error, and

GPS fix type.

- Setting bit 1 (2) produces lines like

```
2006  9  4 13:13:00 o/s= 340 drift=  0 pwm= 8382  Fix= "3D"
```

showing the current GPS offset, drift, PWM measure, and fix type.

- Setting bit 2 (4) produces lines like

```
2006  9  4 13:13:00 Lat= "51'21.6526N"  Long="001'09.8148W"
```

showing the GPS latitude and longitude.

- Setting bit 3 (8) produces lines like

```
Boot Log : Power_cycles=    11 Watchdog_resets=    51
         Last boot  2006  8 23 08:49:22    2006  8 23
            08:50:40 Run 12Days 04:22:20
```

showing the number of times the digitizer has been reset, with the time of the last reset and the current up-time.

- Setting bit 4 (16) produces lines like

```
2006  9  4 13:13:00 External supply : 14.3V Temperature
         29.75'C
```

showing the current power supply voltage and temperature.

For example, issuing

```
6 SETDSS (= 2 + 4)
```

will cause the digitizer to begin outputting status blocks containing GPS timing and position information only:

```
2006  9  4 13:13:00 o/s=    340 drift=    0 pwm= 8382  Fix= "3D"
2006  9  4 13:13:00 Lat= "51'21.6526N"  Long="001'09.8148W"
```

To use a DM24 with a DCM running a DSS server, you should issue

```
31 SETDSS
```

To return to normal operation, issue the command

```
0 SETDSS
```

5.6 Triggering

TRIGGERS

Syntax: _components_ TRIGGERS

Selects which component or components can generate an STA/LTA trigger. Only these components will be examined by the triggering algorithm.

components is an integer below 16, whose binary bits represent the Z (1), N (2), E (4) and auxiliary (8) components respectively as described above. Issuing 0 TRIGGERS will disable the triggering system.

When LOWLATENCY is active, this command is used to set the components which are output as low-latency streams. Issuing 0 TRIGGERS will disable the low latency mode.

GTRIGGERS

Syntax: _components_ GTRIGGERS

Selects which component or components can generate a level trigger. Only these components will be examined by the triggering algorithm.

components is an integer below 16 with the same meaning as in TRIGGERS.

S/WTRIGGER

Syntax: S/WTRIGGER

Causes the digitizer to trigger immediately, and begin outputting triggered streams according to its configuration.

TRIGGERED

Syntax: _tap_ _components_ TRIGGERED

Selects which component or components will be _output_ when a trigger is generated, and at which tap (sample rate).

tap is the tap number at which to output the triggered stream. You can set which taps output which sample rate using the SAMPLES/SEC command, described above.

components is an integer below 16, which represents which components to output in the same fashion as in the CONTINUOUS command, above.

(This command and the previous one have similar names; remember that a component TRIGGERS the system, whilst taps and components are TRIGGERED.)

STA

Syntax: *Z-secs* *N-secs* *E-secs* *X-secs* STA

Sets the length of the "short-term" averaging period in the *STA/LTA* triggering algorithm.

Z-secs, *N-secs*, *E-secs* and *X-secs* are the time period over which to calculate the average for the *Z*, *N*, *E*, and auxiliary components respectively. If a component is not considered by the triggering algorithm (see TRIGGERS, above), the value you specify here will be ignored.

For example, 1 1 2 2 STA will calculate short-term averages over 1 s for the *Z* and *N* components, and over 2 s for the *E* and auxiliary components.

If you issue STA with only one argument, it is used for all four components. For example, 5 STA will calculate averages over 5 s of all components.

LTA

Syntax: *Z-secs* *N-secs* *E-secs* *X-secs* LTA

Sets the length of the "long-term" averaging period in the *STA/LTA* triggering algorithm.

Z-secs, *N-secs*, *E-secs* and *X-secs* are the time period over which to calculate the average for the *Z*, *N*, *E*, and auxiliary components respectively. If a component is not considered by the triggering algorithm (see TRIGGERS, above), the value you specify here will be ignored.

For example, 15 20 20 20 STA will calculate long-term averages over 15 s for the *Z* component, and over 20 s for the *N*, *E* and auxiliary components.

If you issue `STA` with only one argument, it is used for all four components. For example, `5 STA` will calculate averages over 5 s of all components.

RATIOS

Syntax: *Z-ratio* *N-ratio* *E-ratio* *X-ratio* RATIOS

Sets the ratio of STA to LTA above which a trigger will be declared in the *STA/LTA* triggering algorithm.

Z-ratio, *N-ratio*, *E-ratio* and *X-ratio* are the time period over which to calculate the average for the *Z*, *N*, *E*, and auxiliary components respectively. If a component is not considered by the triggering algorithm (see `TRIGGERS`, above), the value you specify here will be ignored.

For example, `4 10 10 10 RATIOS` will cause the DM24 to trigger if the STA/LTA ratio is above 4 for the *Z* component, *or* above 10 for the remaining components.

The arguments to this command must be integers. If you want to specify a fractional ratio, use the command `FRATIOS` instead.

FRATIOS

Syntax: *Z-ratio* *N-ratio* *E-ratio* *X-ratio* FRATIOS

Sets the ratio of STA to LTA above which a trigger will be declared in the *STA/LTA* triggering algorithm.

This command is exactly the same as `RATIOS`, except that its arguments are divided by 10 before being entered into the system.For example, `25 100 100 100 FRATIOS` will cause the DM24 to trigger if the STA/LTA ratio is above 2.5 for the *Z* component, *or* above 10 for the remaining components.

BANDPASS

Syntax: *tap* *filter* BANDPASS

Tells the DM24 which tap to use for *STA/LTA* triggering calculations.

Data is taken from this tap and passed through a band-pass filter before it is examined. This filtering maximises sensitivity within the frequency band of interest, and filters out noise outside this band.

The corner frequency of the band-pass filter depends on the values of *tap* and *filter*:

- *filter* = 1 creates a filter with a corner at 10 % of the Nyquist frequency for tap *tap* (*i.e.* 5 % of its sample rate)

- *filter* = 2 creates a filter with a corner at 20 % of the Nyquist frequency for tap *tap* (*i.e.* 15 % of its sample rate)

- *filter* = 5 creates a filter with a corner at 50 % of the Nyquist frequency for tap *tap* (*i.e.* 25 % of its sample rate)

When LOWLATENCY is active, this command is used to set the tap used as the source of low-latency data. Data from this tap is decimated inside the DSP, and output on a separate stream at a rate 10 times slower than the configured rate.

MICROG

Syntax: *level* MICROG

Sets the output level above which a trigger will be declared in the *LEVEL* triggering algorithm. *level* is measured in counts.

HIGHPASS

Syntax: *filter* HIGHPASS

Instructs the DM24 to pass the stream(s) which generate *LEVEL* triggers through a high-pass filter before examining them. *filter* can be

- 1, for a 100 s high pass filter,

- 2, for a 300 s filter,

- 3, for a 1000 s filter, or

- 0, to disable the high pass filter.

PRE-TRIG

Syntax: *time* PRE-TRIG

Sets the pre-trigger recording time. *time* is the number of seconds of data to output from *before* a trigger is declared.

POST-TRIG

Syntax: *time* POST-TRIG

Sets the post-trigger recording time. *time* is the number of seconds of data to output after a trigger condition lapses. If an event persists for some time, *all* triggering components must fall below the threshold before the trigger condition will lapse; only then will the post-trigger period begin.

TRIGGERIN

Syntax: TRIGGERIN ENABLE | TRIGGERIN DISABLE

Enables or disables external trigger input, in instruments equipped with this option.

Enabling external trigger input allows you to trigger the DM24 from an external logic level supplied through its digital output port. This voltage can be between 5 and 10 V supplied between the *Trigger In* pin and signal ground. If the DM24 is triggered externally, it will behave exactly as if it had generated the trigger itself.

TRIGGEROUT

Syntax: TRIGGEROUT ENABLE | TRIGGEROUT DISABLE

Enables or disables external trigger output, in instruments equipped with this option.

Enabling external trigger output allows you to trigger other equipment through a relay contained within the DM24 whenever it triggers. The DM24's digital output port contains two pins (*Trigger out, common* and *Trigger out, normally-open*) which are connected when it triggers. In particular, you can connect a second digitizer with TRIGGERIN ENABLE in effect, in which case triggered data from both instruments will be transmitted whenever the DM24 triggers.

If a DM24 has both TRIGGERIN ENABLE and TRIGGEROUT ENABLE in effect, *only* triggers which the DM24 itself has generated will be output. Triggers received through the *Trigger in* port will cause the DM24 to output triggered streams, but will *not* be passed on to other digitizers.

POLARITY

Syntax: 0 POLARITY or 1 POLARITY

Sets the sense of the *Trigger In* pin on the *DATA OUT* port.

With `0` `POLARITY` set, the *Trigger In* pin is active low, *i.e.* a trigger will be generated if this pin is connected to ground. `1` `POLARITY` switches the pin to be active high.

You must issue `TRIGGERIN` `ENABLE` to enable external trigger input.

5.7 Calibration

SINEWAVE

Syntax: *component* *freq-or-period* *unit* SINEWAVE

Instructs the DM24 to inject a sine-wave calibration signal, starting on the zero crossing.

component specifies which component is to be calibrated, one of `Z`, `N/S`, `E/W`, or `ALL`. Some sensors use only the Z calibration loop for all three components.

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

```
N/S 4 HZ SINEWAVE
```

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

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

Whilst calibration is in progress, the fourth (auxiliary, or *X*) data channel is switched to monitor the returning calibration signal.

SQUAREWAVE

Syntax: *component* SQUAREWAVE

Instructs the DM24 to inject a square-wave (step function) calibration signal, consisting of a positive step on the start of the next clock minute, followed by a negative step some minutes later (by default, 2). The calibration is disconnected the same number of minutes after the negative edge.

component specifies which component is to be calibrated, one of Z, N/S, E/W, or ALL. Some sensors use only the Z calibration loop for all three components.

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

Whilst calibration is in progress, the fourth (auxiliary, or *X*) data channel is switched to monitor the returning calibration signal.

RANDOMCAL

Syntax: *component* RANDOMCAL

Instructs the DM24 to inject a white-noise calibration signal generated by an onboard pseudo-random number generator.

component specifies which component is to be calibrated, one of Z, N/S, E/W, or ALL. Some sensors use only the Z calibration loop for all three components.

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

Whilst calibration is in progress, the fourth (auxiliary, or *X*) data channel is switched to monitor the returning calibration signal.

The pseudo-random number generator produces true white noise over the entire passband, as shown in the power spectral density plot below:

Power Spectral Density of broadband noise source
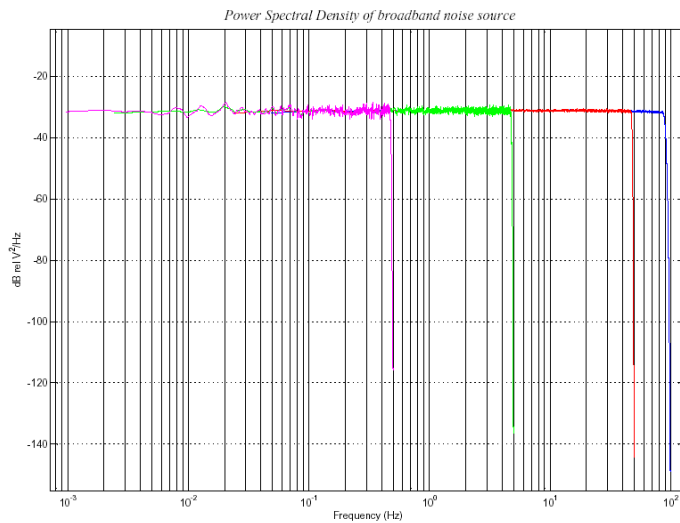
The different coloured lines show the results of experiments which measure the power spectral density over several frequency bands. Together, the results show a flat noise level over the entire passband to within experimental error.

MINUTE

Syntax: *duration* MINUTE

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

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

If you do not issue MINUTE, calibration signals will default to 2 minutes.

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

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

%AMPLITUDE

Syntax: *value* %AMPLITUDE

Sets the relative amplitude of the signal, as a percentage. For `SQUAREWAVE` and `RANDOMCAL` calibrations, the default of 100% is normally suitable. If you have a high-gain sensor, you may have to use a lower value. For `SINEWAVE` calibrations, you may have to adjust the `%AMPLITUDE` setting to suit the frequency of the calibration signal.

You can insert `%AMPLITUDE` commands into calibration commands as described above, *e.g.*:

```
Z 3 MINUTE 50 %AMPLITUDE RANDOMCAL
```

5.8 Actions

LOCK

Syntax: `LOCK` or `LOCK MONITOR`

Locks the sensor mass(es) of the instrument connected to *SENSOR A*.

If you issue LOCK, the command returns immediately, allowing you to close the terminal connection and follow the progress of the lock from the data streams.

If you issue `LOCK MONITOR`, the system displays the mass position for each component, measuring one position each second (*i.e.* one reading every 4 seconds for each component of a 4-component instrument.) The process returns when locking is complete.

The mass positions are measured to 16-bit accuracy, with full deflection corresponding to values around ±32000 counts.

UNLOCK

Syntax: `UNLOCK`

Unlocks the sensor mass(es) of the instrument connected to *SENSOR A*.

`UNLOCK` returns immediately, whilst `UNLOCK MONITOR` monitors the progress of the unlock by displaying mass positions, as for `LOCK MONITOR` (above.)

CENTRE

Syntax: `CENTRE`

Centres the sensor mass(es) of the instrument connected to *SENSOR A.*

`CENTRE` returns immediately, whilst `CENTRE MONITOR` monitors the progress of the unlock by displaying mass positions, as for `LOCK MONITOR` (above.)

When the masses are correctly centred, the mass positions should read less than ±1000 counts.

MASSES?

Syntax: `MASSES?`

Begins reporting the current mass positions for all three components, once per second, until you press a key. Mass position information is also output on Mux channels M8, M9 and MA, if you have enabled them.

Over time, and especially if the temperature changes significantly, the sensor masses may drift off centre. If this is not corrected, velocity output will eventually be lost.

%AUTO-CENTRE

Syntax: *distance* `%AUTO-CENTRE`

Instructs the DM24 to perform a round of centring whenever a mass position drifts further than *distance* from zero. *distance* is measured as a percentage of full scale.

Setting *distance* to zero disables automatic centring.

O/SNULL

Syntax: *component value* `O/SNULL`

Remove any DC offsets in a stream by applying a counter-offset in software. As manufactured, for technical reasons, the ADC nulling offset is set to around 75000 counts. You should only need to change this if the digitizer's CMOS RAM becomes corrupted; it is always better to zero the instrument by levelling and centring as far as is possible, or by adjusting potentiometers (in sensors where these are present.)

component specifies which component to adjust: 0, 1, 2, and 3 denote the Z, N, E and X components of *SENSOR A*, and 4, 5, 6 and 7 are the corresponding components of *SENSOR B*.

value specifies the adjustment to apply to the component.

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

RE-SYNC

This command is only available in units with a precision real-time clock module fitted.

Syntax: `RE-SYNC` *ON|OFF*

`RE-SYNC ON` instructs the DM24 to resynchronize the real-time clock module to GPS time when a GPS fix is next obtained.

`RE-SYNC OFF` cancels a previous `RE-SYNC ON` instruction, so that attaching a GPS module will no longer cause the DM24 to resynchronize.

?LITHIUM

This command is only available in units with a precision real-time clock module fitted.

Syntax: `?LITHIUM`

Query the current status of the RTC's internal battery. This command is in the extended dictionary: to use it, first type `ok-1` and finish with `[seal]`.

RE-BOOT

Syntax: `RE-BOOT` (interactive)

Causes the DM24 to reset after a delay of 2 s.

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

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

5.9 Filing

SHOW-FLASH

Syntax: `SHOW-FLASH`

Reports status information about the Flash memory in the DM24, if fitted. For example:

SHOW-FLASH for a new system with 8 × 64Mb chips fitted:

```
512MB Flash File buffer : 16 Blocks Written  0 Unread   524,288
Free
Oldest data  [16] Blank
 Read point  [16] Blank
Latest data  [16] Blank
File Replay  [16] Blank
```

SHOW-FLASH for a system in use with 1 × 64Mb chip fitted:

```
64MB Flash File buffer : 65,536 Blocks Written  65,532 Unread  4
Free
Oldest data  [36,272]  GURALP TESTZ1 2003 12 3 20:20:41
 Read point  [36,272]  GURALP TESTZ1 2003 12 3 20:20:41
Latest data  [36,268]  GURALP TESTX2 2003 12 4 10:09:12
File Replay  [36,272]  GURALP TESTZ1 2003 12 3 20:20:41
```

The first line displays general status information, namely the quantity of Flash memory available (64MB Flash File buffer), how many 1k GCF blocks have been written (65,536 Blocks Written), how many remain to be transmitted (65,532 Unread), and how much space (in 1k blocks) remains (4 Free).

The next lines show, in turn,

 · the stream and timestamp of the oldest data in memory,

 · the current position of the read pointer,

 · the stream and timestamp of the latest data in memory, and

 · the current position of the replay point.

The read pointer normally points to the oldest data in the file; however, if all the data up to the replay point has already been downloaded, the read pointer is set to the replay point and the number of blocks remaining Unread is updated. Downloads where a time-period is not specified always start from the read pointer.

RESET-FLASH

Syntax: RESET-FLASH

Resets the Flash memory pointers. The DM24 will start overwriting old data from the beginning of memory. You can still access this data, if it has not been overwritten.

ERASEFILE

Syntax: `ERASEFILE` (interactive)

Removes all data from the Flash memory, and resets all pointers to the beginning. You will be asked for confirmation before you do this, as all data will be destroyed.

If you have been running the DM24 with a Firewire disk attached, remember that there will be some data still in Flash memory awaiting transfer, up to the amount you last set with `MBTRANSFER`. You should make sure this data is transferred with the `DISKMENU` command before you `ERASEFILE`.

Depending on the amount of Flash memory installed, `ERASEFILE` may take several minutes to complete.

EVENTSLIST

Syntax: *`event-specification`* `EVENTSLIST`

Displays details of triggered events. *`event-specification`* can have several forms:

*   `RECENT`, to display the most recent events. By default, 16 events are displayed. You can double or halve this number by prefixing RECENT with either `SHORTER` or `LONGER`. You can use several of these commands, *e.g.*

    ```
    LONGER LONGER RECENT EVENTSLIST
    ```

    will display 64 events. The DM24 remembers this setting, so a further `LONGER RECENT EVENTSLIST` would display 128 events.

*   `EARLIER`, to display the previous set of events of the currently-configured length, *e.g.* if `RECENT EVENTSLIST` displays the 16 events #30 to #45, `EARLIER EVENTSLIST` will display the 16 events #14 to #29.

*   `COMPLETE`, to display all events currently held in Flash memory.

*   *`yyyy mm dd hh mm`* `SEARCH`, to look for events in the 10-minute period defined by *`yyyy mm dd hh mm`*, *e.g.*

    ```
    2005 12 26 04 13 SEARCH EVENTSLIST
    ```

will display events between 04:10 and 04:20 on 2005-12-26. The time format is the same as for `FROM-TIME` and `TO-TIME`, above.

If an event occurs, but nothing is filed (*e.g.* because the digitizer is in *DIRECT* mode), it will be listed with the message `No File`.

- two numbers *event-id* *number-of-events*, to display *number-of-events* starting at event number *event-id*.

RESET-LIST

Syntax: `RESET-LIST`

Empties the events list. You will no longer be able to see event information with the EVENTSLIST command, or download events with EVENTS (see below.)

This command does not delete any data. If you empty the events list, and the digitizer is in a suitable filing mode, you can still download event data using the commands in Section 5.10, "Downloading over the serial port".

DIRECT

Syntax: `DIRECT`

Instructs the DM24 not to use Flash memory for storage. Instead, all data is transmitted directly to clients. A temporary RAM buffer allows clients to request blocks they fail to receive using the Block Recovery Protocol.

FILING

Syntax: `FILING`

Instructs the DM24 not to transmit blocks to clients, but to store all digitized data in the Flash memory. The memory is used in circular fashion, *i.e.* if it becomes full, incoming blocks begin overwriting the oldest in memory.

DUPLICATE

Syntax: `DUPLICATE`

Instructs the DM24 to transmit all new data directly to clients (as in DIRECT mode) as well as storing it in Flash memory (as in FILING mode). If a client fails to acknowledge a block, the digitizer does not attempt to retransmit it.

DUAL

Syntax: DUAL

Instructs the DM24 to transmit any *continuous* streams directly to clients (as for DIRECT mode) but to store *triggered* data into Flash storage (as for FILING mode.)

If you choose this mode, the instrument will send heartbeat messages in addition to any continuous streams you have configured. Scream! can pick these up and download new data as necessary.

ADAPTIVE

Syntax: ADAPTIVE

Instructs the DM24 to transmit current blocks to clients if possible, but to store all unacknowledged blocks in the Flash memory and re-send them when time allows. This differs from DIRECT in the following ways:

- the client does not have to keep track of which blocks it has not received, and

- the entire Flash memory can be used for blocks awaiting retransmission, rather than a temporary RAM buffer.

Adaptive mode is best suited for installations where the link between digitizer and client is intermittent or difficult of access.

FIFO

Syntax: FIFO

Instructs the DM24 to begin writing new blocks to Flash memory as for FILING, but also to transmit data to clients. Data is transmitted in strict order, oldest first; the DM24 will only transmit the next block when it receives an acknowledgement of the previous block. Once a block is transmitted, it is marked as such in the Flash memory, and may be overwritten later.

HEARTBEAT

Syntax: *interval* HEARTBEAT

When the DM24 is in *FILING* mode, it outputs status messages periodically over the RS232 port (see Section 6.1, page 84.) This command changes how often these messages are produced.

If the digitizer has been configured to dial out over a modem link (see +MODEM, above), it will dial out whenever it generates a heartbeat message.

interval is measured in units of 30 ms. For example, issuing

600 HEARTBEAT

will cause the DM24 to output heartbeat messages every (600 × 30) = 18000 ms = 18 s.

Alternatively, you can insert the word HOUR and specify *interval* in hours:

5 HOUR HEARTBEAT

The maximum value allowed for HEARTBEAT is 300 000 000 (= 2500 HOUR).

If you connect to a digitizer in FILING mode using Scream!, Scream! will not detect the digitizer until it has sent a heartbeat message. Therefore, you should use a relatively short heartbeat interval if you have a continuously-connected instrument.

MS-GAP

Syntax: *interval* MS-GAP

Sets the interval the digitizer should wait for a GCF ACK (acknowledged) message, before assuming that the block could not be transmitted.

If a period of *interval* passes without an acknowledgement, the digitizer's behaviour depends on the current filing mode (see above.)

interval is measured in milliseconds. The default is 150. If the value is greater than the average time between blocks being generated, and an outage occurs in the return communications link, the digitizer will be producing data faster than it can transmit it, and gaps will start to

be observed. However, systems using slower communications links (*e.g.* radio links) may be unable to acknowledge blocks in under 150 ms. You should choose a value for *interval* which is suitable for your particular installation.

RE-USE

Syntax: `RE-USE`

Instructs the DM24 to use its Flash memory as a circular buffer, overwriting the oldest data when it becomes full.

In this mode, the Flash memory will always contain the latest data.

WRITE-ONCE

Syntax: `WRITE-ONCE`

Instructs the DM24 not to overwrite data in the Flash memory when it becomes full Instead, when the digitizer runs out of space, it switches to *DIRECT* filing mode and will leave the Flash memory untouched.

MODE?

Syntax: `MODE?`

Displays the current disk usage mode (`RE-USE` = Circular; `WRITE-ONCE` = Write Once.)

5.10 Downloading over the serial port

DOWNLOAD

Syntax: `DOWNLOAD`

Sets up a data transfer from the Flash memory over the serial connection. Which data is downloaded depends on various parameters you can set, which allow you to select a particular stream, streams of a specified sample rate, or streams within a certain time window. You can set parameters separately, or string the definitions before the `DOWNLOAD` command, *e.g.*

```
ALL-FLASH STREAM HPA0N1 DOWNLOAD

2004 12 01 00 00 FROM-TIME ALL-DATA DOWNLOAD

100 S/S ALL-TIMES DOWNLOAD
```

`DOWNLOAD` (starts another download with the same parameters as last time)

See below for full details of the parameter commands.

The `DOWNLOAD` command returns immediately, so that you can issue more commands if required. To close the connection and begin downloading, issue the `GO` command. You can pause the download by entering terminal mode, and restart with another `GO` or abort with `END-DOWNLOAD`.

ALL-FLASH

Syntax: `ALL-FLASH`

Sets the read point to the oldest data held by the DM24. This command does not alter which streams are to be transmitted; you should specify streams or use the `ALL-DATA` command in addition to this one.

ALL-DATA

Syntax: `ALL-DATA`

Instructs the DM24 to transmit all the data streams it holds next time a `DOWNLOAD` is issued. This command does not alter the read point or time period; you should specify a time period or use the `ALL-FLASH` command in addition to this one.

STREAM

Syntax: `STREAM` *stream-id* (*n.b.*)

Instructs the DM24 to transmit only the stream with ID *stream-id*. Stream IDs are normally a 4-character device code (*e.g.* `HPA0`) followed by a component letter (`N`) and a tap number (`1`).

Unlike most FORTH commands, the *stream-id* parameter goes *after* the command.

STATUS-ONLY

Syntax: `STATUS-ONLY`

Instructs the DM24 to transmit only status streams (text streams, normally with stream IDs ending in `00`.)

S/S

Syntax: `rate S/S`

Instructs the DM24 to transmit only streams with sample rates equal to *rate*. If *rate* is zero, only status streams are transmitted.

Note that this command should not be confused with the `SAMPLES/SEC` command.

ALL-TIMES

Syntax: `ALL-TIMES`

Clears any time selection in force, allowing you to download all data held by the DM24. This command does not alter which streams are to be transmitted; you should specify streams or use the `ALL-DATA` command in addition to this one.

FROM-TIME

Syntax: `yyyy mm dd hh mm FROM-TIME`

Instructs the DM24 to transmit only data more recent than *yyyy*-*mm*-*dd hh*:*mm*, where

- *yyyy* is a four-digit year (1989 – 2069);

- *mm* is the month number (1 – 12);

- *dd* is the day of the month (1 – 31);

- *hh* is the hour of the day (0 – 23); and

- *mm* is the minute of the hour (0 – 59).

TO-TIME

Syntax: `yyyy mm dd hh mm TO-TIME`

Instructs the DM24 to transmit only data older than *yyyy*-*mm*-*dd* *hh:mm*, where *yyyy*, *mm*, *dd*, *hh* and *mm* have the same meanings as in FROM-TIME, above.

EVENTS

Syntax: *event-specification* EVENTS

Instructs the DM24 to transmit only data recorded during triggered events. *event-specification* can have several forms:

- RECENT, to download the most recent events. By default, 16 events are displayed. You can double or halve this number by prefixing RECENT with either SHORTER or LONGER. You can use several of these commands, *e.g.*

  LONGER LONGER RECENT EVENTS

  will download 64 events. The DM24 remembers this setting, so a further LONGER RECENT EVENTS would download 128 events.

- EARLIER, to download the previous set of events of the currently-configured length, *e.g.* if RECENT EVENTS downloads the 16 events #30 to #45, EARLIER EVENTS will download the 16 events #14 to #29.

- COMPLETE, to download all events currently held in Flash memory.

- *yyyy* *mm* *dd* *hh* *mm* SEARCH, to look for events in the 10-minute period defined by *yyyy* *mm* *dd* *hh* *mm*, *e.g.*

  2005 12 26 04 13 SEARCH EVENTS

  will download events between 04:10 and 04:20 on 2005-12-26. The time format is the same as for FROM-TIME and TO-TIME, above.

  If an event occurs, but nothing is filed (*e.g.* because the digitizer is in *DIRECT* mode), it will be listed with the message No File.

- two numbers *event-id* *number-of-events*, to download *number-of-events* starting at event number *event-id*. You can find out *event-id* using the command EVENTSLIST (above.) Thus, if EVENTSLIST returns

```
#   7  Filed @ 63,772   PLPGG SBHYZG 2006  1  4 16:07:50
#   8  Filed @ 63,812   PLPGG SBHYZG 2006  1  4 16:22:24
#   9  Filed @ 63,952   PLPGG SBHYZG 2006  1  5 10:14:59
#  10  Filed @ 64,005   PLPGG SBHYZG 2006  1  5 10:16:49
#  11  Filed @ 64,039   PLPGG SBHYEG 2006  1  5 10:17:45
```

you can instruct the digitizer to download these 5 events with the command

```
7 5 EVENTS
```

Once you have specified the events to be downloaded, issuing `DOWNLOAD` will make the DM24 begin transmitting data as soon as your terminal session is ended.

GO

Syntax: `GO`

Closes terminal mode, and begins the download you have set up. You can pause the download by re-entering terminal mode, and restart with another `GO` or abort with `END-DOWNLOAD`.

Once the download has completed, the DM24 will carry on transmitting real-time data, if you have so configured it.

END-DOWNLOAD

Syntax: `END-DOWNLOAD`

Aborts any downloads which were in progress at the time you entered terminal mode.

5.11 Downloading over FireWire

DISKMENU

Syntax: `DISKMENU` (interactive)

Allows you to select various options for downloading data over the optional FireWire interface. When you issue this command you will see the message

```
Plug in FireWire cable
```

and the DM24 will wait for you to plug in a compatible disk. When it detects one, it will print out information about the disk:

```
FireWire Connection *BR
Node: FFC1 #Nodes 2
Reading Node FFC0 .
LaCie Group SA
1394-IDE Rev B2
LaCie DATA BANK drive LUN 0
Logging on @AgentCSR= 0010:00000
Capacity 39.0GB

Press a key for options else
7 seconds to automatic disk backup
```

At this point, pressing a key will cause the DM24 to bring up an options menu and pause. If you do not press a key in 7 seconds, the disk will be automatically backed up.

```
Disk Options :-
 (A) save All data
 (N) save New data
 (S) save Selected time window
 (D) Directory - contents
 (R) Reset disk - overwrite
 (X) eXit
 A/N/S/D/R/X ?
```

During the operation of any of these options, progress reports will occasionally be printed out and shown on the terminal.

MBTRANSFER

Syntax: *size* MBTRANSFER

If a Firewire disk is plugged in to the DM24 outside the DISKMENU system, and there is enough new data in Flash memory, it will automatically transfer the new data to the disk.

The MBTRANSFER command sets how much new data there needs to be, before the DM24 will power up the disk and transfer it. If the disk is left attached, the DM24 will then wait until it has collected the same amount of data again before starting another transfer.

size is the amount of data to transfer, in megabytes; it must be greater than 10 and less than the total quantity of Flash memory in the device. Larger values will save power, because the disk needs to be accessed less often.

If you plug a Firewire disk into the DM24 when there is less than *size* Mb of data ready, no data will be transferred. If you need to transfer smaller amounts of data, you should use the DISKMENU system.

DIR

Syntax: `DIR` (interactive)

Lists the files you have downloaded on to a FireWire disk. When you issue this command you will see the message

```
Plug in FireWire cable
```

and the DM24 will wait for you to plug in a compatible disk. When it detects one, it will print out information about the disk, and list all the files that are present. Each time you issue `DISKMENU` to download data, or power on the digitizer with a FireWire disk connected, a new file is created.

6 Inside the DM24

6.1 State of health information

The DM24 outputs diagnostic information in a *status stream*. This is a special GCF stream whose name ends in 00.

Status streams can take two different forms, depending on the current filing mode:

- In FILING mode, a short *heartbeat message* summarizing the current status is transmitted at intervals of between 10 seconds and a few minutes. This interval is configurable. The heartbeat message lets clients know that the digitizer is still operational, even though it is not sending data. For example, if you connect a PC running Scream! to an autonomous station over a dial-up link, Scream! can automatically download recorded data: this is made possible by the heartbeat message, which tells Scream! that the data exists.

- In other modes, status messages are output continuously, in GCF blocks. When each block is full, it is transmitted from the *DATA OUT* port with the rest of the data.

Heartbeat messages

These are output at fixed intervals, and always have the same format. Older digitizers may not include all the lines described here.

```
   64MB Flash File buffer : 65,520 Blocks Written  65,520 Unread
16 Free
  Latest data  [392]       PLPGG SBHYX2 2006  1 18 14:55:57
  Oldest data  [400]       PLPGG SBHYN4 2005 11 30 06:47:38
  #  22 2006  1 18 14:48:36  No File Last Event
  2006  1 18 14:56:15 1 MicroSeconds Fast  Freq error 0 e-9  Auto
3D [-4]
  PLPGG SBHY00 CMG-3T
  Boot Log :   143 Power cycles    294 Watchdog resets
  Last boot  2006  1 12 16:18:57    2006  1 17 17:15:14
  2006  1 18 14:56:15 External supply : 13.0V Temperature  24.68'C
  2006  1 18 14:56:15 Mass positions   -486    -300    -424
```

Flash memory usage

The first three lines describe the internal Flash memory. First, the overall usage is described:

```
   64MB Flash File buffer : 65,520 Blocks Written  65,520 Unread
16 Free
```

Here, a 64 Mb Flash memory store contains 65,520 data blocks, of which none have already been downloaded. This leaves 16 blocks of free space, since each block is exactly 1Kb long, and (65,520 + 16) × 1 Kb = 65,536 Kb = 64 Mb.

```
  Latest data  [392]      PLPGG SBHYX2 2006  1 18 14:55:57
  Oldest data  [400]      PLPGG SBHYN4 2005 11 30 06:47:38
```

These two lines show the date and time of the oldest and newest data in the buffer, together with the *System ID* (PLPGG) and the *Stream ID* (SBHYX2 and N4) of the corresponding data stream.

Triggered events

```
#  15  Filed @ 64,167  PLPGG SBHYZG 2006  1  5 10:31:30  Last
Event
```

This line gives the date and time of the last trigger, together with its *System ID* and *Stream ID* as above. Also given is the event sequence number (as used by the EVENTSLIST command), and the position in the buffer where data from the event begins.

If a trigger has occurred, but no data was output (*e.g.* because the digitizer was in *DIRECT* filing mode), the digitizer will report

```
#  22 2006  1 18 14:48:36  No File Last Event
```

GPS

The next line describes the current status of the GPS system. When the digitizer is first powered up, the message will be something like

```
2005 8 10 12:35:00 GPS control OFF  Auto 3-D [-5 Not sync'd]
```

The message GPS control OFF denotes that the clock is not yet being controlled by the GPS. Owing to noise purposely injected into the GPS timing stream, as well as issues of signal travel time, the GPS time cannot be directly used to synchronize the clock. Instead, the digitizer maintains a rolling average of time measurements, and uses this to apply corrections to the clock so that it remains accurate over a long period.

The Auto 3-D message denotes that the signal is strong enough to obtain a full 3-dimensional GPS fix. If the signal is weak, or there are few satellites visible to the receiver, you may see Auto 2-D here. If the signal is too weak to obtain a fix, No FIX will be displayed.

After a short time, the message will change to

```
2005 8 10 12:36:00 GPS Control settling  Auto 3-D [-5 Not sync'd]
```

Eventually, the GPS control system will be able to synchronize the internal clock, and the message will change to

```
2005 8 10 12:38:01 GPS Control settling  Auto 3-D [-4]
2005 8 10 12:41:01 326 MicroSeconds Slow  Freq error -7 e-9  Auto
3-D [-4]
```

The system is now reporting the current offset of the internal clock from GPS time (whether slow or fast), and the current frequency error. It will now continuously adjust the internal clock for as long as the GPS is powered up.

If you have chosen to save energy by enabling *GPS power cycling*, the DM24 will switch off the GPS once a satisfactory fix is obtained, and begin free-running on the internal clock. Whilst this is happening, the line will report

```
2005 8 10 17:06:27 GPS switched Off
```

Boot status

```
PLPGG SBHY00 CMG-3T
Boot Log :   143 Power cycles    294 Watchdog resets
Last boot  2006  1 12 16:18:57   2006  1 17 17:15:14
```

These three lines repeat information from the last re-boot:

- in the first, the *System ID*, the *Stream ID* of the status stream, and the current *Sensor Type*;

- in the second, the number of times the digitizer has been power cycled, and the number of times it has been reset without power cycling (*e.g.* by a `re-boot` after reconfiguring the module: a "soft" reset)

- in the last, the date and time of the last power cycle and of the last soft reset.

Environmental measurements

```
2006  1 18 14:56:15 External supply : 13.0V Temperature  24.68'C
```

The next line displays the current state of the DM24's power supply, and its internal temperature.

Mass positions

```
2006  1 18 14:56:15 Mass positions  -486    -300    -424
```

The final line provides the instantaneous mass positions reported by the sensor at the time given.

Status blocks in continuous mode

In continuous mode, each status block contains a number of single-line messages:

```
2006  1 18 14:38:00 o/s=      90 drift=      0 pwm= 8187  Auto 3D
2006  1 18 14:39:00 o/s=      90 drift=      0 pwm= 8187  Auto 3D
2006  1 18 14:40:00 o/s=      90 drift=      0 pwm= 8187  Auto 3D
2006  1 18 14:41:00 o/s=      90 drift=      0 pwm= 8187  Auto 3D
2006  1 18 14:42:00 o/s=      90 drift=      0 pwm= 8187  Auto 3D
2006  1 18 14:43:00 o/s=      78 drift=    -12 pwm= 8188  Auto 2D
2006  1 18 14:44:00 o/s=      89 drift=     11 pwm= 8188  Auto 3D
2006  1 18 14:45:00 o/s=      94 drift=      5 pwm= 8188  Auto 3D
2006  1 18 14:45:00 External  supply : 13.0V Temperature  24.62'C
2006  1 18 14:46:00 o/s=     148 drift=     54 pwm= 8188  Auto 3D
2006  1 18 14:47:00 o/s=     174 drift=     26 pwm= 8188  Auto 3D
2006  1 18 14:48:00 o/s=     211 drift=     37 pwm= 8188  Auto 3D
2006  1 18 14:48:36 SOFTWARE Trigger  : Trigger# 22
2006  1 18 14:49:00 o/s=     263 drift=     52 pwm= 8187  Auto 3D
2006  1 18 14:49:10 End of Trigger
```

The messages appear in the order they are generated by the different software modules inside the digitizer.

GPS status messages

The status of the attached GPS receiver is reported every minute:

```
2006  1 18 14:47:00 o/s=    174 drift=    26 pwm= 8188  Auto 3-D
```

In this line:

- o/s gives the current offset of the internal clock from GPS time, in microseconds;

- drift is the difference between the current o/s and the last, which gives an indication of the level of drift;

- pwm, or *Pulse Width Modulation*, is the feedback control parameter;

- Auto 3-D denotes that enough GPS satellites are currently visible to obtain a full 3D fix.

- If `No Fix` is displayed, the GPS received has not (yet) been able to obtain a satisfactory fix.

- If `Missing PPS` is displayed, the digitizer has received fewer than 60 pulses on the 1pps (pulse per second) line in the last minute. You will see at least one `Missing PPS` message in the first minute of operation.

Every 20 minutes, at 10, 30 and 50 past the hour, the GPS synchronization status is displayed. This line has the same format as the GPS line in the heartbeat message, *e.g.*

```
2005 8 10 12:41:01 326 MicroSeconds Slow  Freq error -7 e-9  Auto
3-D [-4]
```

Finally, every hour, the DM24 displays general timing and position information, including details of the visibility of GPS satellites:

```
2005 6 8 11:00:00 GPS Date/Time 08/06/05 11:00:00
2005 6 8 11:00:00 Auto 3-D  SV#'s 4 7 13 20 23 24 25   ( 7 )
2005 6 8 11:00:00 Lat 51'21.6591N  Long 001'09.8218W
```

Trigger notifications

When a trigger occurs, a message is immediately saved to the current status block. You may not see this message straight away, however, since the status block must be full before the digitizer will send it.

```
2006  1 18 14:48:36 SOFTWARE Trigger  : Trigger# 22
```

The trigger type is mentioned, as well as the sequence number (for later retrieval, if necessary, using the `EVENTSLIST` command.) When the trigger condition passes, the system reports

```
2006  1 18 14:49:10 End of Trigger
```

Environmental measurements

These are measured every 10 minutes (at 5, 15, 25, 35, 45 and 55 past the hour), and are given in the same form as for heartbeat messages:

```
2006  1 18 14:45:00 External supply : 13.0V Temperature  24.62'C
```

6.2 Updating firmware with Scream!

You can update the digitizer firmware using any terminal program which supports the Xmodem protocol, such as `hypertrm` or newer versions of Scream!. If you are using Scream!, right-click on the digitizer's icon in the main window and select **Terminal** from the pop-up menu:
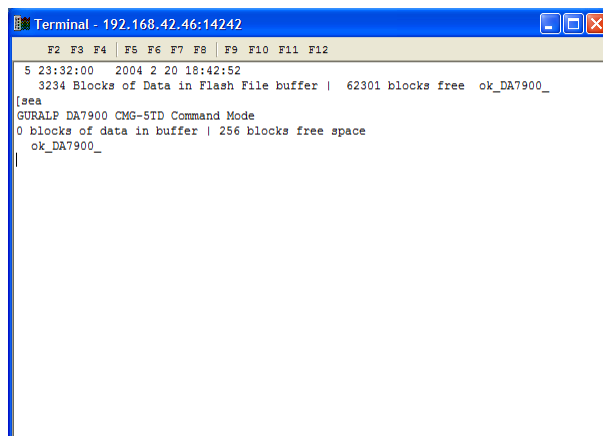
Check that there is two-way communication with the digitizer by pressing Enter. The digitizer should reply with ok on a new line.

Type `re-boot` to reinitialize the digitizer, and confirm with `y`. As it is restarting, the digitizer will report its status over the terminal connection, followed by a maintenance menu:

```
MPE ARM ANS ROM PowerForth v6.20
ARM Serial BootStrap v1.100, 11 August 2003
Copyright (c) 2002-3  GSL, EDSL & MicroProcessor Engineering Ltd.
Port 0 38400 baud
Port 1 38400 baud
Port 2 38400 baud

Guralp Systems Ltd - ARM-BOOT v01.0 mgs 29/07/04 [b 015]
System Code versions loaded :-
0103:0000 Guralp Systems Ltd  DMARM  v01.0 mgs 09/07/04 [Build
017]
0107:0000 Guralp Systems Ltd - DM+FW  v01.1  mgs  11/08/04 [Build
007]    Default
010B:0000 Blank
DSP Code :
0101:0000  ARMT16D16-050304.BIN
0102:0000  dsprot037.bin 04/08/04         Default
Command keys:
C - set real time Clock (2004 8 13 09:29:48 )
I - view/upload InfoBlock
F - run the Forth monitor
R - Run an application
E - Erase an application
S - update System program
B - update Boot program
```

```
D - update DSP code
N - set the default application Number (3)
Q - Quit maintenance system
3  seconds to auto-start
Enter command:
```

If you do not press a key in the next 5 seconds, the DM24 will start up normally.

The DM24 has three firmware components, which can be updated separately: the system program, the DSP code and the boot loader. Firmware releases are available on the Güralp Systems website. If a release updates more than one component, you should be sure to update the boot loader first, then the system program and DSP code.

Loading a new system program

To update the system firmware, press S at the maintenance menu. The digitizer will display

```
Update System program
```

There are three slots available for system application code. The digitizer will use the slot *following* the one currently set as Default. You should note which slot is currently in use, so that you can revert to the old firmware in case of a problem.

The digitizer will then request a transfer using the Xmodem protocol. If you are using Scream!, a file browser window will appear automatically.

Navigate through the directories on your computer and select the file to be uploaded, or type in its full path and file name. Click **Open**.
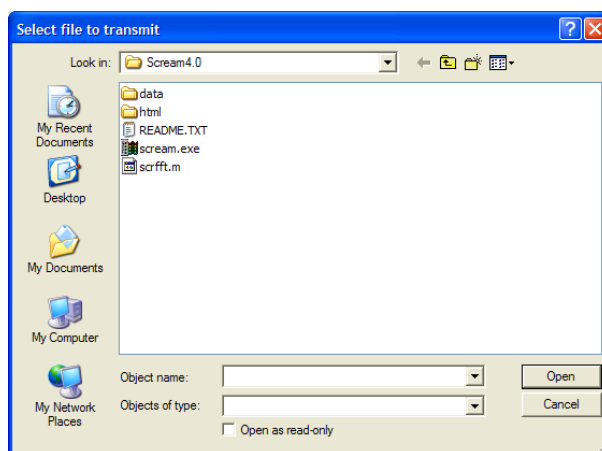
Whilst the file is loading, a progress window will be displayed. Depending on the speed of the link, it may take up to 20 minutes to transfer the firmware.

Once the file is fully transferred, the DM24 will return to the maintenance menu. Press ENTER, and wait whilst the system boots.

You can run system code other than the default by pressing R at the maintenance menu, followed by the slot number of the new code. This will run the DM24 with the new firmware for one session only. When it is rebooted, the DM24 will revert to the Default application.

Loading new DSP code

Press D at the maintenance menu. The digitizer will reply with

```
Enter 0/1 to select DSP code to update
```

Select which of the two DSP code slots you want to overwrite, and press ENTER. The default is always 0.

```
Enter Filename/date - upto     31 characters
```

You can enter a descriptive string for the DSP code here. The DM24 will print this string at every boot-up, to remind you which version of the DSP code you are using.

When you press ENTER, the digitizer will then request a transfer using the Xmodem protocol, as described above.

Loading a new boot loader

There is only one slot available for the boot loader. Press B at the maintenance menu to update it.

The digitizer will then request a transfer using the Xmodem protocol, as described above. **Be sure to check beforehand that the file is a valid DM24 boot loader!** Replacing the boot loader with invalid code will make it impossible to boot up the digitizer.

When you are returned to the maintenance menu, press Q or wait 30 seconds for the system to restart.

6.3 Setting up external triggering

Güralp digitizers and digital instruments can be supplied with external triggering capabilities installed. The external trigger system is designed

for maximum flexibility: you can trigger other digitizers or your own equipment using built-in relays, or any equipment may be used as a trigger source. In addition, a trigger circuit can link together any number of digitizers so that they trigger simultaneously when they receive a signal.

Overview

The digitizer or digital instrument has two internal components related to triggering.

- The trigger generator runs the triggering algorithm and determines whether a trigger has occurred. If external trigger *output* has been enabled, the trigger generator also operates a relay which connects the two *Trigger Out* pins of the *DATA OUT* port. These are normally pins E and F.

  The *Trigger Out* pins are only connected whilst the *generator* is active. This does not include any pre-trigger or post-trigger period, which is dealt with by the trigger receiver. A trigger signal may be as short as one second.

- The trigger receiver acts upon trigger signals: normally, by recording additional data streams. The receiver will always start recording if the trigger generator produces a signal. If external trigger *input* has been enabled, the receiver will also act on a logic signal received on the *Trigger In* pin of the *DATA OUT* port.

  Any signal between +3 and +30 V referenced to power ground (pin A) can be used: the instrument's own power supply (pin B) can be used if you wish.

The *Trigger Out* pins are *not* connected if you provide a *Trigger In* voltage. The instrument must trigger *itself* for the relay to switch. This arrangement prevents any trigger loops from occurring.

The diagrams on this page show the additional connections you will need to make. Pins A and B, and the data pins, should be connected to your power and data systems as normal.

Triggering your own equipment
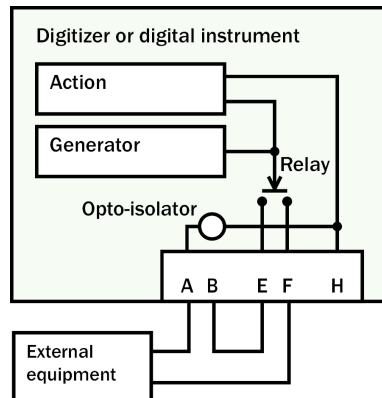
If your equipment can trigger from 24 V DC, the simplest arrangement is to use the voltage across the sensor's power supply as a trigger.

- Connect the ground pin A to your equipment's trigger return line. If your equipment does not have a separate trigger return line, consult its documentation for how to apply trigger voltages. Güralp digitizers use the power ground line as a trigger return. (The diagram above does not show the power supply to either the sensor or the triggered equipment: only the triggering system is shown.)

  Because a trigger signal may last for only a short time, inserting pins E and F directly into your equipment's power circuit is not normally advisable. Ideally, the equipment should be continuously powered and listening on dedicated trigger input lines. If this is not possible, it may be enough to build a control circuit with a time-out period, which supplies your equipment with power for a suitable minimum length of time whenever pins E and F are connected.

  The digitizer cannot anticipate a trigger. Pre-trigger recording is achieved using a continuously-updated buffer of the most recent data. Any external equipment must have its own buffering capabilities if you need pre-trigger data.

- Connect pin B to pin E, and pin F to your equipment's trigger signal input.

- Connect the remaining pins as normal.

If your equipment needs a different voltage, you will need to provide a separate voltage source for the triggering system. Be careful not to connect two power supplies together. The instrument's power supply can be protected by inserting a diode from pin B to pin E (see below.)

Using an external trigger source
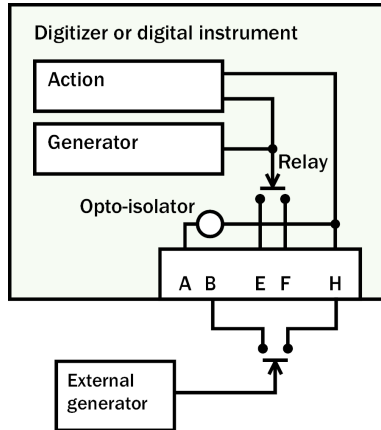
To trigger an instrument from an external source through a relay:

- Connect a relay between pins B and H, connected to your generator so that the two pins are connected when a trigger occurs.

- The relay allows you to power the external generator from any source. This includes the instrument's own power supply at pins A and B, if it is suitable.

- Connect the other pins as normal.
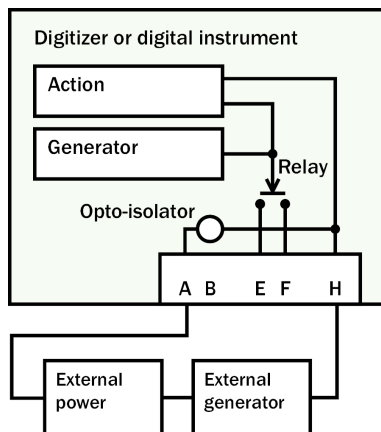
If you prefer, you can use a separate power source for your trigger generator. However, because pin H is referenced to power ground, the external power supply must share a common ground with that of the digitizer.

Triggering several Güralp instruments simultaneously

A common use of the external triggering feature is to ensure that all instruments in an array trigger at the same time. This can be achieved with the wiring layout below. With this arrangement, any instrument can generate a trigger, which will be passed on to all the instruments in the array.
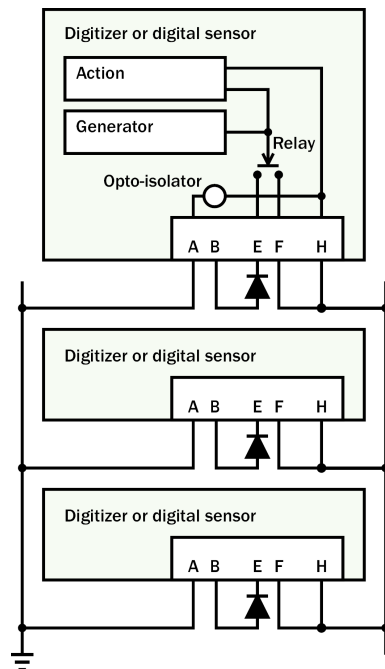
For each instrument:

- pin A is connected to a common ground,

- pin B is connected to the instrument's power supply as normal and also to pin E through a diode,

- pins F and H are connected to each other and to a common trigger line, and

- the remaining data pins are connected to your recording equipment as normal.

The diode at pin E is important, because if two instruments generate a trigger simultaneously, their power supplies will be connected *via* the trigger line. If all your instruments share the same power supply, you may not need the diode.

6.4 Technical details

Internally, DM24 digitizers are structured as shown in the following diagram, where each box represents a separate internal subsystem.
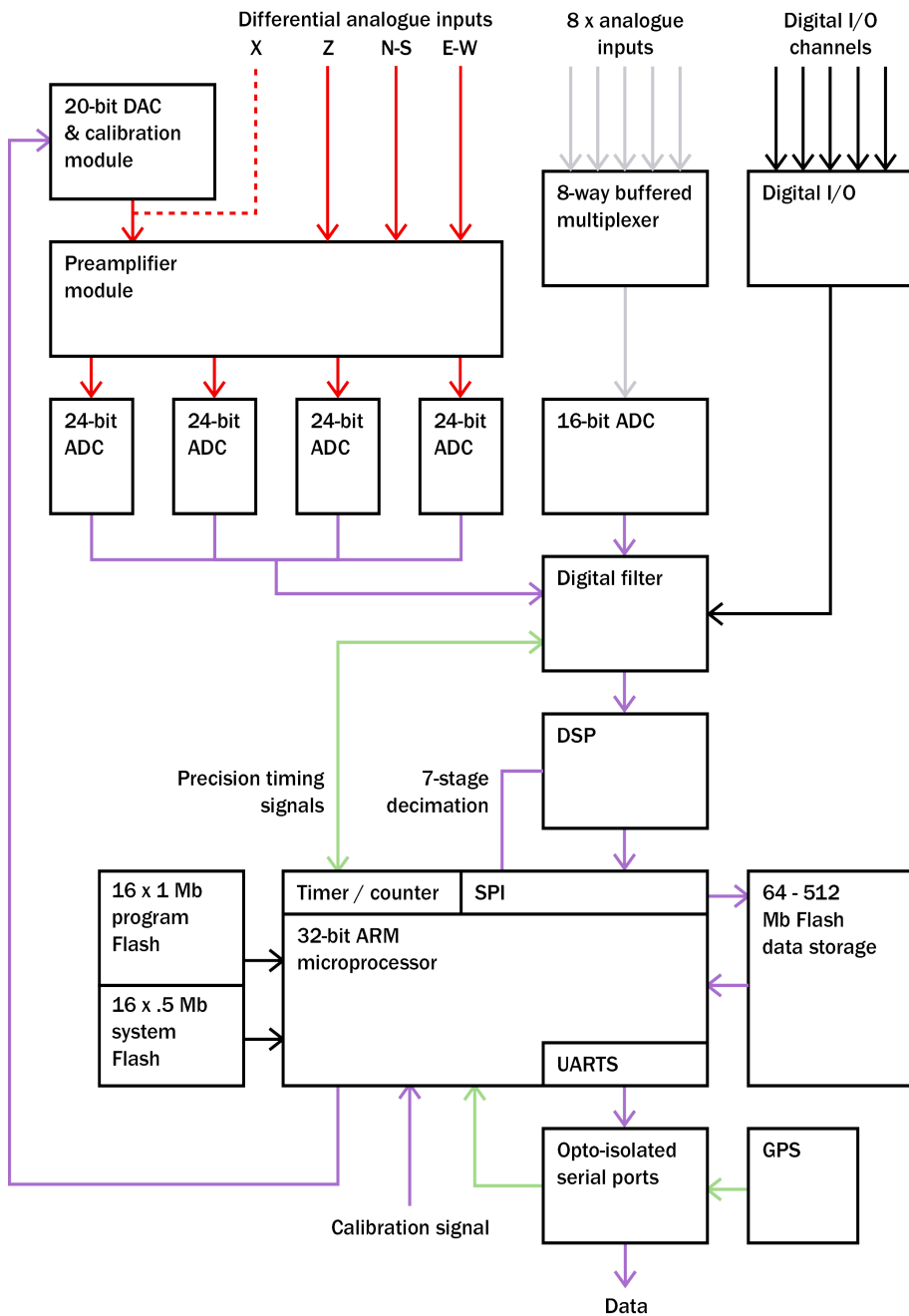
The system is designed around a low power, high performance ARM microprocessor. This is a 32-bit processor with a large address space for data storage and manipulation. It also includes many integrated functions such as multiple timers and serial I/O ports. In addition, the system contains a Cirrus Logic CS5376 digital filtering chipset and TMS320VC33 digital signal processor (DSP). The CS5376 provides data to the DSP at 2,000 samples per second, triggered by timing signals from the ARM processor. The DSP can control all 5 ADCs and process the data in real time.

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. This way, data samples are accurately time stamped at source. To keep sampling accurately in step with UTC, you can synchronise the microprocessor's time-base to an external reference such as GPS, or in larger arrays to a centrally-transmitted time reference. Transmitting a time reference avoids the cost and power consumption of multiple GPS receivers, and since it only involves sending 2 characters per second it can utilise a low bandwidth, even half-duplex link.

To achieve the high degree of timing precision required for a 24-bit digitizer system, the microprocessor time-base is run from a precision voltage controlled oscillator. On-board software keeps this oscillator tuned to the external reference so that its frequency is accurately set and maintained through changes in temperature or ageing. Once the system has stabilised, the control is sufficiently accurate to maintain precision sampling for several days without an external reference. The system also automatically compensates for the pure time delay introduced by the digital filtering/decimation processes in the DSP.

The DSP software consists of 6 cascaded programmable filter/decimation stages, which allow you to select multiple data output rates simultaneously. Each stage can be set individually for decimation factors of 2, 4, or 5. Data can be output at any or all of these rates according to constraints of 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 ARM microprocessor.

The primary digital interface for the systems is the multiple serial port card, which allows the DM unit to support up to 8 serial ports using the ARM's on-board UARTs (Universal Asynchronous Receiver/Transmitters). On a DM unit with analogue inputs one serial port is usually configured to send the data packets to a local SAM or DCM unit for storage, or via a modem or radio link to a central

recording station. A second serial port is often used with a local GPS receiver for time synchronization, or alternatively the first (data) port can be used for time synchronization from a central station.

The UARTs and serial port module are optically isolated to avoid any ground loops that could degrade the performance of the ADC's. The serial port module also includes 32k of RAM for data buffering and formatting by the transmission/reception process.

7 Güralp Compressed Format

Güralp Systems sensors and data modules use Güralp Compressed Format (GCF) to share seismic data. The format can be used for data storage or transmission over a serial link or TCP/UDP network.

This section describes the specification of GCF format.

7.1 GCF blocks

A GCF file or stream consists of a sequence of *blocks*, which can be up to 1024 bytes long. Each block consists of a 16-byte header followed by either

- a series of data records, containing initial and final sample values and a sequence of first differences between intervening sample values, or

- status information in ASCII text format.

The format of the block's body is determined by information in the header.

The GCF header

The header is 16 bytes long, split into four 4-byte fields:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
System ID				Stream ID				Date code				Data format			

System ID : If the top bit of this field is unset, the bottom 31 bits of this field specify a label of up to 6 characters identifying the originating system, encoded as a base 36 number. The base 36 digit in each position corresponds to a single character (0 – "0" ... 9 – "9" , 10 – "A" ... 35 – "Z"), with the least significant digit placed at the right-hand end of the string.

If the most significant base 36 digits are zero, they are omitted from the string; hence the encoding 1 corresponds to the string 1, not 000001.

For example, the string HPA1 would be encoded as the number $(17 \times 36 \times 36 \times 36) + (25 \times 36 \times 36) + (10 \times 36) + 1 = 825913$.

The field is a signed 31-bit positive integer, allowing System IDs up to ZIK0ZJ.

If the top bit of this field is set, the bottom 26 bits of this field specify a label of up to 5 characters using the same encoding. In this case, the field is a signed 26-bit positive integer, allowing System IDs up to ZZZZZ. Bits 26 – 30 of the System ID field are reserved in this case.

Stream ID : a unique 6-character label identifying the device, component and sample rate:

1	2	3	4	5	6
Device serial number				Component	Output tap

The 6-character label is encoded in 4 bytes as a base 36 number, in the same manner as the *System ID*, above.

Date code : The date and time when the data in the block begins, expressed as a 32-bit number where

- the bottom 17 bits are the time in seconds since midnight, normally between 0 and 86399 but possibly 86400 or 86401 in years with 'leap seconds'; and

- the top 15 bits are the Güralp day number, with day zero on 17 November 1989. The day number increments when the seconds number rolls over at midnight.

Data format : The final header element contains 4 bytes defining the format of the data in the block:

1	2	3	4
reserved	Sample rate	Compression code	Number of data records

Sample rate : The sample rate of the data records, an integer number of samples per second. If this field is zero, the block body contains status information in ASCII text format.

Compression code : A code for the compression format used for all the data in the block. Currently accepted values are

1	Data records contain one 32-bit difference
2	Data records contain two 16-bit differences
4	Data records contain four 8-bit difference

Other values are reserved for future expansion.

Number of data records : The number of 32-bit data records in the block. Combining this with the compression code enables you to find out the total number of sample points in the block; dividing by the sample rate allows the time duration of the block to be determined. You should check for status blocks (which have *Sample rate* = 0) before performing this calculation. For status blocks, the number of characters is *Number of data records* × 4.

The block duration is always a whole number of seconds, and always starts on a whole second boundary. A data block has a maximum size of 1024 bytes. If the compression algorithm changes the compression format, blocks may appear which are not filled to the maximum capacity.

The rest of the block contains the data fields.

The GCF body

The body of a GCF block contains

- the absolute value of the first sample, a 32-bit signed integer referred to as the Forward Integrating Constant or FIC (this is not a data record, and is not counted in the *Number of data records*);

- a series of differences between following samples—32-bit, 16-bit or 8-bit signed integers according to the *Compression code*;

- the absolute value of the last sample, a 32-bit signed integer, referred to as the Reverse Integrating Constant or RIC. The RIC can be used as a checksum, as it should match the last decompressed sample value. It is not a sample in itself.

Because the value of the first sample is used as the FIC, the data record immediately after it is always zero.

Note: When data from a 24-bit digitizer is compressed into GCF blocks *and* the digitizer selects compression code 1 (32-bit data records) *and* the block is being transmitted over a serial link, the digitizer *may*

truncate the 32 bit differences to 24 bits by omitting the top byte of each difference. This does not apply to true 32-bit data, even for blocks where the differences would fit into 24 bits.

This optimization is made purely to use the serial link more efficiently, and is not part of the GCF file format. When such data is stored on a disk or transmitted over a network using TCP or UDP, it must be expanded back to the full 32 bits.

Because 24-bit values have a range of 16 million (±8 million), differences between them must be able to indicate ±16 million, which is 25 bits. However, the serial compression code discards the 25th bit. When decompressing the data, you will need to reconstitute this bit.

You can check that you have correctly reconstituted the sign bits by comparing the value you obtain at the end of the GCF block with the RIC.

7.2 Sending GCF streams over a network

GCF blocks can be embedded in TCP or UDP packets for transmission over a network to other Güralp instruments or computers running GCF-compatible software such as Scream!.

A GCF server is expected to understand control messages, and to respond with data as appropriate. This allows clients to start and stop data transfer and to request that any missing blocks be re-transmitted.

Initiating a connection

The default behaviour of a GCF server is to listen for UDP packets containing GCF commands. A client sends a command as a null-terminated string in a single UDP packet. The commands a client can issue are

GCFPING : acknowledge this packet;

GCFSEND:B : start sending data in big-endian ("network") byte order;

GCFSEND:L : start sending data in little-endian ("Intel") byte order;

GCFSEND : start sending data, in default byte order (Scream! interprets this as *GCFSEND:B*).

The server responds to any of these with a packet containing the string *GCFACKN*, again null-terminated.

A clients should continue issuing *GCFSEND* packets periodically while it still wants to be sent data. If a client does not issue a *GCFSEND* packet for a long period, the server will stop sending data to it.

If the server has active clients when it shuts down, it sends a packet containing the string *GCFNOSV* to all of the clients.

Data packets

Once the client has sent a *GCFSEND* packet, the server will start sending it GCF blocks, each in a single UDP packet. There are two formats used, "Version 31" and "Version 40".

Version 31 data packets

1024 octets – The GCF block as described above.

1 octet – The version number (decimal 31)

1 octet – The length of the following string, in octets

32 octets – A string describing the source of the data, padded to length 32 with zeros. The string takes the form STREAM-ID/COMxx/HOSTNAME where COMxx is the name of the serial port (COM1, etc.) and STREAM-ID is as in the GCF block (see above)

2 octets – The sequence number, in the byte order specified below (same as for data)

1 octet – A code for the byte order, 1 = big-endian (default), 2 = little-endian

Version 40 data packets

1024 octets – The GCF block.

1 octet – The version number (decimal 40)

1 octet – A code for the byte order as above

2 octets – The sequence number, in the byte order specified

1 octet – The length of the following string, in octets

48 octets – A string describing the data source, as above but padded to length 48 with zeros.

Recovering missing data

Because the UDP packets have sequence numbers, the client can detect when a packet has been lost. To recover this data, it initiates a TCP connection to the server, on the same port number. If the server accepts, the client sends a single-byte command to the server. The commands available are:

0xf9 (249) : Requests the server to use TCP only when communicating with this client. Subsequent GCF data packets will be sent over the active TCP connection, with the same format as the normal UDP packets.

This feature is supported by the server in Scream! 4.0 and above.

0xfc (252) : Requests a version string, returned in PASCAL format (*i.e.* first octet = length, remainder = null-terminated string)

0xfe (254) : Requests the oldest sequence number held by the server. The sequence number is returned as 2 octets in big-endian byte order

0xff (255) sequence-number : Requests a block by sequence number. The block is returned on the TCP connection in one of the above formats. If the block is not available, the server returns `0xff 0xff 0xff 0xff`. The sequence number is 2 octets long, with big-endian byte order.

When the client has all the blocks it needs, it is free to close the connection.

7.3 Sending GCF streams over a serial link

Before it can be sent over a serial link, each GCF data block must be packaged in a 'transport layer', which consists of a 4-byte transmission header and a 2-byte checksum tail.

The transport layer

The transmission header consists of 4 bytes:

1	2	3	4
ASCII `G` (`0x47`)	Block sequence number	Block size (MSB)	Block size (LSB)

Block sequence number : An unsigned integer, which increments by 1 after each block, wrapping round to 0 from 255.

Block size : The size of the block in bytes, excluding the transmission header and checksum tail, but including the GCF block header.

After the transmission header, the GCF block is sent (with a length equal to the number of bytes specified in *Block Size*), followed by a two-byte checksum. This value is the sum of all bytes in the block header and body, modulo 65536, and is presented in big-endian byte order.

To optimise the use of available transmitter bandwidth the transmitted data block is truncated to the actual data length. This reduction is only applied to the difference records - the first and last absolute values are still transmitted as 32 bit values.

ACK and NACK signals

After transmission of the block is complete, the transmitter waits a nominal 150 ms for either a *NACK* or *ACK* signal before starting to transmit the next block.

If it receives an *ACK*, transmission of the next block commences immediately. If *NACK* is received, the block is re-transmitted.

The receiver should read the block, calculate the data checksum, and compare that with the value sent in the transmission header. If the two values match, the receiver should send an *ACK* signal, otherwise a *NACK*.

ACK and *NACK* signals can be in two formats: (older) 2-byte and 6-byte. The 2-byte signal is simply the first 2 bytes of the 6 byte signal. When both the transmitter and receiver use the 6 byte version, the link is said to be operating BRP (Block Recovery Protocol), which allows recovery of lost data (from up to 255 blocks ago) as well as error correction on a per-block basis.

The format of an *ACK* or *NACK* message is

Byte	1	2	3	4	5	6
ACK	0x01	Stream ID LSB	^S (0x13) or 0	Stream ID	Stream ID	Stream ID MSB
NACK	0x02	Stream ID LSB	Block number	Stream ID	Stream ID	Stream ID MSB

Stream ID should match the 4-byte stream ID of the last received block. Each system is able to identify its own *ACK* or *NACK* by matching this ID. 2-byte systems only match the least significant byte and ignore the rest.

For a *NACK* message, *Block number* specifies which block number to rewind to.

For an *ACK* message, the third byte is either unused (0), or `0x13` (Ctrl-S) to switch to command mode.

DM24 digitiser units transmit data as complete blocks become available, without any flow control apart from *ACK* and *NACK*.

8 Connector pinouts

8.1 SENSOR A and B ports

This is a standard 26-pin mil-spec plug (02E-16-26P).

Pin	Function
A	Vertical velocity +ve
B	Vertical velocity –ve
C	N/S velocity +ve
D	N/S velocity –ve
E	E/W velocity +ve
F	E/W velocity –ve
G	Vertical mass position
J	N/S mass position
K	Busy indicator LED
L	E/W mass position
N	Signal ground
P	Calibration signal
R	Vertical calibration enable
S	N/S calibration enable
T	E/W calibration enable
U	Centre
W	Unlock
X	Lock
Y	Logic signal ground
b	Power 0 V
c	Power +10 to +24 V

8.2 AUXILIARY port

This is a standard 19-pin mil-spec plug (02E-14-19P).

Pin	Function
A	Optional *SENSOR B* auxiliary / calibration channel +ve
B	Optional *SENSOR B* auxiliary / calibration channel –ve
C	Optional *SENSOR B* signal ground
D	Optional *SENSOR B* Mux channel M3
E	Optional *SENSOR B* Mux channel M4
F	Optional *SENSOR B* Mux channel M7
G	Leave unconnected
H	Optional *SENSOR B* Mux channel M5
J	*SENSOR A* auxiliary / calibration channel +ve
K	*SENSOR A* auxiliary / calibration channel –ve
L	*SENSOR A* signal ground
M	Optional *SENSOR B* Mux channel M6
N	Digital ground
P	Leave unconnected
R	*SENSOR A* Mux channel MB
S	*SENSOR A* Mux channel MC
T	*SENSOR A* Mux channel MF
U	*SENSOR A* Mux channel MD
V	*SENSOR A* Mux channel ME

8.3 GPS port

This is a standard 10-pin mil-spec plug (02E-12-10P).

Pin	Function
A	Power 0 V
B	Power +12 V
C	1pps signal
E	Digitizer console transmit

F	Digitizer console receive
G	RS232 ground
H	Digitizer console ground
J	RS232 transmit to GPS
K	RS232 receive from GPS

8.4 DATA IN port

This is a standard 6-pin mil-spec plug (02E-10-06P).

Pin	Function
A	RS232 transmit
B	RS232 receive
F	RS232 ground

8.5 FIREWIRE port

Where present, this is a standard 6-pin mil-spec plug (02E-10-06P).

Pin	Function
A	Power 0 V
B	TPA +ve
C	TPA −ve
D	TPB −ve
E	TPB +ve
F	Power + V

8.6 USB port

Where present, this is a standard 6-pin mil-spec plug (02E-10-06P).

Pin	Function
A	+5 V DC (USB Type A pin 1)
B	Data –ve (USB Type A pin 2)
C	Data +ve (USB Type A pin 3)
D	0 V (USB Type A pin 4)
E	Shielding
F	Switched power +10 to +35 V

8.7 DATA OUT port

This is a standard 10-pin mil-spec plug (02E-12-10P).

Pin	Function
A	Power 0 V
B	Power +10 to +36 V
C	RS232 CTS
D	RS232 RTS
E	External trigger output
F	External trigger output
G	RS232 ground
H	External trigger input
J	RS232 receive
K	RS232 transmit

9 Digitizer specifications

Seismic channels	Number	4 – 8
	Format	32 bit
	Inputs	Differential with transient protection; ±10 V input range
	Input impedance	1 MΩ, 10 nF
	Common mode rejection	110 dB at 10 Hz
Mux channels	Number	8
	Format	24 bit
	Inputs	Single ended; ±10 V input range
GPS	Unit	External GPS (CMG-GPS2)
	Power	supplied through *GPS* connector
	Time format	NMEA
	Max. cable length	50 m
Sensor control	Functions available	Lock, unlock, and centre sensor (active low CMOS); enable calibration
Sensor calibration	Types	Sine and square wave; adjustable amplitude and frequency
Digital signal processing	Type	Texas TMS320CV33
	Hardware sampling rate	2 KHz
	Sample output rates	6 cascaded rates, each 2, 4, or 5 times lower than the previous rate (even integers only)
	Anti-aliasing filters	2 pole
	Low-pass filters	FIR
	Out-of-band	140 dB

		rejection
	In-band ripple	−140 dB
	Trigger modes	STA/LTA, threshold, external trigger
Digitizer performance	Output format	32 bit
	Noise-free resolution (NPR)	22.5 bits at 20 samples/s; 21.5 bits at 100 samples/s
	Absolute accuracy	0.5% standard (0.1% optional)
	Type	5th-order, single-bit low-pass noise shaper
	Analogue transducer outputs	3-C signals
Clock	Oscillator	8×10^{-7} standard (5×10^{-8} oven-controlled optional)
	External receiver interface	GPS RS232 and PPS
	External receiver synchronisation	$<50\,\mu s$
Internal thermometer	Accuracy	±0.33 ℃ (30 ℃) ±0.5 ℃ (10..50 ℃) ±1.0 ℃ (−10..75 ℃)
	Linearity	±0.5 ℃
	Resolution	0.0625 ℃
Power	Supply	+10 to +24 V DC
	Current at 12 V DC	~0.12 A

10 Revision history

2006-11-23 G   Revised and reorganized

2006-09-04 F   Firmware v103b12 (SETDSS)

2006-05-19 E   Firmware v102b73 and DSP v1055 (LOWLATENCY)

2006-04-21 D   Firmware v102b68

2006-02-07 C   Firmware v102b58 (GCFIP, EVENTSLIST, *etc.*)

2005-12-23 B   New functionality and corrected pinouts

2005-08-16 A   New document