CMG-CD24

Compact Digitiser

Operator's Guide

Part No. MAN-C24-0001

Designed and manufactured by
Güralp Systems Limited
3 Midas House, Calleva Park
Aldermaston RG7 8EA
England

Issue C 2011-03-29

Table of Contents

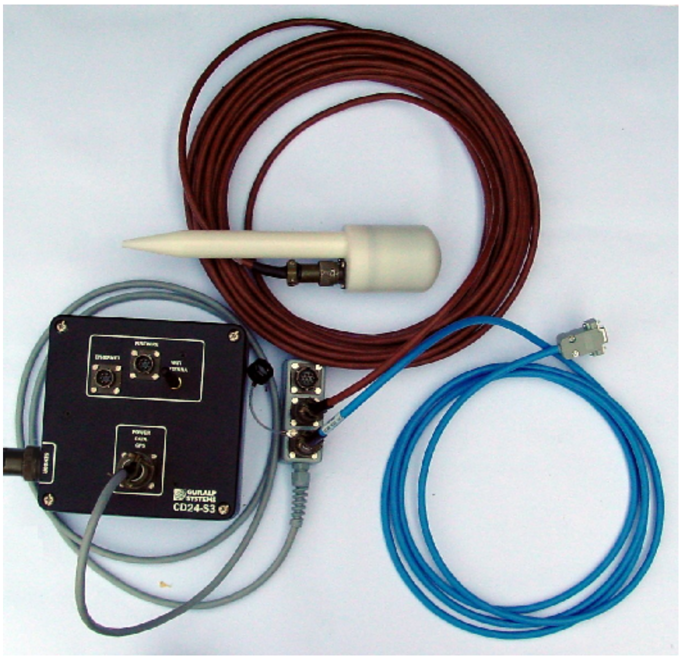
1 Introduction

The CD24 is a compact, very low power, multi-purpose digitiser, with three 24-bit differential inputs and 8 lower-speed, single-ended auxiliary inputs. Equipment with analogue outputs connects to the CD24 via a 26 way mil-spec connector.

Key features include:

- 24-bit sigma-delta analogue to digital converters.
- Low power: < 1W from 10V–28V DC.
- ±10V balanced differential input lines.
- Lightweight and waterproof.
- RS232 output in GCF (Güralp Compressed Format).
- Multiple user-configurable output rates.

Once connected to 10 – 28 V DC power, the CD24 will begin operating automatically, digitising its inputs and either outputting digital data to your own recording system or saving them to internal Flash memory.



1.0.1 State of health information

The CD24 constantly monitors the status of the GPS and timing systems, outputting information in a plain text status stream.

An electronic thermometer also provides regular measurements of the unit's internal temperature, which are reported in the same stream. The thermometer is calibrated to an accuracy up to ± 0.33 °C, with a linearity of ± 0.5 °C.

1.1 Options

1.1.1 Storage and interfaces

The CD24 can be supplied with up to 16 Gb of internal Flash memory for data storage. The amount you need will depend on the length of your experiment and the sampling rates used.

You can download data from the internal storage:

- over the RS232-compatible data port, directly into Scream! or other Güralp data modules;

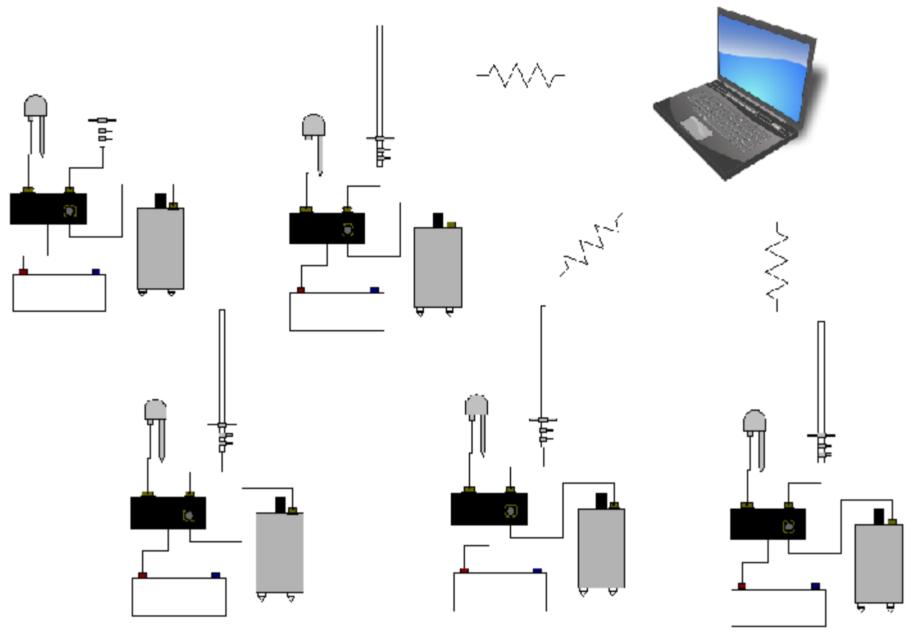
- over a fast IEEE.1394 (FireWire) link with optional power; or

- if fitted, using the Ethernet interface to transfer data over a local area or wireless network.

1.1.2 Wireless networking

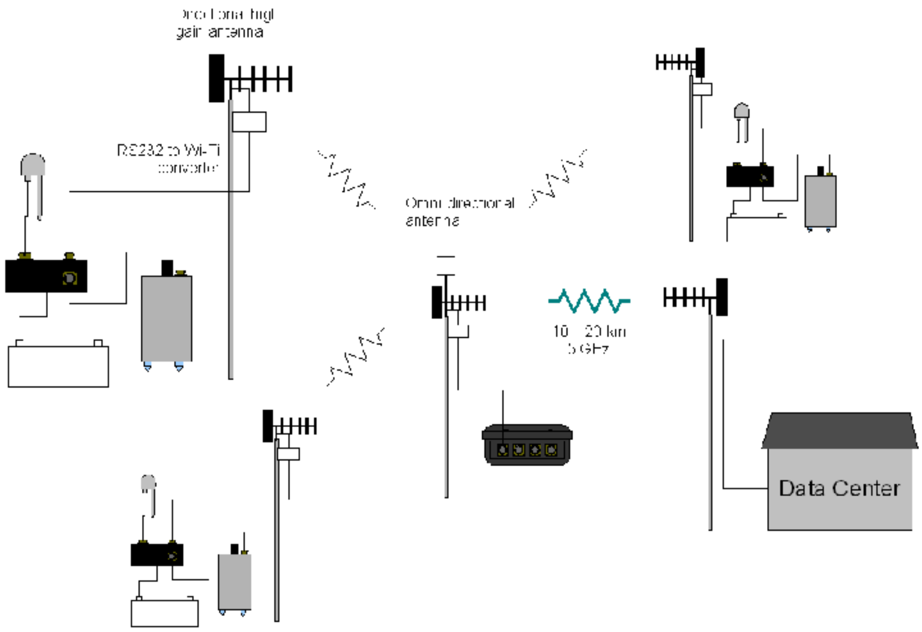
The CD24 can be fitted with an optional 802.11b ("Wi-Fi") wireless interface in addition to the Ethernet port. This option allows data flow to be established from autonomous installations with a minimum of setting up.

For temporary deployments, instruments and digitisers can be buried in shallow pits with only the antenna above ground. You can then contact to each station from a wireless-enabled PC running Scream! without disturbing the instrument, including monitoring real-time data and configuring the digitiser.



More permanent arrays also benefit from wireless technology, particularly in remote areas or where the terrain makes long cable runs impractical.

For example, stations might be installed with high-gain antennae directed towards a visible natural feature which is easier to access.



At this location, which can be up to 500 metres away, a low-power CMG-EAM data module might act as an access point for the array elements and forward data onto a higher-bandwidth radio link.

In semi-permanent arrays, a wireless-enabled CMG-EAM or laptop PC can be set up as a temporary access point for the duration of a site visit.

2 Setting up the CD24

This section gives an overview of how to set up a CD24 and begin recording data. We recommend that you set up a test digitiser in your office or laboratory as a “dry run” to gain a basic understanding of the system and to check that it is functioning as expected.

This test installation will use the digitiser's default settings. Data will be received using Güralp Systems' Scream! software, available from the website: www.guralp.com

2.1 Connectors

The CD24's output connectors are located on the lid. The sensor input is located on the side. The digitiser can be supplied with a number of options, so not all the connectors may be present on your digitiser. The input connector is configured to connect directly to one of GSL's sensors and has all the necessary power and control functions.

All CD24s have a 19-pin mil-spec connector on the lid for connection to a supplied breakout box with the following connections:

- a 6-pin socket for connecting the supplied GPS unit;
- a 10-pin plug for connecting to a PC's serial interface or a Güralp data module..
- a 6-pin mil-spec plug for connecting to a power source.

You may need to attach a suitable connector to the power cable provided. The CD24 draws a nominal current of 55 mA from a 12 V supply when in use; thus, using a 12 V, 25 Ah sealed heavy-duty lead-acid battery, you should expect the digitiser to operate for more than a week without recharging.

The CD24 may also have connectors for the FireWire, Ethernet or Wi-Fi interfaces.

2.2 Test installation

To test the CD24, you will need access to a PC with a 9-pin serial port (RS232), a 12 V power source and a working sensor (e.g. CMG-3ESP, ESPC, 40T or 6T).

Install Scream! on your PC and run it.

Connect the wire from the breakout box to the CD24's 19-pin connector labelled: POWER DATA GPS.

Connect the 6-pin connector on the breakout box to the GPS unit using the GPS cable. Position the GPS so that it has a good view of the sky.

Note: If you do not have a view of the sky, you can operate the CD24 without a GPS unit, but timing information may be inaccurate.

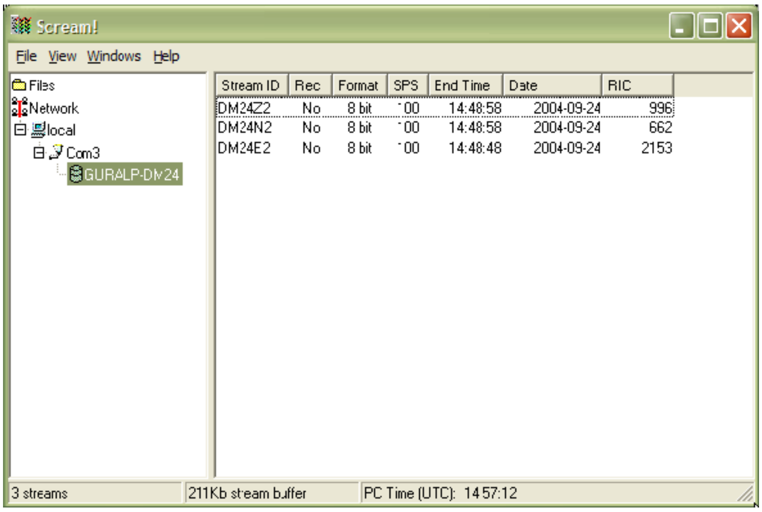
Connect the sensor to the 26-pin connector on the side of CD24.

Connect the 6-pin data plug on the breakout box to the 9-pin serial port on your PC using the serial cable.

Use the power cable to connect the 10-pin power plug on the breakout box to a fused 10 – 28 V power source.

The CD24 and instrument are now fully operational and will already be producing data.

After a few seconds, you should see the CD24 digitiser appear under **Network – Local – COM1** in the left-hand panel of Scream!'s main window. (If your PC has multiple serial ports, it may appear under some other *COM*_port name.) Soon after, data streams will begin appearing in the right-hand panel. Streams with higher sample rates will appear sooner than those with lower sample rates:



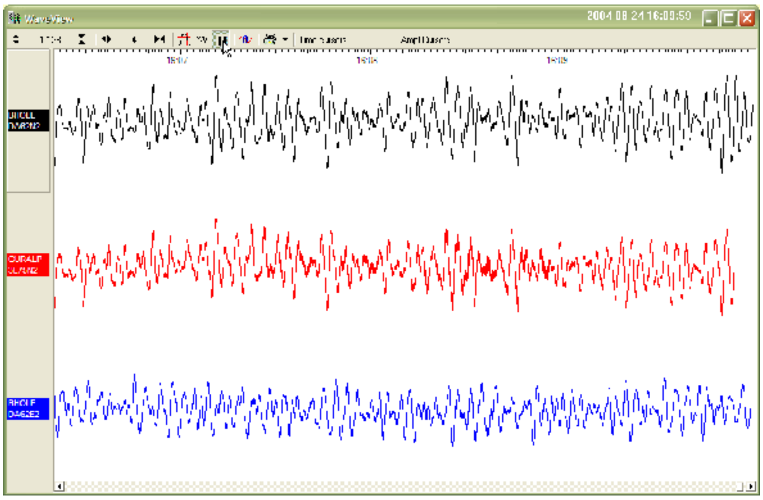
If this does not happen, check all connections, and ensure the power supply is providing the correct voltage and current.

Each data stream has a *Stream ID*, a six-character string unique to it. Stream IDs normally identify the instrument, component and sample rate of each stream. Thus the stream `1026Z2` refers to a Z-component stream from instrument 1026, at tap 2. For more details on taps and sample rates, see section 3.1.2, page 27.

Data streams ending in `00` are *status* streams containing any extra information sent from the digitiser.

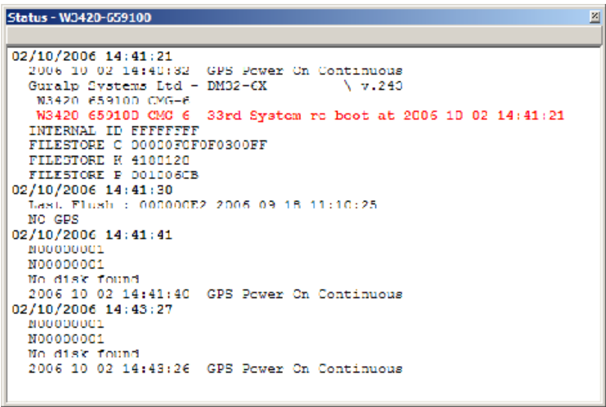
To view data, select a stream and then double-click to open a *Waveview* window.

You can view several streams at once by holding down `SHIFT` as you select, and then double-clicking the selection.



To start recording new data to a file, right-click on a stream or a selection of streams and choose **Start recording** from the pop-up menu. Recording settings, directories, etc., can be altered by selecting **File → Setup...** from the main menu and switching to the *Recording* tab.

To view status information, select the stream and right-click to open a pop-up menu. Select **View**.



The first few status blocks will consist of the CD24's start-up messages, including its software revision number and the data streams selected for downloading and triggering.

Later blocks give information on the GPS system (number of satellites visible, the location of the GPS antenna, time synchronization status, *etc.*) and the baud rates in use for each channel.

For more information on SCREAM! refer to the user manual available from the Güralp Systems' website: www.guralp.com

2.3 Setting up the Ethernet or wireless interface

CMG-CD24 digitisers with Ethernet or Wireless features installed use an embedded Lantronix Wi-Port module to provide the network interface. Configuration of the Ethernet or Wireless interface is made using the Lantronix' **DeviceInstaller** utility for Microsoft Windows, using a DHCP server or the via the serial port. You will need a PC with a network or wireless interface installed or an RS232 connector,

You may find it easiest to gather together all the Wi-Fi hardware before taking it into the field and configuring it from a local wireless-enabled PC.

There are two types of wireless network topology supported by the Wi-Port.

- *Infrastructure* networks need additional hardware, such as wireless access points and routers, to work. Any host on the wireless network will communicate with the access point or router, which manages all the connections and ensures data are transmitted correctly. This device may also provide connectivity to the Internet or your local network.

- *Ad hoc* networks can be set up with no additional hardware. Each host on the wireless network attempts to communicate directly with the other hosts. *Ad hoc* networks are easy to set up, but they are only suitable with a small number of hosts. In seismic networks, infrastructure mode is normally preferred, since sensors do not need to communicate with each other. For more information see Appendix F – Setting up an “ad hoc” wireless network on page 113.

2.3.1 Using DeviceInstaller

1. Download and install the **DeviceInstaller** utility from the Lantronix Web site at `http://www.lantronix.com/`

2. **DeviceInstaller** also requires the Microsoft .NET framework to be installed. If you do not have this already, it can be downloaded at `www.microsoft.com`.

   Note: DeviceInstaller will not work through routers or across the Internet. All the devices need to be on the same network segment as the PC.

3. Find out the MAC address of the CD24's network interface. This should be printed on a label on the case.

4. If the *Data Out* port on the breakout box is connected to anything, disconnect it.

> **NOTE:** Any connection to the Data Out port on the breakout box will disable networking

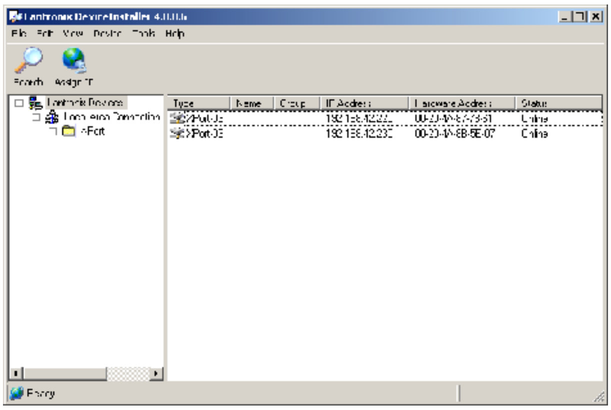
5. **For Ethernet networking,** connect the CD24's *ETHERNET* port to the the PC's network interface either using a crossover Ethernet cable or through a network hub. Note that using a hub, you can connect several CD24s to the same PC and configure them all at the same time.

6. **For Wireless Networking** configure your wireless router or access point to use a network name (SSID) of `LTRX_IBSS`. Disable any security features of the wireless router or access point.

7. Run **DeviceInstaller**.

8. **DeviceInstaller**'s main window has two panels, a tree on the left (with *Lantronix Devices* at the top) and a table on the right.

9. The program will automatically look for Lantronix devices on all of your computer's network interfaces. If necessary, you can narrow the selection by clicking on an entry in the tree on the left. If the program does not list the device, press F5 or use Device > Search from the menu system.



10. A Wi-Port entry should appear in the table on the right, denoting that a device has been detected.

11. If more than one Wi-Port entry appears, **DeviceInstaller** has detected several devices.

12. For every detected device, the program shows the *Hardware Address* (*i.e.* the MAC address) and the IP address it is currently using. If you are using a wireless router with a DHCP server, or an access point connected to a network with a DHCP server, the device will use DHCP to assign it an address. Otherwise, a random address will be chosen automatically.

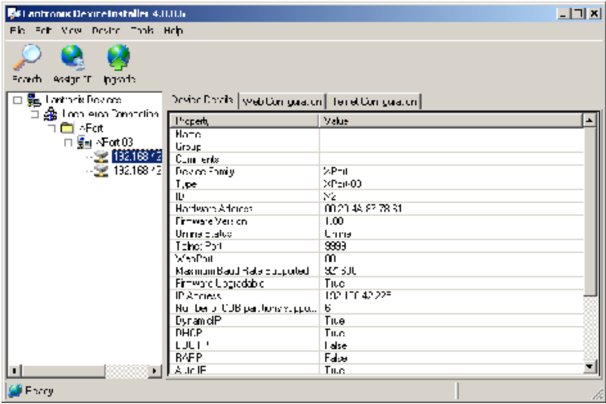
    Note: Automatic random addresses all begin with 169.254. The CD24 will choose a different one every time it is power cycled or rebooted.

13. The address of the CD24 may be shown in red with the status *Unreachable*. If this happens, the sensor and PC cannot communicate because they are not on the same subnet. Click **Assign IP** to start the IP configuration wizard. Follow the instructions in the wizard to set the IP address, or configure DHCP if you are using a DHCP server. When you have finished, press F5 or use Device > Search from the menu system to find the sensor with its new IP address.

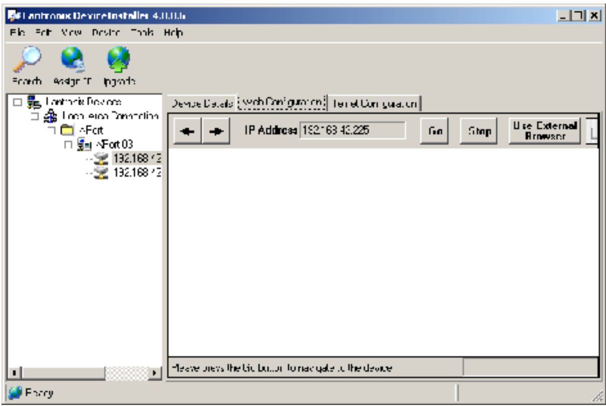
    Note: The IP address of the digitiser must have be on the same subnet as the computer you want to connect to. The LAN setting on the **DeviceInstaller** device tree identifies the IP address of your computer. The first three number groups typically need to be the same on all devices (digitisers and computer).

14. If you want to configure the CD24 to use a static IP address, use the **Assign IP** wizard as above and click **Search** again.

15. Double-click on the entry which corresponds to the CD24 you want to configure. The right-hand panel will change to show the current properties of the device.



16. Switch to the **Web Configuration** tab and click **Go** to open the Web configuration interface.



17. You can also click Use External Browser to use your own Web browser to configure the system.

18. Follow the steps at 2.3.3 to configure the module from its Web interface.

2.3.2 Using DHCP

If you cannot install **DeviceInstaller** on your PC, or you do not wish to, you can also get access to the CD24 using a standard DHCP server. In most cases you will need to have administrative privileges to do this.

1. Install and start the DHCP service on your PC.

2. **For Ethernet networking** connect the CD24's *ETHERNET* port to the the PC's network interface, either using a crossover Ethernet cable or through a network hub. Note that using a hub, you can

connect several CD24s to the same PC and configure them all at the same time.

3. **For Wireless Networking** configure your wireless router or access point to use a network name (SSID) of `LTRX_IBSS`. Disable any security features of the wireless router or access point.

4. DHCP will not work through routers or across the Internet. All the devices need to be on the same network segment as the PC.

5. Monitor the DHCP server to find out what IP address it gives to each digitiser.

6. To configure a device, enter its IP address into a web browser.

2.3.3 Configuration with the web interface

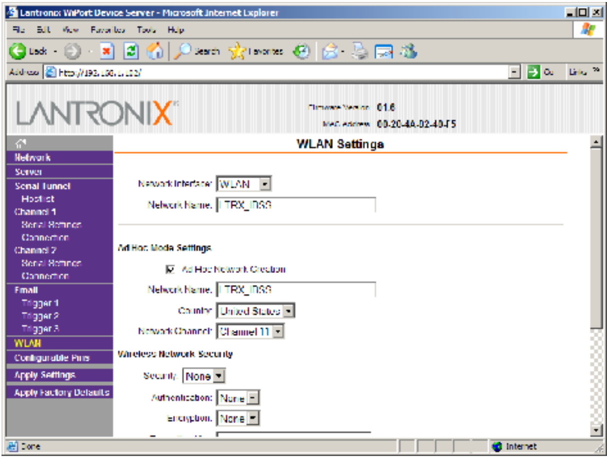
Once you have access to the Wi-Port's Web interface, you can configure it with its proper settings.

1. The Web page is divided into three. A menu on the left switches between the pages of configuration options on the right. There is also a banner at the top, which tells you the current firmware revision and the MAC address.

2. To navigate around the Web site, click on the entries in the left-hand menu. When you have made changes to the settings on any page, save them by clicking **OK** before you leave the page. Once you have made all the changes click on **Apply Settings** to configure the digitiser.

2.3.3.1 Wireless Settings

1. Click on **WLAN** (Wireless Local Area Network) to open the **WLAN Settings** page.



2. Change the *Network Name* (*i.e.* SSID) from `LTRX_IBSS` to a suitable name for your installation. This name will be announced to any nearby wireless devices when they search for networks.

3. If you are using an *ad-hoc* network, change the second *Network Name* box as well. Otherwise, deselect *Ad Hoc Network Creation*.

4. Under *Wireless Network Security*, set *Security* to *WEP* and configure the security parameters. If you do not do this, anyone will be able to access the CD24 and change its configuration.

5. Make a note of the security parameters you have used.

6. Click **OK**, followed by **Apply Settings** in the main menu. The Wi-Port will restart.

7. If you are setting up an infrastructure network, configure your wireless access point or router to use the new name and security settings, and power cycle the CD24 to make it reconnect to the network.

8. Reconnect your computer to the wireless network using the new name and security settings.

2.3.3.2 Configuring the serial channels

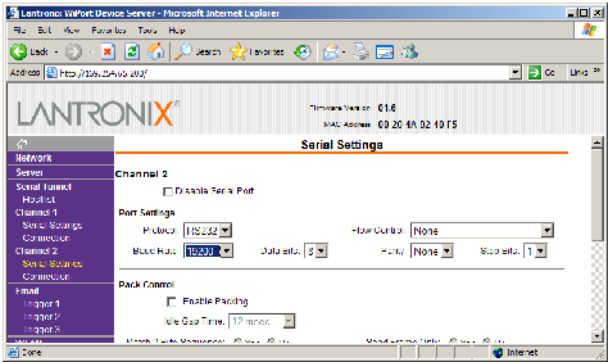
1. The Wi-Port has two serial channels to which you can connect. By default, these are exposed on ports 10001 and 10002.

2. Channel 1 (normally port 10001) is connected to a serial console (which is also exposed on the power port of the breakout box). If you have problems connecting to the CD24, you can attach a

standard Güralp Systems power/data cable to this port and use Scream! to access the console.

3. Channel 2 (port 10002) is connected to the CD24's digital output, *unless* you have connected a serial data cable from the breakout box to a computer. If the breakout box is connected, the CD24 will send data streams through that interface rather than to the Wi-Port.

4. Click on **Channel 2 – Serial Settings**.



5. If the *Baud Rate* is incorrect, set it to the default of 19,200.

   Note: If you change the digitiser's output baud rate in Scream! or using the terminal, you must come back to this page and change the *Baud Rate* setting here as well.

6. The remaining settings can be left at their default values. Click **OK** to save your changes.

7. For full information on the Wi-Port's configuration options, please refer to the Wi-Port documentation, which is available on the Lantronix Web site, www.lantronix.com.

8. When you have finished setting up the Wi-Port, apply the new settings by clicking **Apply Settings**. The Wi-Port will re-boot with the new settings in effect.

   Note: If the Wi-Port is still using an automatically chosen random IP (beginning with 169.254), the IP address will change when you do this. You will need to go back to **DeviceInstaller** to find out the new IP address.

2.3.4 Installing wireless hardware

The small antenna supplied with the CD24 is adequate for initial testing or temporary installations with an access point within 50m of the digitiser.

To send data over a larger distance, or if the line of sight between the antenna and the access point is blocked, you will need to use a larger and more powerful antenna.

In infrastructure mode, you can reduce the power requirements by using a directional antenna pointed at the location of the access point. The access point does not need to be permanently present. For example, you could set up an array of CD24 digitisers with antennas pointed towards a prominent natural feature with line of sight to all the digitisers, and access them all from this location using a laptop PC.

2.4 Configuring the digitiser

Autonomous CD24 installations will need to be configured before deployment. You can do this either

- using the graphical interface provided by Scream! (see Chapter 3 on page 25), or
- over a terminal connection (see chapter 5 on page 53).

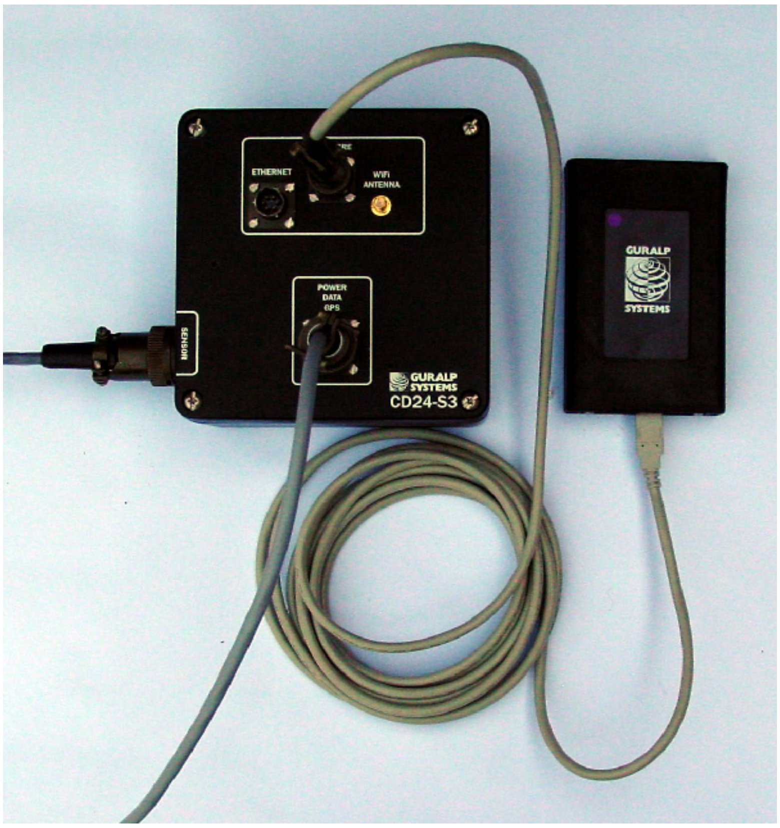
Both methods provide full access to the configuration options of the CD24.

In particular, the CD24 can operate in a number of *transmission modes*. These modes determine 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. See section 3.2.5 on page 40 for more details.

2.5 Downloading data over FireWire

The easiest way to download data over FireWire is to connect a suitable disk to the FireWire port of the CD24 and power-cycle the unit.

If you have ordered a CD24 with the powered FireWire option, you can attach the disk directly to the CD24 with no additional connections. Otherwise, you will need to connect the disk to a power source through the supplied adapter.



When the digitiser restarts, it will automatically detect the disk and flush all new data to it.

If you do not want to restart the digitiser, you can also flush data to disk manually:

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

2. Connect a suitable disk to the FireWire port of the CD24. Provide power for the disk if necessary.

3. Issue the command `FLUSH`

   This will download all data from the CD24 that it has not already transferred. If you want to transfer the entire contents of Flash memory, use the command `FLUSHALL`. For more details, see section 5.11.3 on page 80.

4. Close the terminal session. If you are using Scream! or an EAM, the CD24 should start transmitting immediately. Otherwise, you may need to issue the command `GO` to start transferring data.

2.5.1 Reading CD24 disks

The CD24 uses a special disk format, DFD, for recording data. This format is also used by other Güralp digitisers such as the DM24.

You can read these data into a PC using Scream! or the Windows `gcfxtract` utilities, which are 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 EAM data module, which uses either a FAT32-compatible journalling file system or an ext3 file system.

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

2.5.1.1 Reading CD24 Disks using SCREAM!

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 both **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**.

2.6 Receiving data in Scream!

There are several ways a CD24 digitiser can be connected to Scream!:

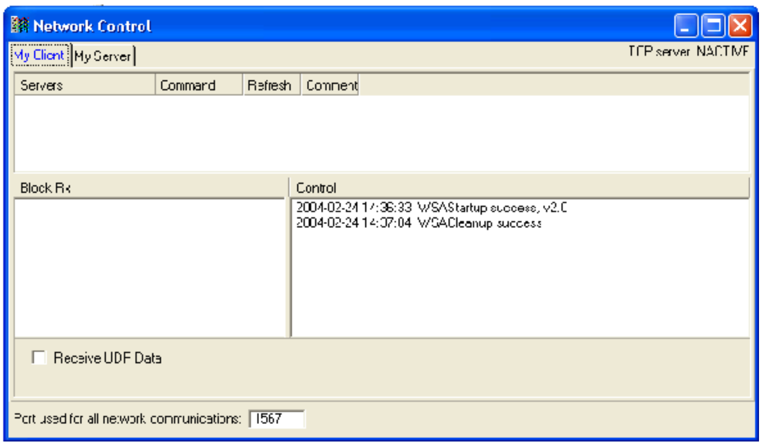
- A direct serial connection can be made from the breakout box to your computer. This is the method we recommend for testing the digitiser (see section 2.2 on page 10).

- The serial port can also be used to connect an external modem. Details of how to connect modems are available on the Güralp Systems Web site.

- Data can be received from the digitiser over the optional Ethernet or wireless links. Before you can do this, you will need to set up its IP address and network configuration, as described in section 2.3 on page 13.

To connect to a CD24 over the network:

1. Run Scream!, and select **Windows – Network Control** from the main menu. Click on the **My Client** tab.



2. Right-click in the white panel beneath *Server*, and select **Add TCP Server…**.

3. Input the IP address of the CD24, followed by a colon and then the output port 10002. For example:

   ```
   192.168.33.2:10002
   ```

   Click **OK**.

4. After a short wait, an entry for the digitiser should appear in the pane. Right-click on the entry and select **Connect**.

5. If the connection is successful, you should see blocks appearing in the *Block Rx* pane and streams will appear in Scream!'s main window. Close the *Network Control* window.

3 Configuration & Control with Scream!

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

3.1 The Configuration dialogue

To change the configuration of any connected digitiser:

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

2. Right-click on the digitiser's entry (*not* the icon for the server or any **Com*XX*** icon). Digitisers are shown with icons depicting a coloured cylinder.

3. Click **Configure...**. Scream! will then contact the digitiser and retrieve its current configuration, a process which will take a few seconds. Once 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 digitiser and reboot. This will take a short while.

   Note: After uploading, allow up to 1 minutes for the digitiser to re-boot and resume transmitting data.

To control a digitiser whilst it is running, either right-click on the digitiser's entry in the list and click **Control...**, or double-click the entry. In either case Scream! will contact the digitiser 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) (see section 3.1.3 on page 29)
- the length of pre-trigger and post-trigger periods
- calibration signal options
- mass control functions

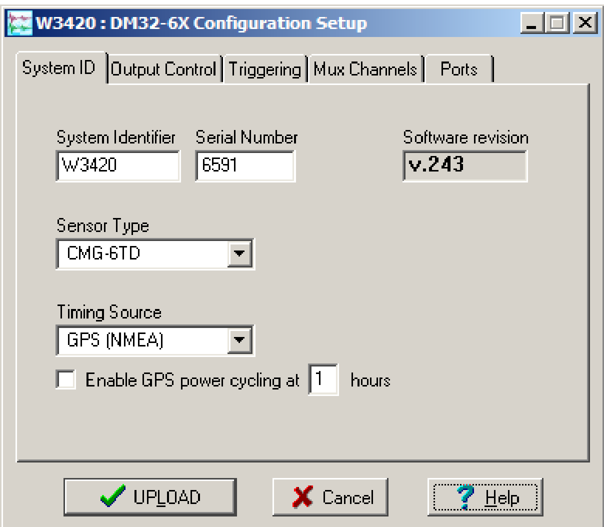
Some of these options can also be altered in the *Configuration setup* window. For more information on the *Control* window, see section 3.2 on page 37.

If you need a more powerful interface to the CD24, you can also issue commands to it directly using Scream!'s terminal mode. A terminal window is opened by right-clicking on the digitiser's entry in the list and selecting **Terminal...**. The digitiser will stop transmitting data while you have a terminal window open but may still store it in Flash memory (depending on the current transmission mode.)

The remaining sections of this chapter describe in detail the configuration options available for the CD24. Many of these options will also be available for other Güralp digitisers.

3.1.1 System ID

The *System ID* pane gives information about the digitiser and its internal software and allows you to change GPS timing parameters.



System Identifier and Serial Number : The digitiser type is identified by its system identifier and serial number. Every data and status block generated by the digitiser 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 digitiser'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, while the serial number cannot be longer than 4.

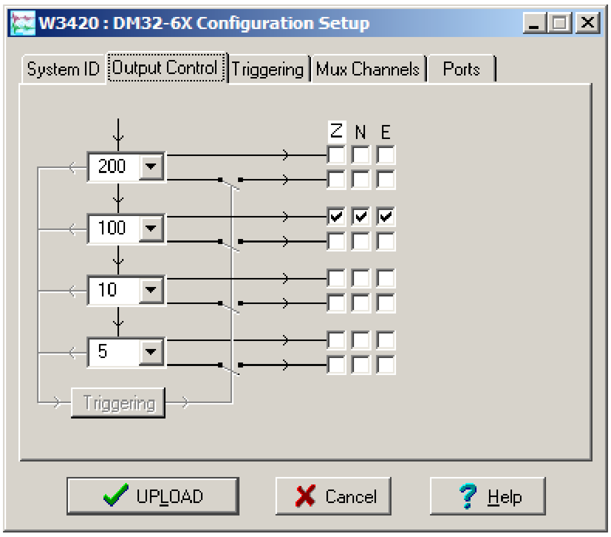
Sensor Type : This option tells Scream! which control commands to make available to the user. The CD24 does not require separate control commands, so you should not change this option.

GPS Type : The digitiser needs to be able to time-stamp accurately all data that passes through it. It sets its clock by receiving time signals from the GPS satellite network using an attached Trimble GPS unit. This is hard-wired into the CD24, so the *GPS Type* setting has no effect.

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.

3.1.2 Output control

The *Output control* tab allows you to select which data streams are sent to Scream! from the digitiser.



The CD24 initially samples incoming data at 2000 Hz. These data are 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 (and the outputs from those stages) are called *taps*. The CD24 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 screen shot above shows a possible configuration for a triaxial instrument. Every channel of the digitiser may be output at any tap; currently, as illustrated, all three axes are being output at Tap 2 (20Hz).

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. The upper check-box of each pair activates *continuous* output, whilst the lower activates *triggered* output. In the example above, the digitiser 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.

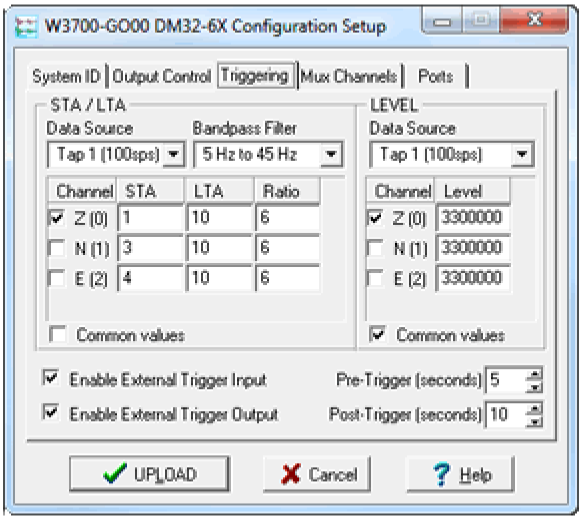
When you enable a triggered stream, the digitiser will output data in that stream only when a particular set of trigger criteria are met. This is shown diagrammatically as data passing through a switch. In the example above, we might want the high-rate data from Tap 0 to be generated only when an event registers at some other tap. To do this, tick one or more of the *lower* set of check-boxes for Tap 0.

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.

Every checked box in this window will give rise to a data stream coming from the digitiser, which will be displayed 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 digitiser, and the last two characters identify the individual stream. The first four characters are set by default to the serial number of the digitiser; you can change this on the *System ID* pane (see page 26) or from the digitiser's console.

3.1.3 Triggering

In its standard configuration, the CD24 outputs continuous data at a sample rate you specify. In addition to this, Güralp digitisers 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 CD24 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 (and above) also allows you to configure each digitiser to receive triggers from other digitisers.

To create a new stream with a trigger, open Scream!'s *Digitiser configuration* window for the relevant digitiser 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 digitisers can use. However, not all models can use both methods. Scream! will find out from the digitiser whether its on-board software supports each method.

3.1.3.1 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.

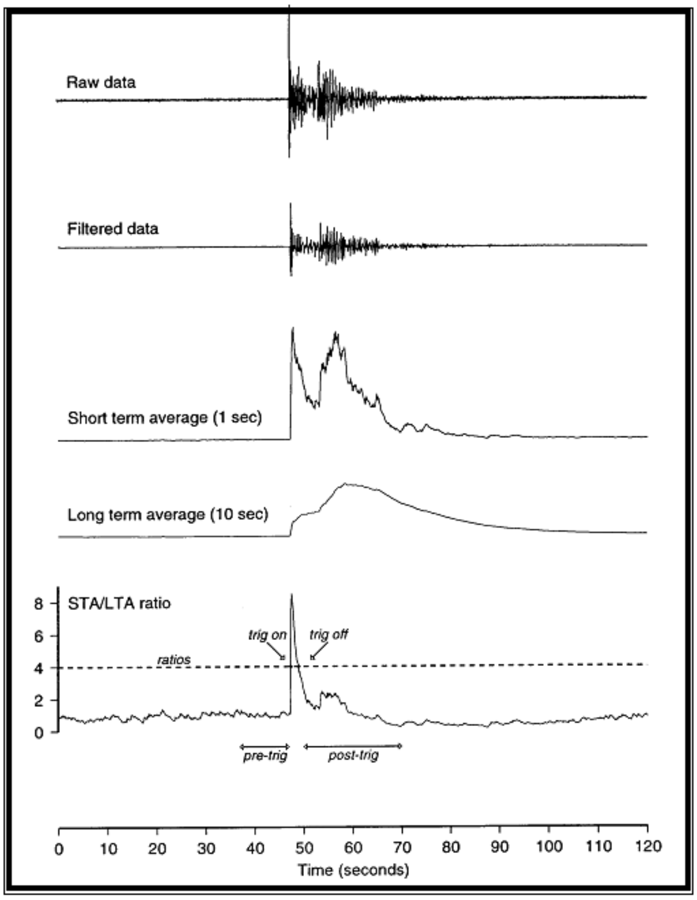
You can select which tap is tested for the trigger from the **Data source** drop-down menu. The tap does not have to output data to Scream! for you to be able to use it here.

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** period, the **LTA** period and 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 clear the **Common values** check box 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 digitiser (see section 3.2 on page 37.)

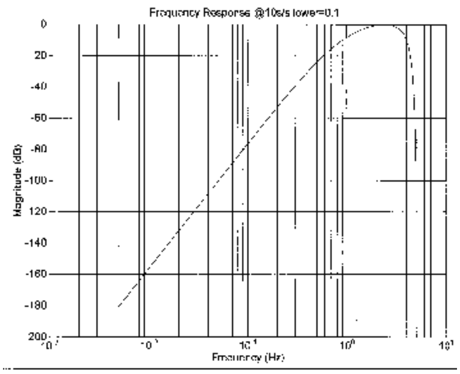
Since it is not generally advisable to trigger from broadband data, the digitiser provides a set of standard bandpass filters to apply to the data streams before they are tested for the trigger condition. This filtering serves to maximise sensitivity within the frequency band of interest, and filter 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 depends on the sample 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.

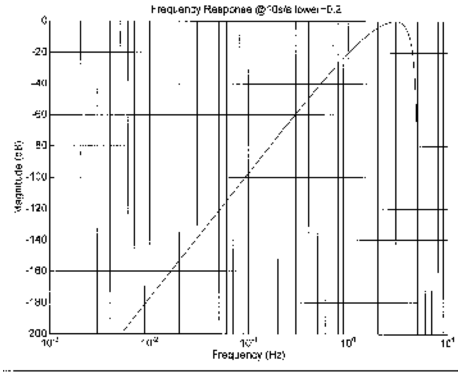
The possible filter configurations are shown in the following table:

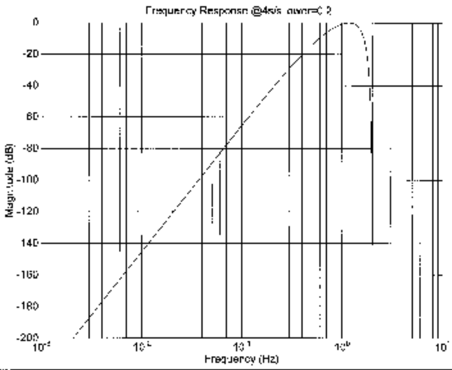
Rate (samples/s)	Bandwidth 1 (Hz)	Bandwidth 2 (Hz)	Bandwidth 5 (Hz)
1000	50 – 450	100 – 450	250 – 450
500	25 – 225	50 – 225	125 – 225
400	20 – 180	40 – 180	100 – 180
250	12.5-112.5	25-112.5	62.5-112.5
200	10-90	20-90	50-90
100	5-45	10-45	25-45
50	2.5-22.5	5-22.5	12.5-22.5
40	2-18	4-18	10-18
25	1.25-11.25	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

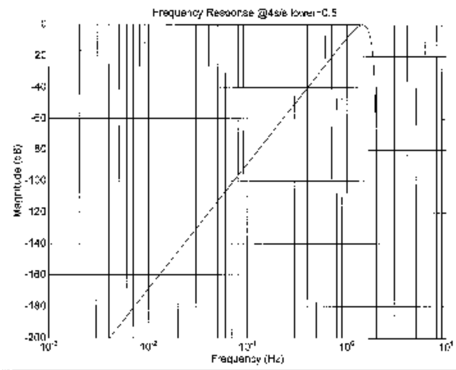
As can be seen, the filter you choose defines the set of permissible sample rates.

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









3.1.3.2 Level

Using the *Level* triggering method, a trigger is generated whenever one of the checked components reaches a certain level above the baseline.

> **Note**: All unfiltered seismic signals will have some degree of offset - i.e. the average value will rarely be zero. It is strongly recommended that a high-pass filter is used to prevent this offset from affecting the level triggering algorithm but please be aware that the high-pass filters also affect the main outputs.

To configure Level Triggering:

1. On the **Output Control** tab, set the **Highpass** filter to 100s, 300s or 1000s to alleviate any offset problems. Note that this filter is applied directly to the continuous data streams and, so, will also affect the main outputs.

2. On the **Triggering** tab, select the tap to be triggered from the **Data source** drop-down menu and the channel(s) to be considered from the **Channel** column of the table.

3. The values in the **Level** column are the number of counts above the baseline that channel must reach before a trigger is generated. The values are determined from the **Details** window for the channel under consideration. Note that the offset must be set to zero in order to determine the real baseline value.

The **Level** values will be the same for each channel unless the "Common values" check-box is deselected.

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 digitiser.

3.1.3.3 External triggering

When a digitiser or digital sensor triggers, it can send a notification signal to connected devices. You can configure other digitisers to respond to this signal by triggering in turn. This is an option which you can specify at the time of ordering.

As an example, to instruct a stand-alone digitiser with digital trigger inputs to respond to trigger notifications 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 trigger notifications to connected devices.

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

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

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

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

3.1.3.4 Pre-trigger and post-trigger recording

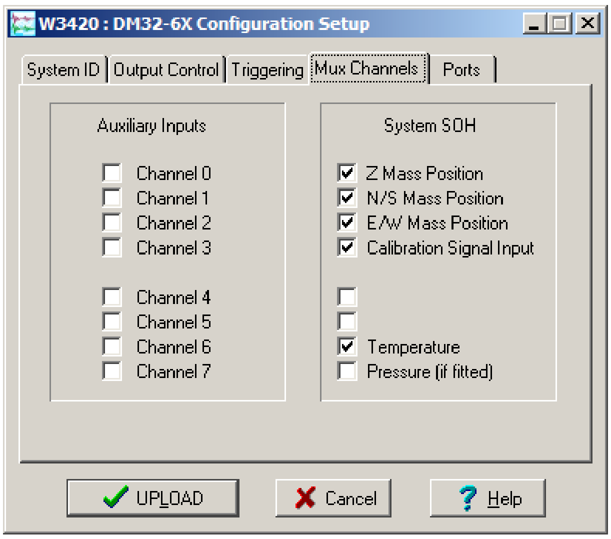
In order to capture all of a seismic event, it is often useful to be able to record data immediately preceding the trigger. Güralp digitisers have an internal buffer of some seconds which allows these data to be added to the triggered stream. Pre-trigger data are particularly useful for emergent-type 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 trigger condition has ended.

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.

3.1.4 Mux channels

The CD24 provides 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 digitiser. Generally, three channels are used to report the sensor mass position, and another measures the internal temperature of the digitiser. In addition to these, up to 12 Mux channels may be supplied for the user's own purposes. Some digitisers have a separate *AUXILIARY* port which can be used as input for these channels.

The collection and transmission of Mux channels is controlled using the *Mux Channels* pane:

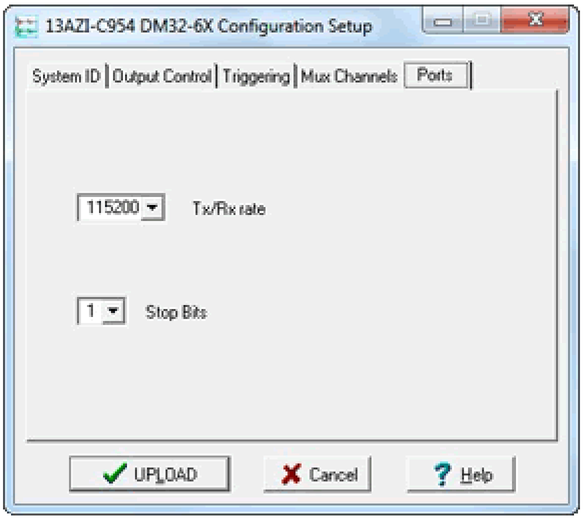


If a tick is placed in the box next to a channel, its data will be collected and transmitted as a data stream in GCF format, just as with the normal data channels. To indicate that the data come from a Mux channel, the Stream ID will take the form `****MX`, where `M` stands for Mux and `X` is a hexadecimal integer (i.e. 0 – 9, and A – F for 10 through 15). The **Z, N/S** and **E/W Mass Position** Mux channels appear as `M8`, `M9` and `MA` respectively.

3.1.5 Ports

The *Baud Rates* pane of the *Configuration setup* window allows you to program the baud rate and stop bits for the CD24's output port.

If you have a CD24 with Ethernet or Wi-Fi options, the settings you configure here are used both on the standard data output port and on the internal port which sends data to the Ethernet/Wi-Fi module. If you change them, you will also need to configure the Ethernet/Wi-Fi module to receive data with the new settings. This can be done using the Lantronix **DeviceInstaller** utility (see section 2.3 on page 13).



The baud rate you choose must satisfy two conditions:

- It must be high enough to allow the transmission of all data generated by the digitiser at the sampling rates you have chosen. For three streams of data at 100 Hz, for example, 9600 baud will usually be sufficient. If you wish to transmit 200 Hz data, however, the baud rate must be at least 19200.

- 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 56kbaud, 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 tick in the check-box marked *Identical TX/RX rates*.

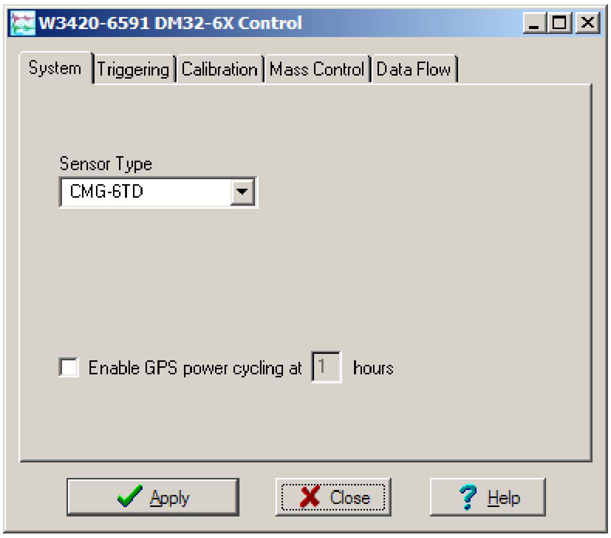
The Stop Bits option allows you to choose whether the serial link uses 1 or 2 stop bits. In most cases this can be left at 1, although 2 may be required if you are sending data over ‘difficult’ transmission lines (for example, some types of radio link). Using 2 stop bits will add a 10% overhead to the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

You will also need to set the data rate for Scream's local serial port, as well as for the EAM or other communications device (if you are using one). In Scream!, you can configure a serial port by right-clicking on the serial port's icon (*not* that of the digitiser) 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.

3.2 The control dialogue

To control a digitiser while it is running, either right-click on the digitiser's entry in the list to the left of Scream!'s main window (*not* the *Local* or *COMXX* icons) and click **Control…**, or simply double-click the entry. Scream! will then contact the digitiser 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 digitiser, where they will take effect immediately.

3.2.1 System



When the *Control* window is first opened, it will be showing the *System* pane.

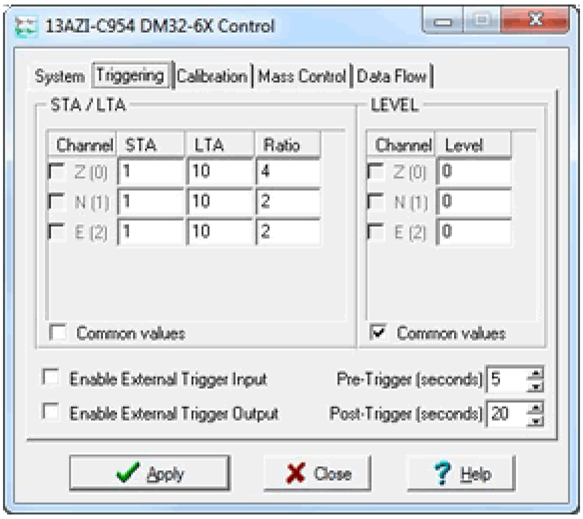
Sensor Type : This option tells Scream! which control commands to make available to the user.

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*.

When this option is selected, the CD24 will only check the GPS time at intervals of a specified number of hours.

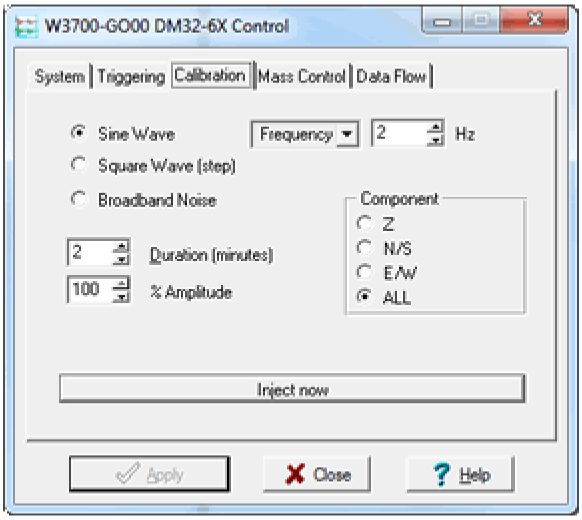
3.2.2 Triggering



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 digitiser. See section 3.1 on page 25 for more details.

3.2.3 Calibration

You can check that your instrument is correctly calibrated by injecting known signals into the sensor's feedback loop. The *Calibration* pane allows you to do this.



Each channel calibrates the corresponding component of the instrument. Select one or all components for calibration.

On three-channel digitisers, the calibration signal is digitised at a slower rate and returned as a Mux channel (see above) ending `MB`. On eight-channel models, it is returned as a full speed channel ending `X`*n*, where *n* is an integer specifying the tap (as for the normal outputs).

The *Duration* box tells the digitiser how long to provide the calibration signal before disconnecting. This avoids the system being inadvertently left in calibration mode. The default is 2 minutes. If you change this setting, it will revert to the default value after one calibration stage.

All Güralp digitisers 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 is specified in 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).

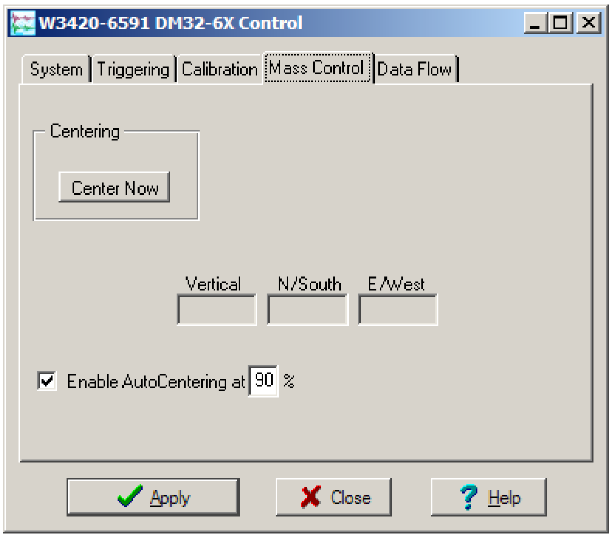
You can specify step calibration by selecting the *Square wave* button. The square wave consists of a positive step at the start of the next minute of the digitiser's internal clock, followed by a negative step after a specified number of minutes. After a further delay of the same number of minutes, 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.

3.2.4 Mass control

If supported by the instrument, the CMG-CD24 can initiate locking, unlocking, or centring of the mass. If the instrument does not support locking, unlocking and centring, instructing the CD24 to "centre" switches the instrument into a one-second response mode, which allows you to monitor the mass positions more easily.

You can issue this instruction from the *Mass Control* tab:



To switch into one-second response mode, click **Centre**.

3.2.5 Data flow

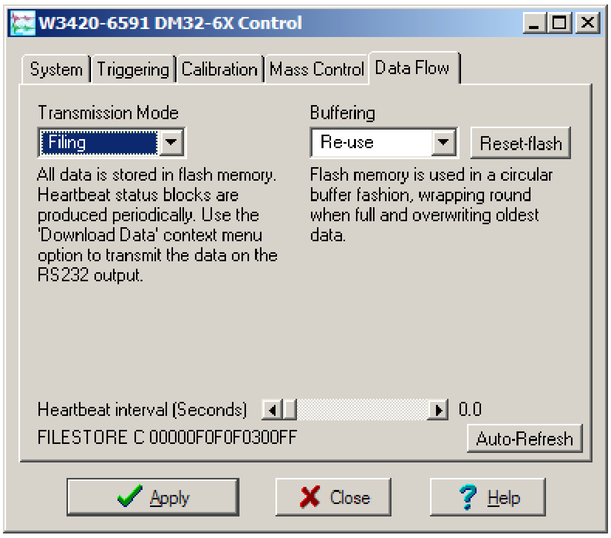
The CD24 operates in one of several *transmission modes*. These modes relate to how the unit uses its Flash memory:

- as a simple data store, from which you can request data (*FILING, DUAL* and *DUPLICATE* modes);
- as a buffer holding unacknowledged blocks, which are transmitted in preference to real-time data (*FIFO* mode); or
- 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 CD24 into *DIRECT* mode.

You can switch between transmission modes in Scream! by right-clicking on the digitiser and clicking on **Control...**, then navigating to the **Data Flow** pane:



To choose a transmission or buffering mode, select options from the *Transmission Mode* or *Buffering* drop-down menus, and click **Apply**. Clicking **Apply** in this window immediately activates the transmission mode you have selected - there is no need to reboot.

An explanation of the chosen mode is displayed beneath each menu. The following sections also explain the filing modes available.

The *Buffering* legend also displays the amount of Flash memory present in your digitizer.

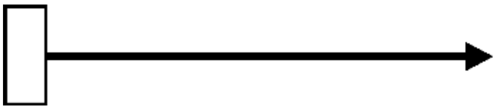
To clear the Flash memory of the digitizer, click the **Reset-Flash** button. You will be asked for confirmation before the memory is cleared.

At the bottom of the tab is a line describing the current state of the digitizer's memory pointers. You can use this line to check that data is being written into memory. Select **Auto-Refresh** to make the line update automatically.

If you prefer, you can use the CD24 terminal to switch between transmission modes. The commands to use, which take effect immediately, are given below.

3.2.5.1 DIRECT

Syntax: `DIRECT`



Instructs the digitizer not to use Flash memory for storage. Instead, all data is transmitted directly to clients. A digitiser 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.

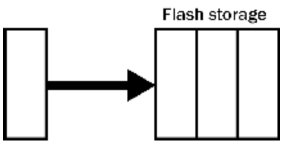
If you expect breaks in communication between the digitiser and its client to last more than 256 blocks, or if you want the digitiser to handle breaks in transmission (rather than relying on the client to request missed blocks), you should use

- *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 digitiser takes a while to catch up to real time.)

3.2.5.2 FILING

Syntax: `FILING`



Instructs the CD24 not to transmit blocks to clients automatically, but to store all digitised 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 digitiser will switch to *DIRECT* mode (see above) when the memory becomes full.

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

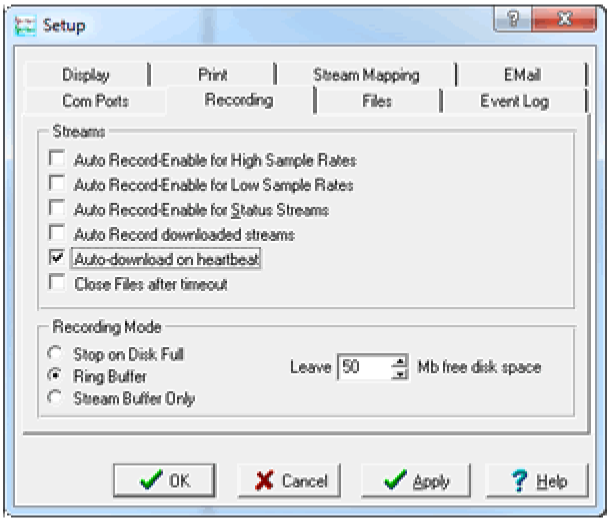
Heartbeat messages

When in *FILING* mode, a digitiser 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 a digitiser is present.

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

You can tell Scream! to download new data automatically whenever it receives a heartbeat message from a digitiser in *FILING* mode. This is useful, for example, in autonomous installations connected by intermittent modem links. To enable this feature:

1. Choose **File → Setup...** from Scream!'s main menu, and navigate to the *Recording* pane.



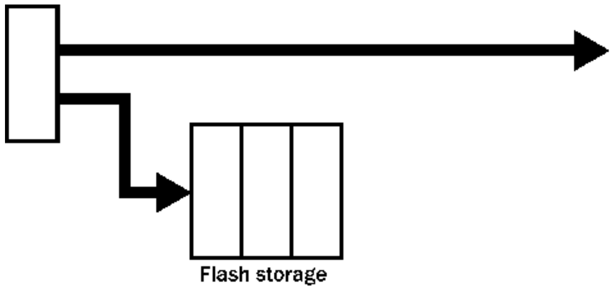
2. Check **Auto-download on heartbeat**.

3. Click **OK**.

Using *FILING* mode with **Auto-download on heartbeat** ensures that Scream! receives all new data whenever it can, regardless of the configuration of any devices between you and the digitiser.

3.2.5.3 DUPLICATE

Syntax: `DUPLICATE`



Instructs the CD24 to transmit streams directly to clients as well as storing all data into Flash storage as for *FILING* mode.

A digitiser 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.

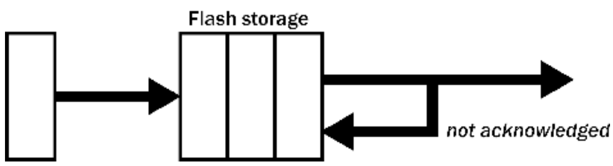
If you expect breaks in communication between the digitiser and its client to last more than 256 blocks, or if you want the digitiser to handle breaks in transmission (rather than relying on the client to request missed blocks), you should use

- *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 digitiser takes a while to catch up to real time.)

3.2.5.4 FIFO (First In First Out)

Syntax: `FIFO`



Instructs the CD24 to begin writing blocks to Flash memory as for *FILING* mode, but also to transmit data to clients. Data are transmitted in strict order, oldest first; the CD24 will only transmit the next block when it receives an explicit acknowledgement of the previous block.

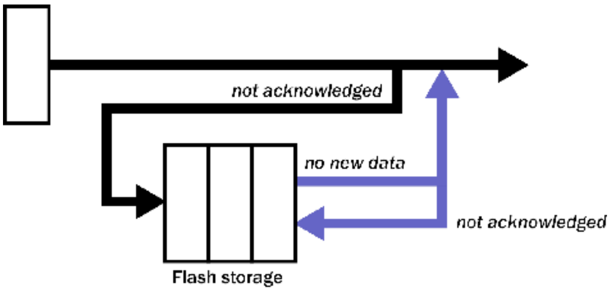
If the communications link is only marginally faster than the data rate, it will take some time to catch up with the real-time data after an outage. If you want data to be transmitted in real-time where possible, but are worried about possible breaks in communication, you should use *ADAPTIVE* mode instead.

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 digitiser, you will need to set up the transmission mode for each device (if applicable) to ensure that data flow works the way you expect.

Like all the transmission modes, *FIFO* mode does not delete data once they have 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 they are overwritten (in the *RECYCLE* buffering mode, see below) or if you delete them manually.

3.2.5.5 ADAPTIVE

Syntax: `ADAPTIVE`



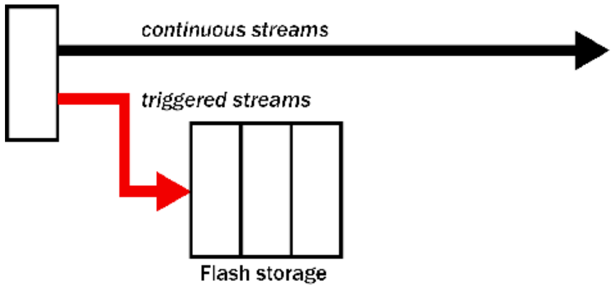
Instructs the CD24 to transmit current blocks to clients if possible, but to store all unacknowledged blocks in the Flash memory and re-send them, oldest first, when time allows. *ADAPTIVE* mode is best suited for “real-time” installations where the link between digitiser and client is intermittent or 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 digitiser 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.

3.2.5.6 DUAL

Syntax: `DUAL`



Instructs the CD24 to transmit continuous streams directly to clients as for *DUPLICATE* mode, but to store triggered data *only* into Flash storage.

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

3.2.6 Buffering modes

3.2.6.1 RE-USE / RECYCLE

Syntax: `RE-USE`

Instructs the CD24 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 digitiser.

3.2.6.2 WRITE-ONCE

Syntax: `WRITE-ONCE`

Instructs the CD24 to stop writing data to the Flash memory when it is full, and to switch to *DIRECT* mode automatically.

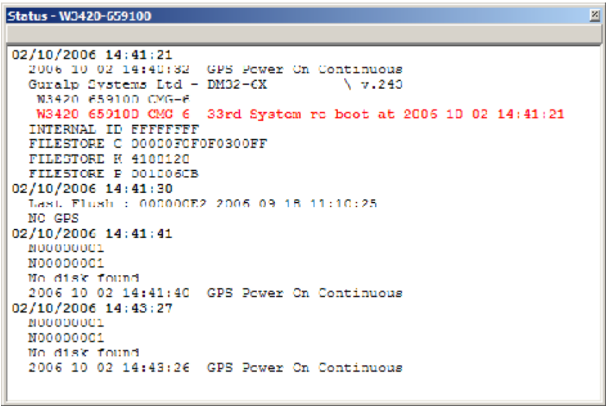
For example, in *FIFO* mode with *WRITE-ONCE* buffering, the station will transmit data to you continuously, but also save them in the Flash memory until it is full. Once full, the digitiser will switch to *DIRECT* mode and continue transmitting, though no further data will be saved. This mode thus lets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

3.3 Digitiser status streams

All Güralp digitisers have a separate stream for reporting information about the system, such as their GPS and time synchronization status. This status information is in plain ASCII text format.

To see a *Status* window for any digitiser, double-click on the *Stream ID* xxxx00. This stream always has a reported sample rate of 0 samples/s.

During boot-up each unit reports its model type, firmware revision number, its *System ID* and serial number. This information is followed by the number of resets that have occurred and the time of the latest reboot from its internal clock. The following lines report the current configuration of the unit's sample rates, output taps, and baud rates. A typical digitiser re-boot status message looks like this:



The system will produce a similar status message whenever it is powered up, and whenever you reboot it (normally, after changing its configuration.)

3.3.1 GPS

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

From a cold start, GPS will initially report `No GPS time` together with its last position (taken from the internal backup.) All messages from the GPS that involve a change of its status are automatically reported. Repeated status messages are not shown to avoid unnecessary clutter.

This report shows the satellites the system has found, and their corresponding signal strengths.

If the system has not been moved from its previous location, it should be able to find enough satellites to obtain an accurate GPS time fairly quickly; if the GPS receiver has difficulty finding satellites, there may be a delay of several minutes before a new message is displayed.

Before beginning, the digitiser's internal time synchronisation software will wait for the GPS unit to report a good position fix from at least 3 satellites, for at least 6 consecutive messages. Messages are normally received every 10 to 20 seconds.

The system will then set the internal clock and re-synchronise the Analogue to Digital Converters so that the data are accurately time-stamped to the new reference. Any data transmitted up to this point will be stamped with the time from the internal backup clock, which is set to the new accurate time at the end of this process. The re-synchronisation will result in a discontinuity in the data received.

From this point, the control process will attempt to keep the internal time-base synchronised to the GPS 1 pulse per second output, by adjusting a voltage-controlled crystal oscillator. First it alters the voltage control to minimise the error. Next it attempts to minimise both the "phase error" (*i.e.* the offset between the internal 1 Hz signal and the GPS) and the drift (the frequency error relative to GPS.) During the control process the system reports the measured errors and the control signal applied, as a PWM (Pulse Width Modulation) value.

During the initial, coarse adjustment stage only the coarse voltage control is used and no drift calculation is made. If the system is operating in a similar environment to that when the system was last powered (most importantly, the same temperature) the saved control parameters will be appropriate and the system should rapidly switch to the 'fine' control mode. The system reports its control status and parameters each minute, with error measurements given in nominal timebase units. In a stable temperature environment the system should soon settle down showing an offset error of only a few thousand (average error < 100 microseconds) and a drift rate under 100 counts (< 1 in 10^{-6}).

4 Calibrating the CD24

4.1 Calibration methods

Sensors attached to the CD24 can be calibrated using the built-in signal generator. There are three common calibration techniques used.

- Injecting a step current allows the system response to be determined in the time domain. The amplitude and phase response can then be calculated using a Fourier transform. Because the input signal has predominantly low-frequency components, this method generally gives poor results. However, it is simple enough to be performed daily.

- Injecting a sinusoidal current of known amplitude and frequency allows the system response to be determined at a spot frequency. However, before the calibration measurement can be made the system must be allowed to reach a steady state; for low frequencies, this may take a long time. In addition, several measurements must be made to determine the response over the full frequency spectrum.

- Injecting white noise into the calibration coil gives the response of the whole system, which can be measured using a spectrum analyser.

Further information about calibration is available on the Güralp Systems Web site.

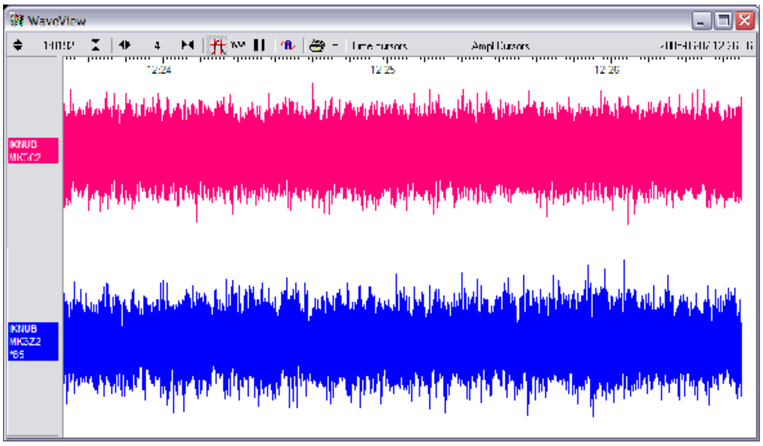
4.2 Noise calibration with Scream!

A connected instrument can be calibrated using the digitiser's pseudo-random broadband noise generator, along with Scream!'s noise calibration extension. The extension is part of the standard distribution of Scream! and contains all the algorithms needed to determine the complete sensor response in a single experiment.

1. In Scream!'s main window, right-click on the digitiser's icon and select **Control…**. Open the *Calibration* pane.

2. Select the calibration channel corresponding to the instrument, and choose **Broadband Noise.** Select the component you wish to calibrate, together with a suitable duration and amplitude, and click **Inject now**. A new data stream ending `C`*n* (*n* = 0 – 7)

should appear in Scream!'s main window containing the returned calibration signal.



3. Open a Waveview window on the calibration signal and the returned streams by selecting them and double-clicking. The streams should display the calibration signal combined with the sensors' own measurements. If you cannot see the calibration signal, zoom into the Waveview using the scaling icons at the top left of the window or the cursor keys.

4. Drag the calibration stream `Cn` across the Waveview window, so that it is at the top.

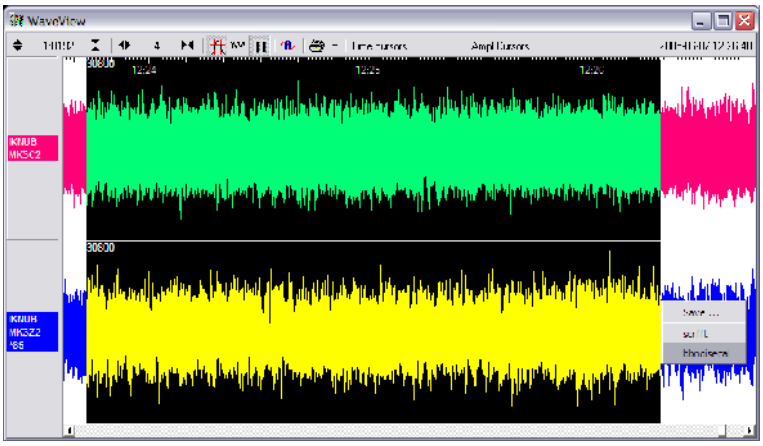
5. If the returning signal is saturated, retry using a calibration signal with lower amplitude, until the entire curve is visible in the Waveview window.

6. If you need to scale one, but not another, of the traces, right-click on the trace and select **Scale...**. You can then type in a suitable scale factor for that trace.

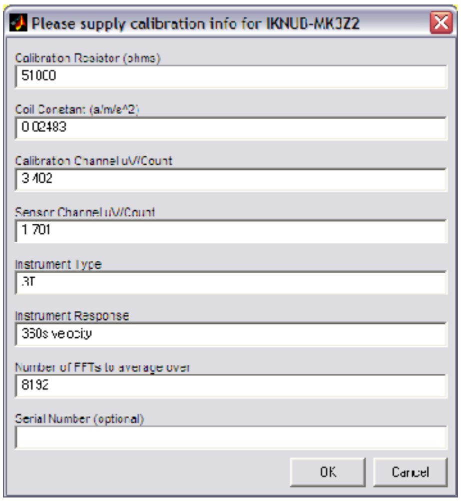
7. Pause the Waveview window by clicking on the  icon.

8. Hold down `SHIFT` and drag across the window to select the calibration signal and the returning component(s). Release the mouse button, keeping `SHIFT` held down. A menu will pop up. If it doesn't it is likely because you have not selected at least two signals (calibration and the returning components)

9. Choose **Broadband Noise Calibration.**



10. The script will ask you to fill in sensor calibration parameters for each component you have selected.



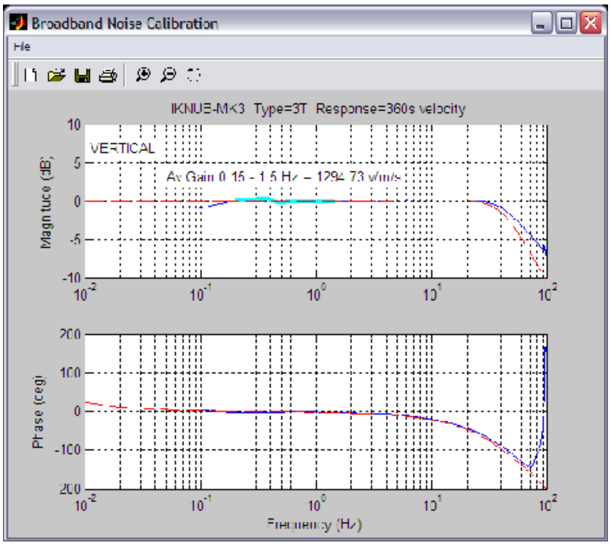
Most data can be found on the calibration sheet for your sensor. Under *Instrument response*, you should fill in the sensor response code for your sensor, according to the table below. *Instrument Type* should be set to the model number of the sensor.

If the file `calvals.txt` exists in the same directory as Scream!'s executable (`scream.exe`), Scream! will look there for suitable calibration values.

See the Scream! manual for full details of this file. Alternatively, you can edit the sample `calvals.txt` file supplied with Scream!.

11. Click `OK`. The script will return with a graph showing the responsivity of the sensor in terms of amplitude and phase plots for each component (if appropriate.)

The accuracy of the results depends on the amount of data you have selected, and the sample rate. To obtain good-quality results at low frequency, it will save computation time to use data collected at a lower sample rate; although the same information is present in higher-rate streams, they also include a large amount of high-frequency data which may not be relevant to your purposes.



The calibration script automatically performs appropriate averaging to reduce the effects of aliasing and cultural noise.

4.2.1 Sensor response codes

Sensor	Sensor type code	Units (V/A)
CMG-40T-1 or 6T-1, 1s – 50Hz response	CMG-40_1HZ_50HZ	V
CMG-40T-1 or 6T-1, 1s – 100Hz response	CMG-40_1S_100HZ	V
CMG-40T or 6T, 2s – 100Hz response	CMG-40_2S_100HZ	V
CMG-40T or 6T, 10s – 100Hz response	CMG-40_10S_100HZ	V
CMG-40T or 6T, 20s – 50Hz response	CMG-40_20S_50HZ	V
CMG-40T or 6T, 30s – 50Hz response	CMG-40_30S_50HZ	V
CMG-40T or 6T, 60s – 50Hz response	CMG-40_60S_50HZ	V

5 Command line interface

You can connect to the internal software of the CD24 over its output serial port and communicate with it.

To enter command mode from Scream!, right-click on the digitiser's icon and select **Terminal...** from the menu that pops up. A window will open, and once the CD24 and computer are communicating properly you will see the prompt

```
ok
```

If you prefer, you can use a terminal program of your own (such as `minicom` on Linux, or one of the programs detailed in section 7.5 on page 108) to connect to the CD24.

Whilst you are in terminal mode, data transfer will be interrupted; the CD24 may use its 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 Enhanced Acquisition Modules (CMG-EAM) also allow you to send commands direct to the CD24 using the command-line tools `data-terminal` and `adc-command`. For more information, please see the manual for the EAM.

If you have problems connecting to the digitiser'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 CD24 expects connections at 19200 baud, with 8 data bits, no parity bit and 1 stop bit. No flow control is used.

5.1 FORTH

The CD24 uses a FORTH-like interpreter to implement its features. To issue a command in FORTH, you must supply the arguments *before* the command, for example:

```
0 19200 BAUD
```

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 above, the numbers have no immediate effect, so stay on the stack. `BAUD` removes itself and the previous two items (here `0` and `19200`) off the stack, then performs its action using these as arguments.

If a command completes with nothing remaining on the stack, the digitiser will show the prompt `ok`. Otherwise, no prompt will be given. Some commands, such as `SAMPLES/SEC`, clear the stack automatically after they execute. Pressing `ENTER` twice will always clear the stack.

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 **bold** and messages returning from the CD24 are given in `medium`.

Some of the less-used commands are not normally available over the terminal interface. In order to access these, you need to import them into the current dictionary with the command `ok-1`. You now have access to the full FORTH word list. To return to the normal state of the interpreter, issue the command `[seal]`.

5.2 General configuration

5.2.1 SET-ID

Syntax: `SET-ID` (interactive)

Sets the system identifier and serial number of the CD24 to values you supply.

```
SET-ID
System Identifier ( WO3008 ) MYCD24
Serial # ? ( 123400 ) 4507
```

The system identifier you supply may contain up to 5 alphanumeric (0 – 9, A – Z) characters. The CD24 will pad any remaining space on the right with zeroes. If you want to use a system identifier less than 5 characters long, insert zeroes on the *left* to make it up to 5 characters. The digitiser will interpret leading zeroes as blank. (Because of this, you cannot have a system identifier that begins with a zero.)

The serial number you supply must contain 4 alphanumeric (0 – 9, A – Z) characters as shown. As for the system identifier, leading zeroes are interpreted as blanks.

5.2.2 BAUD

Syntax: *port* *baud-rate* BAUD

Sets the baud rate for one of the serial ports on the CD24, in bytes per second. The CD24 has a single port, numbered 0. For example,

```
0 19200 BAUD
```

This will reset a standard CD24 to its default configuration.

The allowable values for *baud-rate* are 4800, 7200, 9600, 14400, 19200, 57600 and 115200. *Note especially* that 38400 baud is not available on the CD24.

If you have a CD24 with Ethernet or Wi-Fi options, the settings you configure here are used both on the standard data output port, and on the internal port which sends data to the Ethernet/Wi-Fi module. If you change them, you will also need to configure the Ethernet/Wi-Fi module to receive data with the new settings. This can be done using the Lantronix **DeviceInstaller** utility (see section 2.3 on page 13 and section 7.4 on page 103.)

5.2.3 LOAD

Syntax: LOAD (interactive)

Starts an Xmodem file transfer for new CD24 firmware. For full instructions, see Chapter 6, page 81.

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

5.2.4 LOAD-I

Syntax: LOAD-I (interactive)

Starts an Xmodem file transfer for a new *Info Block*. This block can be up to 1 K long, and will automatically be transmitted from the CD24 when it first powers up. You can use the *Info Block* to store any information you like: for example, about the digitiser, your project, or calibration data for attached sensors.

Before uploading an *Info Block*, you must convert it to Intel Hex format. Freely-downloadable tools exist that can help you with this conversion. Similar software is also available from Güralp Systems.

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

5.2.5 TEMP?

Syntax: `TEMP?`

Display the current temperature measurement from the internal thermometer.

5.2.6 ETHER

Syntax: `ETHER ENABLE | ETHER DISABLE`

Enables or disables the optional Ethernet and Wi-Fi devices on the CD24.

When the Ethernet device is enabled, data produced by the CD24 will be sent to the device for transmission across the network, *unless* you have plugged a serial cable into the *Data Out* port of the breakout box. In this case, data will be sent over the standard RS232 interface only. This is the default behaviour.

When the Ethernet device is disabled, data will always be sent out over the standard RS232 interface, and the internal Ethernet/Wi-Fi module will not be used.

5.3 GPS and timing systems

5.3.1 GPS-TYPE

Syntax: *`type`* `GPS-TYPE`

Tells the CD24 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.

5.3.2 HR-CYCLE

Syntax: *`interval`* `HR-CYCLE`

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

Setting *interval* to 0 will make the CD24 leave the GPS on continuously. This is recommended if your installation has access to mains power.

To find out the current `HR-CYCLE` setting, issue `HR-CYCLE?`

5.3.3 XGPS

Syntax: `0 XGPS | 1 XGPS`

Manually switches on or off the GPS system, overriding the `HR-CYCLE` command (see above). If you issue `0 XGPS`, the digitiser will switch off the relay; `1 XGPS` will switch it on. Once the GPS system is switched on, the digitiser will automatically check the timing signal and synchronise its internal clock before switching off the GPS and returning to normal operation.

5.3.4 SET-RTC

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

Sets the system's real time clock. This time will be used from power-up until it is corrected by an attached GPS. If you are not using GPS but are synchronizing from some other time source, you will need to re-issue this command regularly to ensure the CD24 does not drift.

5.3.5 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 2006  2  1 12:53:27 ok
```

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 CD24 does not recognize the time format you have used, it will output and error message.

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

5.3.6 TIME?

Syntax: `TIME?`

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

`year month day hour:minute:second ok`

5.3.7 LEAPSECOND

Syntax: `yyyy mm dd LEAPSECOND`

Manually notify the digitiser 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*.

5.3.8 SQPATCH

Syntax: `SQPATCH ENABLE | 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 digitiser is offset by one second to counteract this problem. If you have set `LEAPSECOND`, above, SQPATCH will automatically be disabled when the leap second occurs, and the digitiser 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`

5.4 Output configuration

5.4.1 SAMPLES/SEC

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

The DSP software on the CD24 supports up to 7 cascaded filter/decimation stages. Each stage can be set to one of three decimation factors, which divide the sample rate by 2, 4 or 5. Decimation factors of 8 and 10 are also available, which the CD24 produces by combining two decimation stages. As a result, data can be output at up to 4 concurrent data rates. These configured output stages are called *taps*.

The ADC within the unit outputs data at 2000 samples/s, so taps can have sample rates between 1 and 1,000 samples/s.

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 or 10. Non-integer values are not allowed.

For example:

```
1000  250  125   25  samples/sec
500   100    5    1  samples/sec
200   100   20    4  samples/sec
400   40    20   10  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
```

5.4.2 SET-TAPS

Syntax: *tap-0* *tap-1* *tap-2* *tap-3* `SET-TAPS`

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

tap-0 to *tap-3* are integers below 8, whose binary bits represent the *Z* (1), *N* (2) and *E* (4) components respectively. Each one sets which components are output at that tap under normal conditions. You cannot set tap 0 to output streams.

For example, if you issue

```
1 5 7 0 SET-TAPS
```

then

- tap 1 will output only the *Z* component (1);
- tap 2 will output the *Z* and *E* components (1 + 4 = 5);
- tap 3 will output all three components (1 + 2 + 4 = 7); and
- tap 4 will not output anything; and

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

5.4.3 SET CONFIG

Syntax: `SET-CONFIG`

Selects which streams and mux channels are to be output as continuous data for each instrument. Two hexadecimal inputs are required as shown below:

```
SET-CONFIG
Hex code to select DSP#1 'taps' {0000,0000} 0070,0000
Hex code to select mux channels {00ff} 0307
```

The 8 digit hex code for the 'taps' is structured as follows:

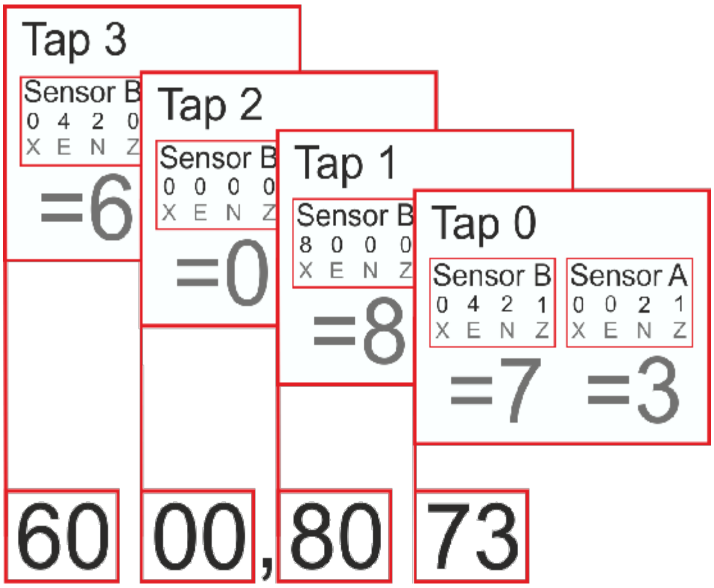
`ABCD,EFGH`

A = Tap0 on Instrument B
B = Tap0 on Instrument A
C = Tap1 on Instrument B
D = Tap1 on Instrument A
E = Tap2 on Instrument B
F = Tap2 on Instrument A
G = Tap3 on Instrument B
H = Tap3 on Instrument A

Each component within a tap on an instrument is given a binary value:

1 = Z
2 = N/S
4 = E/W
8 = X (the auxiliary input, present on 4 and 8 channel systems only)

The value at each of the eight hex code positions is the total of the values of the required components, expressed in hexadecimal. For example:



In the above example the following data outputs are activated:

N and E from Sensor B at Tap 3
No outputs from Sensor B at Tap 2
X channel from Sensor B at Tap 1
Z, N and E from Sensor B at Tap 0
Z and N from Sensor A at Tap 0

Further examples:

To set the N component at Tap 2 of Instrument A, the hex code would be:

```
0002,0000
```

To set the all 3 components at Tap 3 of Instrument B, the hex code would be:

```
0000,7000
```

The Hex Code for the Mux channels is configured in much the same way:

```
ABCD
```

A = M0 to M3
B = M4 to M7

C = M8 to MB
D = MB to MF

The least significant bit is the lower channel within each group (i.e. M0 = 1 and M3 = 8).

For example, to configure mass position outputs for the first instrument (M9, MA and MB), the required code would be:

```
0070
```

Note:

M8 = Z Mass position
M9 = N/S Mass position
MA = E/W Mass position
MB = Calibration signal (on 3 channel digitisers)
ME = Temperature

5.4.4 COMPRESSION

Syntax: *__bits__* *__size__* `COMPRESSION` or `NORMAL COMPRESSION`

Sets the maximum amount of compression to use. Greater compression means the digitiser 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 digitiser compresses data without loss, so compression is most effective when the data contain relatively little information. In most cases, when a seismic event occurs, the digitiser 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 digitiser 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`.

5.5 Triggering

5.5.1 TRIGGERS

Syntax: *components* `TRIGGERS`

Selects which component or components can *generate* a 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. Thus, for example,

- `1 TRIGGERS` will trigger from the *Z* component only (1);
- `6 TRIGGERS` will trigger from either the *N* or *E* components (2 + 4 = 6);
- `7 TRIGGERS` will trigger from any of the three components (1 + 2 + 4 = 7);
- `0 TRIGGERS` will disable the triggering system.

5.5.2 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 `TRIGGERS` command, above.

(These two commands have similar names; remember that a component `TRIGGERS` the system, whilst taps and components can *be* `TRIGGERED`.)

5.5.3 STA

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

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

Z-secs, *N-secs*, and *E-secs* are the time period over which to calculate the average for the *Z*, *N*, and *E* 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 2 2 STA` will calculate short-term averages for 1 s of the *Z* component, and 2 s of the horizontal components.

5.5.4 LTA

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

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

Z-secs, *N-secs*, and *E-secs* are the time period over which to calculate the average for the *Z*, *N*, and *E* 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 STA` will calculate long-term averages for 15 s of the *Z* component, and 20 s of the horizontal components.

5.5.5 RATIOS

Syntax: *Z-ratio* *N-ratio* *E-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*, and *E-ratio* are the time period over which to calculate the average for the *Z*, *N*, and *E* 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 RATIOS` will cause the CD24 to trigger if the STA/LTA ratio is above 4 for the *Z* component, *or* above 10 for the horizontal components.

5.5.6 BANDPASS

Syntax: *tap* *filter* `BANDPASS`

The CD24 passes the stream(s) which generate STA/LTA triggers through a band-pass filter before examining them. This filtering does not affect the continuous outputs. The corner frequency of the band-pass filter can be changed with the `BANDPASS` command.

- *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)

5.5.7 MICROG

Syntax: *level* `MICROG`

Sets the output level above which a trigger will be declared when using the `LEVEL` triggering algorithm. *level* is interpreted in counts. To interpret in ground units use `MICRO-G`.

5.5.8 MICRO-G

Syntax: *level* `MICRO-G`

Sets the output level above which a trigger will be declared when using the `LEVEL` triggering algorithm. *level* is interpreted in ground units (μg) if there is a correctly populated infoblock (calvals), otherwise the level will be interpreted in counts (see `MICROG`).

5.5.9 HIGHPASS

Syntax: *filter* `HIGHPASS`

Instructs the digitiser 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.

Note that this filter will affect the data being output as continuous streams.

5.5.10 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.

5.5.11 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.

5.5.12 TRIGGERIN

Syntax: `TRIGGERIN ENABLE | TRIGGERIN DISABLE`

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

Enabling external trigger input allows you to trigger the CD24 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 CD24 is triggered externally, it will behave exactly as if it had generated the trigger itself.

5.5.13 TRIGGEROUT

Syntax: `TRIGGEROUT ENABLE | TRIGGEROUT DISABLE`

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

Enabling external trigger output allows you to trigger other equipment through a relay contained within the CD24 whenever it triggers. The CD24'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 digitiser with `TRIGGERIN ENABLE` in effect, in which case triggered data from both instruments will be transmitted whenever the CD24 triggers.

If a CD24 has both `TRIGGERIN ENABLE` and `TRIGGEROUT ENABLE` in effect, *only* triggers which the CD24 itself has generated will be output. Triggers received through the *Trigger in* port will cause the CD24 to output triggered streams, but will *not* be passed on to other digitisers.

5.6 Calibration

5.6.1 SINEWAVE

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

Instructs the CD24 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`, or `E/W`.

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.

5.6.2 SQUAREWAVE

Syntax: *component* `SQUAREWAVE`

Instructs the CD24 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`, or `E/W`.

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

5.6.3 RANDOMCAL

Syntax: *component* `RANDOMCAL`

Instructs the CD24 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`, or `E/W`. 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.

5.6.4 MINUTE

Syntax: *duration* `MINUTE`

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

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

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

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

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

5.6.5 %AMPLITUDE

Syntax: *percentage* `%AMPLITUDE`

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

5.7 Actions

5.7.1 CENTRE

Syntax: `CENTRE` or `CENTER MONITOR`

Centres the sensor mass(es) of the instrument.

`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.

5.7.2 %AUTO-CENTRE

Syntax: *distance* `%AUTO-CENTRE`

Instructs the CD24 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.

5.7.3 RESP

Syntax: *value* `RESP`

The CD24 provides a 1 second response mode for use when monitoring mass positions or adjusting offsets. To enter this mode, issue the command `1 RESP`.

Once you have finished monitoring the mass positions, you can return to broadband response mode by issuing `0 RESP`.

5.7.4 MASSES?

Syntax: `MASSES?`

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

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

5.7.5 RE-BOOT

Syntax: `RE-BOOT`

Causes the CD24 to reset. Some configuration changes will only take effect after you have rebooted the digitiser.

5.8 Flash storage and filing

5.8.1 SHOW-FLASH

Syntax: `SHOW-FLASH`

Reports status information about Flash memory in the CD24. For example:

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

```
show-flash FILESTORE C 0000FFFF00000000
FILESTORE K 1048160
Last Flush: CHIP - -1 0000FFFF
Last write: CHIP – 35 00000FF8 ok
```

The first two lines display internal diagnostic information, whilst the last two lines describe the position in Flash

- where data was last flushed, and
- where data was last written.

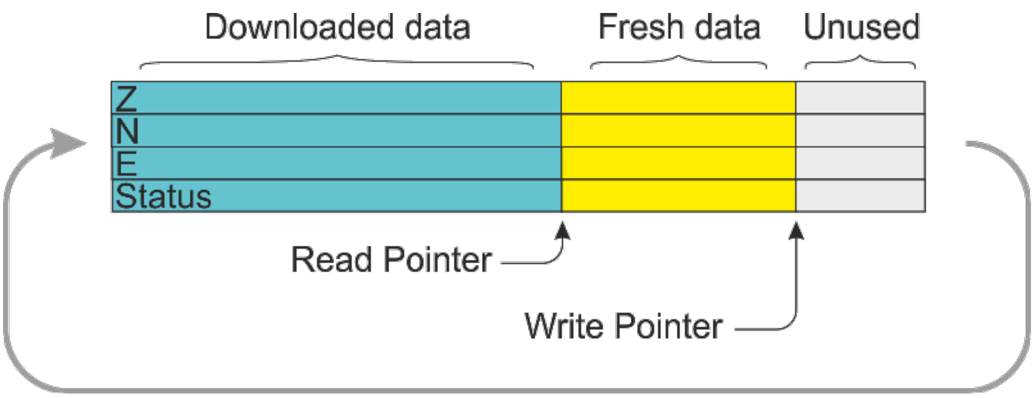
5.8.2 DOWNLOAD

Syntax: `DOWNLOAD` (but see below)

Sets up a data transfer from the Flash memory over the serial connection direct to SREAM! or other software.

SCREAM! Can be configures to auto-record data. Refer to the manual for more information.

The flash memory is used as a ring buffer. Two pointers into the memory keep track of where data were last read (the “Read Pointer”) and last written (the “Write pointer”). When either pointer reaches the end of physical memory, it wraps round back to the beginning. The behaviour when the write pointer reaches the read pointer (i.e. when the memory becomes full of data, none of which have been downloaded) is governed by the commands `RE-USE/RECYCLE` and `WRITE-ONCE`.



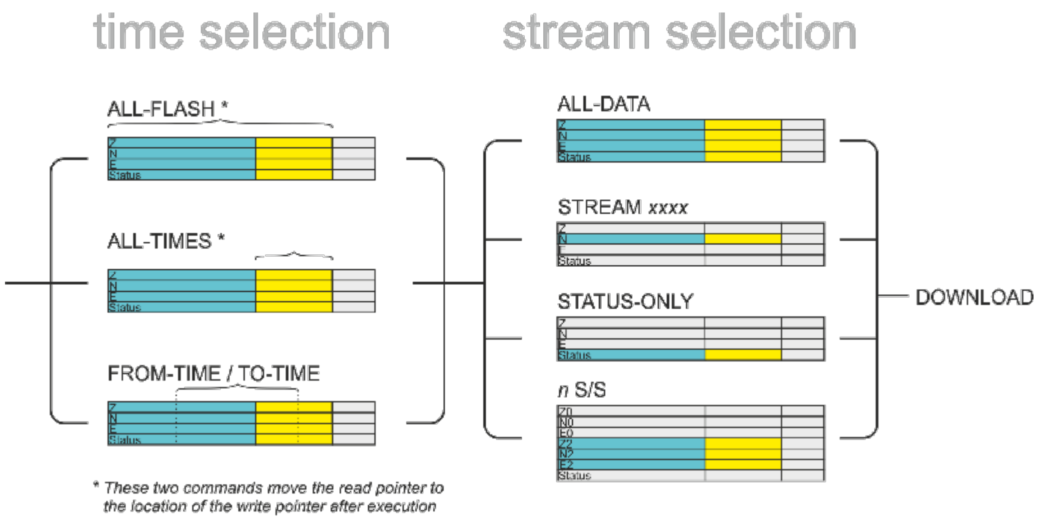
Which data are downloaded depends on various parameters you can set, which allow you to select a particular stream, streams of a specified sample rate, or streams within a certain time window. You can set parameters separately, or place the definitions before the `DOWNLOAD` command, *e.g.*

```
ALL-FLASH HPA0N1 STREAM DOWNLOAD

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

100 S/S ALL-TIMES DOWNLOAD

ALL-DATA ALL-TIMES DOWNLOAD
```

Before `DOWNLOAD` will work, it needs to know

- the desired time period, which is specified with `ALL-FLASH`, `ALL-TIMES`, or `FROM-TIME` and/or `TO-TIME`, and
- the streams you want to download, which are specified with `ALL-DATA`, `S/S`, or `STATUS-ONLY`.

The parameters are illustrated in the diagram below and fully described in the following sections. If you miss out a parameter, `DOWNLOAD` will use the value you last used.



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 a download by entering terminal mode, and restart with another GO or abort with END-DOWNLOAD.

When you complete a DOWNLOAD without specifying a time period, the CD24 marks the latest position with an internal *read pointer*, which can be used as a start point for the next DOWNLOAD with the command ALL-TIMES (see below.)

5.8.3 ALL-FLASH

Syntax: ALL-FLASH

Moves the read pointer to the oldest data held by the CD24, and sets up the DOWNLOAD to transfer all data since then. When it has finished, the read pointer will be at the end of the downloaded data.

This command does not alter which *streams* are to be transmitted; you should also specify streams or use the ALL-DATA command.

When you issue ALL-FLASH, the old position of the read pointer is forgotten. Issuing ALL-TIMES will not restore it.

5.8.4 ALL-TIMES

Syntax: `ALL-TIMES`

Clears any time selection in force. The next `DOWNLOAD` will begin at the read pointer, and end with the newest data. When it has finished, the read pointer will be moved to the end of the downloaded data.

5.8.5 FROM-TIME

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

Instructs the CD24 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).

5.8.6 TO-TIME

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

Instructs the CD24 to transmit only data earlier than *yyyy*-*mm*-*dd* *hh*:*mm*, where *yyyy*, *mm*, *dd*, *hh* and *mm* have the same meanings as in `FROM-TIME`, above.

You can combine `FROM-TIME` with `TO-TIME` to download data from a specific time window.

When a `TO-TIME` download completes, the read pointer will be moved to the end of the downloaded data. The old position of the read pointer is forgotten, so issuing `ALL-TIMES` may transmit data you have previously downloaded.

5.8.7 ALL-DATA

Syntax: `ALL-DATA`

Instructs the CD24 to transmit all the data streams it holds next time a `DOWNLOAD` is issued. This command does not alter the read pointer or specify a time period.

5.8.8 STREAM

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

Instructs the CD24 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.

The read pointer will be moved to the end time of the download, so a subsequent `ALL-TIMES DOWNLOAD` will *not* transfer any other streams that were recorded during this period. To retrieve these streams, you will have to specify the time period explicitly with `FROM-TIME` (and `TO-TIME` if necessary), or download all stored data with `ALL-FLASH`.

5.8.9 STATUS-ONLY

Syntax: `STATUS-ONLY`

Instructs the CD24 to transmit only status streams (text streams, normally with stream IDs ending in `00`.)

The read pointer will be moved to the end time of the download, so a subsequent `ALL-TIMES DOWNLOAD` will *not* transfer any data streams that were recorded during this period. To retrieve these streams, you will have to specify the time period explicitly with `FROM-TIME` (and `TO-TIME` if necessary), or download all stored data with `ALL-FLASH`.

5.8.10 S/S

Syntax: *rate* `S/S`

Instructs the CD24 to transmit only streams with sample rates equal to *rate*. If *rate* is zero, only status streams are transmitted.

The read pointer will be moved to the end time of the download, so a subsequent `ALL-TIMES DOWNLOAD` will *not* transfer any other streams that were recorded during this period. To retrieve these streams, you will have to specify the time period explicitly with `FROM-TIME` (and `TO-TIME` if necessary), or download all stored data with `ALL-FLASH`.

This command should not be confused with the `SAMPLES/SEC` command.

5.8.11 RESET-FLASH

Syntax: `RESET-FLASH`

Resets the Flash memory pointers so that both point to the start of physical memory. The CD24 will start overwriting old data from the beginning of memory. You can still access these data, if they have not been overwritten.

5.8.12 ERASEFILE

Syntax: `ERASEFILE` (interactive)

Clears the entire Flash memory. When you issue this command, the CD24 will ask you for confirmation. Enter `y` to confirm.

You will not be able to access any data previously held in Flash memory after issuing this command.

5.9 Transmission modes

The CD24 operates in one of several *transmission modes*. These modes relate to how the unit uses its Flash memory. For more details, see section 3.2.5, page 40.

5.9.1 DIRECT

Syntax: `DIRECT`

Instructs the CD24 not to use Flash memory for storage. Instead, all data are transmitted directly to clients.

5.9.2 FILING

Syntax: `FILING`

Instructs the CD24 not to transmit blocks to clients automatically, but to store all digitised 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.

You can retrieve blocks from a digitiser in *FILING* mode by connecting to its terminal interface and issuing `DOWNLOAD` commands, or by transferring the data to a FireWire disk.

When in *FILING* mode, a digitiser transmits “heartbeat” messages over its data port. These short messages take the place of blocks, and ensure that programs such as Scream! know that a digitiser is present. You can change the frequency of heartbeat messages using the command `HEARTBEAT`.

5.9.3 DUPLICATE

Syntax: `DUPLICATE`

Instructs the CD24 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 digitiser does not attempt to retransmit it.

5.9.4 DUAL

Syntax: `DUAL`

Instructs the CD24 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 digitiser will send heartbeat messages in addition to any continuous streams you have configured. Scream! can pick these up and download new data as necessary.

5.9.5 ADAPTIVE

Syntax: `ADAPTIVE`

Instructs the CD24 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.

5.9.6 FIFO

Syntax: `FIFO`

Instructs the CD24 to begin writing blocks to Flash memory as for `FILING`, but also to transmit data to clients. Data are transmitted in strict order, oldest first; the CD24 will only transmit the next block when it receives an explicit acknowledgement of the previous block.

5.9.7 HEARTBEAT

Syntax: *interval* HEARTBEAT

When the CD24 is in *FILING* mode, it outputs status messages periodically over the RS232 port. This command changes how often these messages are produced.

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

```
600 HEARTBEAT
```

will cause the CD24 to output heartbeat messages every (600 × 30) = 18000 ms = 18 s.

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

5.9.8 MS-GAP

Syntax: *interval* MS-GAP

Sets the interval the digitiser 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 digitiser's behaviour depends on the current transmission 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 digitiser will be producing data faster than it can transmit them, 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.

5.10 Buffering Modes

5.10.1 RE-USE

Syntax: `RE-USE`

Instructs the CD24 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.

5.10.2 WRITE-ONCE

Syntax: `WRITE-ONCE`

Instructs the CD24 not to overwrite data in the Flash memory when it becomes full Instead, when the digitiser runs out of space, it switches to *DIRECT* transmission mode and will leave the Flash memory untouched.

5.10.3 MODE?

Syntax: `MODE?`

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

5.11 FireWire disks

5.11.1 DIR

Syntax: `DIR`

Displays the contents of the FireWire disk as a directory listing.

```
dir N00000002
V31333934
Logon0000C000 00000000
@L00000000,00100000,0000FFC1
FW INIT
DISKSIZE K 60051600
STREAM     | start             | finish
| length
620600 18  2002 12 13 15:08:50 2096304 2001 01 C5 04:43:24
2096288
Diskfree (sectors) 118006880
Diskfree (MB) 57620
ok
```

The first lines give general status information about the storage available, followed by the directory itself—notably

`N00000002` : the number of devices connected to the hub (here, 2);

`FW INIT` : denotes that the disk was successfully mounted;

`DISKSIZE K 60051600` : the size of the device, in kilobytes;

`620600` : the stream ID of the sensor;

`18` : the starting cluster number;

`2002 12 13 15:08:50` : the date and time of the earliest block in memory;

`2096304` : the end cluster number;

`2001 01 C5 04:43:24` : the date and time of the latest block in memory;

`2096288` : the total number of clusters of data held.

If there is no disc connected, or the cable is faulty, you will see the message `FW Ierr` (*i.e.* input/output error).

5.11.2 FLUSH

Syntax: `FLUSH`

Starts transferring data from Flash memory to an attached IEEE.1394 (FireWire) device, starting at the point where the previous `FLUSH` ended (if any.) The CD24 remembers the new flush point, so that next time you issue `FLUSH` no data will be repeated.

If you want to transfer the entire Flash storage, use `FLUSHALL` instead.

During the transfer the CD24 will report the sector numbers that are being transferred:

```
flush Last Flush : 00200056 2002 12 17 09:22:22
00200056 Starting Transfer 00200056
CHIP - 00200056
00200812
00201012
00201812
...
Transfer Finished
```

If no data have been written to Flash since the last `FLUSH`, you will see the message `No data to save`.

If there is no disc connected, or the cable is faulty, you will see the message `No disk found`.

5.11.3 FLUSHALL

Syntax: `FLUSHALL`

Transfers all the data currently in Flash storage, and updates the `FLUSH` pointer so that subsequent `FLUSH` operations do not duplicate the data.

5.11.4 RESET-DISC

Syntax: `RESET-DISC | RESET-DISK`

Resets the FAT (file allocation table) of a Firewire disc, so that it contains no files. You should only use this command if you want to overwrite any data already on the disc. You will be asked for confirmation before the operation proceeds.

In emergencies, you may be able to recover data from a disc which has been erroneously reset by dumping the disc contents directly onto your computer (with `dd` or a similar direct read tool), as long as you have not allowed new data to overwrite the old.

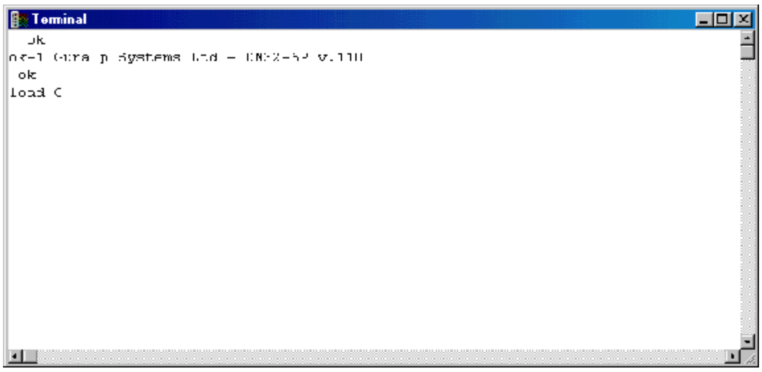
If there is no disc connected, or the cable is faulty, you will see the message `FW Ierr`.

6 Updating the CD24

The firmware of the CD24 can be updated remotely over its output port.

In Scream!'s main window, right-click on the digitiser's icon and select **Terminal...** from the pop-up menu. (If this fails, connect the digitiser directly to a serial port and right-click on the serial port instead.)

Check that there is two-way communication with the digitiser by pressing Enter. The digitiser should reply with ok on a new line. Type `ok-1` to enable advanced commands. The digitiser will reply with a message describing the current firmware version.



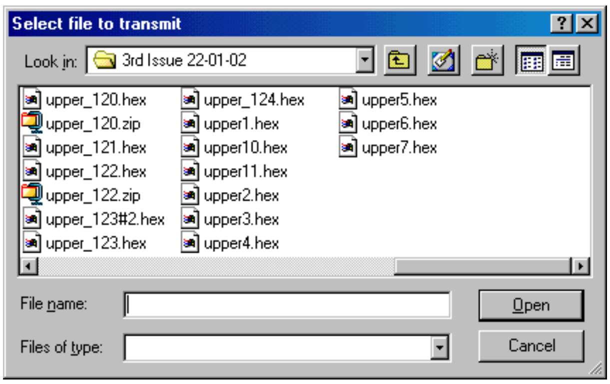
If the firmware needs updating:

1. Type `load` and press `ENTER`. The digitiser will display

    ```
    load C
    ```

    and then wait for up to 10 seconds while the device is prepared for file upload.

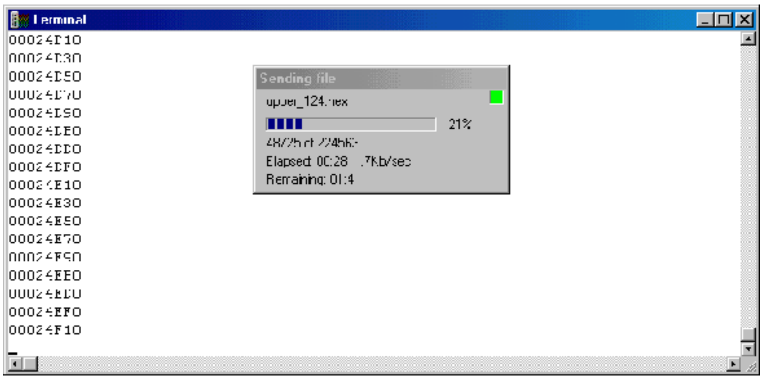
2. Right-click on the terminal window and select *Send file...*:



Firmware updates for the CD24 normally have filenames like `upper_122.hex`.

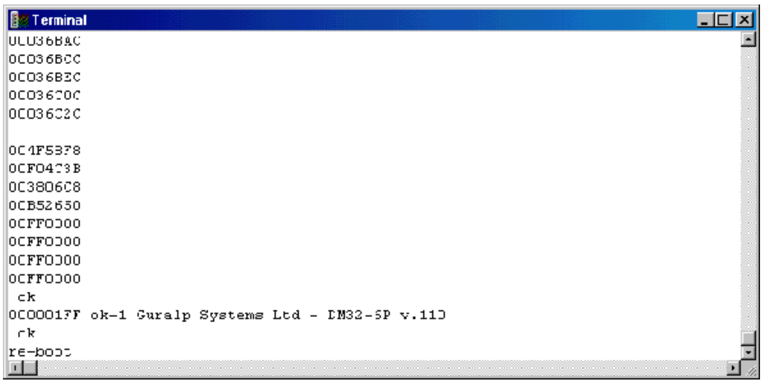
3. Choose the latest file and click **Open**.

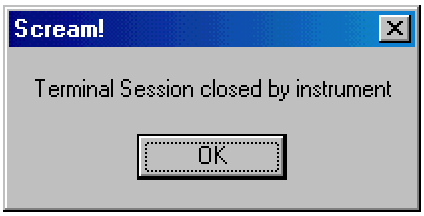
4. If the file opens successfully, Scream! will show the progress of the upload:



Depending on the speed of the link, it may take up to 20 minutes to transfer the firmware.

5. When the transfer completes, type `re-boot` to restart the CD24.





Allow 30 seconds for the digitiser to restart.

6. Right-click on the digitiser's icon in Scream! and select **Configure...** Check that the *Software Version* corresponds to the version you have just uploaded.

7. To check that the digitiser boots correctly after a cold start you may wish to power cycle the device.

7 Appendices

7.1 Appendix A - InfoBlocks

The CD24 has a 1kb buffer inside its firmware memory which can be used to store information about attached sensors. Users are free to store any data they wish in the digitiser's InfoBlock (***info**rmation **block***).

Typically, this is used to store calibration parameters, poles and zeroes, etc. Newer digital sensors have their calibration information pre-loaded into the information block, in the format described below. Software applications, such as Scream!, can read the information and use it to display values using physical units rather than counts.

Information about viewing and uploading digitiser information blocks using Scream!'s graphical user interface can be found on our website at www.guralp.com/articles/20071012-howto-upload-infoblock but, if Scream! is not available, InfoBlocks can be loaded from the digitiser command line using the LOAD-I command, as described in section 5.2.4 on page 55.

7.1.1 Format of the default information block

The calibration information begins with the line `[`*`instrument-id`*`]`. The *`instrument-id`* is formed from the system ID and stream ID (serial number), separated by a dash, e.g. *`GURALP-DEMO`*. It is also the string which identifies the digitiser in the lefthand pane of Scream!. This information is not actually used by the digitiser or by Scream!, but is included for consistency with the calvals file and other utilities (see www.guralp.com/articles/20060818-howto-scream-scaling and the Scream! manual for information about the calvals file).

After the identifier, calibration information is stored in the form `FIELD=VALUE`, with one field on each line. The fields used are shown below:

Field	Value
`Serial-Nos` *[optional]*	An optional serial number to be displayed in the title of Scream! graphs.
`VPC`	The sensitivity of the Z, N/S, and E/W digitiser input channels, in μV per count, separated by commas. These are given on the digitiser calibration sheet.
`G`	The gain of the Z, N/S, and E/W sensor

Field	Value
	components, separated by commas. For velocity sensors, the gain, or sensitivity, is given on the sensor calibration sheet in V/ms^{-1}. The gain of an accelerometer is expressed on its calibration sheet in V/ms^{-2}. Because the outputs are differential, these are written as "2 × single-ended-sensitivity". Most set-ups (including all those using DM24mk3 and CD24 digitisers) will use the doubled value, but older integrated instruments combining a DM24mk2 with a sensor will use only the single ended sensitivity value.
`COILCONST`	The coil constant for the Z, N/S and E/W sensor components, in A/ms^{-2}, separated by commas. These are given on the sensor calibration sheet. For a CMG-5T accelerometer, the values are all set to unity; use COILCONST=1,1,1 for these.
`CALRES`	The value of the calibration resistor, in Ω, as given on the sensor calibration sheet. For a CMG-5T, use CALRES=1.
`CALVPC`	The sensitivity of the digitiser's calibration channel, in μV per count, as given on the digitiser calibration sheet. Older CMG-5TD instruments do not have calibration input facilities, and thus CALVPC can be omitted.
`GRAVITY`	The local acceleration due to gravity at the installation site, in ms^{-2}. This field is used by Scream! to display streams in physical units. By default, a standard average g value of 9.80665 ms^{-2} is used, but this field can be changed for greater accuracy if desired.
`TYPE` *[optional]*	The model number of the instrument, used for display purposes.
`RESPONSE`	A string describing the theoretical response of the instrument, in the form response-type unit. See the table below for the correct values.

7.1.2 Response codes and units

Instrument description	Response type	Unit
CMG-3T (30s–50Hz)	`CMG-3_30S_50HZ`	`Vel`
CMG-3T (60s–50Hz)	`CMG-3_60S_50HZ`	`Vel`
CMG-3T (100s–50Hz)	`CMG-3_100S_50HZ`	`Vel`

Instrument description	Response type	Unit
CMG-3T (120s–50Hz)	CMG-3_120S_50HZ	Vel
CMG-3T (360s–50Hz)	CMG-3_360S_50HZ	Vel
CMG-3T (120s–100Hz)	CMG-3_120S_100HZ	Vel
CMG-3TB (30s–50Hz)	CMG-3B_30S_50HZ	Vel
CMG-3TB (100s–50Hz)	CMG-3B_100S_50HZ	Vel
CMG-3TB (120s–50Hz)	CMG-3B_120S_50HZ	Vel
CMG-3TB (360s–50Hz)	CMG-3B_360S_50HZ	Vel
CMG-3TB (360s–100Hz)	CMG-3B_360S_100HZ	Vel
CMG-3V (30s–100Hz)	CMG-3V_30S_100HZ	Vel
CMG-40T (1s–100Hz)	CMG-40_1S_100HZ	Vel
CMG-40T (2s–100Hz)	CMG-40_2S_100HZ	Vel
CMG-40T (10s–100Hz)	CMG-40_10S_100HZ	Vel
CMG-40T (20s–50Hz)	CMG-40_20S_50HZ	Vel
CMG-40T (30s–50Hz)	CMG-40_30S_50HZ	Vel
CMG-40T (60s–50Hz)	CMG-40_60S_50HZ	Vel
CMG-40T (100s–50Hz)	CMG-40_100S_50HZ	Vel
CMG-5T (DC–100Hz)	CMG-5_100HZ	Acc
CMG-6T (1s–100Hz)	CMG-6_1S_100HZ	Vel
CMG-6T (2s–100Hz)	CMG-6_2S_100HZ	Vel
CMG-6T (10s–100Hz)	CMG-6_10S_100HZ	Vel
CMG-6T (30s–100Hz)	CMG-6_30S_100HZ	Vel

7.1.3 Example files

The calibration information for a CMG-3T weak-motion velocity sensor might look like the following:

```
[GURALP-DEMO]
Serial-Nos=T3X99
VPC=3.153,3.147,3.159
G=1010,1007,1002
COILCONST=0.02575,0.01778,0.01774
CALVPC=3.161
CALRES=51000
TYPE=CMG-3T
RESPONSE=CMG-3_30S_50HZ Vel
GRAVITY=9.80122
```

CMG-5T accelerometers use 1Ω calibration resistors, and their coil constant is set to unity. For example:

```
[GURALP-CMG5]
Serial-Nos=T5585
```

```
VPC=2.013,2.028,2.036
G=0.256,0.255,0.255
COILCONST=1,1,1
CALRES=1
TYPE=CMG-5T
RESPONSE=CMG-5_100HZ Acc
GRAVITY=9.81089
```

7.2 Appendix B - Setting up external triggering

Güralp digitisers and digital instruments can be supplied with external triggering capabilities installed. The external trigger system is designed for maximum flexibility: you can trigger other digitisers or your own equipment using built-in relays and any equipment may be used as a trigger source, using the built-in opto-isolator. In addition, a trigger circuit can link together any number of digitisers so that they trigger simultaneously when they receive a signal.

7.2.1 Overview

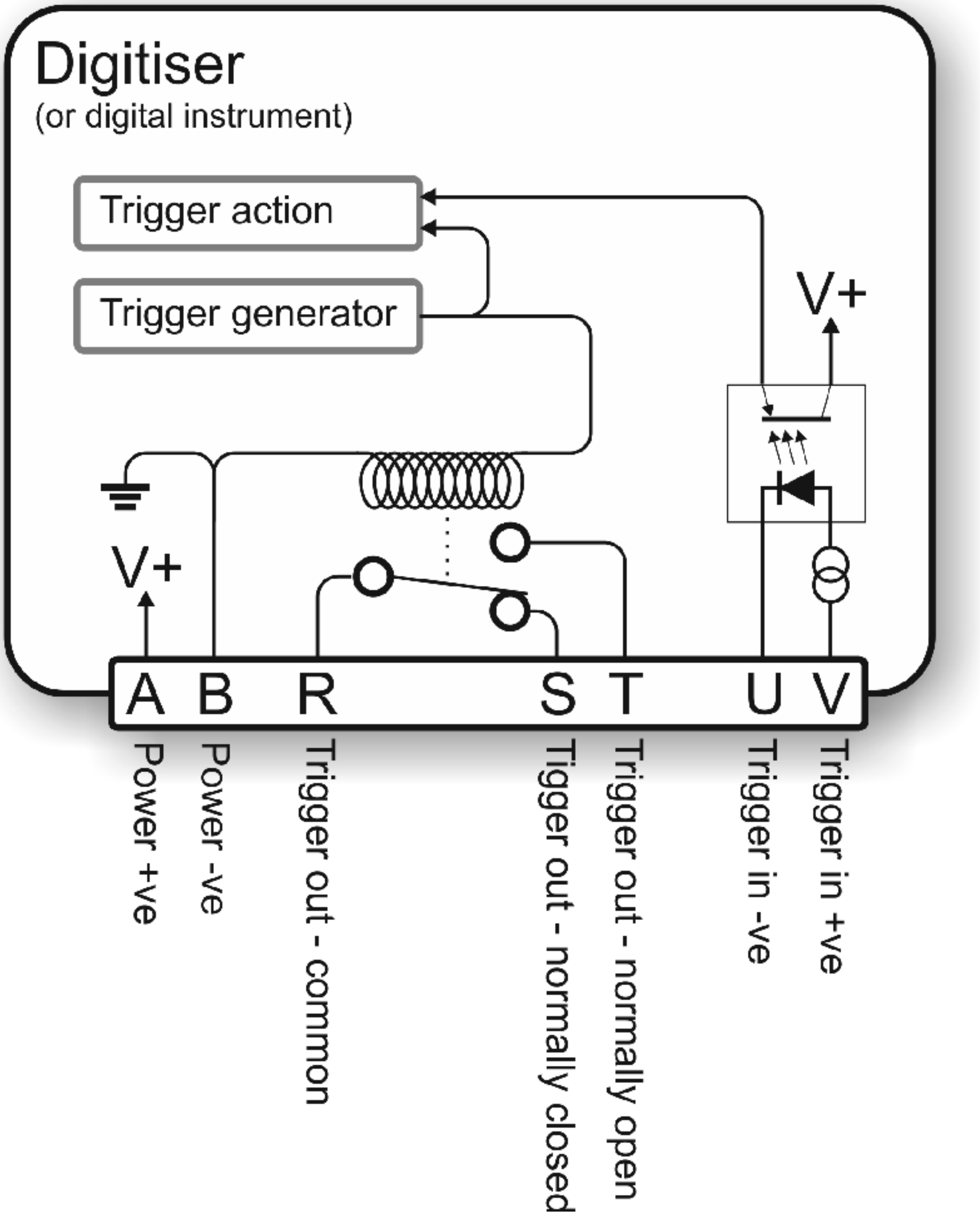
The digitiser or digital instrument has two internal components related to triggering: the trigger generator and the trigger receiver.

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 disconnects the *Trigger Out Common* pin (on the *POWER/DATA/GPS* port) from the *Trigger Out Normally Closed* pin and connects it to the *Trigger Out Normally Open* pin. See section 7.3.1.1 on page 96 for connector details.

The relay is only activated 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 or transmitting additional data streams. The receiver will always enable these extra streams if the trigger generator determines that a trigger has occurred. If the external trigger *input* has been enabled, the receiver will also act on a logic signal received on the *Trigger In* pin of the *POWER/DATA/GPS* port.

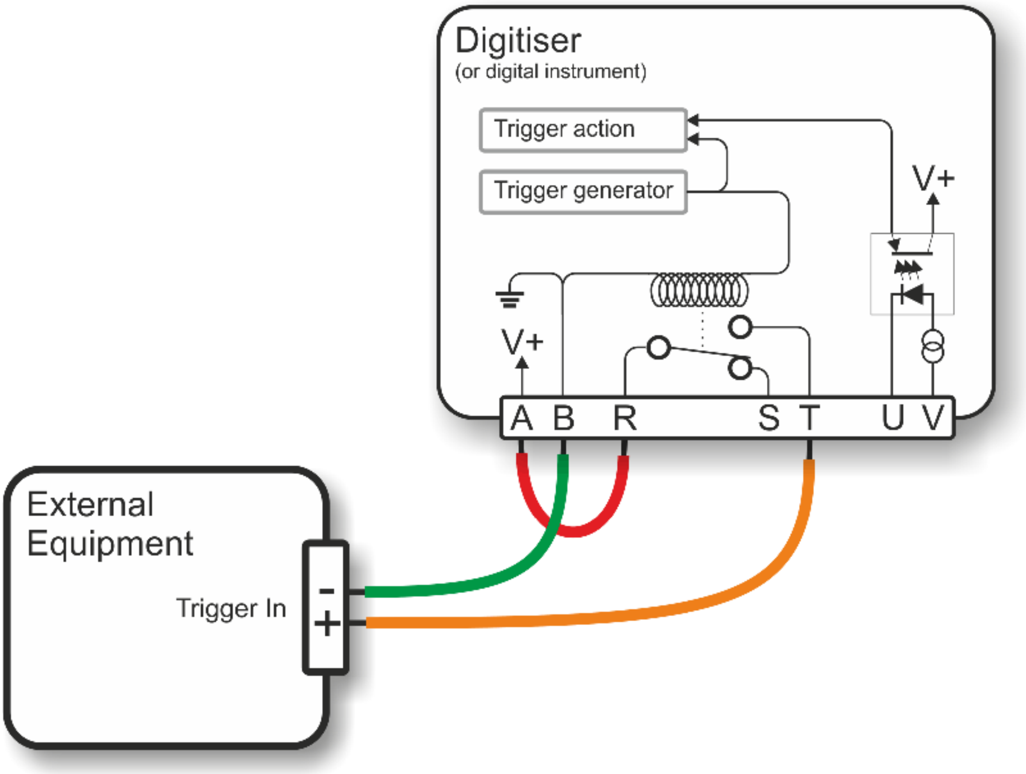
Any signal between +3 and +40 V can be used - the trigger input pins drive an opto-isolator protected by a constant-current circuit.



The *Trigger Out* relay is *not* activated if you provide a *Trigger In* voltage. The digitiser must trigger *itself* for the relay to switch. This arrangement prevents any trigger loops from occurring.

The diagrams on this and the following pages show the additional connections you will need to make. Pins not illustrated should be connected to your power and data systems as normal.

7.2.2 Using CD24 triggering to activate external equipment



If your equipment can trigger from the same voltage as the CD24's power supply, the simplest arrangement is to use the voltage across the sensor's power supply as the trigger supply.

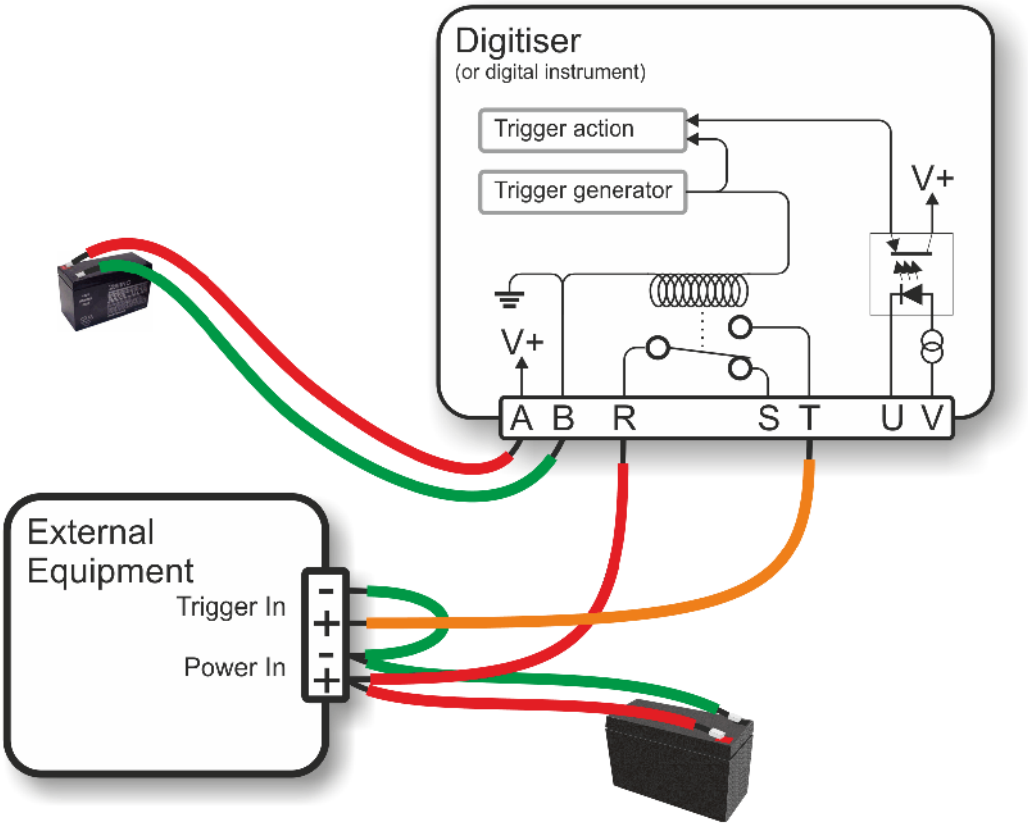
- Connect the ground pin (B) to your equipment's trigger return line. If your equipment does not have a separate trigger return line, consult its documentation for how to apply trigger voltages. (The diagram above does not show the power supply to either the sensor or the triggered equipment: only the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

  Because a trigger signal may last for only a short time, using pins T and B directly to power your external equipment 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 a trigger is activated.

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

- Connect pin A to pin R, and pin T to your equipment's trigger signal input.
- Connect the remaining pins as normal.

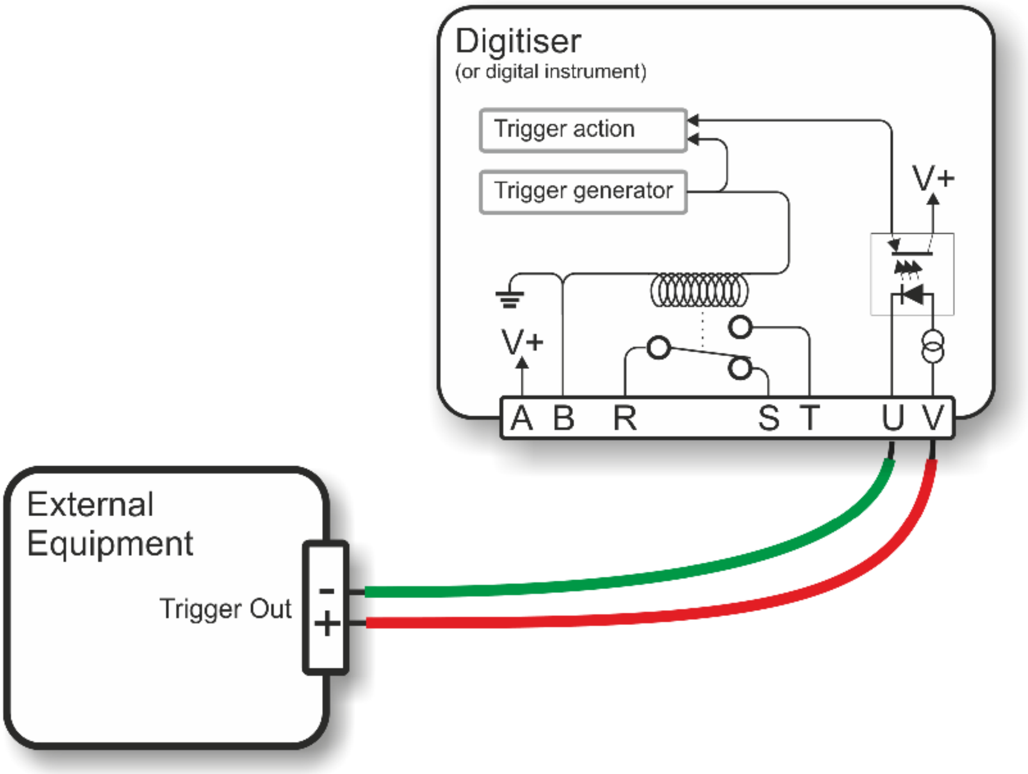
If your equipment needs a different voltage, you will need to provide a separate voltage source for the triggering system. **Be careful not to connect two power supplies together.**



The diagram above illustrates how to trigger the external equipment using its own power supply, which is connected to the trigger input via the normally-open relay contacts (pins R and T).

In this configuration, the two power supplies are completely electrically isolated courtesy of the relay. It is normal practice, though not essential, to connect the two power supply negative terminals to a common earth point.

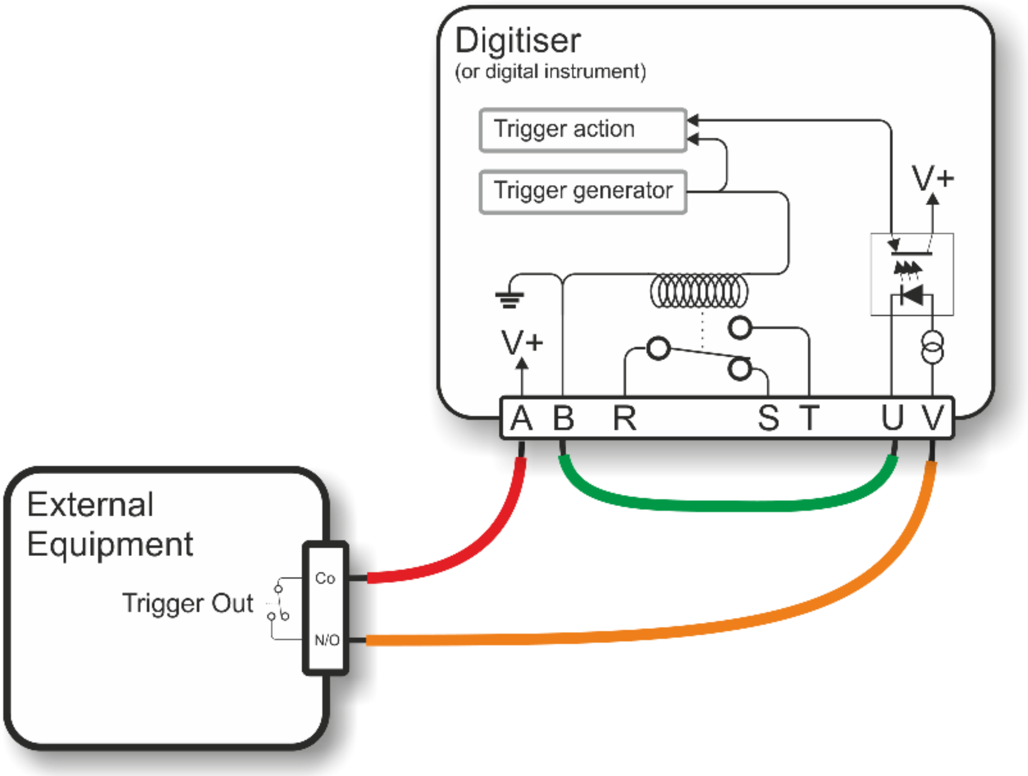
7.2.3 Using an external trigger source



To trigger a digitiser from an external source which provides a triggering voltage, you merely need to connect the external trigger voltage to pins U and V of the digitiser as shown above. The voltage can be anywhere between 4 and 40 V DC as the constant current circuit protects the LED of the optoisolator.

If the external equipment provides a normally open relay contact, the digitiser's power supply can be used to activate the trigger input:

- Connect the common pin of the relay to the positive supply on pin A.
- Connect the normally open pin of the relay to the positive trigger input on pin V.
- Connect the trigger input return (pin U) to the negative supply on pin B.
- Connect the other pins as normal.



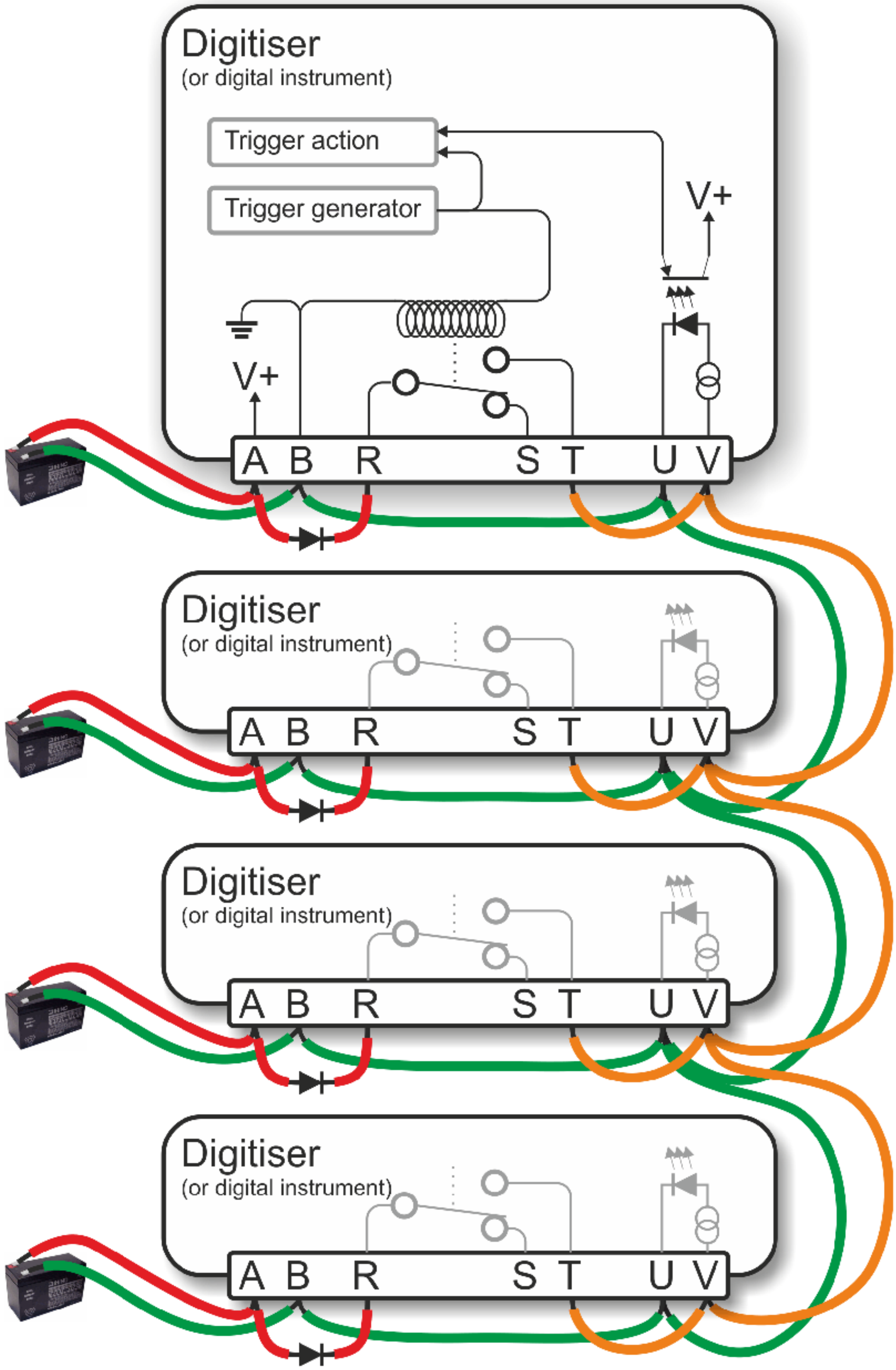
7.2.4 Triggering several CD24 digitisers simultaneously

A common use of the external triggering feature is to ensure that all digitisers in an array trigger at the same time. This can be achieved with the wiring layout described in this section. With this arrangement, any digitiser can generate a trigger, which will be passed on to all the digitisers in the array.

For each digitiser:

- pins B (power supply ground) and U (trigger input return) of every digitiser are connected to a common ground;
- pins T (trigger out, normally-open) and V (trigger in, positive) of every digitiser are connected to a common trigger line (shown in orange on the diagram);
- for each digitiser, pin R (trigger out, common) is connected to the power supply positive rail via a diode (an IN4001 is suitable);
- pins A and B (power supply input) are connected to individual power supplies as normal; and

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



The diode between pins A and R is important, because if two digitisers generate a trigger simultaneously, their power supplies will both be connected via the internal relay contacts to the common trigger line on pins V, and hence connected together. This can cause considerable current flow with consequent risk of fire, as well as severe damage to equipment and cables.

In the case where a single power supply is used to power all of the equipment, this is not an issue and pin A should be connected directly to pin R on all units.

The more common case, where each unit has it's own power supply, is shown above. Please note that all the power supply's ground terminals will be connected together: they must, therefore, have floating outputs or grounded negative terminals.

7.2.5 Combining CD24 and DM24 digitisers in a single array

The trigger inputs of a CMG-DM24 digitiser are slightly different to those on a CD24: the return pin on the DMG-DM24 is connected internally to the power supply ground (it is isolated on the CD24).

When building mixed arrays of CD24s and DM24s (or digital instruments containing them), extra care should be taken with the interconnections. Please contact Güralp Systems Ltd. technical support for advice.

7.3 Appendix C - Connector pinouts

7.3.1 Digitiser connectors

7.3.1.1 POWER/DATA/GPS port

This is a standard 19-pin “mil-spec” plug, conforming to MIL-DTL-26482 (formerly MIL-C-26482). A typical part-number is 02E-14-19P although the initial “02E” varies with manufacturer.

Suitable mating connectors have part-numbers like ***-14-19S and are available from Amphenol, ITT Cannon and other manufacturers.

Pin	Function	Pin	Function
A	Power +10 to 36 VDC	L	Isolated ground
B	Power 0 V	M	Isolated power 0 V for GPS
C	RS232 transmit	N	Auxiliary serial port transmit
D	RS232 receive	P	Auxiliary serial port receive
E	RTS	R	External trigger output link, common contact (for S and T)
F	CTS	S	External trigger output link, normally closed contact
G	Isolated power + 5 V for GPS	T	External trigger output link, normally open contact
H	GPS transmit	U	External trigger input +ve
J	GPS receive	V	External trigger input – ve
K	GPS PPS		

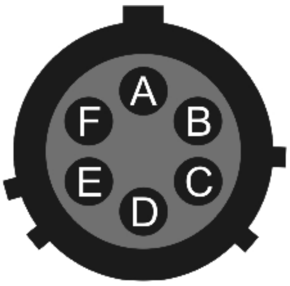
Wiring details for the compatible socket, ***-14-19S, as seen from the cable end (*i.e.* when assembling).

7.3.1.2 FireWire port

This is a standard 6-pin “mil-spec” plug, conforming to MIL-DTL-26482 (formerly MIL-C-26482). A typical part-number is 02E-10-06P although the initial “02E” varies with manufacturer.

Suitable mating connectors have part-numbers like ***-10-06S and are available from Amphenol, ITT Cannon and other manufacturers.

Pin	Function
A	Power 0 V
B	TPA +ve
C	TPA −ve
D	TPB −ve
E	TPB +ve
F	Power + V (powered FireWire option)



Wiring details for the compatible socket, ***-10-06S, as seen from the cable end (*i.e.* when assembling).

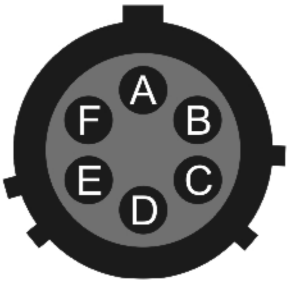
7.3.1.3 Ethernet port

Digitisers with the Wi-Fi and Ethernet networking options have an additional 6-pin mil-spec plug (02E-10-06P) for this interface.

This is a standard 6-pin “mil-spec” plug, conforming to MIL-DTL-26482 (formerly MIL-C-26482). A typical part-number is 02E-10-06P although the initial “02E” varies with manufacturer.

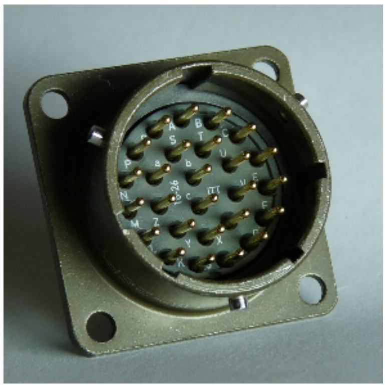
Suitable mating connectors have part-numbers like ***-10-06S and are available from Amphenol, ITT Cannon and other manufacturers.

Pin	Function
A	Data transmit +ve (RJ45 pin 1)
B	Data receive +ve (RJ45 pin 3)
C	*not connected*
D	*not connected*
E	Data receive –ve (RJ45 pin 6)
F	Data transmit –ve (RJ45 pin 2)



Wiring details for the compatible socket, ***-10-06S, as seen from the cable end (*i.e.* when assembling).

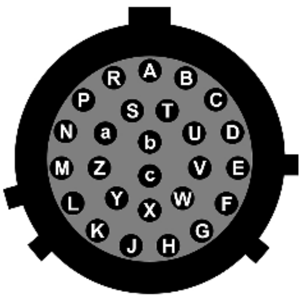
7.3.1.4 Sensor input



This is a standard 26-pin "mil-spec" plug, conforming to MIL-DTL-26482 (formerly MIL-C-26482). A typical part-number is 02E-16-26P although the initial "02E" varies with manufacturer.

Suitable mating connectors have part-numbers like ***-16-26S and are available from Amphenol, ITT Cannon and other manufacturers.

Pin	Function	Pin	Function
A	Vertical velocity +ve	P	Calibration signal
B	Vertical velocity –ve	R	Vertical calibration enable
C	N/S velocity +ve	S	N/S calibration enable
D	N/S velocity –ve	T	E/W calibration enable
E	E/W velocity +ve	U	Centre
F	E/W velocity –ve	V	*not connected*
G	Vertical mass position	W	Unlock
H	*not connected*	X	Lock
J	N/S mass position	Y	Logic signal ground
K	Busy indicator LED	Z	*not connected*
L	E/W mass position	a	*not connected*
M	Power Optional -12VDC	b	Power 0 V
N	Signal ground	c	Power +10 to +24 V(Optional +12VDC)



Wiring details for the compatible socket, ***-16-26S, as seen from the cable end (*i.e.* when assembling).

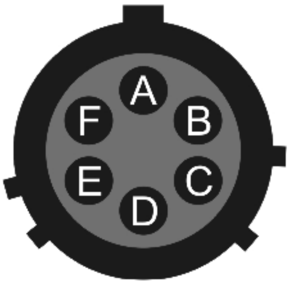
7.3.2 Breakout box connectors

7.3.2.1 Breakout box data port

This is a standard 6-pin “mil-spec” plug, conforming to MIL-DTL-26482 (formerly MIL-C-26482). A typical part-number is 02E-10-06P although the initial “02E” varies with manufacturer.

Suitable mating connectors have part-numbers like ***-10-06S and are available from Amphenol, ITT Cannon and other manufacturers.

Pin	Function
A	RS232 transmit
B	RS232 receive
C	RTS
D	CTS
E	*not connected*
F	Isolated ground



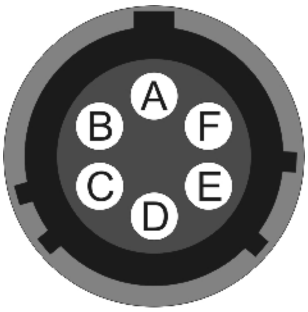
Wiring details for the compatible socket, ***-10-06S, as seen from the cable end (*i.e.* when assembling).

7.3.2.2 Breakout box GPS port

This is a standard 6-pin "mil-spec" socket, conforming to MIL-DTL-26482 (formerly MIL-C-26482). A typical part-number is 02E-10-06S although the initial "02E" varies with manufacturer.

Suitable mating connectors have part-numbers like ***-10-06P and are available from Amphenol, ITT Cannon and other manufacturers.

Pin	Function
A	Isolated ground
B	RS232 receive from GPS
C	RS232 transmit to GPS
D	PPS
E	*not connected*
F	Power +12 V



Wiring details for the compatible plug, ***-10-06P, as seen from the cable end (*i.e.* when assembling).

7.3.2.3 Breakout box power port

This is a standard 10-pin “mil-spec” plug, conforming to MIL-DTL-26482 (formerly MIL-C-26482). A typical part-number is 02E-12-10P although the initial “02E” varies with manufacturer.

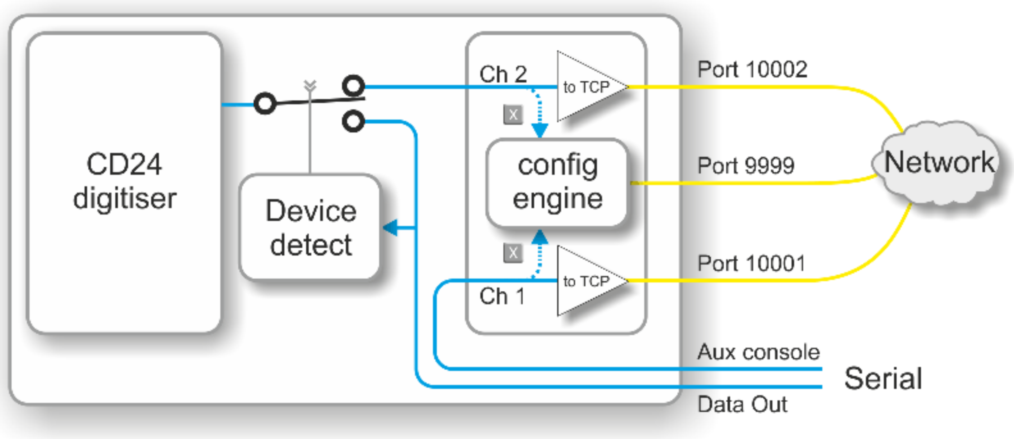
Suitable mating connectors have part-numbers like ***-12-10S and are available from Amphenol, ITT Cannon and other manufacturers.

Pin	Function
A	0 V
B	+12 V DC supply
C	*not connected*
D	*not connected*
E	*not connected*
F	*not connected*
G	*not connected*
H	*not connected*
J	Auxiliary serial port (RS232) receive
K	Auxiliary serial port (RS232) transmit

Wiring details for the compatible socket, ***-12-10S, as seen from the cable end (*i.e.* when assembling).

7.4 Appendix D - Advanced network configuration

The CMG-CD24 uses an embedded Lantronix networking module to provide Ethernet and WiFi functionality. For Ethernet-only digitisers, an 'WiPort NR' module is used. For digitisers with WiFi support, a 'WiPort' is used. Both the WiPort NR and the WiPort have serial-accessible configuration systems which can be used to configure them in the event that communication over a network is lost.



The Lantronix modules have two serial channels. Channel 2 is used for seismic data, which is typically sent over the network on TCP port 10002, although this is configurable. Channel 2 is connected internally to the CD24's data output, unless you have connected a serial data cable from the breakout box to a computer. If a device is detected on the normal serial output, the CD24 will only send data streams through “Data out” and not through the networking module. The digitiser will still be visible on the network but no data will be sent.

Channel 1 is normally unused but is exposed on the Power/Data/GPS connector (on the pins identified as “Auxilary console”). Serial data sent to this channel will be converted to TCP and sent over the network on port 10001 - please contact Güralp Systems technical support if you wish to make use of this facility.

In addition to the two data channels, you can also access two configuration interfaces via the network: a web-based configuration system and a console-based system. The console-based system is reached by using telnet to connect to TCP port 9999.

If you have problems connecting to the CD24 over a network, you can access the configuration menu over a serial link (via channel 1) by interrupting the boot process. See the following section for instructions. For full information about the WiPort NR and WiPort's configuration options, which are used during the process, please refer to the relevant documentation, which is available on the Lantronix Web site: www.lantronix.com. For the WiPort NR, the detailed documentation is at http://www.lantronix.com/pdf/WiPort-NR_UG.pdf and, for the WiPort, the equivalent document can be downloaded from http://www.lantronix.com/pdf/WiPort_UG.pdf.

7.4.1 Accessing the configuration menu via the serial Interface

Access to the configuration menu over the serial interface can be obtained using Scream! or any serial terminal emulator, examples of which are given in section 7.5 on page 108. A special “Auxiliary terminal breakout cable” is required: please contact Güralp Systems technical support for details.

First, with the power to the digitiser turned off, connect the auxiliary terminal breakout cable to the PC and start the emulator. Configure the emulator for 9600 baud, 8 data bits, no parity bit and one stop bit (8-N-1), regardless of the configured settings of the networking module. Next, hold down the X key while turning on the power to the digitiser. After a few seconds, a banner will appear, showing the MAC address of the network interface, along with software and library version information. Press the Enter key to access the set-up menu. If you do not press a key, the system will proceed to boot normally.

7.4.2 Configuring the network interfaces

Once you have access to the networking module's configuration menu, you can configure it with its proper settings.

The networking module has two serial channels. Channel 1 (normally accessible via TCP port 10001) is exposed on the power port of the breakout box. (This is the channel that you are currently using if you have followed the instructions in the previous section).

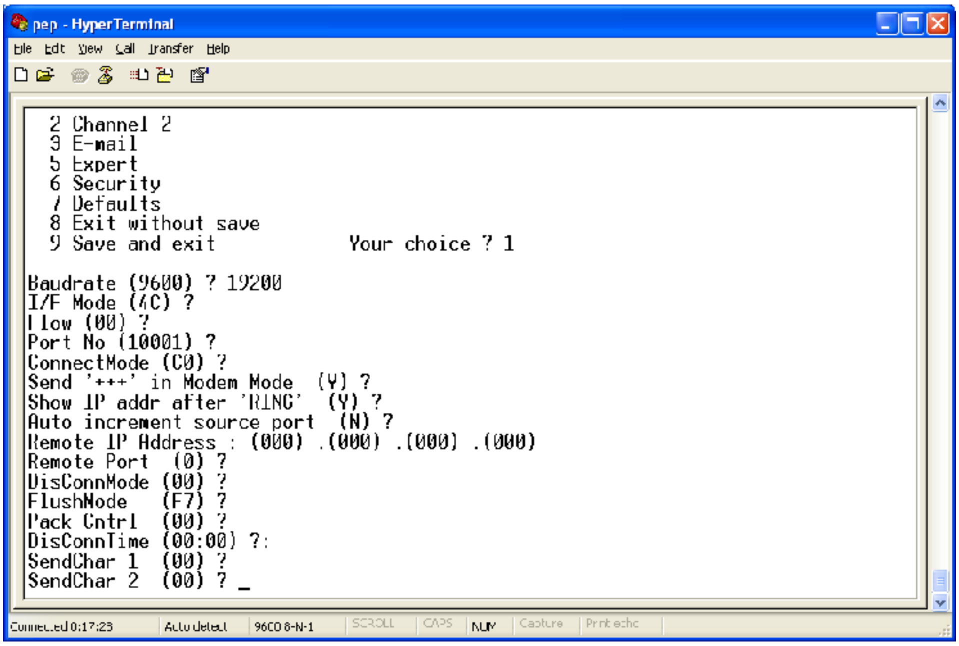
Channel 2 (normally accessible via TCP port 10002) is connected to the data output of the digitiser when no other serial device is connected. It is disconnected when the digitiser detects that Scream! or a terminal emulator is connected, thus disabling data flow over the network.

During the configuration process, you are prompted, in turn, for every value in the current section. If you are unsure at any point, pressing the Enter key will retain the current value. Please note that many values need to be entered using special codes. These are all documented in the relevant Lantronix manuals.

From the main menu:

1. Each channel is configured individually. To configure either, enter either **1** (selecting Channel 1) or **2** (selecting Channel 2) and then press the Enter key.

2. Set the *Baud Rate* to **19200**. This is the default baud rate for the CD24's digital output. If you change the baud rate in Scream! or using the terminal, you must change the *Baud Rate* setting here to match.



3. The remaining settings can be left at their default values, which is done by pressing **Enter** at each prompt until you are returned to the main menu.

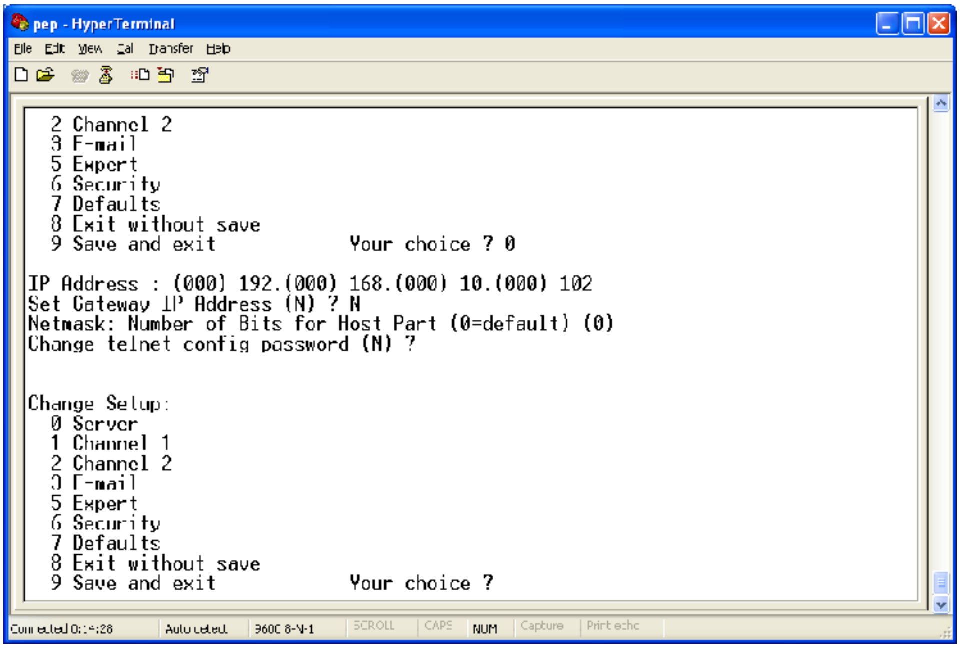
4. When you have finished setting up the module, apply the new settings by selecting option **9 Save and Exit**. The module will re-boot with the new settings in effect.

7.4.3 Configuring the Ethernet port

To configure the Ethernet port

1. If DHCP is not being used to assign IP addresses, enter the required address manually. The IP address must be set to a unique value in the network. Enter each octet and press Enter to move to the next octet.. The current value is displayed in

parentheses. If you do wish to use DHCP, enter 0 at each prompt (an IP address of 0.0.0.0 is used to select DHCP operation).



2. If the digitiser is to be connected to a routed network, enter the address of the default gateway in the same manner.

3. At the netmask prompt, enter 0 if you are using normal (classful) internet addressing. If you have a non-standard or classless addressing scheme, enter the number of bits of the IP address to be used for network identification. Note that this is not the standard way of specifying netmasks; it is more akin to the /*n* modifier used in CIDR address specification.

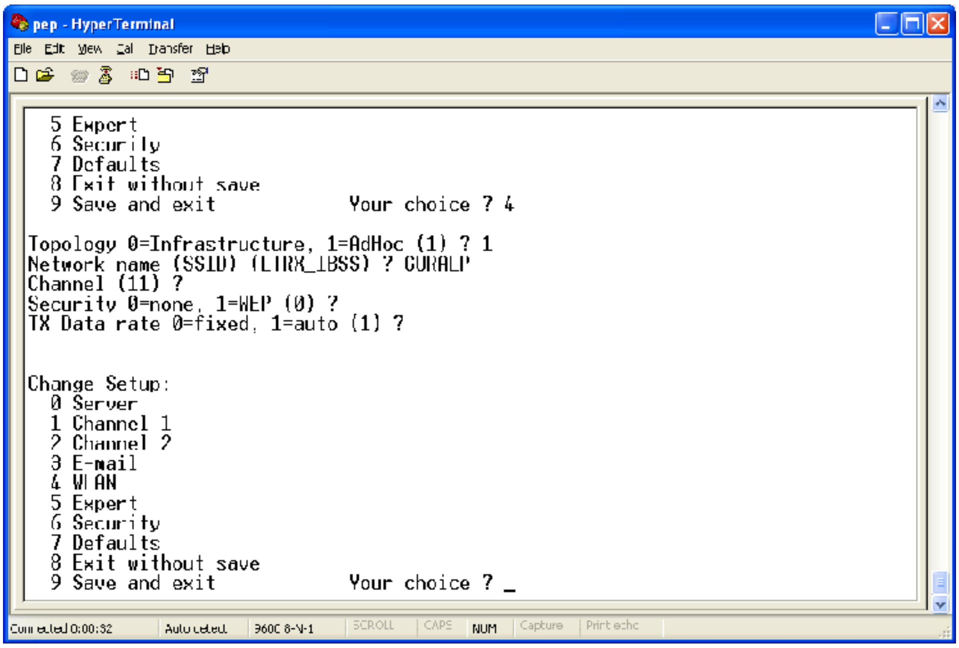
7.4.4 Configuration of the WiFi interface

If your system has WiFi capabilities, they can be configured using the same menu system.

1. From the main menu, select '4' and then press the Enter key to access the WiFi settings.

2. Configure your topology, keying 0 for Infrastructure or 1 for Adhoc mode and then press enter.

3. Enter the desired network name (SSID). Systems are shipped with a default SSID of `LTRX_IBSS` so that they can be found and configured by DeviceInstaller but you can enter any suitable value here.



4. The Wifi communications channel can normally be left at its default. If you are deploying the system in an area where there are many other wireless devices, you may have to either experiment with this value to obtain reliable connections or use a wireless scanner to identify an unused (or relatively quiet) channel.

5. The final prompt allows you to disable or enable the security features of the wireless interface. Systems are shipped with security disabled in order to simplify access for DeviceInstaller.

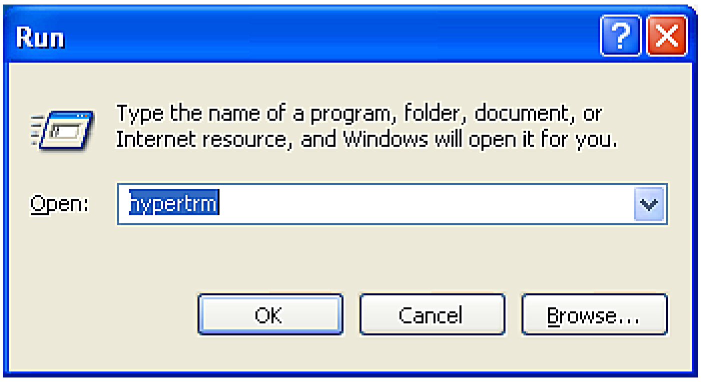
7.5 Appendix E - Using third-party terminal emulators

There are a number of terminal emulator programs that you can use to access the serial ports of the digitiser and the optional networking interface. The terminal emulator built into Scream! is recommended but, if this is not available, there are a variety of alternatives. Three of these are detailed below.

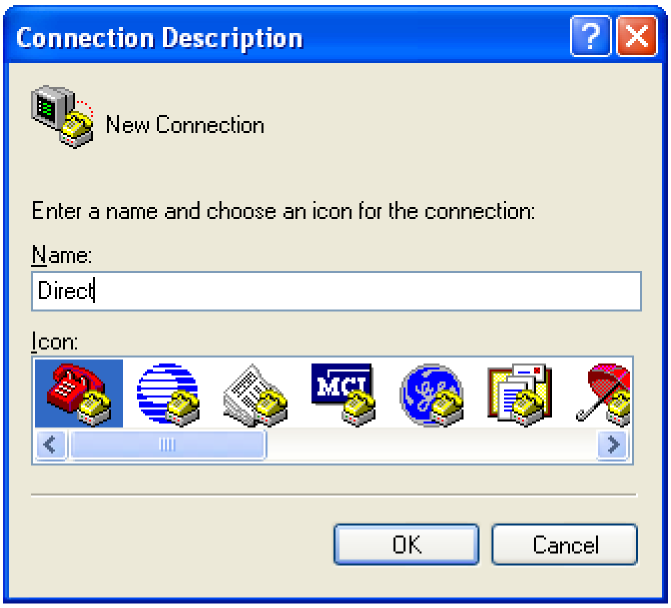
7.5.1 Hyperterminal, as provided with Windows XP.

Click on "Start" and then on "Run".

Enter 'hypertrm' and click on 'OK'.



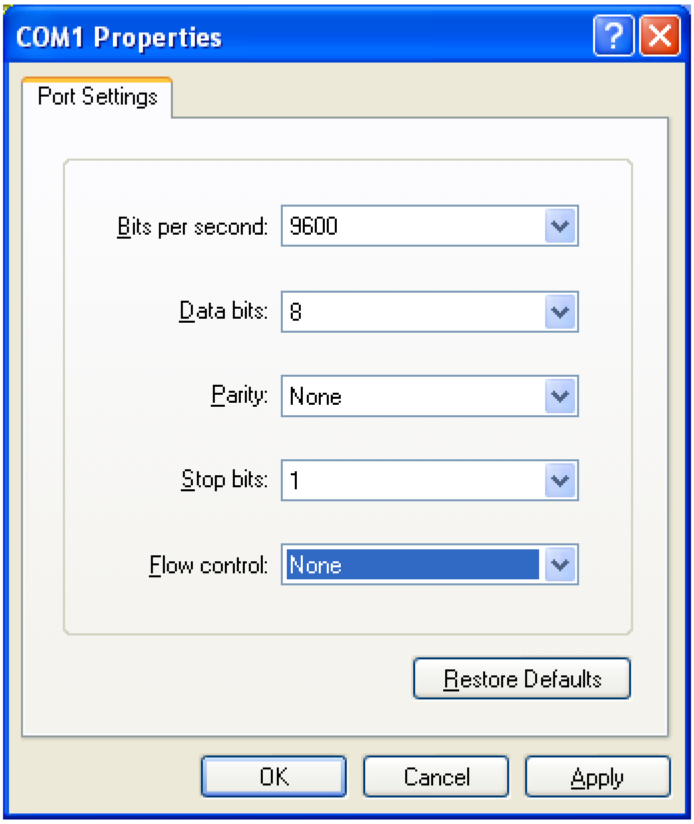
The program will ask you for a name for the connection:



Enter any suitable name, then click OK.

You will then be prompted to enter COM port and modem details:

The “Country/region”, “Area code” and “Phone number” boxes can be ignored: they are only used when working with modem connections. Select the name of the correct COM port from the “Connect using” drop-down menu, then click OK. You will then be prompted to select port configuration settings:



Ensure the following parameters are set:

Bits per second: 9600
Data bits: 8
Parity: None
Stop bits: 1
Flow control: None

Click on OK and the program will then connect provide you with a terminal emulator screen, from which you can access the command line of your system.

7.5.2 Using Hyperterminal with Windows Vista or Windows 7.

HyperTerminal is not provided with the Windows Vista or Windows 7 operating systems but the necessary files can copied from the i386 directory of the Windows XP CD, if you have one available. The two files you will need are:

hypertrm.dll
hypertrm.exe.

Copy the two files into your windows/system32 directory.

If you do not have a Windows XP disc the files can be downloaded from: www.mediafire.com

To access HyperTerminal, use Windows+R on your keyboard. Enter 'hypertrm' and click on OK.

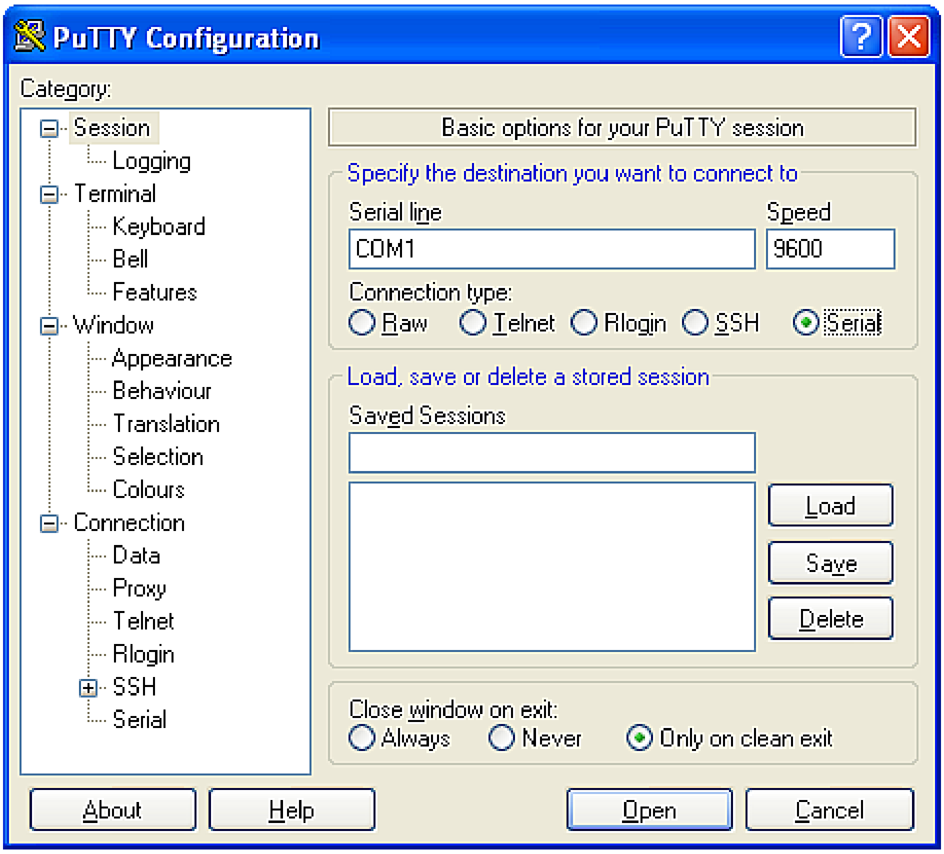
Now follow the instructions given in section 7.5.1, above.

7.5.3 Using PuTTY.

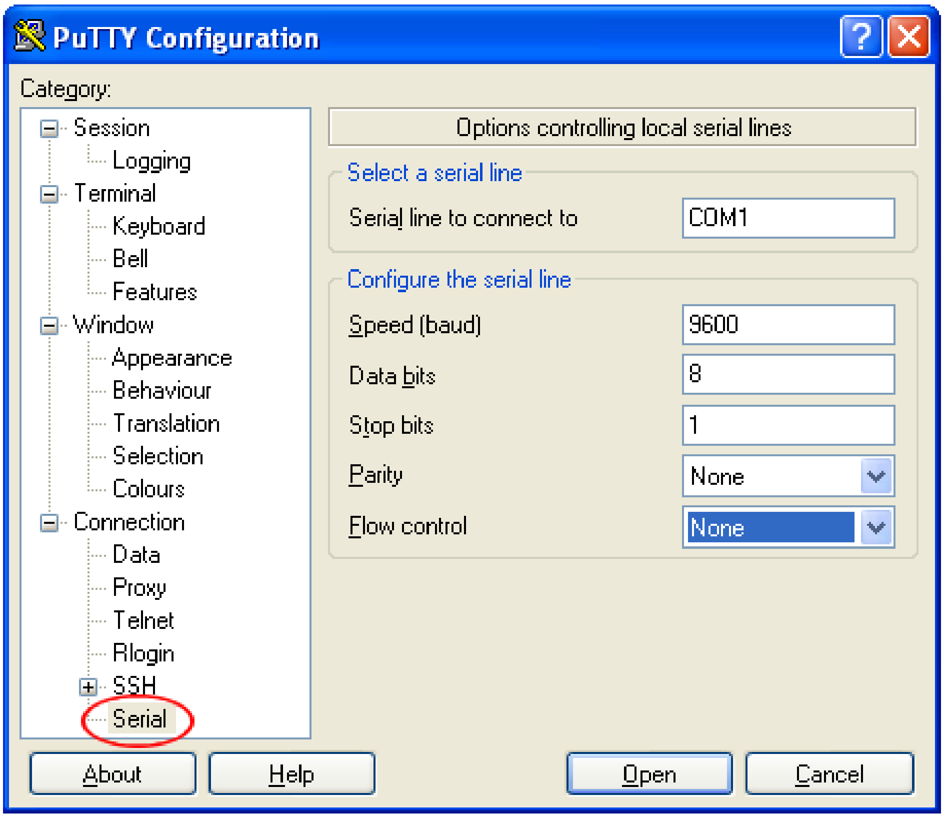
PuTTY is a free terminal package for windows which is useful if HyperTerminal is not available. It can be downloaded from www.chiark.greenend.org.uk. The easiest package to use is the 'windows installer'. Install PuTTY by following the on-screen instructions.

Start PuTTY by clicking on the desktop icon or Start-menu entry and, using the “Connection type” radio buttons on the right-hand side of the screen, select the 'Serial' option.

The dialogue will change to allow you to specify the serial port and the line speed. Enter the name of the correct serial port and type “9600” in the “Speed” field:



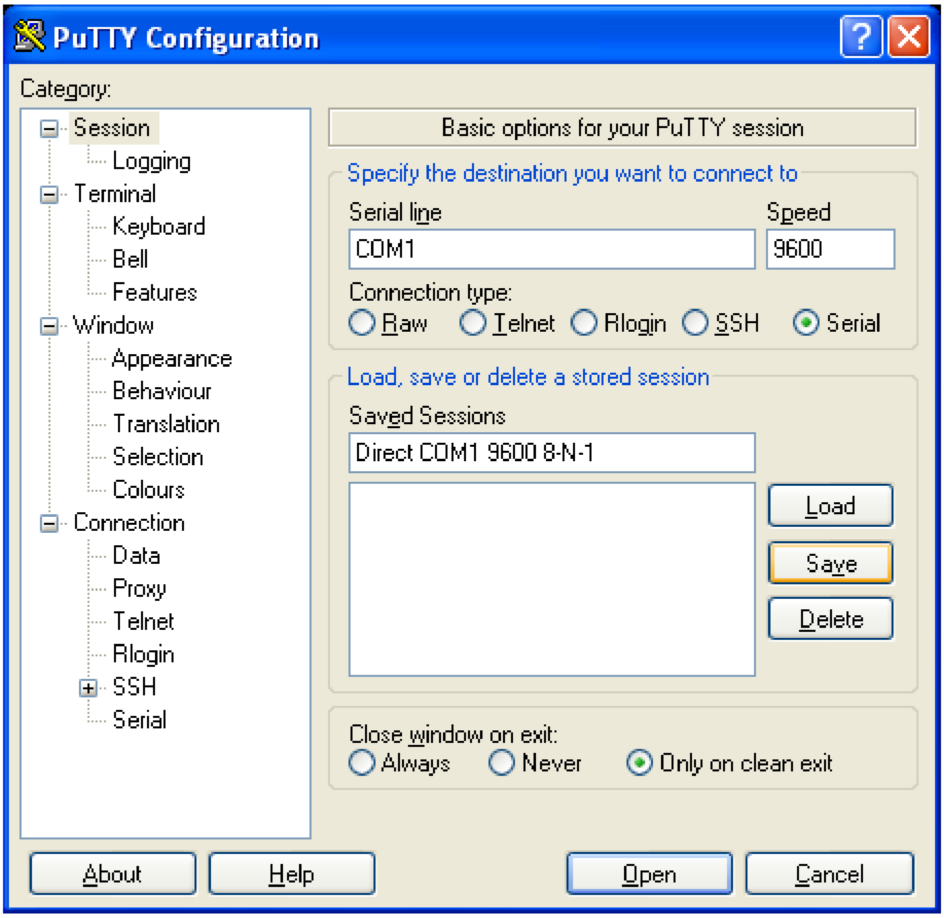
Now click on “Serial” at the bottom of the category menu on the left:



Ensure the following configurations are set:

Speed (baud): 9600
Data bits: 8
Stop bits: 1
Parity: None
Flow control: None

To save the settings, click on the 'Session' option at the top of the left-hand “Category” menu. Enter a suitable session name in the 'Saved Sessions' field then click 'Save'.



The next time you start PuTTY, your saved session will appear in the list and you can simply double-click it to open a new session with the same settings. For now, click the “Open” button to start the terminal emulator.

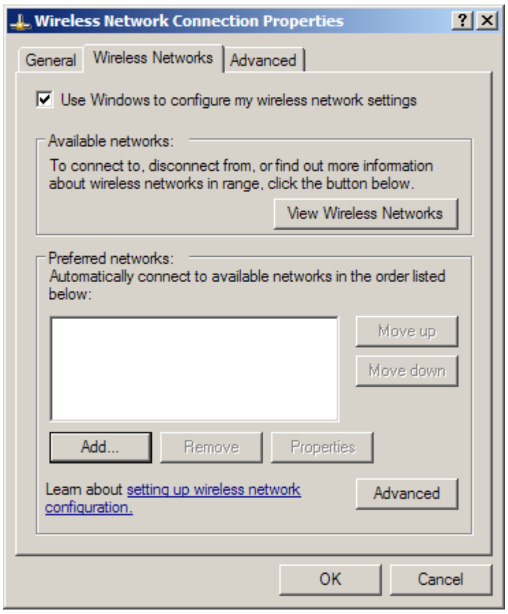
7.6 Appendix F – Setting up an "ad hoc" wireless network

If you do not have a wireless router or access point, you can configure your computer to set up an *ad hoc* wireless network when the CD24 comes within range.

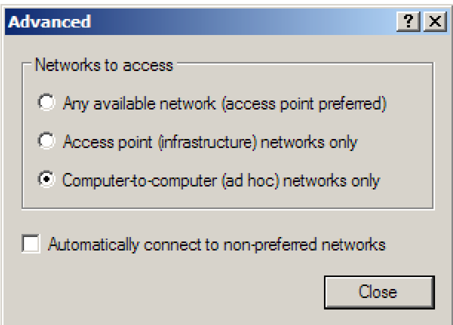
To configure Windows XP to set up an *ad hoc* wireless network:

1. Open the *Control Panel* and select *Network Connections.*

2. Right-click on the **Wireless Connection** icon and select **Properties.** Switch to the *Wireless Networks* tab.

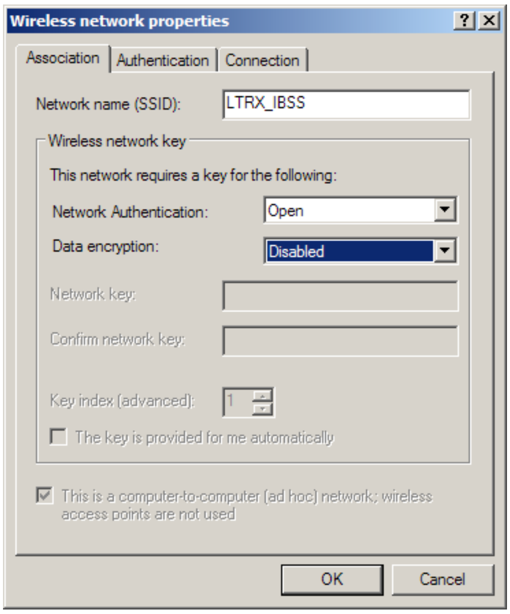


3. Under *Preferred networks*, click **Advanced**. Select *Computer-to-computer (ad hoc) networks only*.



Ensure the *Automatically connect to non-preferred networks* box is not ticked. Click **Close** to return to the *Wireless Network Connection Properties* window.

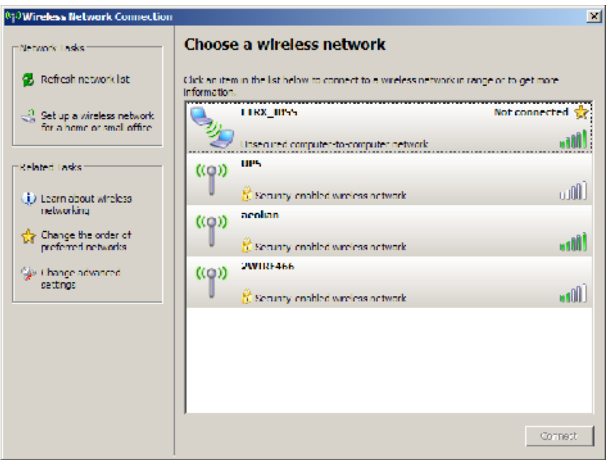
4. Under *Preferred networks*, click **Add....** Switch to the *Association* tab.



5. Fill in the *Network name (SSID)* of `LTRX_IBSS`

6. Set *Network Authentication* to *Open* and *Data encryption* to *Disabled*. Click **OK**.

   The network connection should now be visible under *Preferred networks*, and in the main *Wireless Network Connection* window.



   Initially, the network will be shown as *Not connected*.

7. Power cycle the CD24. After a short while, your computer should report that it has connected to the *LTRX_IBSS* network.

8. Use **DeviceInstaller** to find the CD24 on the new network.

   If your computer is configured to obtain its network address automatically, both it and the CD24 will be using automatic random IP addresses.

   Automatic random addresses all begin with 169.254. Both hosts will choose a different one every time they are power cycled or rebooted, or when the wireless network connection is lost.

   To prevent this happening, configure your computer to use a static IP address, and use the Assign IP wizard in DeviceInstaller to assign a static IP address to the CD24.

7.7 Appendix G - Specifications

Outputs and response	Input range	±10V differential
	Nominal Sensitivity	0.9μV/count
	Standard output format	24-bit
	Noise-free resolution (NPR) at 20 samples/s	> 132 dB r.m.s. (> 22 bits)
	Digital signal processor	TMS3200 at 144 MHz
	Output rate	User selectable
	RS232 baud rate	User selectable
Physical	Operating temperature range	–10 to +75 °C
	Case material	Die-cast aluminium
	Internal thermometer accuracy	±0.33 °C (30 °C) ±0.5 °C (10..50 °C) ±1.0 °C (–10..75 °C)
	Internal thermometer linearity	±0.5 °C
	Internal thermometer resolution	0.0625 °C
	Dimensions (excluding connectors)	160 x 160 x 90mm
	Weight	1.95kg
Power	Voltage requirements	10..24V DC
	Current at 12 V DC with GPS	165 mA

8 Revision history

2008-10-03	A	New document
2011-01-10	B	Revised and reformatted. Added triggering information and additional network configuration.
2011-03-21	C	Added CENTRE and %AUTOCENTRE commands. Various minor revisions.