Callisto Manual

Revision History

Style Sheet is: X:\Company\SmartMasters\Orion

Filenames are: X:\Company\Manuals\Callisto\RevA\Manual
X:\Company\Manuals\Callisto\RevA\CallistoTitleWP

Rev	Date	Author	Description
A	14 Jan 99	Milivoje Jevtovic, Emil Farkas	Initial release.

Approval: _______________________________

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Table of Contents

1. Introduction

Congratulations on your choice of Callisto RF digitiser. As you use your new Callisto digitiser we know you will appreciate the many features that provide excellent performance.

It is very important to understand how the Callisto digitiser operates before you use it. On the following pages you will find a wealth of information regarding all aspects of Callisto digitiser. Please read the instructions carefully.

If you have problems or need technical support, please submit requests for technical support by e-mail or fax. This permits you to fully explain your problem and include "evidence" as it allows us to submit your problem to the most knowledgeable person for reply.

by e-mail: **support@nanometrics.ca**

by fax: **To: Support at fax (613) 592-5929**

by phone: **Please ask for Support at (613) 592-6776**

Nanometrics Inc.
250 Herzberg Road
Kanata, Ontario Canada
K2K 2A1

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2. Organization of this Manual

This manual is organized in ten major sections:

Chapter 1	**Introduction** Introductory notes to this manual.
Chapter 2	**Organization of this Manual** Notes on how to use this manual.
Chapter 3	**Unpacking and Post Delivery Inspection** Identification of the components you have purchased. It also references an "as-shipped" section.
Chapter 4	**Technical Description** Description of features and technical specifications of the Callisto.
Chapter 5	**Getting Started** Recommendations for using the digitiser for the first time.
Chapter 6	**Hardware setup** Hardware setup instructions.
Chapter 7	**Software configuration** Description of software configuration parameters and configuration menus.
Chapter 8	**Servicing** Recommended maintenance and repair procedures, including firmware update instructions.
Appendices	These list mostly tabular material such as error messages, and pin connections.

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3. Unpacking & Post Delivery Inspection

Open and inspect the shipment for possible damage. Carefully check each item for damage or defects. The following list includes items generally included with Callisto. This list might vary from application to application. To find out the exact list of items included in your shipment refer to the shipping documents.

The system should have the following contents:

1. Callisto digitiser
2. GPS Antenna and Mounting Bracket
3. GPS Antenna Cable
4. RF Antenna Cable
5. Power cable
6. Yagi RF antenna
7. Callisto digitiser Manual
8. As-shipped Sheet
9. Release Notes (if applicable)
10. CD with digitiser Test program and firmware code

Checking the As-Shipped Sheets

As written, this manual covers the Callisto digitiser. Please study the as-shipped data sheet to determine the exact configuration of the digitiser. The as-shipped sheet lists the serial numbers of the parts shipped, the exact hardware configuration and calibration constants associated with your hardware. It also includes a hard copy of the as-shipped sheet of the Callisto digitiser. This will determine how your Callisto digitiser operates when first turned on. Several features may have been added to the digitiser since this manual was released. Such new features are described in the Release Notes which have precedence over what is in the manual.

Backup

It is strongly recommended that you backup the CD or the diskette.

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4. Technical Description

Overview of the Hardware

The Callisto RF telemetry digitiser is specifically intended to be deployed with full duplex radio telemetry seismograph networks with error correction.

The Callisto integrates all necessary hardware to digitise the analog signal produced by the seismometer, to time-stamp digital data, to transmit the data and the SOH information it to the central site in form of RF signals and to receive messages from the acquisition centre. It includes a 24 bit high resolution digitiser, high precision GPS timing sub-system, digital radios for both inbound and outbound links and all necessary hardware for the interconnection and operation of all of the above.

The following block diagram provides you with a clear view of the different hardware modules integrated in Callisto.

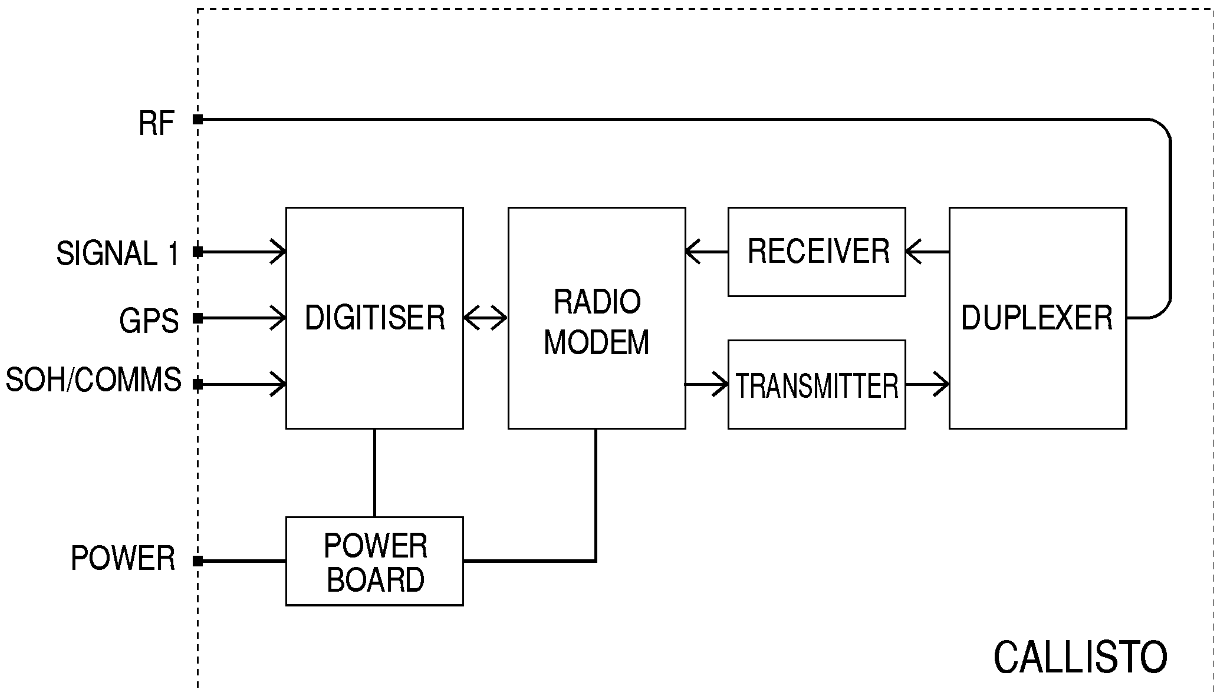

Figure 1: Callisto RF digitiser block diagram.

Digitiser Module

Functional capabilities

The digitiser will digitise from one to six channels of data with sample rates from 10 s/s to 1000s/s. However, the sample rate should be selected considering the throughput of the communication link, which is determined by the baud rate of the radio modem. A typical application is when a three channel digitiser module is used with 9600 baud radio modem. In this case sample rate of 100 sps or lower should be selected.

Data are assembled into packets with a CRC for error detection. Each packet includes a comprehensive header which holds parameters such as the sequence number, time in long seconds and the oldest packet available. See the appendix for more information on the data format.

The digitiser may have two software filters. The first filter is a decimating FIR (Finite Impulse Response) filter which is used for low pass filtering of the data. This is always required due to the nature of Delta-Sigma converters. The second filter is an optional IIR (Infinite Impulse Response) high pass filter to remove the DC offset from the data. Appendix D shows the corner frequencies of these software filters.

An internalGPS clock is used for time synchronization.

The SETUP menu is used to configure the digitiser parameters to suit the application and to store these parameters in the non-volatile Flash memory chip. A full list of configurable parameters is given in the Configuring the Firmware chapter.

Time and output data timing

The digitiser keeps internal time which is referenced to a GPS clock. If the GPS clock is not locked the digitiser can free run on its own internal oscillator. When the GPS relocks, the digitiser will phase lock back onto the GPS time. All data from the digitiser is time stamped with the absolute UTC time.

Hardware description

This section gives a brief overview of the digitiser hardware. Later sections of the manual will define the software. The input impedance and digitiser sensitivities are user settable parameters which are set through one resistor respectively for each channel. The user should refer to the as-shipped data sheet to get the actual values for these parameters.

Differential Amplifier

There is an input differential amplifier for each channel input signal. The gain of this stage is used to set the overall system sensitivity. Gains of between 1 and 256 are typical. A potentiometer is associated with each input and is adjusted to give maximum common mode rejection. The input impedance is usually left as a high impedance input (>50K). The gain and input impedance are user setable parameters which are set through one resistor respectively for each channel. The user should refer to the as-shipped data sheet to get actual values for the resistors.

Analog Anti-alias Filter

The anti-alias filter requirements are quite low due to the high input sample rate used with delta-sigma converters. The anti-alias filter is a 5th order Bessel filter to give linear phase response. A single operational amplifier generates the low pass poles. The filter has a gain of 1 and is configured for low noise.

Analog-digital Converter (ADC) & Digital Anti-alias Filter

A 120 dB Delta-sigma modulation ADC is used for conversion. This IC samples at a high rate, digitally filters and decimates the data, and then outputs the data. This output data is then filtered and decimated by the DSP before the final resolution is achieved. Different sample rates are achieved by decimating more or less. Delta Sigma ADC output one bit of data at a high rate which is to be filtered to produce higher resolution at lower sample rates. Sample rate is traded off for resolution. This works because the delta sigma modulator has all its quantization noise at frequencies which are later filtered out.

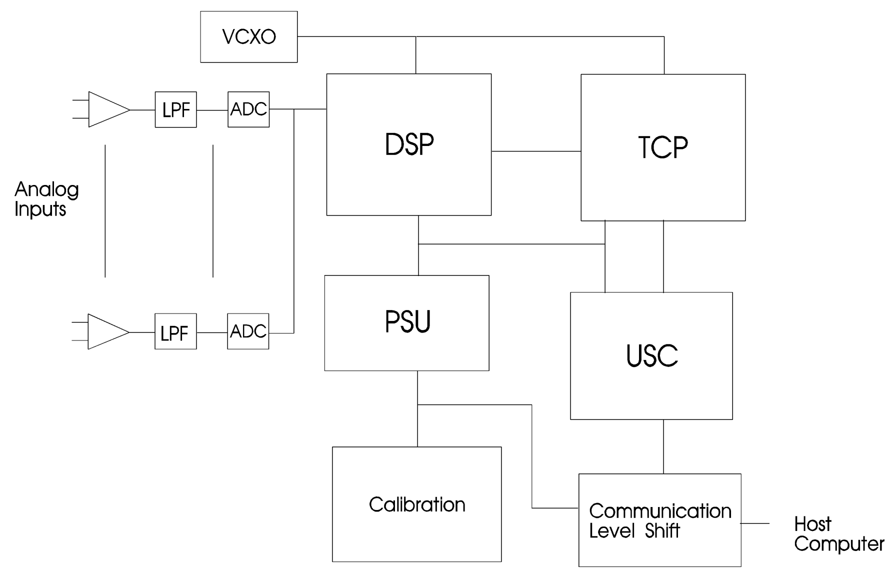

Figure 2: Block diagram of the digitiser module.

DAC and Calibration (Optional)

Calibration signals are obtained from a laser-trimmed precision 12 bit D/A converter chip. Under software control, the calibration signal can be set to any value with a resolution of 1 in +/- 2048. Full scale is usually +/- 5V. Calibration relays switch the calibration signal to one side of the calibration coil. Another pole on the relay grounds the other end of the calibration coil when active. The as-shipped sheet specifies actual calibrator parameters. When determining sensor sensitivity, allowance must be made for the wire loop resistance and the calibration coil resistance.

Output Ports

The internal hardware is controlled by ports on the TCP, several eight bit ports and some programmable logic. The TCP interfaces with the RS232 status bits and the universal serial controller (USC) for RS232 data.

When the calibration and/or active sensor control option is selected the TCP controls the calibration DAC and two eight bit control ports. This selects the calibration port, the calibration output signal level and frequency in addition to the active sensor control lines.

State-of-Health

The digitiser monitors a number of analog state-of-health (SOH) channels, six 'slow' and three 'fast'. Three of the slow channels are used internally to monitor the input voltage, the internal temperature of the VCXO and the radio signal to noise ratio. The remaining are externally available to the user.

The three external user SOH channels have input amplifiers configured as virtual ground inverters. There is a low pass filter incorporated with a 1.6Hz roll off. An open input will appear as a +2.5V input. These inputs have a range of +/- 25V and a nominal sensitivity of 48.8mV/bit.

The battery level monitor has a nominal sensitivity of 24.4 mV/bit, with an offset of +0.1V as a result of internal voltage drops.

The temperature monitors each have nominal input sensitivities of 0.217°C/bit with an offset of -61°C.

These SOH are typically sampled at 0.125Hz. The software controls how often they are logged.

In addition to these SOH there are three FAST SOH channels typically sampled at one Hz. These FAST SOH have an input range of ±10V and a sensitivity of 19.7mV/bit. An open input will appear as a 2.5V input. These inputs are used to monitor mass position in an active sensor.

The scale calibration factor is built from two constants. One is the actual sensitivity of the digitiser SOH digitiser which is expressed in millivolts per least significant bit and is a factory setting. The other constant is the sensitivity of the sensor. This might be expressed as "units" per volt. For example, with a temperature sensor, this might be set to 44 degrees Celsius per volt. Both of these parameters are set in the appropriate SOH Config menu.

The offset is used to allow for the sensor not producing zero output volts when registering zero "units". The offset is expressed in "units". For example, for a temperature sensor, the offset is expressed in degrees Celsius.

The appropriate scale and offset values for the internal SOH parameters are determined during the final test and are entered into the as-shipped configuration file. A hard copy of this file is shipped with the digitiser.

Watchdog Timer

The main processor in the digitiser has a built in watchdog timer that protects the digitiser from getting hung in an endless software loop. If for any reason the watchdog is not serviced by the software at the correct frequency, an automatic hardware reset signal is generated which restarts the entire digitiser.

RS232D I/O

The digitiser supports communication using RS232 convention. One external port will always be configured for RS232 communication. There are also status lines (CTS, DTR, and RING) which may be used for communication with a modem.

Note: RS232 convention states that:

- 'MARK' or off = '1' = -ve voltage on signal line
- 'SPACE' or on = '0' = +ve voltage on signal line

where all voltages are measured with respect to logic ground.

Flash Memory

A Flash memory chip is used to store both firmware and user parameters. The contents of this chip are read on system initialization to establish such parameters as sample rate. A menu driven interface is provided to change those parameters.

CPU

The digitiser uses two separate processors, a Motorola DSP56002 and an Intel 80C196NT. The DSP interfaces to the ADCs and performs the digital filtering on the raw data. After filtering is completed the data is transferred to the 80C196NT. This processor collects a packet of data and generates the correct output format before transmitting the packet of data to the host. It also performs many other timing and housekeeping functions.

Internal Construction

The digitiser accepts Eurocard size boards. They plug into a custom back-plane. The chassis supports up to 6 cards. However, not all positions are populated at all times.

A minimum system (3 channel) consists of 5 cards: analog, TCP, communications, Mem-Cal and power supply. The analog board contains the front-end analog components and the interface between the DSP and the ADC. The TCP contains both processors, the USC, and SOH ADC circuits. The power supply contains a switching power supply. The Mem-Cal board contains 2.0 megabytes of RAM and calibration circuits.

A six channel digitiser has an additional analog board installed beside channels 1-3. The board for channels 4-6 is different than the board for channels 1-3. However, they may be placed in either ADC slot. The board for channels 1-3 must be present at all times when the unit is running. Note that a 1-3 channel ADC is different from a 4-6 channel ADC and they are not interchangeable.

Internal batteries

This rechargeable lithium battery is used by the GPS engine to maintain its satellite almanac and other parameters and to run a low power real time clock. The lithium battery will maintain the GPS for 3 to 6 months.

RF Module

Operation

On the link from the digitiser to the acquisition centre, the radio modem modulates the RS232 data received from the digitiser and transmits the modulated signal to the RF transmitter. The RS232 digitiser data is a scrambled multiplexed data stream of first- and re-transmitted seismic data packets and filler packets. The transmitter transmits the data in form of FSK radio signals to the acquisition centre.

On the link from the acquisition centre, the digital data receiver receives FSK radio signals. The radio modem demodulates the RS232 from the RF carrier and transmits the packets to the digitiser. The demodulated RS232 data is a scrambled data stream of requests for re-transmission, mass centering or sensor calibration messages.

The radio modem will function in either an Asynchronous mode or in a Synchronous mode at either 4800 Baud or 9600 Baud.

Hardware description

The hardware components of the RF module include the digital data transmitter, the digital data receiver and the radio modem. The operational mode and the baud rate of the radio modem are factory configured.

The radio modem can operate in either asynchronous or synchronous mode. For asynchronous operation the U3 should be installed and resistors R7 and R8 should not installed. This is the default configuration. The synchronous mode can be enabled by removing U3 and adding 0 Ohm resistors for R7 and R8. In default configuration the radio modem is configured for 9600 Baud. 9600 Baud is enabled by installing 0 Ohm resistors for R20 and R9. Removing these resistors and installing 0 Ohm resistors for R24 and R14 4800 Baud is enabled.

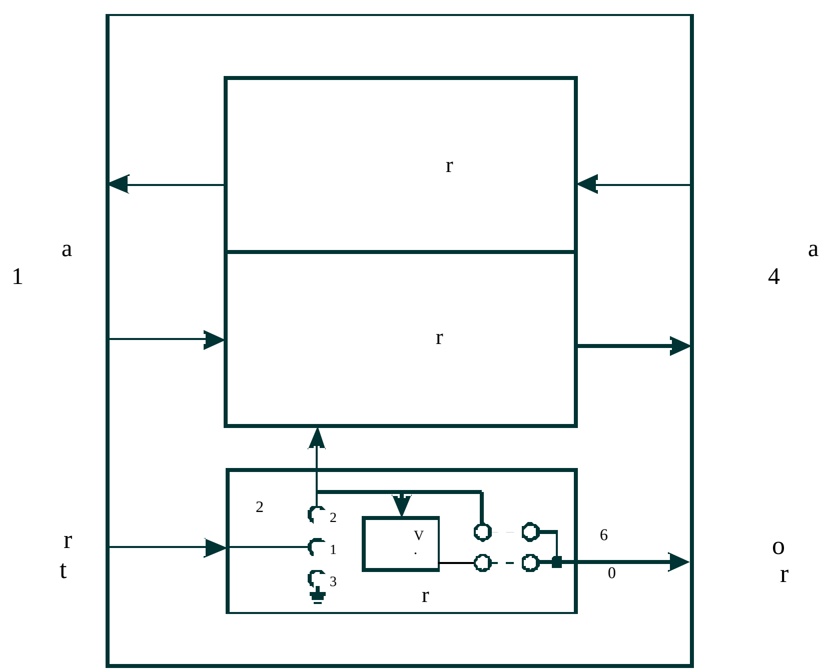

Figure 3: Block diagram of the radio modem

Overview of the Firmware

Acquisition Software

Introduction

Callisto software operates in the following areas:

- FIR low pass and decimation to support the sigma delta AD converters
- Precision timekeeping and synchronization with UT using GPS
- Continuous non-approximating broadband seismic data compression
- Power on self-test
- Support and digital filtering and recording of internal and external state-of-health signals
- Support of a comprehensive information and error logging facility

Code storage and software updates

The software code supports three processors. Low level code is stored in electrically programmable ROM. Service procedures allow the low level code to be updated without disassembling the Callisto.

5. Getting Started

Introduction

This section is intended to provide the information required to verify that the Callisto is performing correctly when received by the customer. Prior to proceeding with field installation, we recommend reading the entire manual before finalizing on the many options which are available to match the digitiser to the actual application.

Testing the digitiser module of Callisto

To get started you will need the equipment shown in the table below:

Quantity	Description
1	Power Supply, 10V-15V, 2A or 12V battery
1	IBM compatible personal computer (PC) with DOS, OS2 or WIN95/NT. This should include a VGA graphics adapter and an unused serial port
1	Seismometer or signal generator (optional)
1	Test cable.
1	RF antenna

Table 1: Additional equipment required to get started

This startup procedure verifies that the digitiser is running and then displays waveform traces on the PC screen using ViewDat test program.

Copy the files from the disk to a new directory on your hard disk and make this the working directory. Connect the Callisto to the PC using a test cable. Connect the RF antenna to the RF connector of Callisto with the supplied RF antenna cable. Connect the power connector of Callisto to a 12V DC power supply and power up the unit. Note: avoid connecting the Callisto to the power without having the RF antenna connected to the RF output.

Start the ViewDat from the command prompt (see Appendix A).

Once the digitiser has finished its self test it will start transmitting data.

In the waveform display mode of ViewDat, the digitiser test program, a trace for each active channel will appear on the screen. With no input signal connected to the Callisto signal input connector, you should see noise for all channels. To increase the sensitivity of the display and see the noise in more detail, change the scale factor of the screen display.

To check the Callisto using a signal generator connect the signal source to the digitiser using the pin-out given in Appendix G. Full scale voltage input will be $+/- \ 5.3 \times 10^5 \ S_D$ where S_D is digitiser input senisitivity in nV/bit as stated in the as-shipped sheet. Input impedance for the digitiser is also stated on the as-shipped sheet.

Testing the RF module of Callisto

This test verifies that data can be transmitted to the NAQS Server system and the error correction feature is operational.

To perform this test you need to have the acquisition center installed and correctly configured for receiving data and sending re-transmission requests to the Callisto which is being tested. Start the acquisition server. Start the Waveform program on the acquisition computer and subscribe for traces from the Callisto being tested.

Set up the Callisto following the instructions from the previous test. After startup you should see the incoming data displayed in form of seismic traces in the Waveform window.

Interrupt the transmission for 1 minute by breaking the Callisto-NAQS link. Note: do not disconnect the power to Callisto or to the PC. Dsiconnect power to the central site radio receiver instead. After re-establishing the link wait 30 seconds and perform a summary extract of the corresponding ringbuffers and save the result in a file. Wait 10 minutes and perform another summary extract. The first summary extract should show the created gap in the data. In the second summary extract you should see the gap filled up by the missed and re-transmitted packets.

6. Hardware Setup

Introduction

This section of the manual describes how to configure the hardware and install the Callisto for field deployment. This section does not include instructions concerning radio tower, antenna, power supply system, seismometer and any other remote site hardware installation.

The sizes of the front panel connectors are different for each connector and they are provided with polarization control guidance. RF antenna, GPS antenna and power cables are included with the unit. Callisto to seismometer cables are either factory supplied or customer built depending on the contract. The signal connector pin assignments are described in Appendix A. Since the seismometer is a third party hardware and it is not always supplied by Nanometrics the next paragraph includes instructions on how to configure and install the Callisto with different type of seismometers.

Signal input

The Callisto input impedance may have been set at the factory to correctly damp the seismometers which are to be used. Please consult the as-shipped sheet to verify. If it is set at a high impedance level (20K) the user must either provide the correct external damping resistors or, alternatively, add the damping resistors to the empty resistor locations on the Callisto analog board. Please see Appendix A for instructions on how to set the damping resistors.

Supplied with calibration option, the Callisto can initiate calibration sequences on receipt of commands over an RS232 link if the calibration option for the digitiser has been purchased.

If the seismometers are equipped with calibration coils, then the user should consider if additional pairs of wires should be used to connect the calibration coils to the Callisto. The connection to the digitiser depends on whether an active or passive sensor is used.

The calibration can be performed remotely from the acquisition system using the NaqsView software. For remote calibration the NAQS Server station file should be configured for the correct use of calibration and mass center control relays and to include the calibration sensitivity, range, output impedance, etc. See the NAQS Server manual and Callisto as-shipped sheet for these information.

Analog Input Characteristics

Input Impedance

The input impedance of the Callisto is normally set to suit the customers sensors (see as-shipped sheet). The user may change the input impedance to dampen the seismometer response if desired. There is one resistor required for each channel to set the impedance.

The resistor value is determined by the desired input impedance and the parallel resistance of 5.0Mohms. $R_{set} = (R_{damp} * 5 * 10^6) / (5 * 10^6 - R_{damp})$. For most practical applications set the resistor value to the desired input impedance. The resistors to set are R85, R86, and R87 (on the ADC board #642) for channels 1-3 respectively. Please see the drawing in the servicing chapter for the location of these resistors. If the unit has six channels then channels 4-6 can be set in exactly the same way.

Input Sensitivity

The as-shipped input sensitivity of the Callisto is shown in the as-shipped sheets. The user may change the input sensitivity if desired. There is one resistor required for each channel to set the sensitivity.

gain = 1.275 uV/bit / desired sensitivity (uV/bit)
Rgain = 2 * 10e4 / (gain x 2 -1)

The maximum input voltage will be 40 Vpp/gain.

The sensitivity can be increased by soldering one resistor per channel onto the ADC printed circuit board. For example, to achieve an overall sensitivity of 192 nV per bit (old style), each gain-setting resistor should be set to 2.22K ohms. The gain resistor for channel 1 is R18, channel 2 is R19, and channel 3 is R60.

The resistors to set are on the ADC board drawing #642 for channels 1-3 respectively. If the unit has six channels then channels 4-6 can be set in exactly the same way.

Sensor Interface

Sensor Power

Unregulated +12V with current limited only by the external fuse is provided as a standard feature. Regulated sensor power is not provided as a standard feature but it is available as a no-charge factory option. +/- 12V at 10mA can be provided using 3 pins on the sensor connector which are reserved as follows:

+12V	Sensor connector pin F
-12V	Sensor connector pin E
Gnd	Sensor connector pin D

Active Sensor Interface

The Callisto can optionally control active sensors such as the Guralp CMG-3T or Streckheisen STS-2 broadband seismometers. Refer to pinouts for connections.

The signal input impedance will be set to the high impedance state for this type of sensor.

Calibration	The calibration signal will be generated when ever calibration is enabled. There are three calibration enable signals intended to enable the internal relays of the seismometer. These signals are open drain signals that are active low. They can withstand voltages up to 20 Volts.
Mass Position Indication	The mass position indicators from the seismometer are connected to three of the SOH analog inputs in the digitiser.
Mass Locking/Unlocking	The masses may be locked or unlocked by the digitiser software. The digitiser generates the logic signals required to control the seismometer lock/unlock functions.
Mass Centering	The masses may be centered by the digitiser software. The digitiser generates the logic signals required to control the seismometer centering function.
6 Channel digitiser	Installation for 6-channel digitizers proceeds as for 3-channel units. Note that the 6-channel Callisto uses two sensor connectors each following the same pin-out. The front panel labels the connectors SIGNAL A and SIGNAL B respectively.

Basic troubleshooting

digitiser looks dead after power on

Check batteries.

Check connections.

Check fuses.

Unable to communicate with digitiser on startup

If the digitiser fails to send any data carefully examine the terminal emulator (ZOC, ViewDat, ProcommPlus) output. If you see a message "Frame error" possibly accompanied by some garbage data, the digitiser is probably sending data at a different baud rate than that for which digitiser test program is configured. Carefully check the factory documentation to determine for what baud rate the digitiser was configured.

Noisy data

Is the data bad on all channels, or just one or two? If this is the case, you should carefully check the corresponding connections. Check to ensure that the channel responds to an input stimulus. (Disconnecting it, or lightly tapping the sensor should prove sufficient) Do one or more channels show a flat line? Do the state of health header fields indicate a problem with that channel? Try switching the sensors around to see if the problem stays with the same channel or moves.

GPS not locking

Most problems with the GPS engines can be traced to a poorly placed antenna. If the GPS is not receiving well, try re-positioning the antenna to a more favourable location. Lastly, ensure the antenna cable is not hanging from the antenna. Secure the antenna cable with a few tie wraps near the antenna to carry the weight of the cable.

The GPS should lock on its own if there is sufficient signal strength. If the GPS is not locking within 15 minutes of power-on, follow the procedure below:

1. Go to the GPS screen on ViewDat.
2. Examine the GPS status on the screen. Are any satellites being tracked?
3. Examine the signal strength values. The signal strength (S/N) from the satellites should be greater than 38.
4. Reposition the antenna to a better location.
5. The GPS clock should lock now.

When the Callisto is integrated in a Nanometrics Digital Seismograph System, for further testing and troubleshooting procedures refer to the Remote Site Installation section of the system documentation.

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7. Firmware Configuration

Overview

This section of the manual provides you with the necessary information on how to configure the Callisto for your specific application. The Callisto as-shipped sheets contain all the important configuration parameters set before shipping. We would strongly advise to record any changes made to the configuration to facilitate troubleshooting and administration.

Configuration Parameters tell the Callisto how it should operate. There are two sets of configuration parameters:

1. Stored User Settings (those in Flash, saved from a previous session)

2. User Settings in RAM

Stored User Settings

Stored User Settings are User Settings that are stored into the Flash memory and do not lose their values even after power is switched off. The digitiser should be configured correctly when received.

User Settings in RAM

User Settings in RAM are read in by the digitiser on power-up from the Stored User Settings.

The User Settings in RAM are those that you are actually changing when you modify parameters. These settings may be saved for use by selecting ‘P’ from the main menu or discarded by selecting ‘R’ from the main menu or powering off the digitiser.

Accessing the Callisto Setup

To access the menu of parameters, connect the Callisto to a PC with a terminal emulator by connecting “Digitiser Config” connector of the Callisto test cable to the PC COM port. Any terminal emulator such as ZOC, Procomm or Crosstalk can be used. Start the terminal emulator. The default communication parameters are 9600, 8 bits, no parity, 1 stop bit, unless the user had previously changed these parameters. Upon startup, the following dialog should appear on the screen:

Tcp version 5.10, compiled Feb 20 1997 20:25:56

Press 'M 'key within 5 seconds or during memory test

Queue Event, empty
Queue Tx1, empty
Queue Tx2, empty
Queue Old, empty
Queue Junk, count = 191, head = 10000, tail = 3faf8
Channel 1, empty
Channel 2, empty
Channel 3, empty
Channel 4, empty
Channel 5, empty
Channel 6, empty

Channel Status, empty
Pointer Tx, empty
Memory Buffer, messages = 191

When these messages appear hit an 'm' or 'M' to access the Callisto menus. The Setup Menu (Main Menu) will then appear as follows:

Orion / digitiser Setup Menu

C: Configuration menu
U: Upload new firmware
P: Program user settings
R: Restart and run with saved settings

Menu Option:

If you wait more than 5 seconds, you will still have the ability to enter the menu again by pressing 'm' or 'M' anytime after the DSP starts digitizing data. At that point, the data flow will halt when you are in the menu and later resume again using the new parameters you have specified.

The sub-menus can be reached by pressing the corresponding key, for example: type 'C' to access the Configuration sub-menu. To exit from the Main Menu type 'R'. This allows the Callisto to start normal data acquisition. To exit from any given sub-menu press the Escape key. This brings you back one level of menu. Typing a space or pressing the Enter key redisplays the current menu. The digitiser is not case sensitive.

If the startup message does not appear or is different then please consult the factory. The menus may also be remotely accessed via a dial-in modem, if the digitiser has been so configured.

Configuration Menus

The configuration menus allow the user to tailor the Callisto for a specific application. Care must be taken when configuring these parameters. Understand what a parameter does before changing it. Generally, the Callisto and Orion are preconfigured at the factory and the user should not have to modify the parameters in these menus.

After the digitiser has been reconfigured, the "Program user settings" option in the top-level Setup Menu must be selected to save the new configuration.

Configuration Top Level Menu

All of the items in the main configuration menu are submenus.

digitiser Configuration Menu

H:	Edit hardware setup parameters
I:	Edit input sensitivity & impedance parameters
G:	Edit gps power cycling parameters
S:	Edit soh calibration parameters
L:	Edit log settings parameters
D:	Edit digitiser parameters
P:	Edit data port parameters
O:	Edit Orion specific parameters
X:	Edit temperature coefficients

Configuration Submenus

Hardware Setup Menu

The parameters in this menu tell the software what hardware is in the digitiser. The serial number should not be changed unless some board swapping is done. The number of channels defines the number of physical ADC channels present. This is usually 3 or 6 channels. The number of memory banks defines the number of 256K blocks of memory present in the digitiser. For HRD's with no memory, this value is 0. For Orion this value is 8, and HRD's with expanded memory the value is 13. The PIC version number applies to the Orion only which is preconfigured and should not be changed. The last item sets the baud rate for the configuration port.

Hardware Setup Edit Menu

S:	Serial number:	000153
C:	Number of channels:	3
B:	Number of memory banks:	0
P:	Pic version number:	2
B:	Configuration Baud rate:	9600

Input Sensitivity & Impedance Menu

The input sensitivity & impedance menu is used to store the ADC gain and damping resistor values. When you change the ADC gain and damping resistor values, update this table at the same time. It saves having to disassemble the Callisto/Orion in the future to determine the values. The first value is the sensitivity and the second value is the impedance as shown in the menu below. These values are not used within the Callisto. On the Orion, these values are used by the Channel Sensitivity menu and should be set correctly.

Input Sensitivity & Impedance Menu

		sensitivity (nV/bit)	impedance (ohms)
1:	Channel 1:	1.000	1.000
2:	Channel 2:	1.000	1.000
3:	Channel 3:	1.000	1.000
4:	Channel 4:	1.000	1.000
5:	Channel 5:	1.000	1.000
6:	Channel 6:	1.000	1.000
A:	Channels 1-3		
B:	Channels 4-6		
C:	Channels 1-6		

Gps Power Cycling Menu

The GPS edit menu configures the power cycling parameters for the GPS engine. The GPS may be have power cycling enabled (1) or disabled (0). If power cycling is disabled the GPS engine is on continuously (this is recommended for most digitiser applications). Power cycling is used to conserve power and trades off against timing accuracy. The power interval is the time between GPS power ups. Every 30 minutes is recommended. The maximum on duration is the time the GPS will remain on if it cannot lock (5 minutes is recommended).

Gps Power Cycling Menu

C:	Enable power cycling:	1
I:	Power interval (min):	60
D:	Maximum power duration (min):	10

Soh Calibration Menu

The SOH information is transmitted by the digitiser in a floating point format of user units such as temperature. This menu allows the user to set the conversion factors for the SOH values. The conversion factors are sensitivity (units/v) and offset (units) and the conversion formula is:

SOHValue = Sensitivity (units/v) * value (V) + offset (units)

The value is a factory calibrated voltage measurement of the SOH input. The first value in the menu below is the sensitivity and the second is the offset.

Soh Calibration Menu

		Units Per Volt	Units Offset
A:	Fast soh 1:	1.000	0.000
B:	Fast soh 2:	1.000	0.000
C:	Fast soh 3:	1.000	0.000
1:	Slow soh 1:	1.000	0.000
2:	Slow soh 2:	1.000	0.000
3:	Slow soh 3:	1.000	0.000
F:	Fast soh 1-3		
S:	Slow soh 1-3		

Log Settings Menu

This menu sets how often the SOH information is recorded and transmitted. The verbosity sets the digitiser instrument log reporting detail. This should be set to normal(30). The verbose mode (31) is used for debugging only.

The fast and slow soh interval set how often the fast and slow SOH information is recorded and transmitted. This value is in seconds. Fast SOH can be sampled a maximum of once a second and slow SOH can be sampled a maximum of every 8 seconds. Typically, these values are set to once a minute to once every 10 minutes. The setting will depend somewhat on the transmission link bandwidth.

Log Settings Menu

V:	Verbosity:	31
F:	Fast soh interval (sec):	60
S:	Slow soh interval (sec):	60
G:	Gps interval (sec):	60

digitiser Menu

The DSP edit menu sets up the parameters associated with the seismic data channels. The number of channels is the transmitted number of channels. You can have a 3 channel digitiser and only transmit one channel of data. The sample rate may be any of the following sample rates:

10, 20, 40, 50, 80, 100, 125, 200, 250, 500, 1000 s/s

The DC removal may be enabled(1) or disabled(0). The DC removal filter is a first order IIR filter which is done after all the FIR filtering. The DC removal filter frequency may be set in the following range of 1 to 1000 milliHertz.

Digitiser Menu

C:	Number of channels:	1
S:	Sample rate:	100
D:	DC removal enabled:	1
F:	DC removal frequency (mHz):	50

Data Communications Menu

This menu sets up the data port on the digitiser. The baud rate may be any of the standard baud rates. Note, that the limitations of the telemetry channel should also be observed when configuring the digitiser to a certain supported baud rate. Changing the tx baud rate will change the rx baud rate also, however a different rx baud rate may be specified. Radio mode may be enabled(1) or disabled(0). If the digitiser is connected to a radio transmitter this mode should be enabled. In radio mode, the digitiser adds filler characters and scrambles the data to keep the transmitter working well.

The bundles per packet defines the length of the transmission packets. This allows the user to tailor the digitiser to the radio link. If the link is noisy then shorter packets are called for. If the link is quiet, the packet can be longer. Typically, 15 bundles/packet is used in most installations. See the data format section for more information on this. If the data communications link supports 2 way communications and the acquisition program will request missing data, re-tx requests may be enabled (1), otherwise re-tx requests should be disabled (0). The tx twice may be enabled (1) or disabled (0). The tx twice delay (in seconds) sets the time delay for transmit twice.

Data Port Menu

B:	Tx & Rx Baud rate:	9600	9600
N:	Bundles per packet:	59	
R:	Enable radio mode:	1	
X:	Enable re-tx requests	0	
2:	Enable tx twice:	2	

D:	Txtwice delay (sec):	60

TCXO Calibration Menu

This menu is sets the temperature curve for the ADC crystal. The only time these values should be changed is when ADC or TCP cards are swapped between HRD's. DO NOT USE this menu otherwise. These coefficients are calibrated at the factory and should never need to be changed. Consult the factory for further details.

Temperature Coefficients Menu

U:	Upload new coefficients
I:	Initialize coefficients
C:	Check coefficent checksum
V:	View coefficients

Orion Specific Menu

In this menu, the Enable Orion mode must be set to 0. This puts the digitiser into digitiser mode. Do not change the other parameters.

Orion Specific Menu

O:	Enable Orion mode:	0		
M:	Disk heat mode:	3		
H:	Minutes of heat per degree:	8		
R:	Safe disk temperature range (C):	5	50	
V:	Battery voltage levels:	12.25	11.5	10.9

8. Servicing

Maintenance

Repair philosophy

Object is to troubleshoot to the board level and replace the board.

Disassembly Instructions

The following tools are required:

1. Phillips screwdriver for #4 and #8 screws.

Instructions:

1. Remove all power from the Callisto.
2. Remove the screws around the edge of the front plate.
3. Remove the card cage chassis from the can.
4. Disconnect the connectors from the card cage
5. Remove the four screws holding the card cage front cover to the card cage

The cards may be removed from the card cage by extracting the cards.

Assembly Instructions

The assembly instructions are the reverse of the disassembly instructions.

Configuration Port

The configuration port is an RS-232 port used for configuration and firmware downloading. It is a three pin port: RX, TX, and GND. The port is on the SOH/communications connector:

TX	Pin H
GND	Pin T
RX	Pin G

Access to that port is enabled with the Callisto test cable through the connector marked "Digitiser Config".

See Appendix G for detailed pin assignment description of a factory test cable and other cables.

Software & Firmware Updates

Firmware Update Procedure

New firmware is uploaded through the factory test port. See the section above for a description of the factory test port. This paragraph contains the necessary intructions for uploading new firmware. For step by step upload instructions refer to Appendix F of this manual.

1. Copy the firmware received on the update diskette to the PC's hard drive
2. Connect cable to factory test port via the communications connector.

3. Connect the cable to a PC communications port.
4. Start a PC terminal emulator program.
5. Set baud rate to 9600, 8 data bits, no parity, 1 stop bit.
6. Disable all modem handshaking options like RTS/CTS, DSR, Xon/Xoff DCD detection
7. Power up the Callisto.
8. There should be a few beeps on the emulator then the text
   "TCP Version X.XX, compiled (date, time)
   Press 'M' key within 5 seconds or during memory test".
   If this does not appear, then check connections and emulator settings. Note the firmware version and date at this point.
9. Press the "M" key. A menu will appear when the memory test is complete. The memory test takes 15 seconds to complete.
10. Press the "U" key to select the upload new firmware option.
11. From the terminal emulator, initiate an ASCII upload of the new hex file on the update diskette.
12. The firmware is uploaded into the Callisto. This will take about 1 minute. When the upload is complete, a message "upload completed, programming flash" will appear. A few seconds later the flash will be programmed and the Callisto reboots. The text for the TCP version will appear again and it should display the new firmware version and date. At this point the firmware upload procedure is complete. The Callisto is now ready for use.
    If the download fails, a download error message will be displayed, try downloading again.

NEVER power down the Callisto while it is doing a upload. This will have catastrophic results.

Internal Configuration Options

Related to the seismometer input

Input Impedance

The ADC board provides space for an optional input shunt resistor which can be used to damp a seismometer. Calculate the required damping resitor value using instructions provide by the seismometer manufacturer. 'Active' seismometers such as the Guralp CMG40 should be used with no damping resistor.

The input impedance of the Callisto is normally shipped in a high impedance state (see as-shipped sheet). The user may change the input impedance to dampen the seismometer response if desired. There is one resistor required for each channel to set the impedance.

The resistor value is determined by the desired input impedance and the parallel resistance of 5.0Mohms. Rset = (Rdamp * 5 * 10e6) / (5 * 10e6 - Rdamp). For most practical applications set the resistor value to the desired input impedance. Figure 9.2 shows the location of the damping resistor for each channel. The damping resistor for channel 1 is R85, channel 2 is R86, and channel 3 is R87. The resistors are located on the ADC board for channels 1-3 respectively. If the unit has six channels then channels 4-6 can be set in exactly the same way.

Input Sensitivity

The as-shipped input sensitivity of the Callisto is shown in the as-shipped sheets. The user may change the input sensitivity if desired. There is one resistor required for each channel to set the sensitivity.

The resistor value is determined by the following formulae:

gain = 1.275 uV/bit / desired sensitivity (uV/bit)
Rgain = 2 * 10e4 / (gain x 2 -1)

The sensitivity can be increased by soldering one resistor per channel onto the ADC printed circuit board. For example, to achieve an overall sensitivity of 192 nV per bit, each gain-setting resistor should be set to 1.62K ohms. Figure 9.2 shows the location of the gain-setting resistor for each channel. The gain resistor for channel 1 is R18, channel 2 is R19, and channel 3 is R60. The resistors to set are on the ADC board for channels 1-3 respectively. If the unit has six channels then channels 4-6 can be set in exactly the same way.

Note with no gain resistor installed, the gain = 0.5 and the sensitivity = 2.55 uV/bit

The input impedance should be left in the high impedance state.

Seismometer	Input Sensitivity	Input Gain	Input Gain Resistors	System Sensitivity
CMG40T	800 nV	1.6	9.09K ohms	1nm/s
CMG40T	2550 nV	1	none	3.186 nm/s

Table 2: Configuring the ADC for CMG40T active seismometer.

Configuring for an active seismometer with mass position monitoring

The first step required when connecting to an active seismometer is setting the input sensitivity and input impedance of the ADC. The input sensitivity would either be chosen to give a system sensitivity of 1nm/s or to set the full scale levels of the seismometer and the Callisto to be the same. Connection to an active sensor (such as CMG40T) will consist of connecting the main sensor coil to the signal inputs with the positive (+) coil connected to the positive (+) input and negative (-) to negative (-). Connect the '+' calibration output to the motor coil '+' and the '-' calibration output to the motor coil return. The output impedance of the calibration signal is 500 ohm with a maximum current of 10mA at a voltage of 5V. A series resistor is used on the calibration '+' outputs to ensure the current is limited to this value. This is not a factor with active sensors since they buffer the calibration signal internally.

The best performance will be found using cables built in the following manner:

> The connection to each sensor should be made with a 6 pair, double shielded with individual internal shielding, 24 AWG (or smaller) cable. An example cable of this type would be Belden 8166. The inner shields of the cable should be connected only at the connector and the sensor end should be left open. The inner shield should be kept isolated from the outer shield. The outer shield should be connected to the chassis ground and to the sensor chassis ground. If the sensor has a ground pin the connection can be done using that pin, however if there is no ground connection (ie. SS1 sensor) then the chassis connection should be made by connecting to the shell of the connector with as short a connection length as possible. A second cable should be connected directly from the battery to the CMG40T for the power connection.

See the next section to configure for passive seismometer calibration with current calibration drive.

Figure 3: Position of gain and damping resistors on the ADC board.

Configuring for a passive seismometer

The first step required when connecting to a passive seismometer is setting the input sensitivity and input impedance of the ADC. The input sensitivity would normally be chosen to give a system sensitivity of 1nm/s. The input impedance should be set to a value to give the critical damping resistance of the seismometer.

Seismometer	Input Sensitivity	Input Gain	Gain Resistors	Input Impedance
Geotech S13	378 nV	3.37	3.48K ohms	5360 ohms
Kinemetrics SS1	159 nV	8.02	1.33K ohms	4220 ohms
Mark Prod. L4C	170.1 nV	7.49	1.43K ohms	8870 ohms

Table 3: Configuring the ADC board for passive seismometers.

Connection to a passive sensor will consist of connecting the main sensor coil to the signal inputs with the positive (+) coil connected to the positive (+) input and negative (-) to negative (-). Connect the '+' calibration output to the motor coil '+' and the '-' calibration output to the motor coil return. The output impedance of the calibration signal is 500 ohm, with a maximum current of 10mA at a voltage of 5V. A series resistor is used on the calibration '+' outputs to ensure the current is limited to this value.

The best performance will be found using cables built in the following manner:

> The connection to each sensor should be made with a 2 pair, double shielded with individual internal shielding, 24 AWG (or smaller) cable. An example cable of this type would be Belden 8162. The inner shields of the cable should be connected only at the connector and the sensor end should be left open The inner shield should be kept isolated from the outer shield. The outer shield should be connected to the chassis ground and to the sensor chassis ground. If the sensor has a ground pin the connection can be done using that pin, however if there is no ground connection (ie. SS1 sensor) then the chassis connection should be made by connecting to the shell of the connector with as short a connection length as possible.

User Configurable Jumper Settings

Mem-Cal:

J3	1-2	Calibration Enable = +5V
J3	2-3	Calibration Enable = +12V

Factory configured jumpers

The is configured using jumpers on various boards. The function of all the jumpers are explained in the following tables. Please see the as-shipped sheets for the actual jumper settings. Note that where applicable, jumper pin 1 has a square pad. The following jumper settings are set at the factory. These jumpers should never be changed. They are listed here for reference only. User configurable jumpers are considered under the function in which the jumper is referenced.

ADC 1-3:

Jumper	*Setting*	*Function*
J3	1-2	PS_SYNC
J6	5-6	Channel 1 Address
J7	1-2	Channel 2 Address
J8	1-2	Channel 3 Address
J10-J18	2-3	Time Slot

Mem-Cal:

Jumper	*Setting*	*Function*
J5	1-2	Voltage Calibration
J4	--	Not Used
J7	--	Not Used
J6	2-3	SOH1 = Mass POS 1

ADC 4-6:

Jumper	*Setting*	*Function*
J6	3-4	Channel 4 Address
J7	2-3	Channel 6 Address
J8	2-3	Channel 6 Address

TCP:

Jumper	*Setting*	*Function*
J5	1-2	USCA CLK
J6	1-2	USCB CLB
J11	1-2	Flash Program

COMMS:

Jumper	*Setting*	*Function*	*Jumper*	*Setting*	*Function*
J3A	1-2	Event_In CMOS Level	J3B	5-6	Event_In CMOS Level
J4A	2-3	Event_Out CMOS Level	J4B	5-6	Event_Out CMOS Level
J5A	2-3	RX232	J5B	5-6	CTS232
J6A	2-3	TX232	J6B	--	N/A
J7A	--		J7B	3-4	RTS232
J7C	--		J12A	1-2	AUX_CLK
J12B	5-6	USCA_RI			

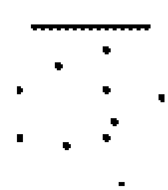


Figure 4: Pin-out for J12, J3, J4, J5, J6

Standard seismometer configurations

Kinemetrics Ranger

Generator constant 345 volt-seconds/ meter
Gain set to 8.02 with 1.33K ohm gain set resistor

Damping set to 4200 ohms with damping resistor
Configure for current drive with no mass position monitoring
System sensitivity 1 nanometer per second per bit

Mark Products L4C

Generator constant 276.4 volt-seconds/ meter
Gain set to 7.49 with 1.43K ohm gain set resistor
Damping set to 8870 ohms with damping resistor
Configure for current drive with no mass position monitoring
System sensitivity 1 nanometer per second per bit

Geotech S13

Generator constant 629 volt-seconds/ meter
Gain set to 3.37 with 3.48K ohm gain set resistor
Damping set to 5340 ohms with damping resistor
Configure for current drive with no mass position monitoring
System sensitivity 1 nanometer per second per bit

Guralp CMG40T

Generator constant 800 volt-seconds/ meter
Gain set to 1.6 with 9.09K ohm gain set resistor
Damping set to open circuit with no damping resistor
Configure for voltage drive with mass position monitoring
System sensitivity 1 nanometer per second per bit

OR

Generator constant 800 volt-seconds/ meter
Gain set to nominal with no gain set resistor
Damping set to open circuit with no damping resistor
Configure for voltage drive with mass position monitoring enabled
System sensitivity 3.186 nanometers per second per bit

Appendix A - Connector Pinouts

Table 4: SOH/Comms Connector Pin-out

Pin Number	Signal Name
A	P1-DGnd
B	SOH - AGnd
C	SOH 3
D	SOH 1
E	Temp (n/c internally)
F	Temp +5V
G	HRD-config-Rx
H	HRD-config-Tx
J	P2-Rx (n/c internally)
K	P2-Tx (MOD-RX-Out)
L	P3-Tx (n/c internally)
M	P1-Tx (Data-Rx, Con-Data-Out)
N	P1-Rx (Con-Data-In)
P	Pwr On (n/c internally)
R	SOH 2
S	Temp-AGnd (n/c internally)
T	HRD-Config-Gnd
U	P2-Gnd (n/c internally)
V	P3-Rx (n/c internally)

Table 5: GPS Antenna Connector

The GPS antenna connector is a standard female TNC bulkhead jack.

Table 6: RF Antenna Connector

The RF antenna connector is a standard female N type bulkhead jack.

Table 7: Power Connector

Pin	Signal Name
A	Battery +
B	Battery -

Table 8: Signal Connector

Pin Number	Signal Name
A	Channel 2 +
B	Channel 1 Gnd
C	Channel 1 -
D	Sensor Gnd
E	Sensor -12V (n/c internally)
F	Sensor +12V
G	Control relay 3
H	Control relay 1
J	Mass Position 3
K	Mass Position 1
L	Channel 3 Calibration +
M	Channel 2 Calibration +
N	Channel 1 Calibration +
P	Channel 3 -
R	Channel 3 Gnd
S	Channel 2-
T	Channel 2 Gnd
U	Channel 1+
V	Logic Gnd
W	Control relay 2
X	Mass Position 2
Y	Channel 3 Calibration -
Z	Channel 1 Calibration -
a	Channel 3+
b	Chassis Gnd (connected to connector shell)
c	Channel 2 Calibration -

Appendix B - Data Format

Introduction

This data transmission format facilitate the transfer compressed seismic data along with a wide variety of status information from an instrument to a central site. It supports error free transmission of data using retransmission requests of bad packets. It also supports polled networks. The data format requires that the instrument have an accurate time source (ie. GPS) for time tagging the data prior to compression and transmission. The compression algorithm is based on taking the first difference of the data and packing the data into bytes, words, or long words . This algorithm achieves about 1.3 bytes per sample at maximum compression.

Most of the status messages can be transmitted at a user defined frequency. This allows the user to tailor ratio of data to status information. This is important on limited bandwidth or noisy transmission mediums. The status information in data format is expandable. As new status information messages are created, they can be added to the data format without affecting the existing information.

Lastly, the data format is simple to implement on small microprocessors. The compression algorithm is simple and requires little memory and processing power.

The following objectives were used in designing the data format:

1. support compressed data
2. support retransmit of packets for error correction
3. support polled networks
4. compatible with Orion
5. simple compression/decompression algorithm
6. simple to implement
7. expandable
8. programmable frequency for status information
9. not wasteful of bandwidth

Description of Packets

All the data (seismic and status data) is gathered into sequenced and time stamped packets. These packets start with a synchronization word plus a Old packet available word and finish with a CRC. The packets consist of 17 byte 'bundles' of data. Each bundle is an independent collection of data. Each packet contains a timestamp bundle followed by n data bundles where n is odd. In order to word align packets, an odd number of bundles is used. This principally benefits the TCP.

The number of bundles in a packet is a programmable parameter. The number of bundles is odd and has a range of 1-255. This allows the packet size to be tailored to the data link. The packet size should be optimized for the data link. Short packets should be used on noisy error prone data links. Packets may be the same size for the entire network, or different on each branch (a branch is connected to one RM-4 port) of the network. All instruments on a given branch must use the same packet size. Short messages must be paddled out to the packet size. Outgoing packets may have a different packet size.

In summary:

- a channel is a unique stream of information
- an instrument may transmit 1 or more channels of information
- a packet contains information from only one channel
- a packet is a uniquely identifiable collection of information that is transmitted
- packets are a configurable fixed size
- a branch connects 1 or more instruments to one port on the RM-4
- all instruments on a branch use the same incoming packet size
- all instruments on a branch use the same outgoing packet size
- outgoing packets do not have the Oldest packet word
- incoming packets contain data, status, or configuration information
- outgoing packets contain retransmit requests, or configurations
- Outgoing is from the central site to remote site, incoming is the opposite
- all data is represented in the little endian format (intel format)

CRC for the Packets

For simplicity CRC's should be an addressable data size, i.e. 8, 16 or 32 bits. Sending 32 bits (4 bytes) is too much overhead, 8 bits is not sufficient Therefore select 16 bits as the CRC size.

There are 2 good common standard 16 bits polynomials, the CRC-16 and the 16 bit CRC-CCITT. The reversal of these polynomials are also known to be good and are also used. The digitiser uses the 16 bit CRC-CCITT. Therefore select the 16 bit CRC-CCITT as the CRC polynomial.

On the bit level CRC's can be calculated from either end. Normally CRCs are calculated most significant bit first, i.e. the byte 0xD5 is done 11010101. Reflected CRCs are calculated least significant bit first, i.e. thye byte 0xD5 is done 10101011. Bits of a byte are transmitted over a serial link least significant bit first. Most CRCs calculated for transmission over a serial link are done least significant bit first. The digitiser uses a reflected CRC algorithm. Therefore, select a reflected CRC algorithm is to be used.

If the accumulated CRC value is 0, it is unaffected by the 0 byte and errors may not be detected. The CRC should not be initialized to 0 if messages contain leading 0s may occur. Since the receiver syncs on a non-zero sync word, this is not a problem if these bytes are included. The digitiser uses 0xFFFF as its initial value for the CRC. Therefore, select 0 as the initial value for the CRC.

If the CRC is sent as is, the accumulated CRC value afterwards is then 0. This can pose problems if messages have the CRC and trailing 0s, see above. Modifying the CRC before transmitting it has little to gain and complicates matters. The Orion XORs the CRC with 0xFFFF before transmitting it and checks for 0xF0B8 on receive. Therefore, select transmitting the CRC as is.

```
#define CrcUpdate(usCrc,ubByte) \  ((usCrc) >> 8) ^ ausCrcTable [((usCrc) &
0xff) ^ (ubByte)]
SendByte (ubByte)
{
       usCrc = CrcUpdate (usCrc,ubByte);
       UscTx = ubByte ^ ubScramble;
}
RecvByte ()
{
       ubByte = UscRx ^ ubScramble;
       usCrc = CrcUpdate (usCrc, ubByte);
       return ubByte;
}
SendMsg (pubData)
{
       usCrc = 0;
       SendByte (ubSync1);
       SendByte (ubSync2);
       SendLong (ulOldestSequenceNumber);
       for (us = 0; us < usNumberMsgByte, us ++)
       SendByte (pubData [us]);
       usCrc2 = usCrc;
       SendWord (usCrc2);
}

RecvMsg (pubData)
{
       while (1)
       {
```

```
                while (1)
                {
                        while (1)
                        {
                                usCrc = 0;
                                if (RecvByte() == ubSync1)
                                        break;
                        }
                        if (RecvByte () == ubSync2)
                                break;
                }
                ulOldestSequenceNumber = RecvLong ();
                for (us = 0; us < usNumberMsgByte, us ++)
                        pubData [us] = RecvByte ();
                usCrc2 = usCrc;
                if (usCrc2 == RecvWord () && usCrc == 0)
                        break;
        }
}


unsigned short ausCrcTable[256] ={
  0x0000, 0x1189, 0x2312, 0x329B, 0x4624, 0x57AD, 0x6536, 0x74BF, 0x8C48,
0x9DC1,
   0xAF5A, 0xBED3, 0xCA6C, 0xDBE5, 0xE97E, 0xF8F7, 0x1081, 0x0108, 0x3393,
0x221A,
   0x56A5, 0x472C, 0x75B7, 0x643E, 0x9CC9, 0x8D40, 0xBFDB, 0xAE52, 0xDAED,
0xCB64,
   0xF9FF, 0xE876, 0x2102, 0x308B, 0x0210, 0x1399, 0x6726, 0x76AF, 0x4434,
0x55BD,
   0xAD4A, 0xBCC3, 0x8E58, 0x9FD1, 0xEB6E, 0xFAE7, 0xC87C, 0xD9F5, 0x3183,
0x200A,
   0x1291, 0x0318, 0x77A7, 0x662E, 0x54B5, 0x453C, 0xBDCB, 0xAC42, 0x9ED9,
0x8F50,
   0xFBEF, 0xEA66, 0xD8FD, 0xC974, 0x4204, 0x538D, 0x6116, 0x709F, 0x0420,
0x15A9,
   0x2732, 0x36BB, 0xCE4C, 0xDFC5, 0xED5E, 0xFCD7, 0x8868, 0x99E1, 0xAB7A,
0xBAF3,
   0x5285, 0x430C, 0x7197, 0x601E, 0x14A1, 0x0528, 0x37B3, 0x263A, 0xDECD,
0xCF44,
   0xFDDF, 0xEC56, 0x98E9, 0x8960, 0xBBFB, 0xAA72, 0x6306, 0x728F, 0x4014,
0x519D,
   0x2522, 0x34AB, 0x0630, 0x17B9, 0xEF4E, 0xFEC7, 0xCC5C, 0xDDD5, 0xA96A,
0xB8E3,
   0x8A78, 0x9BF1, 0x7387, 0x620E, 0x5095, 0x411C, 0x35A3, 0x242A, 0x16B1,
0x0738,
   0xFFCF, 0xEE46, 0xDCDD, 0xCD54, 0xB9EB, 0xA862, 0x9AF9, 0x8B70, 0x8408,
0x9581,
   0xA71A, 0xB693, 0xC22C, 0xD3A5, 0xE13E, 0xF0B7, 0x0840, 0x19C9, 0x2B52,
0x3ADB,
   0x4E64, 0x5FED, 0x6D76, 0x7CFF, 0x9489, 0x8500, 0xB79B, 0xA612, 0xD2AD,
0xC324,
   0xF1BF, 0xE036, 0x18C1, 0x0948, 0x3BD3, 0x2A5A, 0x5EE5, 0x4F6C, 0x7DF7,
0x6C7E,
   0xA50A, 0xB483, 0x8618, 0x9791, 0xE32E, 0xF2A7, 0xC03C, 0xD1B5, 0x2942,
0x38CB,
   0x0A50, 0x1BD9, 0x6F66, 0x7EEF, 0x4C74, 0x5DFD, 0xB58B, 0xA402, 0x9699,
0x8710,
   0xF3AF, 0xE226, 0xD0BD, 0xC134, 0x39C3, 0x284A, 0x1AD1, 0x0B58, 0x7FE7,
0x6E6E,
```

```
  0x5CF5, 0x4D7C, 0xC60C, 0xD785, 0xE51E, 0xF497, 0x8028, 0x91A1, 0xA33A,
0xB2B3,
  0x4A44, 0x5BCD, 0x6956, 0x78DF, 0x0C60, 0x1DE9, 0x2F72, 0x3EFB, 0xD68D,
0xC704,
  0xF59F, 0xE416, 0x90A9, 0x8120, 0xB3BB, 0xA232, 0x5AC5, 0x4B4C, 0x79D7,
0x685E,
  0x1CE1, 0x0D68, 0x3FF3, 0x2E7A, 0xE70E, 0xF687, 0xC41C, 0xD595, 0xA12A,
0xB0A3,
  0x8238, 0x93B1, 0x6B46, 0x7ACF, 0x4854, 0x59DD, 0x2D62, 0x3CEB, 0x0E70,
0x1FF9,
  0xF78F, 0xE606, 0xD49D, 0xC514, 0xB1AB, 0xA022, 0x92B9, 0x8330, 0x7BC7,
0x6A4E,
  0x58D5, 0x495C, 0x3DE3, 0x2C6A, 0x1EF1, 0x0F78
};
```

Outgoing Packets

All outgoing packets are a fixed size of 30 bytes. There are no retransmit requests from the destination for outgoing packets.

The basic format is as follows:

2 bytes	Synchronization Word = AA BB
2 bytes	Instrument ID (5 bits model type, 11 bits serial number)
4 bytes	Long Seconds
1 byte	Packet Type
3 bytes	Packet Information Header
4 x 4 bytes	Data Section
2 bytes	Packet CRC

Retransmission Request by Sequence Number Packet

1 byte	Packet type = 1
1 byte	Channel
2 bytes	Spare
4 bytes	Sequence number 1 requested
4 bytes	Sequence number 2 requested
4 bytes	Sequence number 3 requested
4 bytes	Sequence number 4 requested

Retransmission Request by Sequence Number Range Packet

1 byte	Packet type = 2
1 byte	Channel
2 bytes	Spare
4 bytes	First sequence number requested
4 bytes	Last sequence number requested
8 byte	Spare

digitiser Calibration Packet

1 byte		Packet Type = 6
1 byte		Channel Mask (ch 1, 2, 3, 4 = 1, 2, 4, 8)
2 bytes		Spare
4 bytes	us-int32	Start Time (long seconds)
4 bytes	float	Frequency in Hz (0.01 <= freq < sample rate / 2)
4 bytes	float	Amplitude in Volts (0 < amp <= 5.0)
2 bytes	us-int32	Duration in seconds (0 < duration <= 3600)

Incoming Packets

All incoming packets consist of a synchronization pattern, oldest packet available for a data stream, timestamp bundle, n other bundles, and a CRC:

2 bytes	Synchronization Word
4 bytes	Oldest Packet Available for a Data Stream
17 bytes	Packet Header Bundle
17 * n bytes	n bundles where n is odd
2 bytes	Packet CRC

Compressed Data Packet

A data packet always consists of a timestamp bundle followed by n data bundles (where n is user defined). A timestamp bundle contains a sequence number, the time of the first sample, instrument ID (model and serial number), sample rate of packet and channel number, and the first sample.

Compressed Data Packet Header Bundle

1 byte	Packet type = 1 (bit 5 = 1 is for retransmit)
4 bytes	Long seconds
2 bytes	Sub-seconds in 10,000th of a second
2 bytes	Instrument ID [5 bit model type, 11 bit serial number]
4 bytes	Sequence Number
1 byte	Sample Rate, Channel # [5 bits for sample rate, 3 bits for channel #]
3 bytes	X0 (first sample)

The instrument ID defines the instrument type transmitting the channel of data. Currently the following instrument ID's are defined:

0	digitiser
1	ORION
2	RM3
3	RM4
4-31	Reserved for future use

The sample rate is an enumerated value. The table below defines the different sample rates:

0	reserved	6	40 s/s	12	250 s/s
1	1 s/s	7	50 s/s	13	500 s/s
2	2 s/s	8	80 s/s	14	1000 s/s
3	5 s/s	9	100 s/s	15	25 s/s
4	10 s/s	10	125 s/s	16	120 s/s
5	20 s/s	11	200 s/s	17-31	reserved for future use

Data Bundle

A data bundle contains between 4 and 16 compressed samples of data. The samples are compressed using a first difference algorithm. The data is compressed as byte, word, or long differences. Each set of four bytes contains either 4 byte differences, 2 word differences, or 1 long difference. The compression bits indicate how each set of 4 bytes is packed. For each 4 byte set there are 2 compression bits. The compression bits are packed into a byte as follows:

byte : ww xx yy zz where the compression bits indicate:

ww- data set 1	00	not used
xx- data set 2	01	byte difference
yy- data set 3	10	word difference
zz- data set 4	11	long difference

The format of the data bundle is as follows:

1 byte	Compression Bits
4 bytes	Compressed data set 1
4 bytes	Compressed data set 2
4 bytes	Compressed data set 3
4 bytes	Compressed data set 4

Null Bundle

This bundle is provided to pad out packets. The first occurance of a Null bundle indicates that there is no further data in the packet. The null bundle contains no useful information. The receiver should disregard this bundle and all remaining bundles, and skip to the next packet.

1 byte	Bundle Type = 9
16 bytes	Filler

Filler Packet

A filler packet is required for radio links. Non-zero data must always be transmitted by radios. To accomplish this the instruments transmit filler packets whenever there is no data to transmit. Repeaters discard received filler packets and generate their own filler packets for transmission. This method is required because a repeater can also multiplex.

The only valid data in a filler packet is the bundle type. The rest of the packet is filled a value that is good for radio transmission (to be defined)

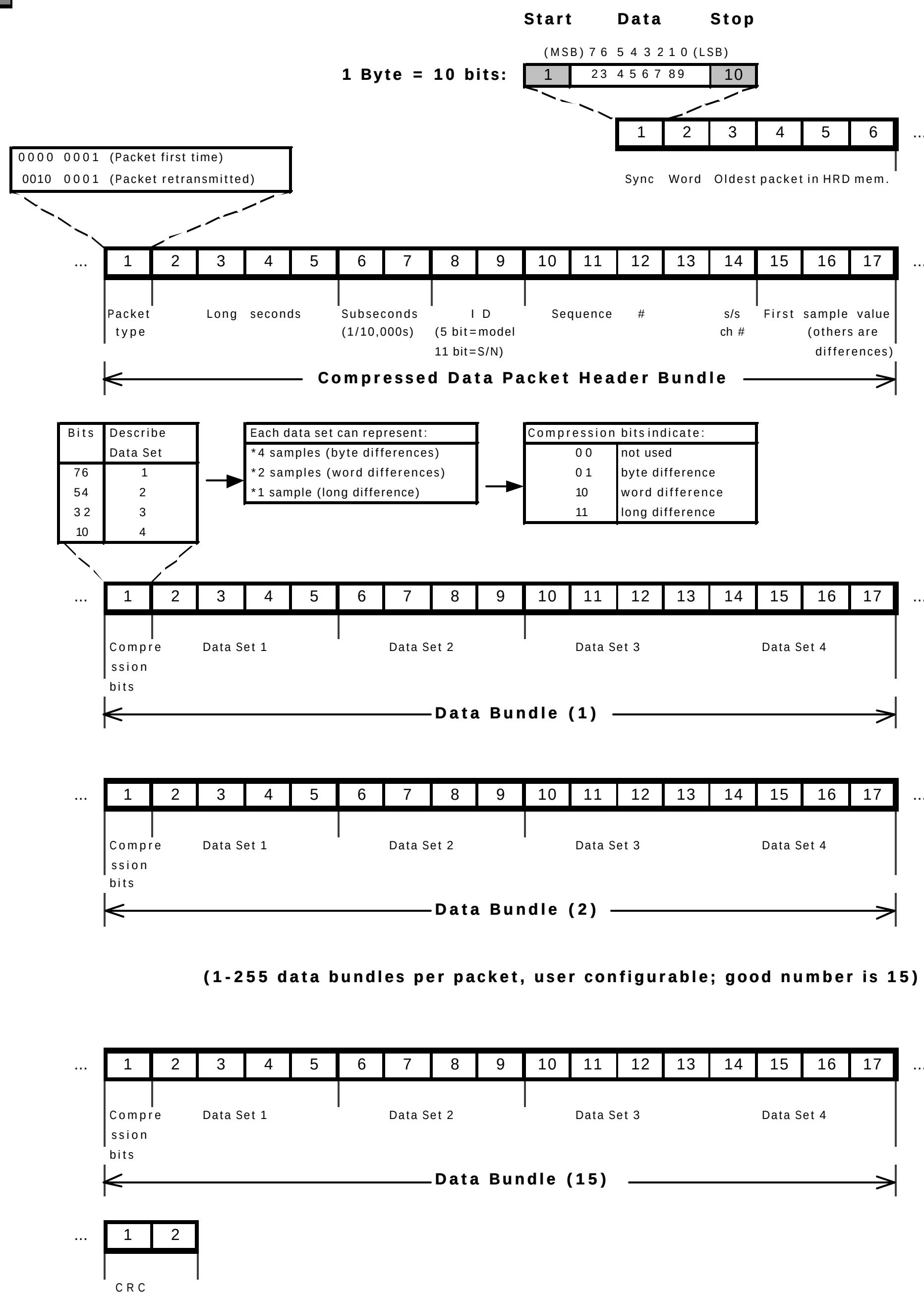
Filler Packet Header Bundle

1 byte	Packet type = 9 (bit 5 = 1 is for retransmit)
16 bytes	defined as filler characters

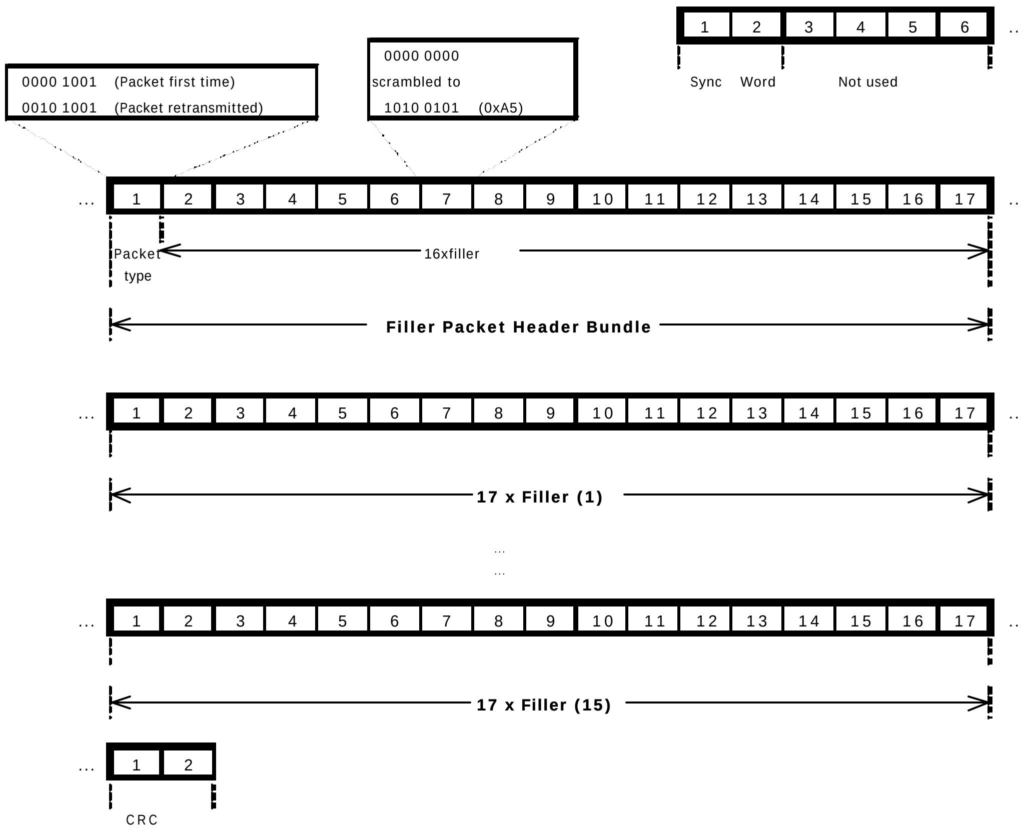
Note : scrambler default is 0xA5

The following is a graphical illustration of an incoming data stream, containing only data packets and filler packets. An actual data stream will also have state-of-health packets.

D a) Compressed Data Packet



F b) Filler Packet



Bandwith Estimate Example

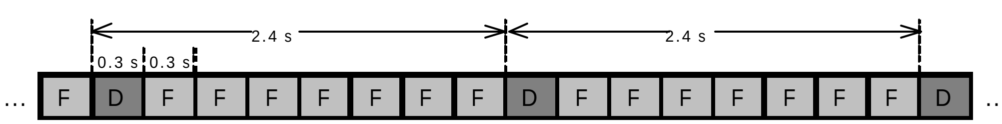
1 ch
100 s/s
9600 baud
15 bundles/packet
signal always quiet (byte difference)

→

16 samples/bundle x 15 bundles = 240 samples/packet
(takes 240/100=2.4 s to digitize a packet)

(6+17+15x17+2)x10=2800 bits/packet
1/9600 s/bit => 2800/9600 = 0.2916666 s/packet

bandwith is used only 0.291666/2.4=0.1215=12.15%
minimum needed baud rate is 9600*0.1215=1166.66 baud
with Sync abd Status packets => cca 1200 baud



Status Packet

A status packet consists of a status timestamp bundle followed by n status bundles. A status timestamp consists of a sequence number, the time (nominal time when the packet was created), instrument ID (model and serial number).

Status bundles have a general format that is outlined below:

1 byte	bundle type = xx
4 bytes	Long seconds
12 bytes	Defined by the specific bundle type

or

1 byte	bundle type = xx
16 bytes	Defined by the specific bundle type

State-of-Health Packet Header Bundle

1 byte	Packet type = 2 (bit 5 = 1 is for retransmit)
4 bytes	Long seconds
2 bytes	Sub-seconds in 10,000th of a second, this value always 0
2 bytes	Instrument ID [5 bit model type, 11 bit serial number]
4 bytes	Sequence Number
4 bytes	Reserved for future use

The instrument ID defines the instrument type transmitting the channel of data. Currently the following instrument ID's are defined:

0	digitiser
1	ORION
2	RM-3
3-31	Reserved for future use

Fast External State-Of-Health Bundle

1 byte	bundle type = 32
4 bytes	long seconds
4 bytes	float of calibrated fast SOH1 in volts or units
4 bytes	float of calibrated fast SOH2 in volts or units
4 bytes	float of calibrated fast SOH3 in volts or units

Slow External State-Of-Health Bundle

1 byte	bundle type = 33
4 bytes	long seconds
4 bytes	float of calibrated slow SOH1 in volts or units
4 bytes	float of calibrated slow SOH2 in volts or units
4 bytes	float of calibrated slow SOH3 in volts or units

digitiser Slow Internal SOH Bundle

1 byte	bundle type = 34
4 bytes	long seconds
4 bytes	float of battery voltage measured at PSU in volts
4 bytes	float of VCXO temperature in degrees Celsius
4 bytes	float of radio SNR in xxxx

GPS Time Quality Bundle

1 byte	bundle type = 39
4 bytes	long seconds
2 bytes	GPS on time
2 bytes	GPS off time during the last cycle
2 bytes	GPS time to lock in seconds
2 bytes	Time difference at lock in counts (divide by 3.84 to get microseconds)
2 bytes	VCXO offset (div. by 16 to get the DAC offset)
1 byte	Reason GPS turned off: 0 -PLL finished correcting time error 1 -GPS on time expired
1 byte	Final GPS mode: 0 -3D navigation 1 -2D navigation 2 -tracking 1 sat or more 3 -searching for satellites

VCXO Calibration Bundle

1 byte	Bundle type = 7
4 bytes	Long seconds
2 bytes	VCXO value
2 bytes	Time difference at lock in counts (divide by 3.84 to get microseconds)
2 bytes	Time Error (in counts)
2 bytes	Frequency Error (in counts/sec or counts/ 16 secs)
2 bytes	Crystal temperature
1 byte	PLL Status?(1=fine locked, 2=coarse locking, 3 =temp. ref, gps off, 4=temp ref, gps on)
1 byte	GPS Status(0=3D, 1=2D, 2=1 sat, 3=search, 4= gps off, 5-6=gps error)

Null Bundle

This bundle is provided to pad out packets. The first occurance of a Null bundle indicates that there is no further data in the packet. The null bundle contains no useful information. The receiver should disregard this bundle and may skip to the next packet.

1 byte	Bundle Type = 9
16 bytes	Filler

Min-Max1 Bundle

The activity indicator provides a 1 Hz or slower filtered summary of a seismic data channel. This would be used to provide the end user with a summary of the collected data. This allows the user to quickly browse large quantities of data for events. The data may be filtered using a 5th order filter. The filter may be low pass, high pass, or band pass. In order not to lose the higher frequency information, the minimum and maximum over the interval of the filtered signal is stored. The interval is a programmable value of 1s or greater.

1 byte	Bundle type = 10
4 bytes	Long seconds
3 bytes	Filtered min. over 1st interval
3 bytes	Filtered max. over 1st interval
3 bytes	Filtered min. over 2nd interval
3 bytes	Filtered max. over 2nd interval

Min-Max2 Bundle

The activity indicator provides a 1 Hz or slower filtered summary of a seismic data channel. This would be used to provide the end user with a summary of the collected data. This allows the user to quickly browse large quantities of data for events. The data may be filtered using a 5th order filter. The filter may be low pass, high pass, or band pass. In order not to lose the higher frequency information, the minimum and maximum over the interval of the filtered signal is stored. The interval is a programmable value of 1s or greater.

1 byte	Bundle type = 11
4 bytes	Long seconds
3 bytes	Filtered min. over 1st interval
3 bytes	Filtered max. over 1st interval
3 bytes	Filtered min. over 2nd interval
3 bytes	Filtered max. over 2nd interval

Instrument Log Bundle

Any errors or warnings generated by the instrument are stored in this bundle. Some typical errors or warnings are GPS locked/unlocked, low battery, clock adjustments, external events, self test errors, status of disk space, duty cycle, etc.

1 byte	Bundle type = 12
4 bytes	Long seconds
2 bytes	Error code , where bits 0-11= error code, bits 12-15 = data format,
2 bytes	Error Level
8 bytes	Error Parameters

ErrorLevel is a bit mapped value which is broken down as follows:

bits 0-7	Area (each bit identifies a separate area)- currently unused
bits 8-10	Processor (TCP, Aux, DSP)
bits 11-15	Error Level (Fatal, error, warning, info, debug

GPS Location Bundle

This bundle contains the latitude and longitude of the instrument's GPS antenna. This bundle has a programmable measurement frequency. The latitude and longitude is stored in an extended floating point format.

1 byte	Bundle type = 13
4 bytes	Long seconds
4 bytes	Latitude
4 bytes	Longitude
4 bytes	Elevation

GPS Satellite Status/Reference Time Error Bundle

This bundle contains the status of the GPS engine's satellite tracking channels. It records the signal to noise ratio, activity, and satellite number for the five satellite tracking channels. The activity indicates whether the GPS channel is idle, searching or locked to a satellite signal. This information is very useful in diagnosing a GPS engine that is not locking.

1 byte	Bundle type = 15
4 bytes	Long seconds
2 bytes	Status bits (see rockwell manual, contains operating mode, figure of merit)
10 bytes	GPS Satellite Channel - 2bytes per channel
	where the 2 bytes are defined:

bits 0-4	Satellite PRN code (0-31)
bits 5-7	Unused
bits 8-13	Signal to Noise Ratio (0-63)
bits 14-15	Activity 0=idle, 1 searching, 3=tracking

D1 (Early) Threshold Trigger Bundle

The D1 threshold trigger bundle reports the start of a threshold trigger event. It is sent at a programmable time after the start of a trigger. It reports the start time of the trigger, along with some statistics about the trigger. The D1 trigger bundle is followed by a D2 trigger which reports the end of a trigger. The D1 bundle contains the peak amplitude, the half period of the amplitude, and the samples after trigger of the peak amplitude.

1 byte	Bundle type = 20
4 bytes	Long seconds
2 bytes	Sub-seconds in 10,000th of a second
2 bytes	LTA value (low word of LTA which is a long, hi word in D2)
2 bytes	Half period of peak amplitude
2 bytes	Samples after trigger of peak amplitude
1 byte	Channel# (3 bits) | trigger # (5 bits)
3 bytes	Peak amplitude

D2 (Late) Threshold Trigger Bundle

The D2 threshold trigger bundle reports the end of a threshold trigger event. It is sent at a programmable time after a trigger is finished. It reports the end time of the trigger, along with some statistics about the trigger. The D2 bundle contains the peak amplitude, the half period of the amplitude, and the samples after trigger of the peak amplitude for the entire trigger event.

1 byte	Bundle type = 21
4 bytes	Long seconds
2 bytes	Sub-seconds in 10,000th of a second
2 bytes	LTA value (hi word of LTA which is a long, low word in D1)
2 bytes	Half period of peak amplitude
2 bytes	Samples after trigger of peak amplitude
1 byte	Channel# (3 bits) | trigger # (5 bits)
3 bytes	Peak amplitude

D1 (Early) STA/LTA Trigger Bundle

The D1 STA/LTA trigger bundle reports the start of a STA/LTA trigger event. It is sent at a programmable time after the start of a trigger. It reports the start time of the trigger, along with some statistics about the trigger. The D1 trigger bundle is followed by a D2 trigger which reports the end of a trigger. The D1 bundle contains the peak amplitude, the half period of the amplitude, and the samples after trigger of the peak amplitude.

1 byte	Bundle type = 22
4 bytes	Long seconds
2 bytes	Sub-seconds in 10,000th of a second
2 bytes	LTA value (low word of LTA which is a long, hi word in D2)
2 bytes	Half period of peak amplitude
2 bytes	Samples after trigger of peak amplitude
1 byte	Channel# (3 bits) | trigger # (5 bits)
3 bytes	Peak amplitude

D2 (Late) STA/LTA Trigger Bundle

The D2 STA/LTA trigger bundle reports the end of a STA/LTA trigger event. It is sent at a programmable time after a trigger is finished. It reports the end time of the trigger, along with some statistics about the trigger. The D2 bundle contains the peak amplitude, the half period of the amplitude, and the samples after trigger of the peak amplitude for the entire trigger event.

1 byte	Bundle type = 23
4 bytes	Long seconds
2 bytes	Sub-seconds in 10,000th of a second

2 bytes	LTA value (hi word of LTA which is a long, low word in D1)
2 bytes	Half period of peak amplitude
2 bytes	Samples after trigger of peak amplitude
1 byte	Channel# (3 bits) | trigger # (5 bits)
3 bytes	Peak amplitude

Event Bundle

1 byte	Bundle type = 24
4 bytes	Long Seconds
4 bytes	End Time in Long seconds
1 byte	Cause (1=external, 2=internal, 4=manual (calibration))
1 byte	Trigger Flags (1 bit per trigger, LSB = trigger 0)
6 byte	spare

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Appendix C - Instrument Log Messages

The Callisto instrument log provides a record of the normal ongoing operation of the instrument, as well as specific incidents which may affect data quality or timing. The Callisto generates 5 different categories of message:

Information	Document the normal operation of the Callisto.
Warnings	Minor incidents which may slightly affect data quality or timing.
Errors	Incidents which may result in significant loss of data.
Fatal Errors	Serious malfunctions of the Callisto.
Debug Info	Verbose trace messages.

This is a complete list of the messages generated by the Callisto digitiser. Some of the messages in this list are relevant only to an Callisto digitiser running in Orion mode. All the messages that reference the "AUX" should never occur while running in Callisto mode.

Informational Messages

Message 1039: DSP diag RC=r cnt=n.

The DSP diagnostics returned the value r on the nth time run. This is an informational message if r is 0 and a warning message otherwise.

Message 1041: TCP turn LEDs on.

The TCP turned on the LEDs after detecting a user button press.

Message 1042: TCP turn LEDs off.

The TCP turned off the LEDs after powering off the AUX or after 5 minutes of no user activity.

Message 1054: Recording Started.

Data recording has started as requested by the AUX.

Message 1055: Recording stopped.

Data recording has stopped as requested by the AUX.

Message 1056: Window started ssss-eeee.

The recording window from time ssss to time eeee has started.

Message 1057: Window ended ssss-eeee.

The recording window from time ssss to time eeee has ended.

Message 1060: Pll fine locked.

The TCP is phase locked. It is using the average of several seconds of GPS messages. The absolute time error is less than 10 microseconds.

Message 1061: Pll coarse locking.

The TCP is phase locking, skewing the time to the correct.

Message 1068: GPS lost navigation.

The GPS engine is not able to generate a navigation solution using the satellites in view.

Message 1069: GPS gain navigation.

The GPS engine is now able to generate a navigation solution using the satellites it is tracking.

Message 1070: User button pressed.

The TCP detected a user button press. The next message indicates the action taken which is turning on the LEDs or powering on the AUX.

Message 1072:	GPS power on.
	The TCP powered the GPS on so that it can correct its internal time.
Message 1073:	GPS power off.
	The TCP powered the GPS off after it had corrected its time to within 1 microsecond or after the maximum on time had elapsed.
Message 1075:	Disk heater on, dd seconds, tt C.
	The TCP powered the disk heater on to warm it up in preperation of starting the AUX processor. There are dd seconds of memory left and the current disk temperature is tt degrees Celsius.
Message 1076:	Disk heater off, dd seconds, tt C.
	The TCP powered the disk heater off after warming it up in preperation of starting the AUX processor. There are dd seconds of memory left and the current disk temperature is tt degrees Celcius.
Message 1079:	Disk temperature tt C.
	The temperature of the disk cartridge has passed one of the safety limits to tt degrees Celcius. If the disk is too hot or too cold the AUX processor may not work correctly. The disk may be heated to within temperature specifications or these limits may be disregarded.
Message 1080:	GPS engine state sssss.
	The GPS engine state has changed to sssss, which is one of the following:

Search	The GPS engine is searching for satellites.
Track	The GPS engine is tracking at least one satellite.
2D Nav	The GPS engine is navigating in 2D, constant altitude.
3D Nav	The GPS engine is navigating in 3D.

Warning Messages

Message 1024:	TCP version m.nn.
	The TCP startup message with version number m.nn.
Message 1025:	Clock zap sss, mmm
	The internal time of TCP has changed by sss seconds and mmm milliseconds. A discontinuity in data timing will result.
Message 1026:	TCP rx msg=mmm, st=xx.
	The TCP received the unexpected message mmm from the AUX while in state xx.
Message 1039:	DSP diag RC=r cnt=n.
	The DSP diagnostics returned the value r on the nth time run. This is an informational message if r is 0 and a warning message otherwise.
Message 1043:	GPS error, ssss.
	The TCP detected an error in the reception of messages from the GPS. The error ssss is one of the following:

Missing	No GPS was detected at startup.
Overrun	A byte was not received in time.
Frame	A byte was received with an invalid stop bit.
Parity	A byte was received with an invalid parity bit.
InvSync	A message header had an incorrect sync word.
HdrCs	A message header had an incorrect checksum.
DataSize	A data message had an invalid length.

	DataCs	A data message had an incorrect checksum.
	BufFull	The GPS message buffer was full.

Message 1044: GPS lost lock.

The GPS has lost lock; its time is unreliable. The TCP is no longer using the GPS for phase locking its time.

Message 1045: GPS gain lock.

The GPS has gained lock; its time is now valid. The TCP is once again using the GPS for phase locking its time.

Message 1046: GPS online.

Messages are now being received from the GPS.

Message 1047: GPS offline, rebooting.

The TCP has not received a valid message from the GPS in over 10 s. Power to the GPS is turned off immediately and back on in 10 s.

Message 1049: TCP rx err len=nnn, xxxx

The TCP received an invalid message from the aux of length nnn. The status word from the serial port was xxxx.

Message 1050: Inv msg len exp nnn got mmm.

The TCP received an invalid message length from the aux. The message said it was nnn bytes; instead it received mmm bytes.

Message 1052: Config saved ok.

The configuration was saved successfully. The TCP is now rebooting to use the new configuration.

Message 1062: Battery voltage, nn.nn.

The input voltage has changed over a battery voltage threshold value. The current voltage reading is nn.nn volts.

Message 1066: Rx invalid config

The TCP received an invalid configuration from the AUX. The TCP is ignoring it and continuing to run with its current configuration.

Message 1071: PLL did not fine lock.

The GPS was on for its maximum allowed duration before it could correct its time error to within 1 microsecond. The GPS is being turned off anyway.

Message 1074 Using xxxx power source.

The Orion swiched the source of its input voltage. The Orion will use the mains/charger power supply if present, otherwise it will use the external battery if it has not been discharged, otherwise it will use the internal batteries.

Message 1077 Disk removed.

The Orion has detected that the disk cartridge has been removed. The AUX processor will not be booted until after it has been inserted. If not inserted before running out of memory, data will be lost.

Message 1078 Disk inserted.

The Orion has detected that the disk cartridge has been inserted.

Message 1081: GPS time error sss, mmm.

The GPS is reporting the digitiser time is incorrect by sss seconds and mmm milliseconds. This error must remain stable for some time before the digitiser will accept it as correct. If the time error is 0, this indicates that the GPS is no longer indicating that the digitiser time is incorrect.

Message 1082: digitiser time valid.

The digitiser time is now accepted as correct and any the GPS must indicate the same error for a prolonged period for it to be accepted. Any large errors in with respect to GPS time are corrected by resetting the GPS engine.

Message 1083: digitiser time invalid.

The GPS engine has repeatedly indicated that the digitiser time is wrong so the digitiser will believe it and proceed as on startup.

Message 1085: Charger mode mmmm.

The internal disk charger is now on either a slow charge or off, indicated by mmmm.

Error Messages

Message 1034: DSP send cmd not ready.

The TCP tried to send a command to the DSP but it was not ready to receive one. The TCP will restart the DSP to ensure proper acquisition.

Message 1035: DSP send cmd failed.

The TCP sent a command to the DSP which it did not acknowledge as completed. The TCP will restart the DSP to ensure proper acquisition.

Message 1036: DSP send word not ready.

The TCP tried to send a word to the DSP but it was not ready to receive one. The TCP will restart the DSP to ensure proper acquisition.

Message 1037: DSP send word failed.

The TCP sent a word to the DSP which it did not acknowledge as received. The TCP will restart the DSP to ensure proper acquisition.

Message 1038: DSP read word not ready.

The TCP tried to read a word from the DSP but it was not ready to send one. The TCP will restart the DSP to ensure proper acquisition.

Message 1040: DSP startup failure.

The TCP failed to download the runtime code to the DSP.

Message 1053: Config failed to save.

The configuration failed to save. The TCP is continuing to run with its current configuration.

Message 1065: Mem bank invalid m of n

A memory check detected an error in memory bank m. The memory was configured to use n memory banks.

Message 1067: DSP invalid bundle xxxx.

The TCP received an invalid bundle from the DSP. The TCP is ignoring this bundle and is allowing the DSP to continue to digitise.

Fatal Error Messages

Message 1029: TCP: AUX time out.

The AUX is not communicating with the TCP. This results in the TCP cycling power to the AUX. If the communications problem repeats, the TCP will also reboot itself.

Message 1048: DSP time out, restarting

The DSP has not sent a valid message to the TCP in over 2 s. The DSP will be restarted.

Message 1051: Mem corrupt in ffff.

A memory buffer corruption was detected in function ffff. The TCP is rebooting.

Message 1059: Mem pointer invalid, xxxxxx.

The TCP detected the invalid pointer xxxxxx in the memory buffer.

Message 1084: Main loop stopped, rebooting.

The TCP detected that the main processing loop is no longer running. It is rebooting to recover.

The TCP may also report any message as a Fatal Message if on startup it finds an invalid memory buffer but a valid message. This message is sent as a Fatal Message to possibly help explain why it rebooted.

Verbose Trace (Debug) Messages

Message 1058: TCP got AUX msg xxx.

The TCP received the message xxx from the AUX.

Message 1063: Event started n trigs, m.

The event detector has declared the start of an event with n triggers; m is a bitmask indicating which triggers were on at the time.

Message 1064: Event ended n trigs, m.

The event detector has declared the end of an event with n triggers; m is a bitmask indicating which triggers were on at the time.

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Appendix D - Filter Response Plots, Poles & Zeroes

Response

Analog signals connected to the Callisto are low pass filtered using a three stage anti-alias filter before being sampled at 240 kHz. This data is later low pass filtered and decimated using a 3 to 5 stage FIR filter to give the output sample rate. Depending on the requested sample rate different filters are used and different number of filter stages are required. The output bandwidth will always be 0.4 x F sample out.

The low frequency response is also configurable using the DC removal IIR filter. With no filter the response is to DC. With the DC removal filter enabled it can be set to a number of predetermined frequencies depending on the customers' application.

System Filter Values

Transfer Functions

The transfer functions of all the components in the Callisto are as follows:

Analog Low Pass Anti-alias Filter

5th order Bessel Low-pass

$$F(s) = \frac{\omega_1{}^2\omega_2{}^2\omega_3}{(s^2 + \frac{s\omega_1}{Q_1} + \omega_1{}^2)(s^2 + \frac{s\omega_2}{Q_2} + \omega_2{}^2)(s + \omega_3)}$$

Note: 1. *Damping and Q are related by the expression D = 1/2Q*

2. *The complex frequency response is obtained by substituting $s=-j\omega$*

Digital FIR Low-pass

$$y(n) = \sum_{i=0}^{N-1} c(i) * x(n-i)$$

Optional Digital IIR High-pass.

$$y(n) = K \times [x(n) - x(n-1)] + F_1 \times y(n-1)$$

Digital Response (Time Domain Difference Equations)

- x(n) is current sample
- x(n-1) is previous sample, etc.
- y(n) is the output sample
- y(n-1) is the previous output sample
- c(i) is a FIR coefficient
- N is the number of coefficients
- K is the filter gain (see coefficients for calculation of value)
- F_1 is the filter coefficient (see coefficients for calculation of value)

Coefficients

The values for all the coefficients for these transfer functions and for the different sample rates are:

5th Order Bessel Analog Low-pass Filter

f_{3db} = 1500Hz

ω_1 = 14713
ω_2 = 16594
ω_3 = 14202
Q_1 = 0.916478
Q_2 = 0.563536

```
Zeros          None

Poles         -2077.65          1080.15
              -2077.65         -1080.15
              -1440.9           2213.4
              -1440.9          -2213.4
              -2260.35             0.0
```

Digital FIR Filters

The individual digital filter stages and associated decimation for each output sample rate is indicated below:

Sample Rate		Stage 1	2	3	4	5
10	Coefficient set	1	2	9	8	10
	# of Coefficients	34	30	256	110	256
	Decimation	5	3	4	10	5
20	Coefficient set	1	2	9	5	10
	# of Coefficients	34	30	256	56	256
	Decimation	5	3	4	5	5
40	Coefficient set	1	2	3	7	10
	# of Coefficients	34	30	118	36	256
	Decimation	5	3	2	5	5
50	Coefficient set	1	2	3	8	3
	# of Coefficients	34	30	118	110	118
	Decimation	5	3	2	10	2
80	Coefficient set	1	2	7	10	
	# of Coefficients	34	30	36	256	
	Decimation	5	3	5	5	
100	Coefficient set	1	2	3	5	3
	# of Coefficients	34	30	118	56	118
	Decimation	5	3	2	5	2
120	Coefficient set	1	1	5	3	
	# of Coefficients	34	34	56	118	
	Decimation	5	5	5	2	
125	Coefficient set	1	2	9	3	3
	# of Coefficients	34	30	256	118	118
	Decimation	5	3	4	2	2
200	Coefficient set	1	2	3	10	
	# of Coefficients	34	30	118	256	
	Decimation	5	3	2	5	
250	Coefficient set	1	2	3	9	
	# of Coefficients	34	30	118	256	
	Decimation	5	3	2	4	
500	Coefficient set	1	2	3	3	
	# of Coefficients	34	30	118	118	
	Decimation	5	3	2	2	
1000	Coefficient set	1	2	3		
	# of Coefficients	34	30	118		
	Decimation	5	3	2		

Note: ***The following sets of filter coefficients are symmetric, so only the first half of each coefficient set is unique.***

FIR 1 Filter

Coefficients:

.37887750E-04	.19972690E-03	.59127680E-03	.11983370E-02
.16771960E-02	.12344440E-02	-.11587740E-02	-.60717290E-02
-.12610230E-01	-.17666850E-01	-.16153700E-01	-.26318100E-02
.26016630E-01	.68053870E-01	.11598610E+00	.15823440E+00
.18304990E+00			

FIR 2 Filter

Coefficients:

.65879140E-04	.18999690E-03	-.48271860E-04	-.12167770E-02
-.24576070E-02	-.56870410E-03	.64952830E-02	.12949710E-01
.54490100E-02	-.21592960E-01	-.46964620E-01	-.27110750E-01
.65665070E-01	.20294310E+00	.30618330E+00	

FIR 3 Filter

Coefficients:

-.10469050E-04	-.23775850E-04	-.57189790E-05	.34235910E-04
.30510890E-04	-.43931380E-04	-.74450120E-04	.33569670E-04
.13626920E-03	.12775610E-04	-.20250920E-03	-.11221470E-03
.24881280E-03	.27300920E-03	-.23787890E-03	-.48829860E-03
.12572530E-03	.72734340E-03	.12936810E-03	-.93176250E-03
-.55240180E-03	.10165270E-02	.11356850E-02	-.87963280E-03
-.18237780E-02	.42009940E-03	.25042740E-02	.43635570E-03
-.30083210E-02	-.17077060E-02	.31243130E-02	.33271760E-02
-.26257430E-02	-.51224640E-02	.13114520E-02	.68085340E-02
.94634530E-03	-.79983710E-02	-.41534900E-02	.82323910E-02
.81525810E-02	-.70231140E-02	-.12595930E-01	.39059990E-02
.16935290E-01	.15189370E-02	-.20422150E-01	-.95799080E-02
.22094260E-01	.20608240E-01	-.20677420E-01	-.35219510E-01
.14170540E-01	.55255850E-01	.19045860E-02	-.87902020E-01
-.45041460E-01	.18229700E+00	.41058640E+00	

FIR 5 Filter

Coefficients:

.12782890E-04	.48643590E-04	.11441210E-03	.19101250E-03
.21918730E-03	.10430840E-03	-.24262950E-03	-.82881090E-03
-.14973390E-02	-.18942790E-02	-.15440160E-02	-.57334200E-04
.25742180E-02	.57240760E-02	.80869100E-02	.79813300E-02
.40091240E-02	-.41013180E-02	-.14800320E-01	-.24551390E-01
-.28451320E-01	-.21612060E-01	-.93961880E-03	.33307630E-01
.76832370E-01	.12189460E+00	.15915570E+00	.18025140E+00

FIR 7 Filter

Coefficients:

.17959570E+00	.15658660E+00	.11696820E+00	.71106050E-01
.29584940E-01	-.19804620E-03	-.15757160E-01	-.19135740E-01
-.14987090E-01	-.82432300E-02	-.24120900E-02	.10071550E-02
.21350310E-02	.18729370E-02	.11472870E-02	.52109530E-03
.16726350E-03	.30742490E-04		

FIR 8 Filter

Coefficients:

.53052610E-05	.10953120E-04	.20675100E-04	.34052430E-04
.50472810E-04	.68211750E-04	.84200660E-04	.93979800E-04
.91897430E-04	.71636490E-04	.27084270E-04	-.46485310E-04

-.15100320E-03	-.28415160E-03	-.43808070E-03	-.59857000E-03
-.74491660E-03	-.85078410E-03	-.88618130E-03	-.82060140E-03
-.62718340E-03	-.28758020E-03	.20297010E-03	.83102670E-03
.15615300E-02	.23363420E-02	.30754000E-02	.36809580E-02
.40450460E-02	.40599480E-02	.36310380E-02	.26909270E-02
.12135200E-02	-.77365120E-03	-.31805090E-02	-.58504900E-02
-.85628220E-02	-.11041720E-01	-.12972550E-01	-.14024250E-01
-.13876500E-01	-.12249520E-01	-.89338860E-02	-.38172700E-02
.30945470E-02	.11665130E-01	.21625100E-01	.32581180E-01
.44036450E-01	.55420730E-01	.66128860E-01	.75563820E-01
.83180910E-01	.88529390E-01	.91287400E-01	

FIR 9 Filter

Coefficients:

-.63165740E-06	-.62659390E-06	.12341120E-07	.19443620E-05
.52688010E-05	.92897450E-05	.12445590E-04	.12748020E-04
.87046720E-05	.38979440E-06	-.99129780E-05	-.18047240E-04
-.19491400E-04	-.11616430E-04	.43002920E-05	.22504380E-04
.34411790E-04	.32263790E-04	.13405330E-04	-.16936110E-04
-.46279200E-04	-.59500730E-04	-.46016810E-04	-.63744060E-05
.45373710E-04	.85775730E-04	.91924170E-04	.53358520E-04
-.19861020E-04	-.97951750E-04	-.14255550E-03	-.12460020E-03
-.40992450E-04	.78728180E-04	.18117280E-03	.21176560E-03
.14223950E-03	-.10259850E-04	-.18378220E-03	-.29509180E-03
-.27808870E-03	-.12008070E-03	.12294540E-03	.34332070E-03
.42759340E-03	.31267720E-03	.25394960E-04	-.31720130E-03
-.55291660E-03	-.54898170E-03	-.27285180E-03	.17702630E-03
.60176520E-03	.78727530E-03	.60901970E-03	.10637440E-03
-.51488380E-03	-.96290410E-03	-.99370050E-03	-.53871000E-03
.23864060E-03	.99472770E-03	.13537440E-02	.10901390E-02
.25880070E-03	-.79823550E-03	-.15868160E-02	-.16872140E-02
-.97042530E-03	.30438790E-03	.15734170E-02	.22119950E-02
.18360320E-02	.51828330E-03	-.11970330E-02	-.25107530E-02
-.27346700E-02	-.16423060E-02	.37022530E-03	.24128750E-02
.34870880E-02	.29651350E-02	.93716220E-03	-.17585740E-02
-.38698640E-02	-.43023520E-02	-.26724400E-02	.43201660E-03
.36408040E-02	.53930380E-02	.46822380E-02	.16054280E-02
-.25721630E-02	-.59171980E-02	-.67056870E-02	-.42873790E-02
.48599150E-03	.55216500E-02	.83789800E-02	.74249080E-02
.27166160E-02	-.38455880E-02	-.92457940E-02	-.10700780E-01
-.70426100E-02	.52905760E-03	.87573810E-02	.13670180E-01
.12425050E-01	.48309240E-02	-.62198690E-02	-.15746090E-01
-.18802240E-01	-.12872000E-01	.55895630E-03	.16093270E-01
.26359450E-01	.25168140E-01	.10638890E-01	-.13085150E-01
-.36463380E-01	-.47557470E-01	-.36446600E-01	.57424880E-03
.58698170E-01	.12526940E+00	.18337210E+00	.21718010E+00

FIR 10 Filter

Coefficients:

-.58341210E-05	-.97909810E-05	-.14950560E-04	-.18411240E-04
-.17651870E-04	-.10377960E-04	.45130490E-05	.26043100E-04
.50695700E-04	.72713060E-04	.85281480E-04	.82442490E-04
.61274060E-04	.23651500E-04	-.23135700E-04	-.67405480E-04
-.95796680E-04	-.97157430E-04	-.66560650E-04	-.81320900E-05
.64496310E-04	.13074540E-03	.16840730E-03	.16048740E-03
.10159850E-03	.17182670E-05	-.11440040E-03	-.21272770E-03
-.25939080E-03	-.23160750E-03	-.12678270E-03	.33505350E-04

.20673650E-03	.33995610E-03	.38523620E-03	.31579180E-03
.13760430E-03	-.10787590E-03	-.35208950E-03	-.51762300E-03
-.54179750E-03	-.39867720E-03	-.11216670E-03	.24520840E-03
.56929360E-03	.75359680E-03	.72298160E-03	.46145650E-03
.24388810E-04	-.47066000E-03	-.87408170E-03	-.10481340E-02
-.91212410E-03	-.47452460E-03	.15975800E-03	.81206220E-03
.12786600E-02	.13927240E-02	.10812130E-02	.39795400E-03
-.48014670E-03	-.12964150E-02	-.17875410E-02	-.17662870E-02
-.11884130E-02	-.18094000E-03	.98108760E-03	.19470490E-02
.23942110E-02	.21323790E-02	.11766510E-02	-.23782690E-03
-.17093030E-02	-.27805280E-02	-.30777790E-02	-.24364060E-02
-.97198160E-03	.93041830E-03	.27128880E-02	.38046110E-02
.38003170E-02	.26026980E-02	.48070990E-03	-.19821030E-02
-.40427900E-02	-.50181070E-02	-.45043970E-02	-.25293030E-02
.41830170E-03	.35003010E-02	.57607290E-02	.64147440E-02
.51099710E-02	.20761460E-02	-.18935850E-02	-.56389330E-02
-.79612020E-02	-.79942670E-02	-.55064680E-02	-.10335250E-02
.42143110E-02	.86632170E-02	.10829570E-01	.97904870E-02
.55284280E-02	-.96807720E-03	-.79023240E-02	-.13135920E-01
-.14809990E-01	-.11950010E-01	-.48711300E-02	.47579920E-02
.14249090E-01	.20571980E-01	.21218270E-01	.15025070E-01
.27228040E-02	-.12974050E-01	-.27805090E-01	-.36865790E-01
-.35778870E-01	-.21855210E-01	.50520950E-02	.42237240E-01
.84486840E-01	.12503380E+00	.15691950E+00	.17445760E+00

DC Removal - IIR Filter

The IIR filter is implemented as a first order IIR filter using the following coefficients calculated at runtime where SR is the output sample rate and f is the filter's 3db corner frequency.

$$F_1 = \frac{1 - \tan(\pi \times f / SR)}{1 + \tan(\pi \times f / SR)}$$

$$K = \frac{1}{1 + \tan(\pi \times f / SR)}$$

The time constant (TC) of the filter can be calculated as follows:

$$TC = \frac{1}{2\pi \times f}$$

Appendix E - ViewDat

Description

VIEWDAT is a simple bench test program for the HRD, Callisto, Orion, and Lynx digitisers. It receives the digitiser output data over an RS-232 serial port, provides a real-time text display of seismic data, GPS status and instrument state-of-health, and a real-time graphical display of seismic data.

Version

1.04

Synopsis

Viewdat [Port] [Baud] [-bN] [-x]

Usage and Options

VIEWDAT may be run under DOS or in a DOS window under OS/2 using the command-line syntax given above. If you wish to use the graphical display mode of VIEWDAT you must run the program as a DOS full-screen session. The data port of the digitiser should be connected to one of the serial ports (com1 or com2). To avoid missing any data, the program should be started before the digitiser is powered up. However, the program may be started at any time; it will start displaying and recording data after receiving the next data sync (at the start of the next data packet).

VIEWDAT recognizes the following command-line options:

Com Port	Specify com1 or com2 to specify to which serial port the digitiser is connected. Default is com2.
Baud Rate	Specify the baud rate for communication with the digitiser. Accepted values are 12(00), 24, 48, 96, 192 and 384. The default is 38400. This MUST be set to the same value as that being used for transmission by the digitiser.
Data Bundles per Packet (-bN)	Specify the number of data bundles per compressed data packet. This must be an odd number in the range of 1 to 59. This MUST be set to the same value as that being used for transmission by the digitiser. The default is 59.
Transmission Mode (-x)	Data transmission may be optimized for wire (default) or radio mode (-x). In radio mode the data is scrambled and the data is augmented by filler in order to maintain the full transmission baud rate. In wire mode the data is unscrambled. This parameter MUST be set to the same value as that being used for transmission by the digitiser.
Help (-h)	Type VIEWDAT -h to display a usage summary.

Commands

VIEWDAT recognizes the following keyboard commands:

V	Toggles between the two display modes (text and graphics).
P	Pauses the display (stops displaying incoming data).
R	Resumes updating the display.
ESC	Exit the program.

In graphics mode VIEWDAT also provides the following commands:

D	Toggle the DC removal option. DC removal Off - the raw data is displayed

	DC removal On - the packet mean is subtracted from the data before plotting.
+/-	Changes the vertical scale factor for the trace plots.

Text Mode Display

The VIEWDAT text display is divided into 4 parts:

1. The top section of the screen shows current signal statistics from each data channel,
2. the next section shows the current GPS status,
3. the third section shows the most recent state-of-health readings and
4. the bottom section logs incoming messages and communication diagnostics.

Data Display

The VIEWDAT display is packet-based. The digitiser outputs data in packets which contain a timestamp, followed by 4N to 16N data samples in a compressed format, where N is the number of data bundles per packet (see above). For example, if N = 59, each packet contains 236 to 944 samples, which corresponds to 1.2 to 4.7 seconds of data at 200 sps. VIEWDAT computes signal statistics based on the data contained within a single packet and displays the following information:

Channel Number	The digitiser channel number (0 to 5).
Sequence Number	The sequence number of this packet. Packets are numbered sequentially for each channel. Sequence number is reset to zero when the digitiser is restarted. Only the last 4 digits of the sequence number are shown.
Time	The time of the first sample in the packet in the format MM:SS.FRAC.
Number of Samples	The number of samples in the packet. This is also the number of samples over which the displayed values are calculated.
Maximum	The maximum sample value in the packet.
Minimum	The minimum sample value in the packet.
Mean	The arithmetic mean of all sample values in the packet.
RMS	The root mean square (standard deviation) of the sample values in the packet.
Trend	The rate of change of the mean value per second. This is determined through a linear regression of the sample value vs. time.
ZC - zero crossings	The number of zero crossings in the packet.
Frequency	Estimated signal frequency is based on the number of zero crossings. This is meaningful only for sinusoidal input signals.

GPS Display

The GPS status display shows the GPS status and activity as determined from the most recent message received.

Status

Unlocked	The GPS is off or unlocked (not providing accurate time information).
Coarse Lock	The GPS is locked and the instrument time is in fast-lock mode.
Fine Lock	The GPS is locked and the instrument time is in fine-lock mode.

Mode

NAV 3D	The GPS has a full 3D time and position solution.
NAV 2D	The GPS has a 2D time and position solution.
ACQ	The GPS is searching for satellites and does not have accurate time and position.

ACQ COLD: The GPS is searching for satellites in cold start mode.

Num Satellites

This shows the number of satellites used for the current GPS time and position solution.

Figure of Merit

An indicator of the horizontal position accuracy: 1 = best; 9 = unlocked.

Date, Time and Position

The middle column of the GPS display shows the time and position returned by the GPS clock. Note that the time may not be completely up to date since the GPS information messages may be buffered for some time before being transmitted to VIEWDAT.

Channel Status

The right hand column of the GPS display shows the current activity of the 5 GPS channels. Each channel may be searching for a satellite, tracking a satellite, or idle. The display also shows the PRN number of the satellite being searched for or tracked and the signal to noise ratio of the incoming GPS signal. The signal to noise ratio must usually be over 30 in order to track a satellite; over 40 is better. Poor signal to noise ratios often indicate that the GPS antenna is obstructed.

State of Health Display

SSOH and FSOH These fields show the most recent readings from the slow and fast state-of-health channels respectively. Readings are shown as counts from a 10-bit A/D and are always between 0 and 1023.

Comm Rx This shows the number of bytes received from the digitiser by VIEWDAT.

Comm Ovr This shows the number of bytes lost due to com port overruns (should be zero).

Bytes Lost This shows the number of bytes lost due to sync or CRC errors. This should be zero for a good communication link. Any change in this value indicates that one or more messages has been lost, usually due to noise or fading on the serial data link.

Graphical Display

In graphical display mode VIEWDAT plots the contents of each data packet as it is received. The vertical scale may be adjusted by pressing + or -; the current scale factor is shown in the status line at the top of the screen. The horizontal scale is adjusted automatically to the number of samples in the data packet. To the left of each trace VIEWDAT displays the maximum, minimum, mean and RMS for the current packet. The sequence number and number of samples for the displayed packet is shown in the upper left corner of the trace box; the time of the first sample is shown in the lower left corner. Definitions of all displayed fields are given above.

Note that VIEWDAT plots packets; since packets on different channels may be generated at different times the traces shown are not, in general, aligned with each other along the time axis.

Environment

Viewdat will run under DOS (DOS 6.2 or higher), in DOS full-screen mode under OS/2, Windows95 or WindowsNT.

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Appendix F - Upgrading digitiser firmware using ZOC

The following is also applicable for upgrading the digitiser firmware in an digitiser.

Remove the disk cartridge from the digitiser prior to upgrading its firmware.

Install ZOC on PC

1. Insert the appropriate ZOC installation diskette (**ZOC for OS/2** or **ZOC for Windows**) into the floppy drive of the PC.
2. Open a command prompt window.
3. Change the working directory to the floppy drive by typing **a:** at the command prompt and pressing **Enter**. (assuming A: is the floppy drive)
4. At the command prompt type **install** (if OS/2) or **setup** (if Windows) and press **Enter**.
5. If the "Destination path" box is empty, type **c:\zoc** (or a suitable alternative) in the box.
6. Press the ZOC **Install** button to start the installation.
7. When notified "All files processed - installation complete", press the **OK** button.
8. When asked "Do you want to read ZOC's DOC files now?", press the **No** button.
9. To close the command prompt window, type **exit** and press **Enter**.
10. Remove the ZOC installation diskette from the floppy drive of the PC and save it in a safe place.

Configure ZOC

1. Start **ZOC** by double clicking on the icon created on the OS/2 desktop or from the entry in the Windows Start button menu.
2. If notified "No CTS signal from COM1", press the **Abort** button.
3. If a "License Agreement" window is displayed, press the **Agree** button.
4. If notified "New month -- do you want a phone cost report?", press the **No** button.
5. If a "Getting Started" help window is displayed, double click on the button at the top left of the help window to close it.
6. Select the **Options** item from the menu bar.
7. Select the **Settings...** item from the Options drop down menu.
8. Check that the I/O Device is set to **Serial/Modem**.
9. Check that the **Com-Port** is set to the PC com port to which the digitiser configuration port is connected.
10. Check that the Com-Port baud is set to **9600**. (The Orion’s are shipped with the configuration port set to 9600 baud. However, it may have been changed since then.)
11. Check that the Com-Port is set to **8N1**. (8 bits data, no parity, 1 stop bit is the only option for the configuration port.)
12. Deselect the Com-Port **Valid CD signal** handshaking option. The other handshaking options should already be deselected. (The digitiser configuration port does not have any of the modem control signals used for handshaking.)
13. Press the **Transfer** tab at the right (if OS/2) or at the top (if Windows) of the "Options Settings".
14. Select the **Compuserve-B+** Protocol.
15. Select both the **Disable ENQ** and the **Disable ENQ message** Compuserve-B+ options. This will prevent ZOC from hanging on binary data.

16. Select the **Zmodem** Protocol.
17. If OS/2, press the right arrow button at the bottom right to go to **[Page 2 of 2]** of the transfer options, otherwise if Windows, press the **Transfer-2** tab.
18. Change the ASCII-/Clipboard Sending option **Char delay** to **0**. This will make ASCII uploads MUCH faster.
19. Press the **Safety** tab.
20. Deselect the **... ending program** Confirm ... option.
21. Deselect the **Warning for high speed without RTS/CTS** Miscellaneous option.
22. If a "Getting Started" help window was displayed on startup press the Window tab and deselect the **Initial help window** Screen Elements option.
23. Press the **Save** button at the top of the "Options Settings" window.
24. Close **ZOC** by double clicking on the button at the top left of the ZOC window.

Copy digitiser firmware to PC's hard drive

Note: the new digitiser firmware must be copied to the PC's hard drive since uploading firmware from a floppy drive is not reliable. (A network drive is possible but a local drive is preferable.)

1. Insert the digitiser Release diskette into the floppy drive of the PC.
2. The digitiser Release diskette contains 7 files.
3. The file DSPDIAGS.HEX contains a diagnostics program which the DSP runs on startup to do basic hardware checks.
4. The file DSPLOAD.HEX contains a utility program used to transfer the main DSP program into the DSP memory.
5. The file FIRS.HEX contains the FIR filter coefficients used by the DSP.
6. The file DSPxx.HEX contains the main DSP firmware (xx indicates the version number) for the digitiser.
7. The file TCPyyy.HEX contains the main TCP firmware (yyy indicates the version number) for the digitiser.
8. The file HRDzz.HEX contains the previous 5 files released in one file (zz indicates the release number) for uploading into HRDs.
9. The file HRDzz.BIN contains the binary image of the file HRDzz.HEX used for burning into flashes.
10. Open a command prompt window.
11. Change the working directory to **c:\zoc\upload** (assuming ZOC was installed in c:\zoc), at the command prompt type **cd \zoc\upload** and press **Enter**. This directory is chosen to make the ASCII uploads easier, however any directory may be chosen.
12. Copy the new digitiser firmware release from the floppy, at the command prompt type **copy a:\digitiser*.hex** and press **Enter**.
13. Close the command prompt window.
14. Remove the digitiser Release diskette from the floppy drive of the PC and save it in a safe place.

Accessing the digitiser setup menu

1. Start **ZOC**.
2. Power on the digitiser.

3. The digitiser will start up with lines similar to the following:
   TCP Version 5.12, released Mar 17 1997 16:36:40
   Press 'M' key within 5 seconds or during memory test
4. Immediately press the **M** key to access the digitiser menu. (There will be at least a 5 second window to press the M key, longer if there is a lot of memory to test.)
5. After a power on the memory test will end with the following lines. (the number of memory banks depends on the digitiser)
   Writing 5555 to 8 banks........
   Checking for 5555, writing aaaa to 8 banks........
   Checking for aaaa, writing 0000 to 8 banks........
6. If the digitiser has proceeded past the memory test, the menu will still be displayed and the configuration may be changed however it is **UNSAFE** to do a firmware upload. The digitiser firmware may be severely corrupted (possibly unrecoverable).
7. If intending to upload new firmware, and the digitiser has proceeded past the memory test or unsure if it has, power it off and start again.

Upload new firmware

1. Access the digitiser setup menu as outlined above.
2. Double check that the digitiser did not proceed past the memory test.
3. Press the **U** key to select the "Upload new firmware" option. (On older firmware, press the **D** key to select the "Download New Firmware" option.)
4. The digitiser will respond with "Ready to Upload..."
5. Select the **Transfer** item from the menu bar.
6. Select the **ASCII-Send...** item from the Transfer drop down menu.
7. Use the **Select ASCII Upload File** dialog box to select the file containing the new digitiser firmware release. Change the Drive and Directory as necessary if the firmware was not copied to the c:\zoc\upload directory.
8. Press the **OK** button to start the upload.
9. Do not touch the digitiser or the PC while the upload is in progress, this will take almost 8 minutes.
10. When it has finished the digitiser will automatically program the new firmware and reboot.
11. The digitiser will start up with a line indicating the new version number and release date.

Uploading at faster than 9600 baud

Note: 9600 baud is the fastest baud rate that is reliable on all machines. However PCs with buffered com ports (have a 16550 compatible UART) or fast 486's and pentiums should upload reliably at 38400.

Uploading at 19200 reduces the upload time from 8 to 4 minutes, while uploading at 38400 reduces it to 2 minutes.

1. Access the digitiser setup menu as outlined above.
2. Press the **C** key to select the "Configuration menu" option.
3. Press the **H** key to select the "Edit hardware setup parameters" option. (On older firmware press the **G** key to select the "Edit data communications parameters" option.)
4. Press the B key to change the "Configuration baud rate" setting.

5. Type the desired new baud rate and press **Enter**.
6. Check that the baud rate has been changed.
7. Press the **Esc** key twice to return to the main digitiser setup menu.
8. Press the **P** key to select the "Program user settings" option.
9. Power off the digitiser.
10. Press the button labeled 9600-8N1 at the bottom left corner of ZOC.
11. Change the Com-Port baud to the new baud rate set in the digitiser.
12. Press the **Save** button.

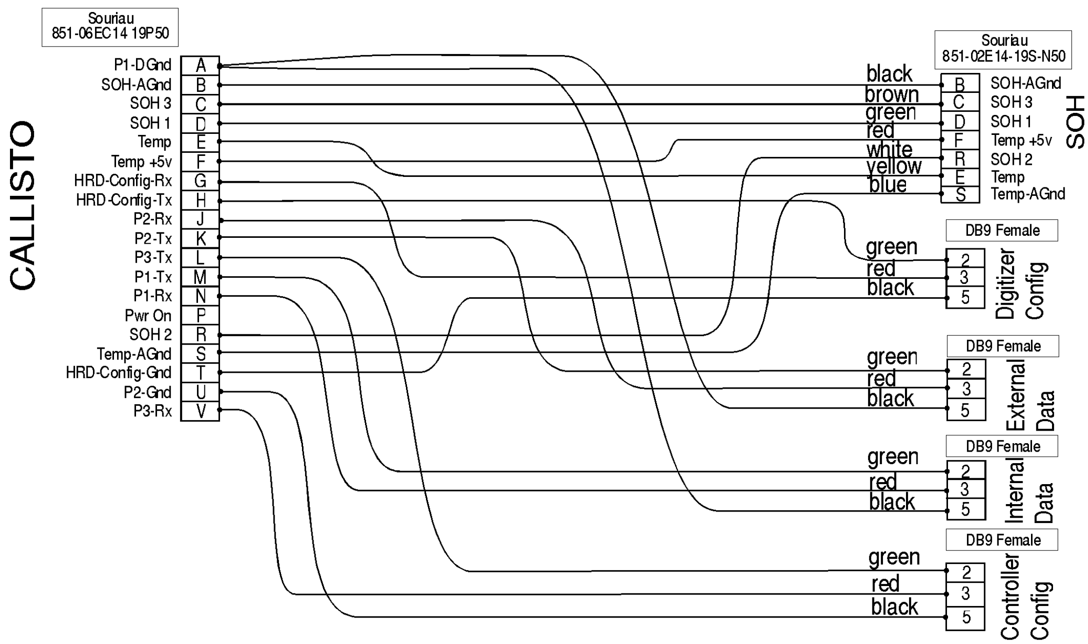
Creating a button for uploading firmware

Note: this feature is only available on ZOC for OS/2.

This feature is of most use when the file to upload is not in the c:\zoc\upload directory and requires a lot of drive and directory changing to find it using the **Select ASCII Upload File** dialog box.

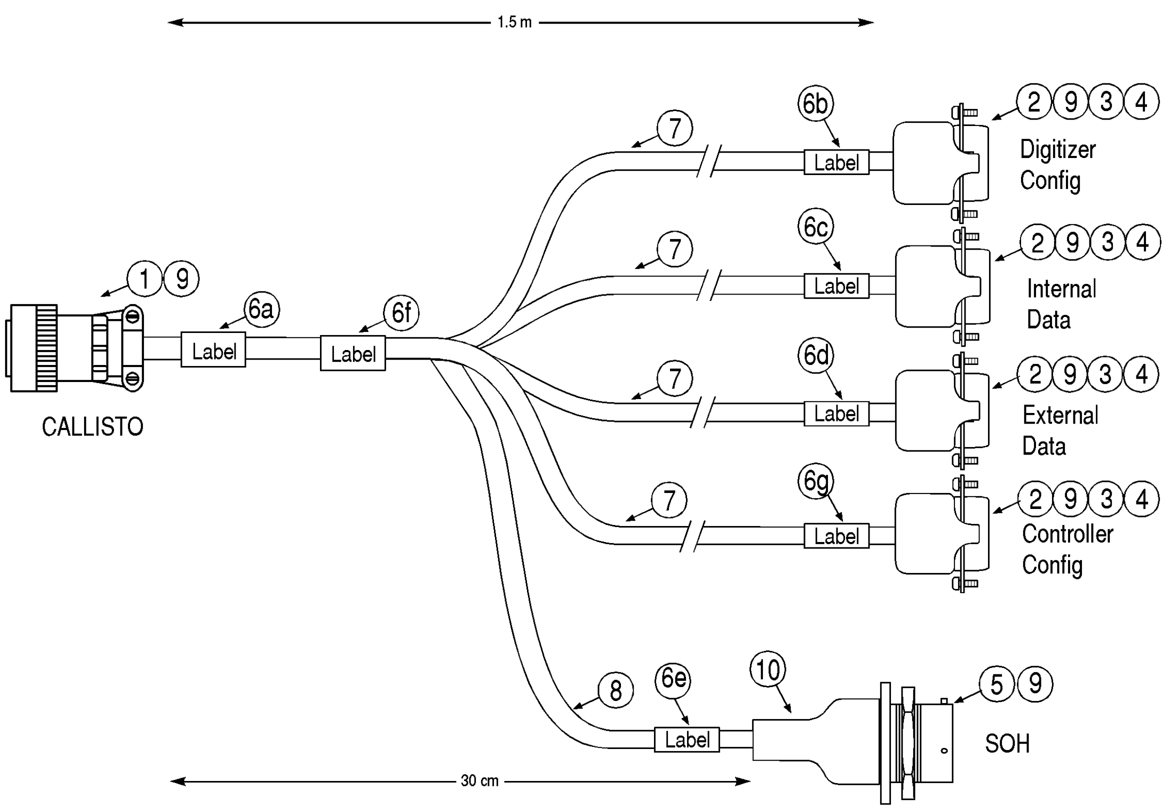
1. Start **ZOC**.
2. Open the **Options Settings** window.
3. Press the **Buttons** tab.
4. Find the first line with nothing under the "Value" heading.
5. Under the "Value" heading type **^XFER=type c:\zoc\upload\hrdzz.hex 1>&%ZOCHFC% -r**. The file indicated should contain the new digitiser firmware release.
6. Under the "Button Text" heading type **HRDzz** (replace zz with the appropriate release number).
7. Press the **Save** button.
8. A button should have been created with the label HRDzz at the top of the ZOC window.
9. Pressing this button is equivalent to selecting the same file using the **Select ASCII Upload File** dialog box (except no **Bytes sent** status).
10. With the digitiser **off**, test the button created by pressing it.
11. A window labeled "ZOC Shell Window" should pop up with the name of the file being uploaded.
12. Double click on the button at the top left of this window to close it. Otherwise it will automatically close several minutes later when the entire file has been uploaded.
13. Close **ZOC**.

Appendix G - External Cable Drawings



REVISION HISTORY		
Rev A	Nov 27/98	Initial
Rev B	Dec 18/98	J.S

Nanometrics	ASSEMBLY DRAWING for CABLE 12258 Page 1 of 2 Cable, test, for Callisto			
Dwg # 12259B	FileName 12259B.CDR	Originator M. Jevtovic	Approved By	Date Dec 18/98



NOTES:

1) Heat shrink tubing to be used on all soldered connector.

2) Heavy wall heat shrink tubing (10) to be used on connector (5).

REVISION HISTORY		
Rev A	Nov 27/98	Initial
Rev B	Dec 18/98	J.S.

Nanometrics	ASSEMBLY DRAWING for CABLE 12258 Page 1 of 2 Cable, test, for Callisto			
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Appendix H - Outline and Installation Drawing