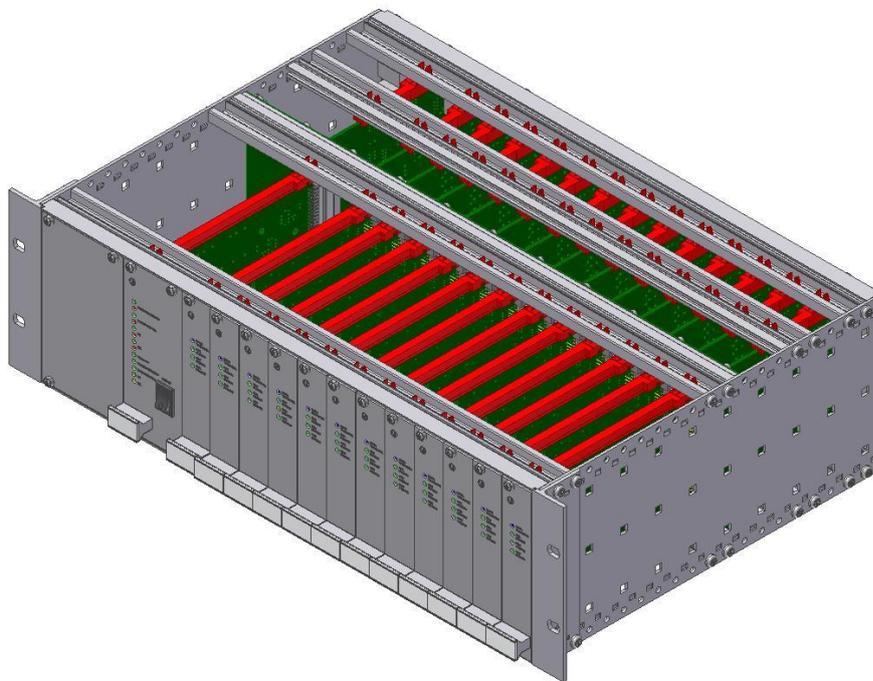




User Manual

CR-6 Central Recording System



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Warnings and Safety



STATIC ELECTRICITY

The Instrument contains CMOS devices and when serviced, care must be taken to prevent damage due to static electricity. This is very important to ensure long term reliability of the unit.



BATTERY LIFE

Although supplied through an AC/DC adapter from the mains, the instrument is optionally shipped with the batteries to provide the backup power supply. If the system is not in use, the batteries should be disconnected. If connected, the batteries are attached using the clamps; the red cable on "+", the black cable on "-" poles of the battery.

Note: The battery lifetime can drastically change depending on operating conditions. Strong discharge of the main battery must be avoided.



REPLACEMENT OF SLOT-IN-MODULES

The slot-in-modules are not hot swappable. When changing any slot-in-modules, the instrument must be switched off first to avoid any damage on the instrument.

GeoSIG Cybersecurity Recommendations

GeoSIG instruments, as described in their documentation, have built-in security and safety features against unauthorised access or use. However, ultimately it is the user's responsibility to ensure the safe and secure usage of our instruments based on their actual implementation. No factory delivered solution can fit each and every possible scenario. The user is advised herein that once you connect a device to a network, you are also connecting that network to that device. It is the responsibility of the user to take appropriate precautions so that all devices should be adequately hardened, such as with individual strong passwords, and should have their traffic monitored and managed via appropriate security features, such as firewalls. Also, non-critical devices should be segmented away from networks that contain sensitive information.

Compliance with a well-defined security procedure helps protect not only an individual device, but also other devices connected through the network. Such procedure would be intended to prevent exploitation of an individual device's resources by unauthorized individuals, including the use of such device to attack other systems on the network or the Internet.

The following recommendations can be considered in establishing such a security procedure:

1. Physical access restriction

All devices must be restricted from unauthorised physical access and a well-defined physical access procedure shall be utilised.

2. No Unattended Console Sessions

Except for the devices which are physically secured, no unattended console sessions shall be left running.

3. No Unattended Network Sessions

No unattended user interface sessions shall be left running towards any device accessed through its network interface.

4. Use of a Firewall

For a network that has any connection to the outside world, a hardware firewall must be running and configured to block all inbound traffic that is not explicitly required for the intended use of the network and the connected devices. The user can also consider limiting outbound traffic.



Any communication ports that are required for the operation must be protected.

5. No Unnecessary Services or Ports

If a service or port is not necessary for the intended purpose or operation of the device, that service must not be running and the port must be closed. (e.g. if seedlink server is running, but not used, turn it off)

6. Use of authentication

Network and console device access must require authentication by means of strong and individualised passwords per device (no passe-partout passwords).

Wireless access must require strong encryption to associate (such as WPA2), or some other strong mechanism to keep casual users near the access point from using it to get full access to the network. WEP or MAC address restrictions do not meet this requirement.

7. Password complexity and security

When passwords are used, they must meet the specifications similar to below:



All default passwords must be changed at time of initial access or latest at deployment into service.

Passwords MUST:

contain eight characters or more

contain characters from AT LEAST two of the following three character classes:

Alphabetic (e.g., a-z, A-Z)

Numeric (i.e. 0-9)

Punctuation and other characters (e.g., !@#\$%^&*()_+|~-=\`{}[]: "; '<>?, ./)

8. Privileged Accounts

Privileged and super-user accounts (Administrator, root, etc.) must not be used for non-administrator activities. A secure mechanism to escalate privileges with a standard account is acceptable to meet this requirement. Network services must run under accounts assigned the minimum necessary privileges.

9. No Unencrypted Authentication

All network-based authentication must be strongly encrypted. In particular, insecure services such as Telnet, FTP, SNMP, POP, and IMAP must not be used or must be replaced by their encrypted equivalents.

10. Software / Firmware updates

Networked devices must only run software/firmware that are updated according to supplier's guidelines. A periodical check of any available updates from the supplier must be sought.

Please contact GeoSIG Ltd if you require any further advice or clarification.

Symbols and Abbreviations

CR-6-BASE	Base Rack of CR-6 System
CR-6-EXT	Extension Rack of CR-6 System
CR-6-COMB	Base Communication Slot-In Module
CR-6-COME	Extension Communication Slot-In Module
CR-6-DM	Master Digitiser Slot-In Module
CR-6-DS	Slave Digitiser Slot-In Module
CR-6-OVPB	Base Over Voltage Protection Slot-In Module
CR-6-OVPE	Extension Over Voltage Protection Slot-In Module
CR-6-OVPS	Sensor Over Voltage Protection Slot-In Module
CR-6-WDB	Base Watchdog Slot-In Module
CR-6-WDE	Extension Watchdog Slot-In Module
RTC	Real Time Clock

1. Introduction



Dear Valued GeoSIG Customer, thank you for purchasing this product.

These Instruments have been optimised to meet the requirements of the majority of customers out of the box and may have even be delivered tailored to your needs. In any case, to be able to get the most out of our product, please carefully study this manual, its appendices and referenced manuals, as well as any other documents delivered with it.

This is a reliable and easy to use device, and at the same time a sophisticated product, which requires care, attention and know-how in configuring, installing, operating and maintenance.

The Central Recording System CR-6 (in further text CR-6 or instrument) is a 24 bit seismic system suitable for centralised data acquisition and recording. The CR-6 is designed for both, temporary and permanent setups such as bridges, tunnels, and tall buildings. It is easy to use and provides user with a possibility to easily reinstall the system and acquire the seismic data from numerous measurement points.

Several types of externally mounted sensors can be used with the instrument, like seismometers, geophones, accelerometers, anemometers or other sensors with single-ended or differential outputs.

The signals such as temperature are considered slow-changing and the chosen sampling rate might be the minimum one (typically a few samples per second suffice). The accelerometers, on the other side, generate the signals of a wider bandwidth and as such require higher sampling rate (typically 50 SPS or higher depending on the required bandwidth, i.e. type of the events observed at the specific site).

The CR-6 collects and records the data, which can later be downloaded and analysed on a remote PC running the dedicated software package GeoDAS. Optionally a screen and keyboard can be connected to the industrial computer of the CR-6 to configure the instrument and view the data on site.

Frequency response (bandwidth) depends on the chosen low-pass filter and the sampling rate. Typical attenuation at 99% of the Nyquist frequency is >120 dB.

During normal operation the instrument continuously amplifies, filters and converts sensor inputs to 24 bit digital form and passes these to the industrial computer. The recording parameters can be set by the computer. The recorded data can then be downloaded over the network and analysed with the GeoDAS software package.

Trigger algorithms include STA/LTA ratio triggering and level triggering. The STA/LTA ratio trigger computes the short term and long term signal averages.

This connection facilitates data acquisition and performs a complete sensors test as well via the menu driven software GeoDAS.

2. Incoming Inspection

All Instruments are carefully inspected both electrically and mechanically before they leave the factory. Please check if all received items correspond to the packing list and your order confirmation. In case of discrepancies please contact GeoSIG or your local representative immediately.

2.1. Damage during Shipment

If requested at the time of order, all instruments can be insured prior to the shipment. If you receive damaged equipment and shipping insurance was previously arranged you should:

- Report the damage to your shipper immediately
- Inform GeoSIG or your local representative immediately
- Keep all packaging and shipping documents



Insurance claims may be void if the above procedure is not followed.

2.2. Warranty

GeoSIG Ltd warrants hardware and software products against defects in materials, workmanship and design for the defined period in the relevant contract or offer, starting from date of shipment and 5 years parts and maintenance support commitment. If GeoSIG receives notice of such defects during the warranty period, GeoSIG shall at its option either repair (at factory) or replace free of charge hardware and software products that prove to be defective. If GeoSIG is unable, within a reasonable time to repair or replace any instrument to a condition as warranted, buyer shall be entitled to a refund of the purchase price upon return of the instrument to GeoSIG. 50 % of freight charges on shipments of warranty repairs or replacements will be borne by GeoSIG (normally one way freight).

2.2.1. Limitation of Warranty

The foregoing guarantee shall not apply to defects resulting from:

- Improper or inadequate maintenance by buyer
- Buyer supplied software or interfacing
- Unauthorised modification or misuse
- Operation and storage outside of the environmental specifications of the instrument
- Improper preparation and maintenance of site.

2.3. Storage (Instrument Shelf Life)

In case the instrument is stored, the batteries have to be maintained according to the storage duration.

Period of time	External power supply	Instrument is operating	Main battery	Real Time Clock backup battery
< 1 month	ON	YES	Connected	Connected
	ON	NO	Connected	Connected
	OFF	NO	Connected	Connected
1 – 3 months	ON	YES	Connected	Connected
	ON	NO	Connected	Connected
	OFF	NO	Disconnected	Connected
3 – 6 months	ON	YES	Connected	Connected
	ON	NO	Connected	Disconnected
	OFF	NO	Disconnected	Disconnected
More than 6 months	ON	YES	Connected	Connected
	ON	NO	Connected	Disconnected
	OFF	NO	Disconnected, must be recharged every 6 months for at least 24 hours.	Disconnected

See chapter 2.3.2 to see how to disconnect and connect the backup battery

2.3.1. Main battery

The instrument is normally connected to a 100 Ah battery, which is charged through a separate power supply module.

2.3.2. Backup battery

The Real Time Clock (RTC) of the CR-6 Recording System is located on the CR-6-DM Master Digitiser Slot-In Module. The autonomy of the RTC on its backup battery is 3 years typical at ambient temperature. To disconnect this backup battery, the jumper JMP_BBATT on the CR-6-DM Master Digitiser Slot-In Module has to be put in position 2-3.

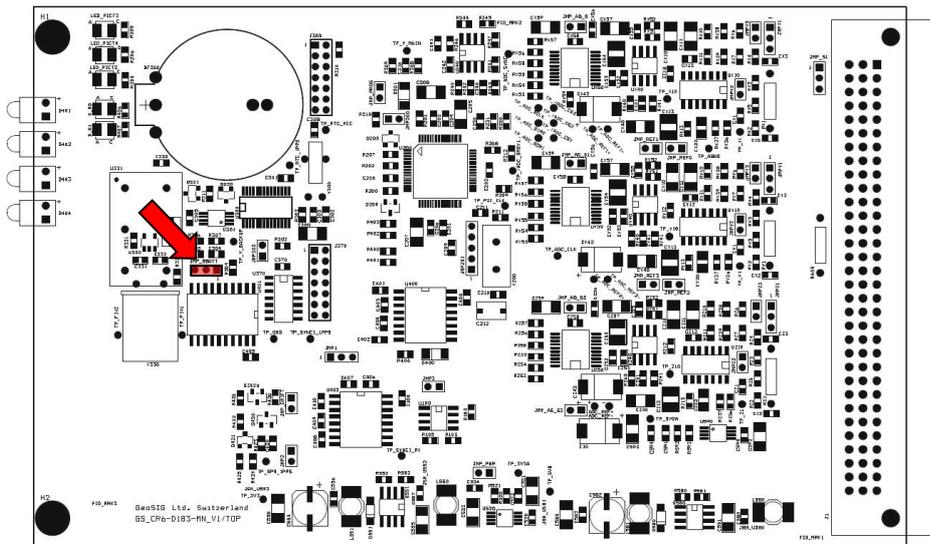


Figure 1. Jumper location to disconnect Backup Battery for RTC

3. System Description

The CR-6 is a multi-channel central recording system mounted in a 19" rack and containing of an industrial computer and one or several digitiser racks. Each rack contains up to 32 channels and several racks can be mounted on top of each other.

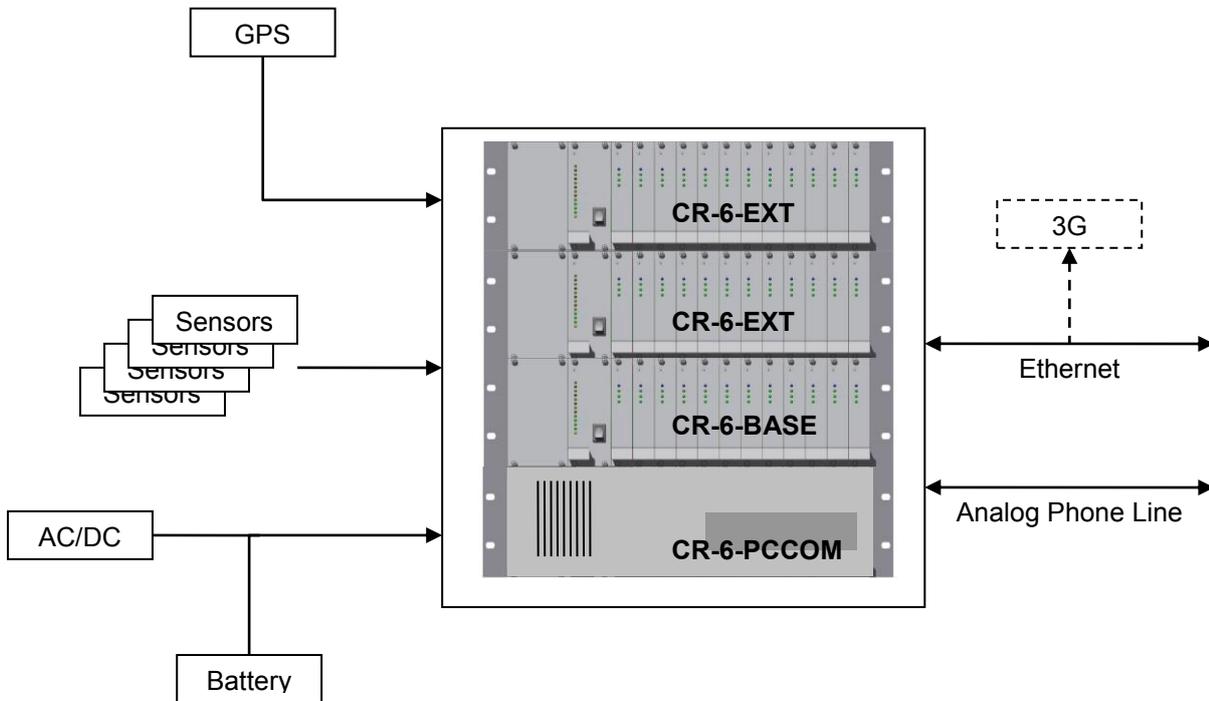


Figure 2. System Overview

The GPS module provides an accurate time source to the CR-6 Recording System. The CR-6 system locks the internal RTC with the GPS time source. If GPS is lost, the internal RTC signal will reproduce the 1PPS signal and run for itself keeping all the channels synchronised.

The CR-6 system can manage up to 36 channels per digitiser rack module and contains an OVP protection on all in and outputs. A wide variety of sensors can be used: acceleration, velocity, displacement, temperature, current, wind speed, wind direction, stress and pressure.

The CR-6 system is powered from an external 12 VDC source (24 VDC on request). The internal watchdog permanently checks the supplied voltage and shuts the system down in case of a voltage drop to protect the battery from deep discharge.

An over voltage protected RJ45 Ethernet input allows the CR-6 to be connected to the local network.

An optional internal modem can be used for the communication between the industrial computer and any remote site. The modem line is protected against over voltage as well.

The block diagram below shows the design of the CR-6 system, including all internal and external connections.

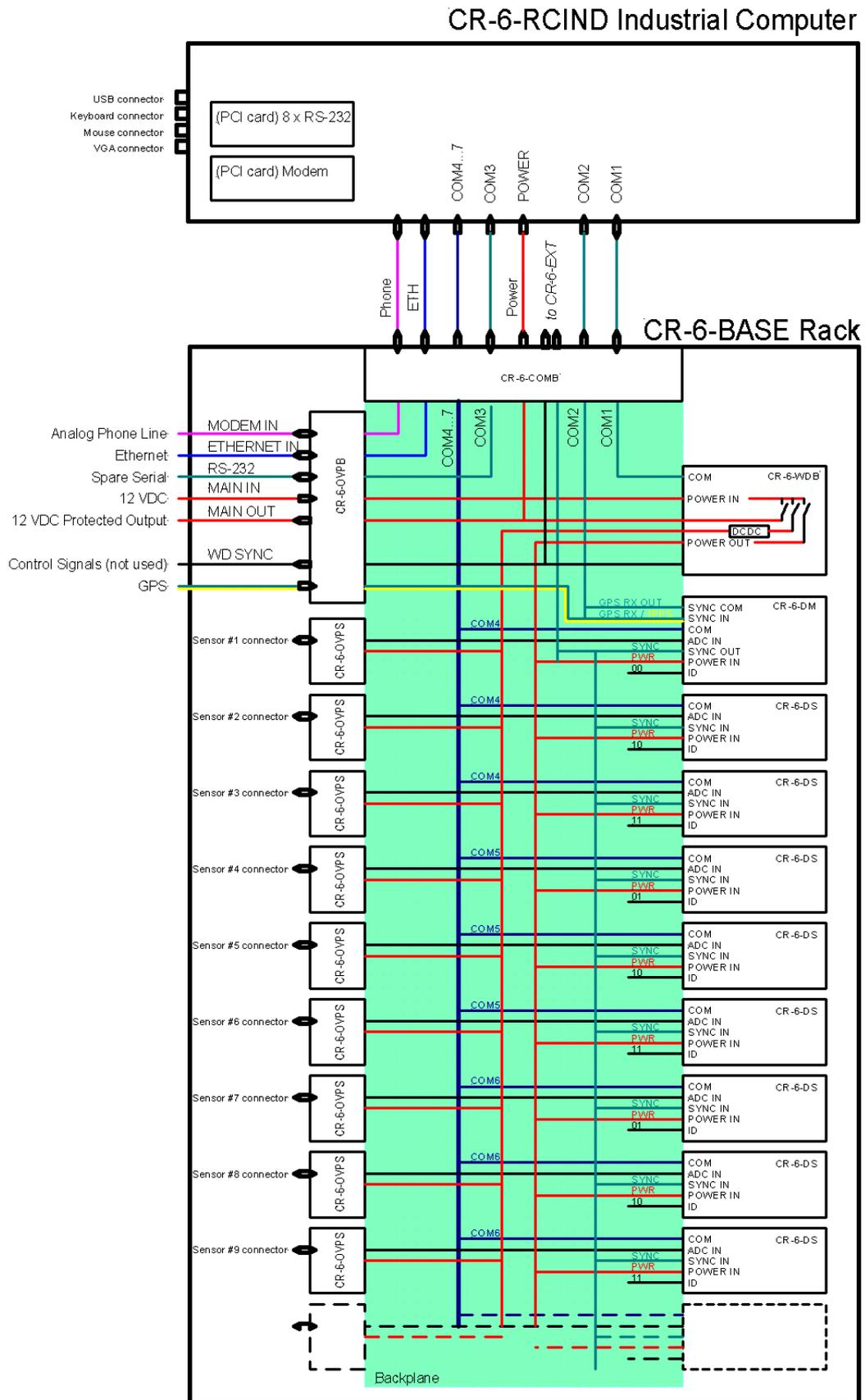


Figure 3. Internal Block Diagram

3.1. 19" Industrial Computer

Depending on the project and the number of channels, a suitable industrial computer will be defined.

3.2. CR-6-BASE Base Rack and CR-6-EXT Extension Rack

Two types of 19" racks are existing: The CR-6-BASE and the CR-6-EXT. The CR-6-BASE Base Rack contains the first 32 channels and is the only rack supplied in case the CR-6 system contains equal or less than 36 channels. If more channels are required, the CR-6-BASE can be coupled with one or more CR-6-EXT Extension Rack(s), each containing another 36 channels.

Both racks look almost the same and have several slot-in modules from the front and the back. The racks are designed, that there are no active components on the backplane, which allows the user to easily replace every part of the system by simply exchanging the related plug-in module.

3.2.1. Front Side

On the CR-6-BASE, the Digitiser Slot-In Module next to the CR-6-WDx Watchdog Slot-In Module is always a Master Digitiser Module (CR-6-DM), containing the RTC. All the others are CR-6-DS Slave Digitiser Slot-In Modules.

The front of the rack is therefore containing:

CR-6-BASE Base Rack		CR-6-EXT Extension Rack	
1x	CR-6-WDB Base Watchdog	1x	CR-6-WDE Extension Watchdog
1x	CR-6-DM Master Digitiser		
11x	CR-6-DS Slave Digitiser	12x	CR-6-DS Slave Digitiser

Each CR-6-Dx Digitiser Slot-In Module contains three channels. Always three CR-6-Dx Digitiser Modules are connected to the same serial port, sending their data time multiplexed over the same line. The CR-6-DS Slave Slot-In Modules can be plugged at any slot, except the first one, which is dedicated for the CR-6-DM Master Digitiser. The Slot-In Modules will recognise its position and transmit the digitised data to the industrial computer accordingly.



Figure 4. Front view of the CR-6-BASE Base Rack

3.2.2. Back Side

On the backside the rack contains:

CR-6-BASE Base Rack

12x CR-6-OVPS Sensor OVP
1x CR-6-OVPB Base OVP
1x CR-6-COMB Base Communication

CR-6-EXT Extension Rack

12x CR-6-OVPS Sensor OVP
1x CR-6-OVPE Extension OVP
1x CR-6-COME Extension Communication

All sensors are connected to the over voltage protection Slot-In Modules CR-6-OVPS. All other external signals (power, phone line, Ethernet, ...) are connected to the CR-6-OVPB or CR-6-OVPS Slot-In Module. All connections to the industrial computer or between the base and the extension rack are routed through the CR-6-COMx Communication Slot-In Modules.

All the Slot-In Modules are described in more details in the following chapters



Figure 5. Back view of the CR-6-BASE Base Rack

4. Slot-In Modules

The slot-in-modules are not hot swappable. When changing any slot-in-modules, the instrument must be switched off first to avoid any damage on the instrument.

4.1. Front Side

4.1.1. CR-6-WDx Watchdog Slot-In-Modules

There are two types of plug in modules:

CR-6-WDB: Base Watchdog Slot-In Module – Mounted in the CR-6-BASE Base Rack

CR-6- WDE: Extension Watchdog Slot-In Module – Mounted in all the CR-6-EXT Extension Racks

The CR-6-WDB Base Watchdog Slot-In Module is the watchdog of the whole CR-6 Recording System. This Slot-In Module supervises the status of the data acquisition software and power supplies.



Figure 6. CR-6-WDB (a) and CR-6-WDE (b) Watchdog Slot-In Module

4.1.1.1. ON/OFF switch

In position “O” the CR-6-BASE or CR-6-EXT rack is powered OFF, in position “I” the rack is powered ON

4.1.1.2. LED's

LED	Green LED	Red LED	Description
COMMUNICATION See also 4.1.1.3	ON	OFF	Normal Operation
	ON		Data Acquisition inactive, timeout counter started.
	OFF		System has been switched of by the watchdog, after a delay the system will be switched on again
		OFF	System is starting up. Supervision not yet started to make sure systems has started.

Function	Green LED	Red LED	Description
POWER SUPPLY See also 4.1.1.4	ON	OFF	Normal Operation
	ON		Supply voltage is too low (By default: < 10.5 V), counter has been started.
	OFF	ON	System has been switched of by the watchdog, supply voltage is still too low.
	ON		Supply voltage is back to normal (By default: > 12 V), system start is delayed to allow the battery to be pre-charged before start of the system.
		OFF	System is starting up. Supervision not yet started to make sure systems has started.

Function	Green LED	Red LED	Description
AC	ON	OFF	AC supply available
	OFF	ON	AC supply not available

Function	Green LED	Red LED	Description
DC	ON	OFF	DC Voltage OK (By default: > 12 V)
	ON	ON	DC Voltage critical (By default: Between 10.5 V and 12 V)
	OFF	ON	Green LED on: DC Voltage too low (By default: < 10.5 V)

Function	LED	Description
PWR OUT	ON	Supply voltage of the computer and external devices is on (Green LED on) or off (Green LED off)
PWR DIGITIZERS	ON	Supply voltage of the digitizers and the GPS is on (Green LED on) or off (Green LED off)
PWR SENSORS	ON	Supply voltage of the sensors is on (Green LED on) or off (Green LED off)

Function	LED	Description
TX	ON	Monitoring of the communication from the watchdog to the industrial computer
RX	ON	Monitoring of the communication from the industrial computer to the watchdog

4.1.1.3. GeoDAS Heartbeat

The CR-6-WDB Base Watchdog Slot-In Module receives a heartbeat signal via COM1 from the data acquisition software GeoDAS, which allows observing the correct operation of the data acquisition. If GeoDAS or the whole PC crashes, the CR-6-WDB receives no Heartbeat anymore and restarts the complete system after a user defined time.

Additionally GeoDAS observe the communication of the CR-6-Dx Digitiser Slot-In Modules and sends a restart command to the watchdog, to restart the affected component if required.

If GeoDAS is manually closed or the computer is manually shut down, it should be kept in mind that the watchdog will restart the complete system, including the computer after a user defined time in case the system is not switched off completely by the I/O button on the front side of the CR-6-WDB module.

4.1.1.4. Supervision of the Supply Voltage

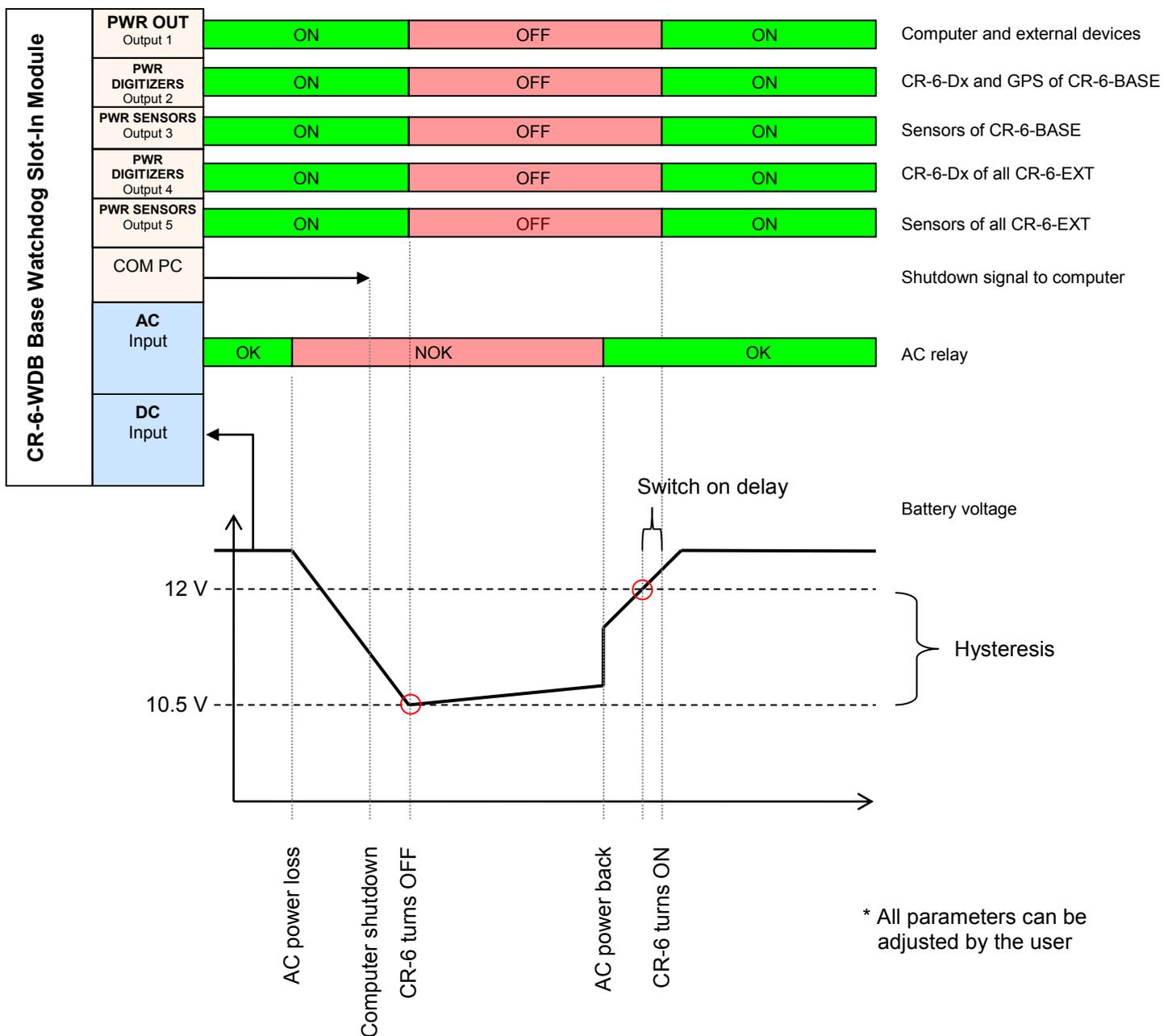


Figure 7. Supply voltage supervision by the CR-6-WDB Module

4.1.2. CR-6-Dx Digitiser Slot-In Module

The CR-6-Dx Digitiser Slot-In Module measures the value of the sensor with an ADC. The filtered value will be transferred to the industrial PC to be recorded and analyzed with GeoDAS.

There are two type of CR-6-Dx Digitiser Slot-In Modules:

CR-6-DM: Master Digitiser Slot-In Module – Has an onboard real time clock (RTC) which synchronises itself to the GPS.

CR-6-DS: Slave Digitiser Slot-In Module – Are synchronised to the RTC of the Maser Module



Figure 8 CR-6-Dx Digitiser Slot-In Module

4.1.2.1. LED's

Function	LED		Description
DATA TRANSFER	ON	OFF	In case the blue LED is on, the Digitiser Module transfers data to the industrial computer
CH1 STATUS	ON	OFF	Channel 1 is enabled (Green LED on) or disabled (Green LED off)
CH2 STATUS	ON	OFF	Channel 2 is enabled (Green LED on) or disabled (Green LED off)
CH3 STATUS	ON	OFF	Channel 3 is enabled (Green LED on) or disabled (Green LED off)

4.2. Back Side

4.2.1. CR-6-OVPSx Sensor OVP Slot-In Module

Each triaxial sensor is connected to a separate CR-6-OVP-S Sensor OVP Slot-In Module. This Module protects the CR-6 Recording System from over voltage, injected on the sensor cable.

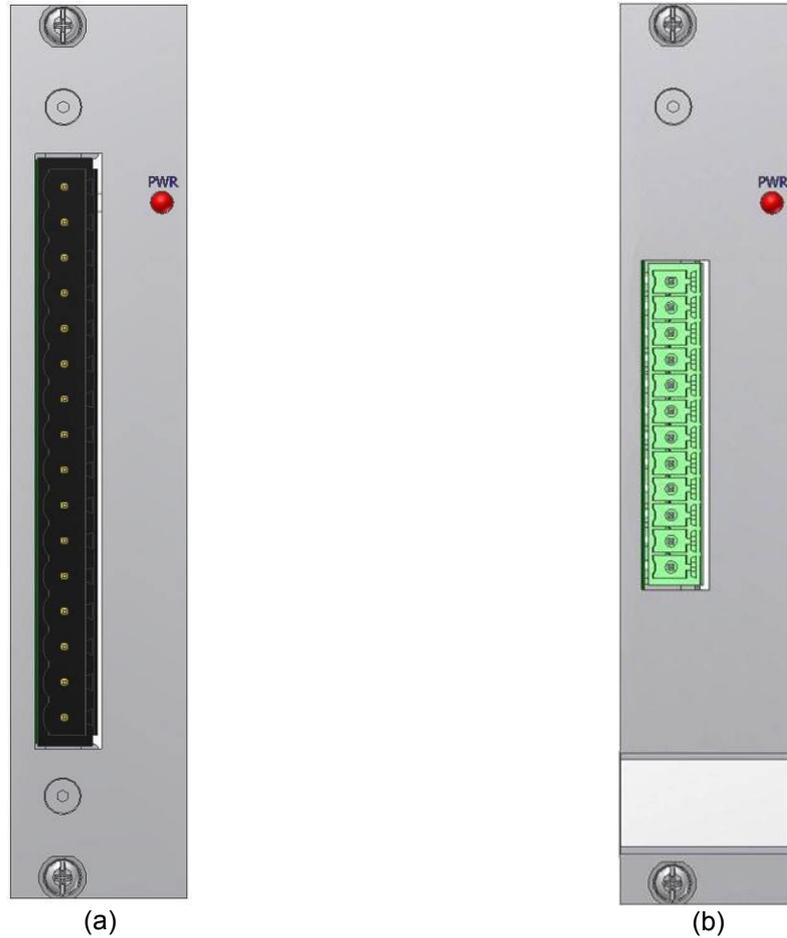


Figure 9. CR-6-OVPS1 (a) and CR-6-OVPS2 (b) Sensor OVP Slot-In Module

4.2.1.1. LED

Function	LED		Description
PWR	ON	OFF	In case the LED is on, the sensor is powered.

4.2.1.2. Connector Pinout

The sensor connector is a CR-4 compatible 16 pin connector, which is used to connect an external sensor to the CR-6 Recording System. The sensor connector provides a stabilised +12 VDC power to the sensor. Optionally also -12 VDC can be provided.

Pin	CR-6-OVPS1 (CR-4 Compatible)	CR-6-OVPS2 (Standard)
1	X+	X+
2	X-	X-
3	GND	Y+
4	Y+	Y-
5	Y-	Z+
6	GND	Z-
7	Z+	S_TEST
8	Z-	GND
9	GND	Power +12 VDC
10	S_TEST	GND
11	GND	S_MODE
12	Positive Power +12 VDC	AGND
13	Power GND	
14	Earth	
15	S_MODE or negative Power -12 VDC	
16	AGND	

4.2.2. CR-6-OVPx OVP Slot-In Module

The CR-6-OVPB or CR-6-OVPE protects the base or extension rack from over voltage on any incoming cables (e.g. power, Ethernet, phone line, ...)

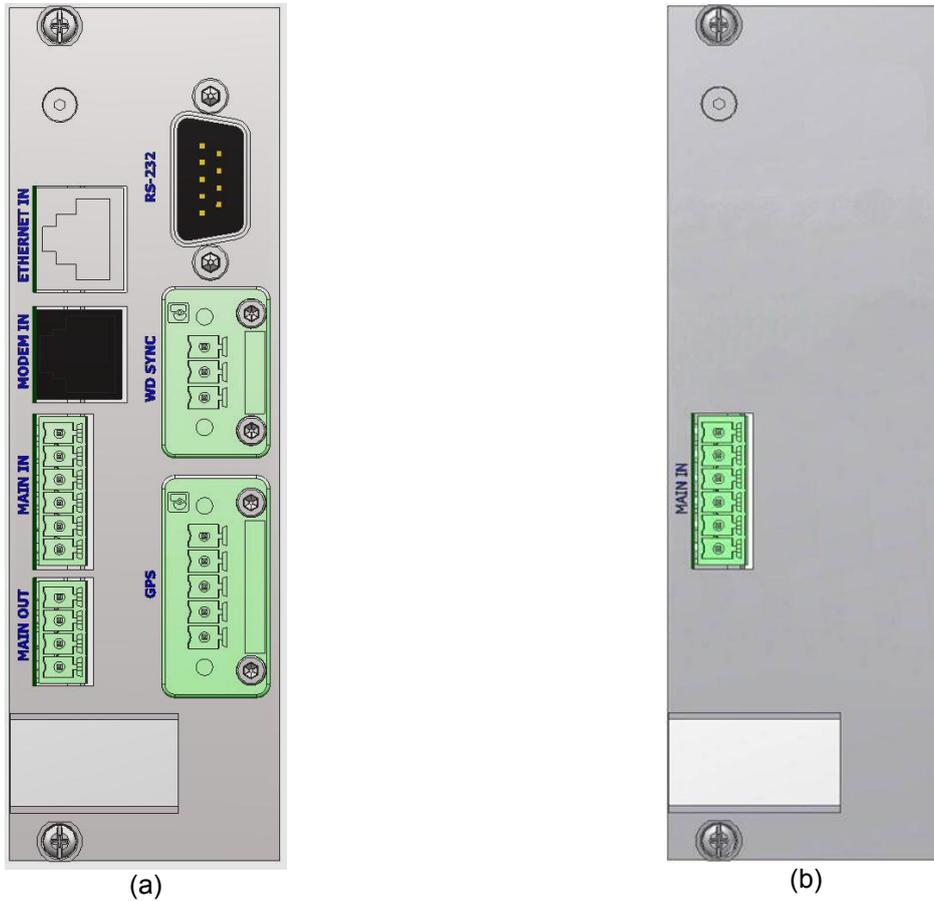
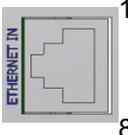
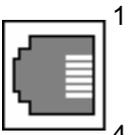
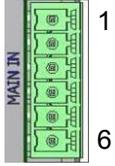
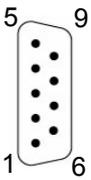
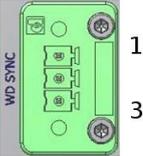
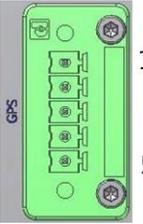


Figure 10. CR-6-OVPB (a) and CR-6-OVPE (b) OVP Slot-In Module

4.2.2.1. Connectors

<p>ETHERNET IN</p>	<p>Connection of the CR-6 to the local LAN with a standard RJ45 Ethernet plug.”</p>  <table border="1" data-bbox="593 1456 1212 1736"> <tr><td>1</td><td>TX+</td></tr> <tr><td>2</td><td>TX-</td></tr> <tr><td>3</td><td>RX+</td></tr> <tr><td>4</td><td>NC</td></tr> <tr><td>5</td><td>NC</td></tr> <tr><td>6</td><td>RX-</td></tr> <tr><td>7</td><td>NC</td></tr> <tr><td>8</td><td>NC</td></tr> </table>	1	TX+	2	TX-	3	RX+	4	NC	5	NC	6	RX-	7	NC	8	NC
1	TX+																
2	TX-																
3	RX+																
4	NC																
5	NC																
6	RX-																
7	NC																
8	NC																
<p>MODEM IN</p>	<p>In case an internal analog or ISDN modem is installed, the external telephone cable can be connected here with a standard RJ11 plug.</p>  <table border="1" data-bbox="593 1859 1212 2072"> <tr><td>1</td><td>NC</td></tr> <tr><td>2</td><td>Phone line A</td></tr> <tr><td>3</td><td>Phone line B</td></tr> <tr><td>4</td><td>NC</td></tr> </table>	1	NC	2	Phone line A	3	Phone line B	4	NC								
1	NC																
2	Phone line A																
3	Phone line B																
4	NC																

<p>MAIN IN</p>	<p>This connector is used to supply the CR-6-BASE or CR-6-EXT. 12 VDC from a battery or a power supply shall be provided.</p>  <table border="1" data-bbox="671 300 1289 535"> <tr><td>1</td><td>12 VDC (optionally 24 VDC)</td></tr> <tr><td>2</td><td>12 VDC (optionally 24 VDC)</td></tr> <tr><td>3</td><td>GND</td></tr> <tr><td>4</td><td>GND</td></tr> <tr><td>5</td><td>AC Control Input (No AC, max. 30 VDC from relay contact)</td></tr> <tr><td>6</td><td>GND</td></tr> </table>	1	12 VDC (optionally 24 VDC)	2	12 VDC (optionally 24 VDC)	3	GND	4	GND	5	AC Control Input (No AC , max. 30 VDC from relay contact)	6	GND						
1	12 VDC (optionally 24 VDC)																		
2	12 VDC (optionally 24 VDC)																		
3	GND																		
4	GND																		
5	AC Control Input (No AC , max. 30 VDC from relay contact)																		
6	GND																		
<p>MAIN OUT</p>	<p>This connector is used to supply any external devices like modems.</p>  <table border="1" data-bbox="671 645 1289 857"> <tr><td>1</td><td rowspan="2">Same voltage as for "MAIN_IN", but output controlled by watchdog. 500 mA max.</td></tr> <tr><td>2</td></tr> <tr><td>3</td><td>GND</td></tr> <tr><td>4</td><td>GND</td></tr> </table>	1	Same voltage as for "MAIN_IN", but output controlled by watchdog. 500 mA max.	2	3	GND	4	GND											
1	Same voltage as for "MAIN_IN", but output controlled by watchdog. 500 mA max.																		
2																			
3	GND																		
4	GND																		
<p>RS-232</p>	<p>This connector is used for any external devices (DTE) with RS-232 interface.</p>  <table border="1" data-bbox="671 969 1289 1283"> <tr><td>1</td><td>CD</td></tr> <tr><td>2</td><td>RXD</td></tr> <tr><td>3</td><td>TXD</td></tr> <tr><td>4</td><td>DTR</td></tr> <tr><td>5</td><td>GND</td></tr> <tr><td>6</td><td>DSR</td></tr> <tr><td>7</td><td>RTS</td></tr> <tr><td>8</td><td>CTS</td></tr> <tr><td>9</td><td>RI</td></tr> </table>	1	CD	2	RXD	3	TXD	4	DTR	5	GND	6	DSR	7	RTS	8	CTS	9	RI
1	CD																		
2	RXD																		
3	TXD																		
4	DTR																		
5	GND																		
6	DSR																		
7	RTS																		
8	CTS																		
9	RI																		
<p>WD SYNC</p>	<p>This connector is not used.</p>  <table border="1" data-bbox="671 1391 1289 1563"> <tr><td>1</td><td>SW3</td></tr> <tr><td>2</td><td>SW4</td></tr> <tr><td>3</td><td>GND</td></tr> </table>	1	SW3	2	SW4	3	GND												
1	SW3																		
2	SW4																		
3	GND																		
<p>GPS</p>	<p>This connector is used to connect the GPS receiver.</p>  <table border="1" data-bbox="671 1671 1289 1989"> <tr> <td></td> <td>RS-485 (default) JMP1: 1-2</td> <td>RS232 JMP1: 2-3</td> </tr> <tr> <td>1</td> <td>RX+ (NMEA)</td> <td>RX (NMEA)</td> </tr> <tr> <td>2</td> <td>RX- (NMEA)</td> <td>GND</td> </tr> <tr> <td>3</td> <td colspan="2">1PPS from GPS receiver</td> </tr> <tr> <td>4</td> <td colspan="2">Power (12VDC) for GPS receiver</td> </tr> <tr> <td>5</td> <td colspan="2">GND</td> </tr> </table>		RS-485 (default) JMP1: 1-2	RS232 JMP1: 2-3	1	RX+ (NMEA)	RX (NMEA)	2	RX- (NMEA)	GND	3	1PPS from GPS receiver		4	Power (12VDC) for GPS receiver		5	GND	
	RS-485 (default) JMP1: 1-2	RS232 JMP1: 2-3																	
1	RX+ (NMEA)	RX (NMEA)																	
2	RX- (NMEA)	GND																	
3	1PPS from GPS receiver																		
4	Power (12VDC) for GPS receiver																		
5	GND																		

4.2.3. CR-6-COMx Communication Slot-In-Module

The CR-6-COMB (Base rack) and CR-6-COME (Extension rack) provide the connector interface to the industrial computer or between several racks.

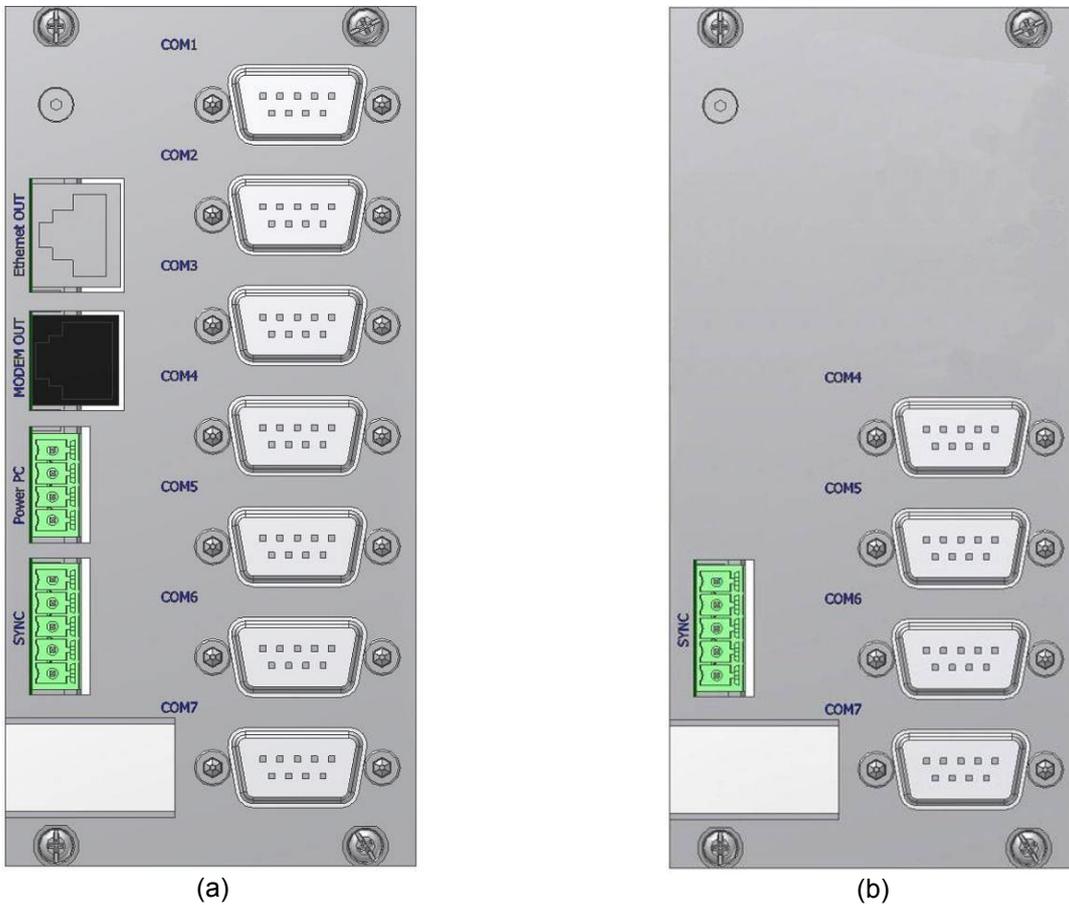
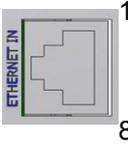
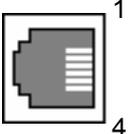
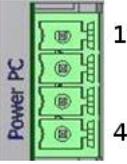
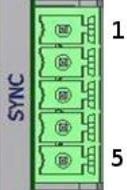
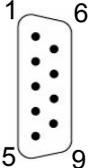
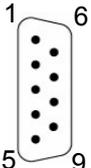


Figure 11. CR-6-COMB (a) and CR-6-COME (b) OVP Slot-In Module

4.2.3.1. Connectors

<p>ETHERNET OUT</p>	<p>Connection to PC to the LAN with a standard RJ45 Ethernet plug.</p>  <table border="1" data-bbox="598 1456 1212 1736"> <tr><td>1</td><td>TX+</td></tr> <tr><td>2</td><td>TX-</td></tr> <tr><td>3</td><td>RX+</td></tr> <tr><td>4</td><td>NC</td></tr> <tr><td>5</td><td>NC</td></tr> <tr><td>6</td><td>RX-</td></tr> <tr><td>7</td><td>NC</td></tr> <tr><td>8</td><td>NC</td></tr> </table>	1	TX+	2	TX-	3	RX+	4	NC	5	NC	6	RX-	7	NC	8	NC
1	TX+																
2	TX-																
3	RX+																
4	NC																
5	NC																
6	RX-																
7	NC																
8	NC																
<p>MODEM OUT</p>	<p>Connection of phone line to the modem with a standard RJ11 plug.</p>  <table border="1" data-bbox="598 1825 1212 2038"> <tr><td>1</td><td>NC</td></tr> <tr><td>2</td><td>Phone line A</td></tr> <tr><td>3</td><td>Phone line B</td></tr> <tr><td>4</td><td>NC</td></tr> </table>	1	NC	2	Phone line A	3	Phone line B	4	NC								
1	NC																
2	Phone line A																
3	Phone line B																
4	NC																

<p>POWER PC</p>	<p>This connector is used to supply the industrial computer.</p>  <table border="1" data-bbox="671 315 1289 506"> <tr> <td>1</td> <td rowspan="2">Same voltage as for "MAIN_IN", but output controlled by watchdog. (Normally 12 VDC)</td> </tr> <tr> <td>2</td> </tr> <tr> <td>3</td> <td rowspan="2">GND</td> </tr> <tr> <td>4</td> </tr> </table>	1	Same voltage as for "MAIN_IN", but output controlled by watchdog. (Normally 12 VDC)	2	3	GND	4												
1	Same voltage as for "MAIN_IN", but output controlled by watchdog. (Normally 12 VDC)																		
2																			
3	GND																		
4																			
<p>SYNC</p>	<p>The sync-connector is used to interconnect a CR-6-BASE with one ore more CR-6-EXT. See chapter 5.2 for details.</p>  <table border="1" data-bbox="671 629 1289 864"> <tr> <td>1</td> <td>1PPS</td> </tr> <tr> <td>2</td> <td>SYNC String</td> </tr> <tr> <td>3</td> <td>SW3</td> </tr> <tr> <td>4</td> <td>SW4</td> </tr> <tr> <td>5</td> <td>GND</td> </tr> </table>	1	1PPS	2	SYNC String	3	SW3	4	SW4	5	GND								
1	1PPS																		
2	SYNC String																		
3	SW3																		
4	SW4																		
5	GND																		
<p>COM3</p>	<p>Connection of PC to the external devices (DTE) with RS232 interfaces.</p>  <table border="1" data-bbox="671 965 1289 1279"> <tr> <td>1</td> <td>CD</td> </tr> <tr> <td>2</td> <td>RXD</td> </tr> <tr> <td>3</td> <td>TXD</td> </tr> <tr> <td>4</td> <td>DTR</td> </tr> <tr> <td>5</td> <td>GND</td> </tr> <tr> <td>6</td> <td>DSR</td> </tr> <tr> <td>7</td> <td>RTS</td> </tr> <tr> <td>8</td> <td>CTS</td> </tr> <tr> <td>9</td> <td>RI</td> </tr> </table>	1	CD	2	RXD	3	TXD	4	DTR	5	GND	6	DSR	7	RTS	8	CTS	9	RI
1	CD																		
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3	TXD																		
4	DTR																		
5	GND																		
6	DSR																		
7	RTS																		
8	CTS																		
9	RI																		
<p>COM1, 2, 4, 5, 6, 7</p>	<p>Purpose of connectors:</p> <ul style="list-style-type: none"> • COM1 – Connection of the industrial computer to the Watchdog • COM2 – Connection of the industrial computer to the GPS • COM4 – Connection of the industrial computer to the CR-6-Dx #1 - 3 • COM5 – Connection of the industrial computer to the CR-6-DS #4 - 6 • COM6 – Connection of the industrial computer to the CR-6-DS #7 - 9 • COM7 – Connection of the industrial computer to the CR-6-DS #10 - 12  <table border="1" data-bbox="671 1626 1289 1939"> <tr> <td>1</td> <td>NC</td> </tr> <tr> <td>2</td> <td>RXD</td> </tr> <tr> <td>3</td> <td>TXD</td> </tr> <tr> <td>4</td> <td>NC</td> </tr> <tr> <td>5</td> <td>GND</td> </tr> <tr> <td>6</td> <td>NC</td> </tr> <tr> <td>7</td> <td>NC</td> </tr> <tr> <td>8</td> <td>NC</td> </tr> <tr> <td>9</td> <td>NC</td> </tr> </table>	1	NC	2	RXD	3	TXD	4	NC	5	GND	6	NC	7	NC	8	NC	9	NC
1	NC																		
2	RXD																		
3	TXD																		
4	NC																		
5	GND																		
6	NC																		
7	NC																		
8	NC																		
9	NC																		

5. Installation

This section lists the procedures involved in installation, configuration and operation of the instrument. The procedures will be outlined as steps to be performed in the field or in house prior to deploying the instrument in the field.

5.1. Site Selection

5.1.1. Environmental Considerations

The choice of an installation site is similar in most respects to that of a regular continuous recording seismic station.

Although the Instrument is in a solid case, a location shall be arranged that is free from direct sunlight, dangers of falling materials in the event of an earthquake and the risk of tampering or vandalism. Furthermore, the installation site must not be affected by weather conditions such as ice, snow or rain.

The user must ensure that the location is provided with either 115 / 230 VAC or 12 VDC (e.g. from a solar panel or battery).

In case of the setup of the event triggered recordings, any local environmental source of noise, disturbance or vibration around the site must be taken into account. This will cause false triggering of the recording system in case the threshold is set too low. These influencing factors must be taken in account when configuring the trigger settings in GeoDAS.

5.1.2. Power Supply Considerations

The CR-6 is powered by battery and/or an external power supply, connected to 230/115 VAC. The power supply works as a battery charger at the same time and therefore guarantees maximum of autonomy in case of a power loss. A solar panel can be used as well instead of a power supply, ask GeoSIG for more detailed specifications.

- With 115/230 VAC power, a cable has to be connected to the external power supply. The cable must consist of Phase, Neutral and Earth Protection.
- If the system is powered only by battery, the battery must be fully charged at least 24 hours uninterrupted before connecting to the system. The configuration of the instrument may be performed while the charger is connected to the instrument.



Please ensure that the right voltage (115 VAC / 60 Hz or 230 VAC / 50 Hz) is selected on the external power supply.

The best solution for the system is to use the battery with the external power supply at the remote installation site. The instrument can be checked and configured locally in the work shop before going on site (e.g. correct time, trigger and all relevant settings). It can be transported then to the installation site (Ensure that the system is "OFF"). When in place and powered again, the system will run with the preconfigured parameters. This will reduce the risk of any complications with regards to the installation site concerning any diverse conditions.



Many times the locations of seismic equipment are highly exposed to electrical disturbances caused by lightning or by the industrial environment. It may sometimes be necessary to use additional surge protectors for the equipment. Contact GeoSIG or your local representative for more information.

5.2. Cabling of a CR-6-BASE

In the figure below the external cabling of the CR-6-BASE Base Rack is shown. To interconnect several racks, please see the next chapter.

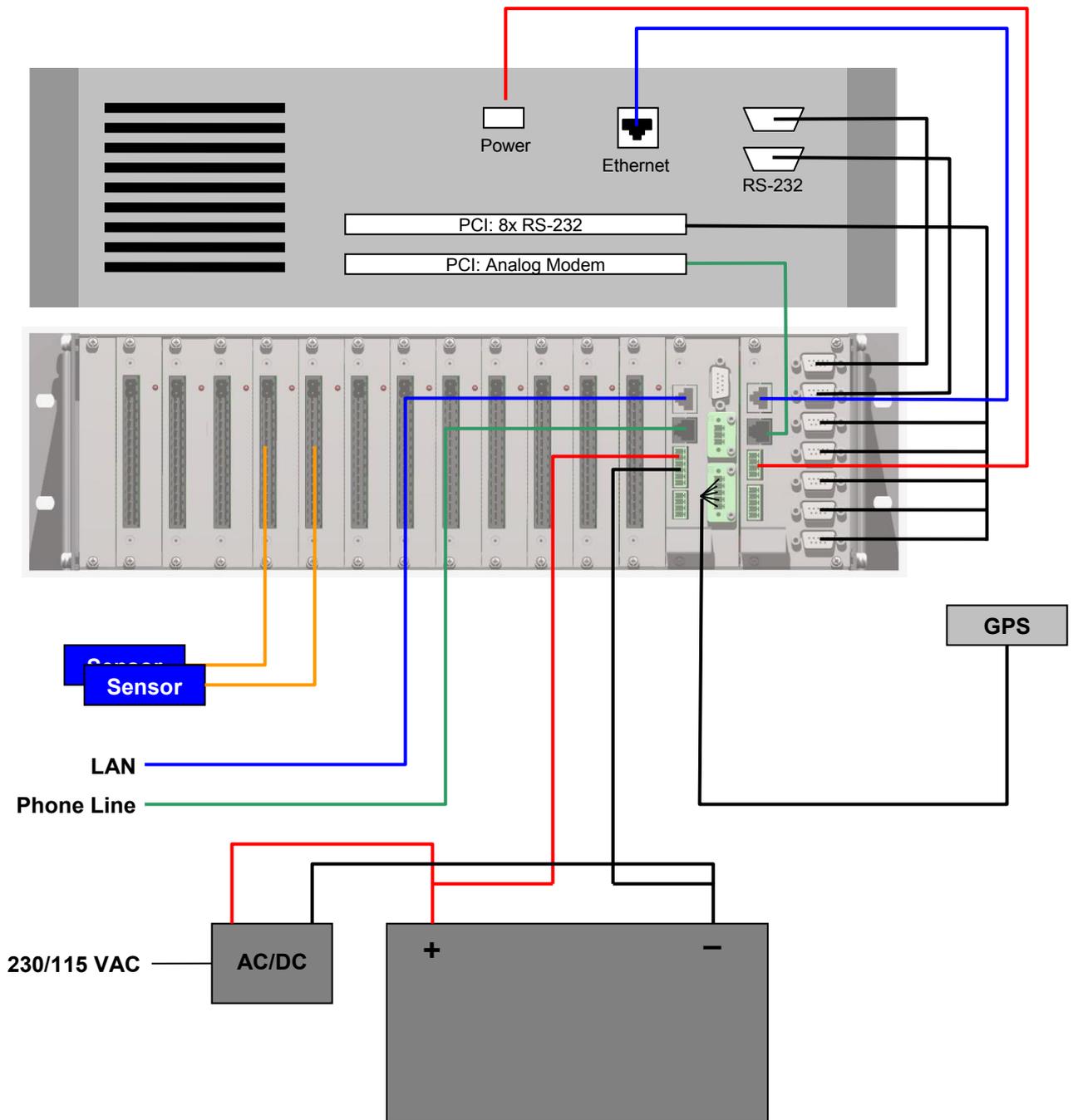


Figure 12. External cabling of a CR-6-BASE

5.3. Interconnection of one or more CR-6-EXT with a CR-6-BASE

In case more than 36 channels are required in one system, the CR-6-BASE Base Rack can be extended by one or several CR-6-EXT Extension Racks, each adding up to 36 additional channels.

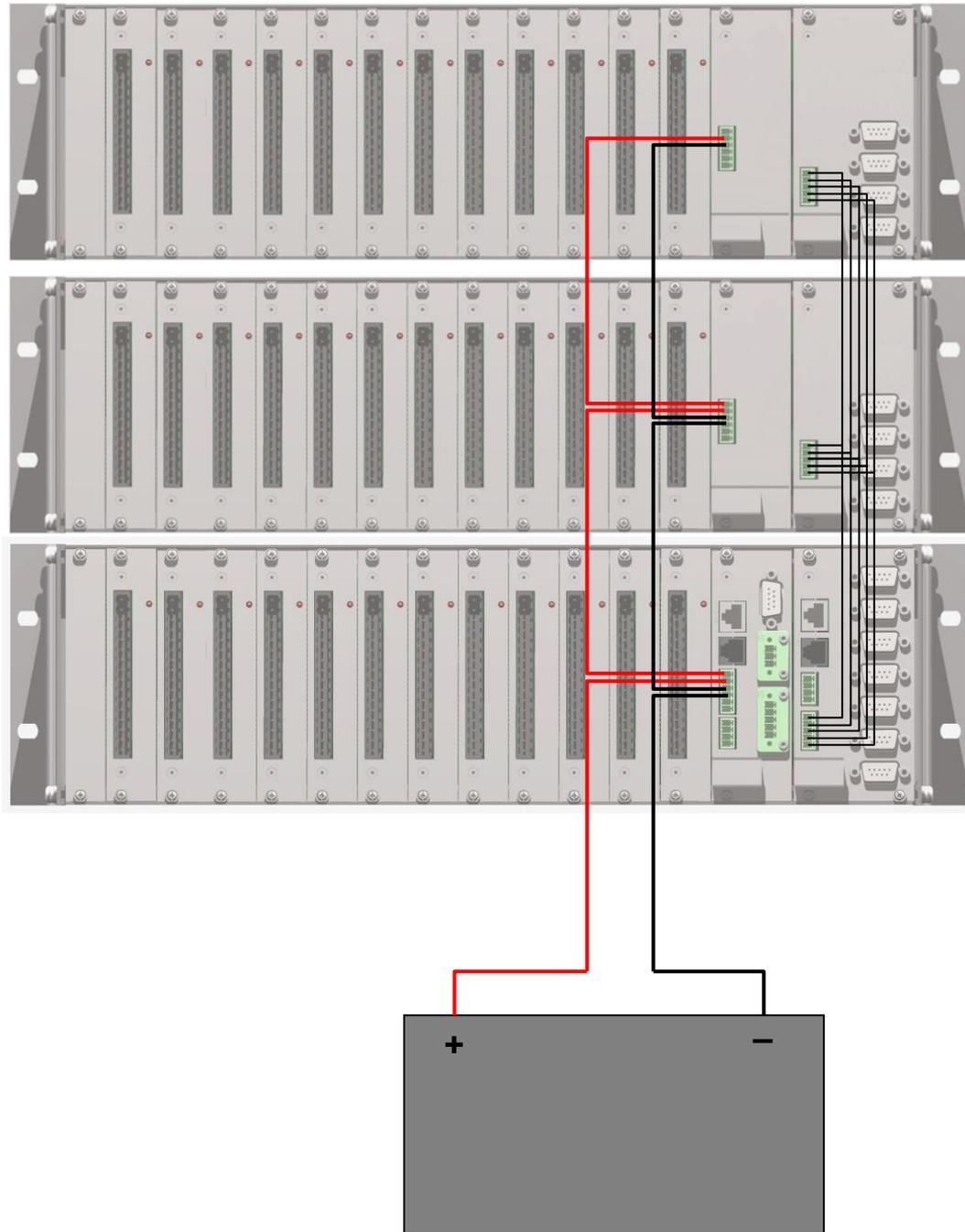


Figure 13. Interconnection of a CR-6-EXT with a CR-6-BASE

6. Configuration and Operation

Configuration and data acquisition is done on the supplied computer running GeoDAS. Basic knowledge of Windows XP and GeoDAS is assumed.

 *For the installation and usage of GeoDAS refer to the GeoDAS User Manual, which explains the use of the software in more details.*

6.1. Data Storage

The data are stored in the following folders:

Permanent recording C:\GeoDAS_DATA\DataStreams\ADxxx

Event recording C:\GeoDAS_DATA\Data\ADxxx

6.1.1. Data Access on a Remote Computer

In case you have another computer in the same network as the CR-6 system, the following steps can be done to have access to the data over the network.

- Open *Windows Explorer* on your remote computer
- Click *Tools* → *Map Network Drive...*

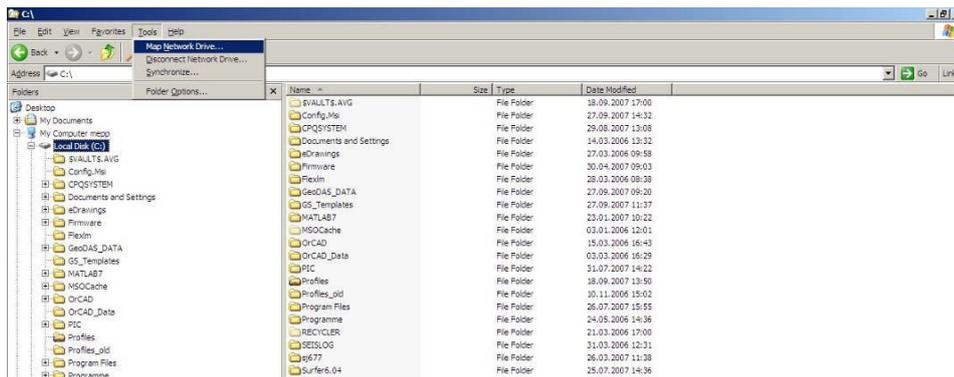


Figure 14. Map a network drive

- Map the drive to the Folder: \\192.168.xx.xx\GeoDAS_DATA. Instead of xx.xx put the IP of the CR-6 industrial computer.

 *If you don't know how to find out the IP Address, do the following steps on the industrial computer of the CR-6 Recording System:*

- Click *Start* → *Run* → type *cmd*, then press *OK*



- Type *ipconfig*, then your *IP* appears

```
Ethernet adapter Local Area Connection:
    Connection-specific DNS Suffix . . :
    IP Address. . . . . : 192.168.10.107
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 192.168.10.254
```

- Type *exit*

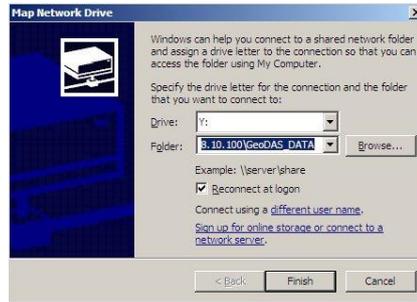


Figure 15. Map of the data folder from the Industrial PC module

- Click *Finish*
- A new drive appears under *My Computer*

From now on all data can be easily copied from this new drive.

6.2. Add new CR-6Dx Digitiser Slot-In Modules

Normally all channels are configured when the system is received from the factory. In case system is not pre-configured and you have to add any other CR-6Dx module, follow the following procedure

- Open in GeoDAS the tab *Settings* → *Channels of Digitisers...*
 - *Name:* <See the table below>
 - *Type:* GeoSIG D183 Digitizer
- Press *Add/Modify*
 - *Local COM or USB Port:* <See the table below>
 - *Sampling Rate:* 50 / 100 / 200 / 500
 - *Baudrate:* 230'400
 - *Time Source* External SYNC Signal
- Press *Add/Modify*
- Select proper *Full Scale* and *Unit*: Double click on the field and enter the full scale of the sensor under *Standard*, as per the sensor specification, then press *OK* and repeat for all channels.
- Press *Add/Modify*
- Press *OK* and restart GeoDAS

After a restart of GeoDAS, all the configured data streams of the digitizers appears in the window *Stations: DataStream*. A blue arrow  next to the channel shows, that data packets are received with no errors

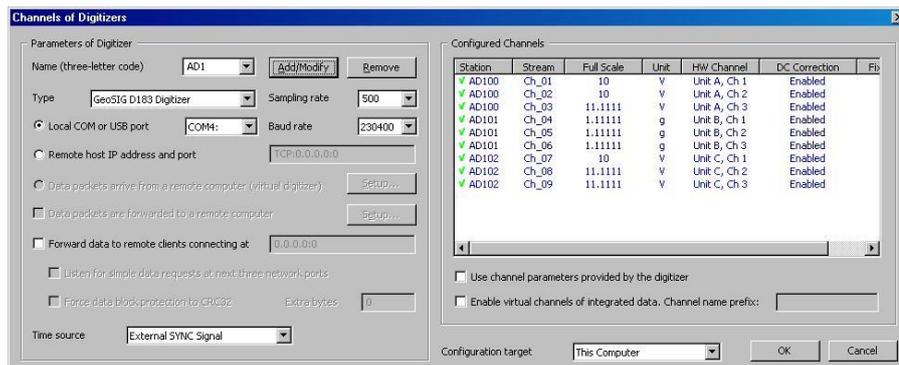
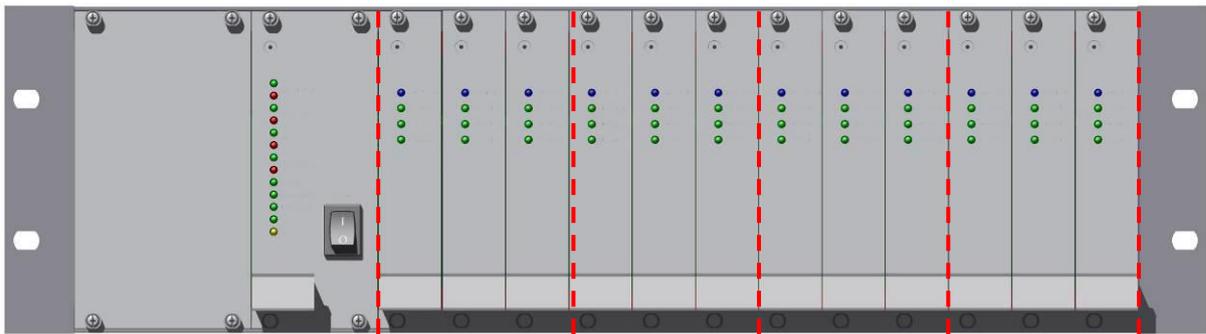


Figure 16. Channels of Digitizers



Name (three letter code)	AD1	AD2	AD3	AD4
COM Port	COM4	COM5	COM6	COM7

In case more than one rack is connected

Name (three letter code)	AD5	AD6	AD7	AD...
COM Port	COM8	COM9	COM10	COM...

6.2.1. Permanent and Event Recording

All the data are streamed from the digitizer modules to GeoDAS. To configure the permanent and event recording, open in the GeoDAS the tab *Settings* → *Data Streams...*

The following windows appear:

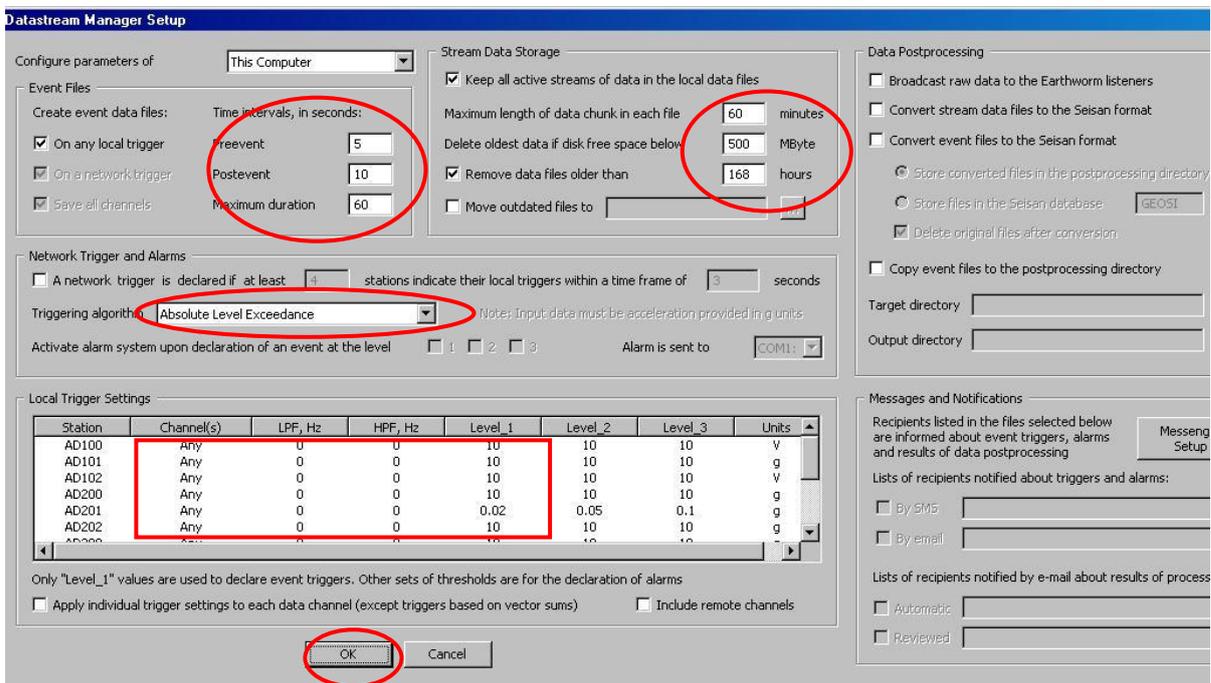


Figure 17. Setup of permanent and event recording

If you edit local parameters of the data stream processing then “This Computer” has to be selected as a Configuration target. But there is also a possibility to adjust data stream parameters in the remote instances of GeoDAS if they are configured as remote nodes allowing the remote configuration. See the *GeoDAS User Manual* for details.

Stream Data Storage (Permanent Recording)

In case the permanent data shall be kept on the system, the flag *Keep all active streams of data in local data files* must be ticked. In this case the following parameters must be set:

<i>Maximum length of data chunk in each file</i>	Length of one data file. Each data channel creates a separate file. For instance, if a system provides twelve channels and 60 minutes is selected here, then twelve files will be created ever hour. If some data blocks of the stream are lost within this time interval, GeoDAS may create more than one file to keep the data.
<i>Delete oldest data if disk free space is below</i>	Since the data files are recorded permanently, the hard disk of the computer is filled up with data quickly. Therefore care must be taken to avoid hard disk overflow. Minimum amount of a hard disk free space must be set, which is allowed for the normal operation of GeoDAS and the Windows operating system. If the free space reaches this limit, GeoDAS will delete the oldest data stream files in order to continue performing normally.
<i>Remove data files older than</i>	Lifetime of permanent data can be specified in hours. Older data will be normally deleted, except if the following option is selected.
<i>Move outdated files to</i>	<i>Files are moved to a specified archive directory instead of deleting them.</i>

Event Files

To create separate trigger files in case a threshold is exceeded the flag *On any local trigger* must be ticked. Then the following parameters must be configured.

<i>Preevent</i>	In case the signal is exceeding the trigger threshold, this value defines how many seconds of data will be added at the beginning of the event file before the threshold has been exceeded.
<i>Postevent</i>	Defines how long the recording will continue, when the signal was falling below the threshold.
<i>Maximum duration</i>	An event file will be closed after this duration, even if the threshold is still exceeded

The trigger threshold must be defined in local trigger settings

Local Trigger Settings

Here for any sensor a trigger can be defined. It can be selected on which axes the trigger should be applied (*Channels*) and a low- and high pass trigger filter (LPF, HPF) can be defined. Only Level_1 must be filled in the CR-6 Recording System. In case a STA/LTA trigger is required instead of a simple threshold trigger, this can be changed in the drop down menu of *Trigger algorithm* under *Network Triggers and Alarm*.

Network Trigger and Alarms

In case an event file should be only created in case several channels are exceeding the trigger threshold, this flag must be ticked. It must then be configured how many channels have to trigger within which time frame to start the recording of all channels. The alarms are not used in CR-6 and shall not be ticked.

For any other settings in this window or details about the triggering algorithms, see the *GeoDAS User Manual* for details.

6.2.2. Configuration of CR-6-WDB Base Watchdog Slot-In Module

In GeoDAS it must be configured, that the data acquisition program is sending a periodical heart beat to the CR-6-WDB Base Watchdog Slot-In Module. From the factory, this watchdog is already configured and does not have to be changed. If you still want to adjust any parameters, please proceed as described below:

 **Do not delete the configured watchdog. Otherwise the system will restart a couple of times per day.**

- Open in the GeoDAS the tab *Settings* → *Watchdogs...*
- Check the following parameters:
 - *Name:* WD1
 - *Port:* COM1
 - *Baud rate:* 115200
 - Press *Add Watchdog*
 - Change all values as seen in Figure 18. For explanations see chapter 6.2.2.1
 - Press *Apply*
 - Press *Save and Exit*

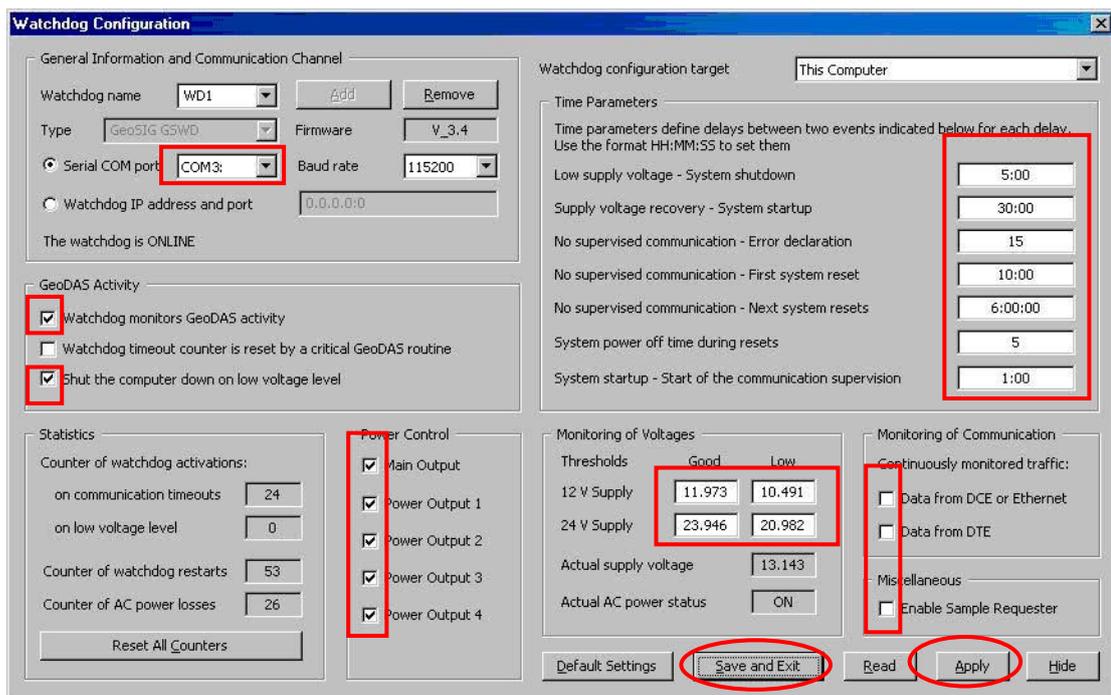


Figure 18: Watchdogs settings of the CR-6

6.2.2.1. Detail Explanation of the Watchdog Parameters

GeoDAS Activity

<i>Watchdog monitors GeoDAS activity</i>	The WD module supervises the heartbeat sent by GeoDAS and will reset the system in case the heartbeat stops
<i>Watchdog timeout counter is reset by a critical GeoDAS routine</i>	Not needed in CR-6, do not tick this flag!
<i>Shut the computer down on low voltage level</i>	In case of low voltage, GeoDAS is initiating a proper Windows shut down before the WD module is switching off the power

Statistics

Counters are showing how many times the WD module has reset the system because of problems with receiving the heartbeat or low supply voltage level. And how many times the system has been started up or AC has been lost.

Power Control

<i>Main Output</i>	Supply voltage of the computer and other optional external devices
<i>Power Output 1</i>	Supply voltage of the CR-6-Dx Digitiser Modules in the CR-6-BASE Base Rack and the GPS
<i>Power Output 2</i>	Supply voltage of all the sensors connected to the CR-6-BASE Base Rack
<i>Power Output 3</i>	Supply voltage of the CR-6-Dx Digitiser Modules in all the CR-6-EXT Extension Racks
<i>Power Output 4</i>	Supply voltage of all the sensors connected to the CR-6-EXT Extension Racks

Time Parameters

<i>Low supply voltage – System shutdown</i>	Defines how long the supply voltage must be below the set “Low” threshold till the system is switched off.
<i>Supply voltage recovery – System startup</i>	Defines how long the system remains off, after the supply voltage has been recovered above the set “Good” threshold.
<i>No supervised communication – Error declaration</i>	Defines how long a heartbeat must be pending till an error is declared.
<i>No supervised communication – First system reset</i>	Defines how long a communication error must apply, before the system will restart the first time.
<i>No supervised communication – Next system resets</i>	In case the heartbeat is not coming back after the first restart, this parameter defines how long a communication error must apply, before the system will restart again and again.
<i>System power off during resets</i>	Defines how long the power is off during the reset of the system
<i>System startup – start of the communication supervision</i>	The CR-6-WDB is not supervising the heartbeat or the voltages during this time to allow the system to be started up properly.

Monitoring of Voltages

<i>Threshold Low</i>	If the supply voltage is below this value, the system will switch off after the user defined delay.
<i>Threshold Good</i>	If after a power loss the supply voltage recovers again above this value, the system will switch on after the user defined delay.
<i>Actual supply voltage</i>	Value of the actual supply voltage
<i>Actual AC power status</i>	Status of AC supply, measured by external relay contact.

Monitoring of Communication and Miscellaneous

These parameters are not needed in CR-6 and shall not be enabled!

6.3. Data Streaming to Remote Computer

6.3.1. Settings on the Industrial Computer of the CR-6

The following settings must be done on the Industrial PC module after login over Remote Desktop:

- Open *GeoDAS*
- Click *Settings* → *Network Links...*
- Put in the following data on the left side of the window (see Figure 19)
 - Enable network links with the remote applications: *Enabled*
 - Network name: *CR-6*
 - IP Address: *Default*
 - Accept request from the remote clients at port: *Enabled, 1024*
 - Support functions of a remote node: *Enabled: - Real time data streaming
- Remote configuration*
- Click *OK*
- Restart *GeoDAS*

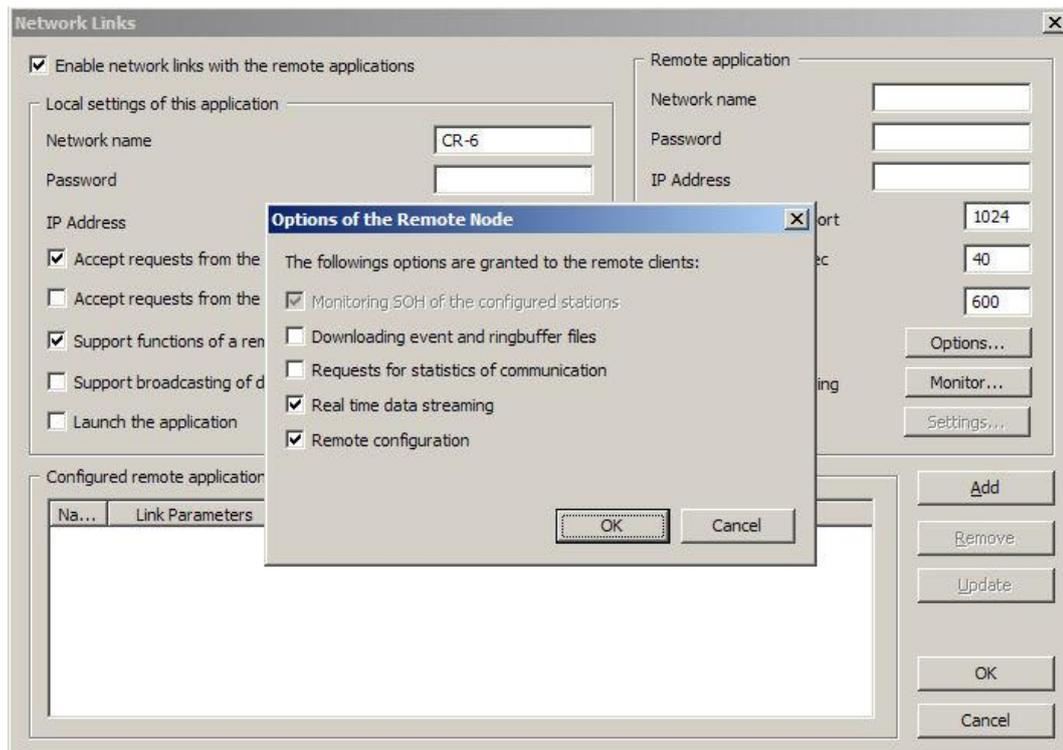


Figure 19. Data forwarding over Network

6.3.2. Remote Computer Settings

The following settings must be done on the computer, where you want to receive the data streams:

- Open *GeoDAS*
- Click *Settings* → *Network Links...*
- Put in the following data (see Figure 20)
 - Enable network links with the remote applications: *Enabled*
 - Local settings of this application, Network name: *Workstation*
 - Local settings of this application, IP Address: *Default*
 - Remote application, Network name: *CR-6*
 - Remote application, IP Address: *<IP Address of the CR-6>*
 - Remote application, Connect through the port: *1024*
 - Remote application, Connection timeout, sec: *40*
 - Remote application, Inactivity timeout, sec: *600*
 - *Remote application, Remote node* *Enabled: - Real time data streaming
- Remote configuration*
 - Permanent monitoring: *Enabled*
- Click *Add*, then *OK*
- Restart *GeoDAS*

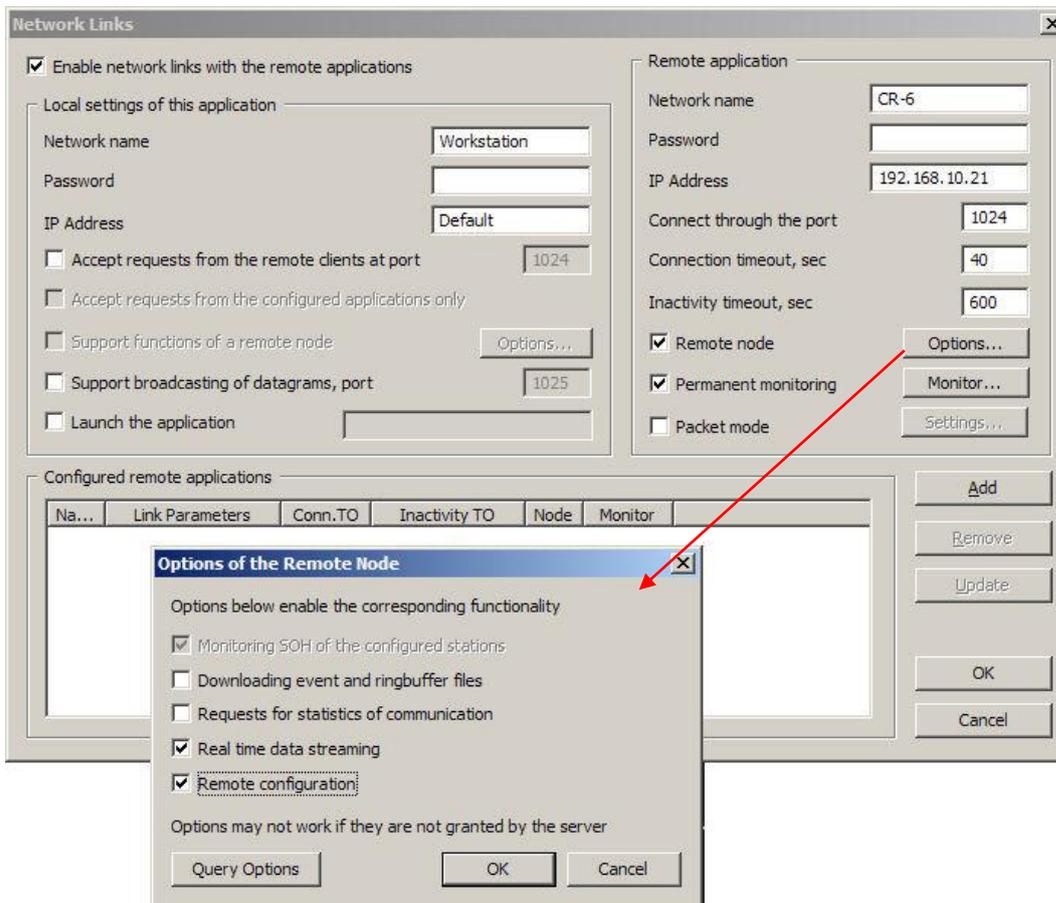


Figure 20. Network Links

- In the window *Remote Nodes and Applications* a new station *CR-6* appears.

- In the window *Stations: Data Streams* the network CR-6 will all channels appears

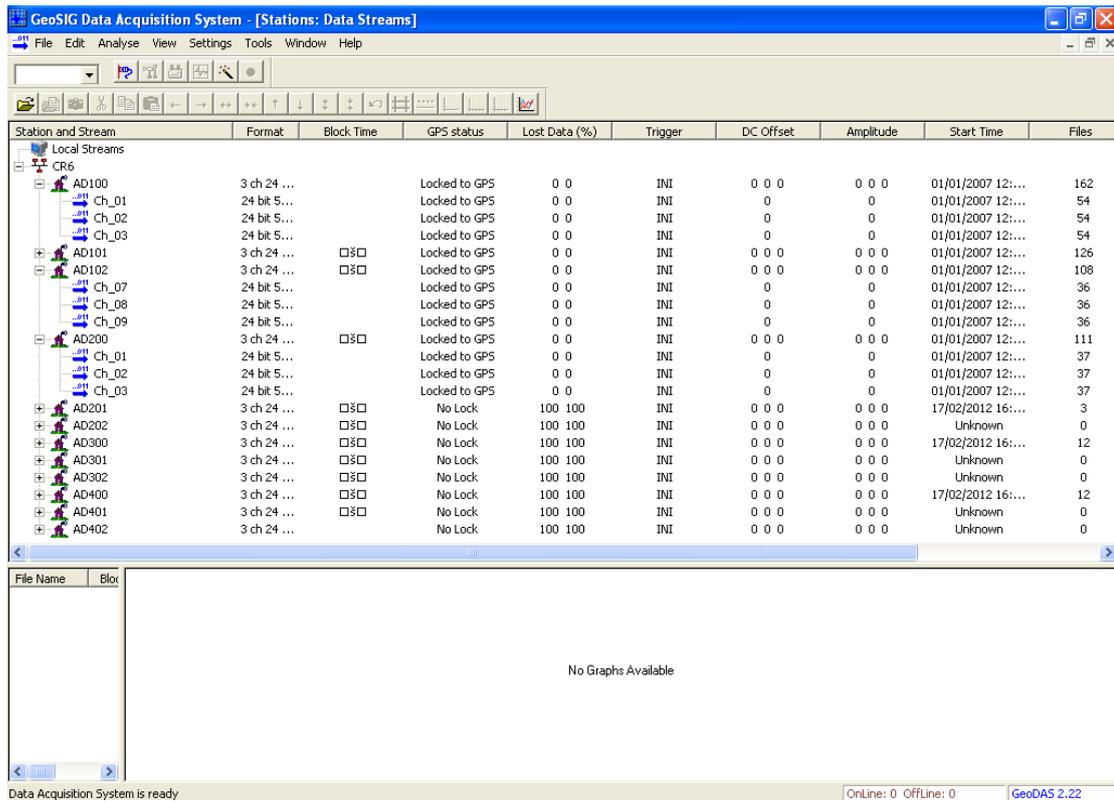


Figure 21 Remote streams

- For display of the streams make a right-click on the channel and press *Data Monitor*

For more details see *GeoDAS User Manual*

7. Functional Description

This section discusses some technical details how the Instrument works. Input signal filtering, digitising, and time accounting are among the functions described.

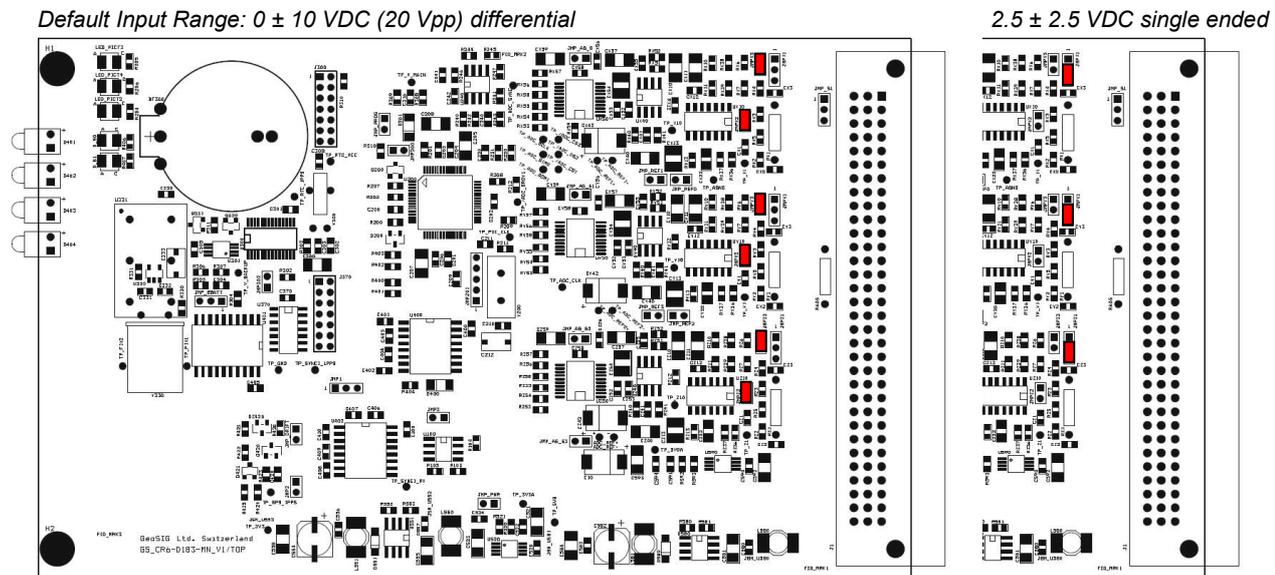
7.1. Signal Conditioning

Electrical signals from seismic sensors connected to the Instrument are range-adjusted in preparation for conversion to digital form and are filtered to prevent aliasing effects. The signals are next sampled and digitised, and then digitally filtered under software control to further reduce noise. Then these data are used for triggering and recording within the GeoDAS software package.

Depending on the jumper configuration, the instrument accepts signals from sensors within the sensor voltage output ranges as follows:

		Jumpers on CR-6-Dx Digitiser Slot-In Modules		
Range		JMPX1 JMPY1 JMPZ1	JMPX2 JMPY2 JMPZ2	JMPX3 JMPY3 JMPZ3
0 ± 10 VDC (20 Vpp)	Differential	open	1-2	1-2
0 ± 2.5 VDC (5 Vpp)	Differential	open	open	open
0 ± 10 VDC (20 Vpp)	Single Ended	1-2	1-2	1-2
0 ± 2.5 VDC (5 Vpp)	Single Ended	1-2	open	open
2.5 VDC ± 2.5 VDC	Single Ended	2-3	open	open

Examples:



Depending on the jumper settings, the input signals will all be internally unified to a single range 0 to 5 V. The Digital Values (DV) for Analog Input Voltages (AIV) are summarised in the following table:

Analog Input Voltage AIV [V]	Digital Value DV [Bit]	
Minimum input	0.0	$-(2^{23} - 1) \times 90\% = -7549746$
Zero input	2.5	0
Maximum input	5.0	$2^{23} \times 90\% = 7549746$

Each channel of the CR-6 has a low-pass 250 Hz 4th-order Butterworth analog filter prior to being sampled and converted to digital form. This filter removes signal energy at frequencies above one-half the input sampling rate (1000 Hz), so that higher frequencies are not aliased by the sampling process. For different

sampling rates, further anti-aliasing is achieved by digital filters in the DSP (equi-ripple FIR filter structures with the linear phase) with a -3dB point above 80% of the Nyquist rate. Any delay from the digital filter is directly compensated inside the DSP.



The sampling rate is common to all three channels digitised by one CR-6-Dx Digitiser Slot-In Module, i.e. the sampling rate cannot be individually set for a specific channel.

7.2. Triggering

The CR-6-Dx Digitiser Slot-In Modules do not have any data storage capability. They act as a digitiser by simply forwarding the data to the remote host. The recording itself is performed by the GeoDAS software package on the industrial computer. For more information about the possibility of triggering or to record the data, please see chapter 6.2.1 consult the *GeoDAS User Manual*.

7.3. Clock

The Instrument has a complete, self-contained time-keeping system (RTC). This clock keeps track of days, hours, minutes and seconds. The instrument synchronise the clock automatically with an encoded external time signal coming from a GPS. The clock operates from the internal battery and runs regardless whether the main switch is at ON or OFF position. If the CR-6 Recording System is stored in shelf please see chapter 2.3.2) to avoid that the backup battery for the RTC is discharged.

7.3.1. GPS Option

The GPS (Global Positioning System) is originally used for navigation. It contains several satellites, which orbit the earth in a distance of about 20 000 km. The signals transmitted by the satellites are used to get the position; minimum 4 satellites have to be received by the GPS receiver to find its exact position. The transmitted signals contain also precise time information, which is used to update the internal clock of the Instrument.

7.3.2. Synchronisation

The RTC of the CR-6-DM Master Digitiser Slot-In Module synchronise its clock to the GPS. All other CR-6-DS Slave Digitiser Slot-In Modules synchronise their time to the CR-6-DM Master Digitiser. This setup guarantees, that all channels remain synchronised, even if the GPS is failing or having no signal.

8. Maintenance

The Instrument has been designed in a way that it requires a minimum of maintenance. If the following procedures are performed frequently, the instrument will last for many years:

- The periodic test indicates any irregularity as soon as it occurs. Therefore it is recommended, to check the recorded sensor test at least **once a year**. Compare the signals of the 3 channels with older records. There should not be a distinctive change.
- The function of a sensor with DC response (capacitive, piezo-resistive and FBA sensors) can be checked by inclining the sensor in every axis. An inclination of 90° causes an acceleration of 1.0 g, 30° an acceleration of 0.5 g and 14.7° an acceleration of 0.25 g. Check this value for every channel. This check should be performed **annually**.
- The function of the sensor can be checked frequently with a tilt table. For testing the sensor has to be installed onto the tilt table. The whole range of $\pm 1g$ has to be checked with the table. Every axis shall be performed. The output signal has to be compared with the calibration values given by the manufacturer.
A sensor without AC response needs to be checked by using a shaking table. The period of this check depends on the used sensor type. For detailed information refer to the data sheet of your sensor.
- The voltage of the optional battery and the charging voltage of the charger shall be measured **annually**. Disconnect the AC power to measure the battery voltage, keep the Instrument switched on. The voltage should be between 11.8 and 13.2 VDC, depending on its charge. Reconnect the AC power cable, switch off the Instrument and disconnect the battery, measure the voltage on the battery cables. The voltage should be 13.8 ± 0.3 VDC.
- The physical condition of the Instrument and the sensor should be checked **annually**. Make sure every cable and connector is in good condition and plugged in properly.
- The optional battery should be replaced every **3 years**. After replacement, adjust the date of installation and the date of the next replacement into the Instrument via GeoDAS.
- The backup battery on the CR-6DM Master Digitiser Slot-In Module should be replaced every **5 years**.