GSR-12 / 16 / 18 / 24
AS-12 / 16
GCR-12 / 16

User Manual Appendix G
Interconnected Recording Networks

GeoSIG Ltd, Ahornweg 5A, 5504 Othmarsingen, Switzerland
Phone: + 41 44 810 2150, Fax: + 41 44 810 2350
info@geosig.com, www.geosig.com

Document Revision

Author	Patrick Camina
Checked	Ricardo Araujo
Approved	Christoph Kündig

Version	Action
04.10.2006	First issue: Re-structured document replacing TN_93_SMI_InterconnNet.doc and pointing out practical aspects such as installation.
09.10.2006	Adjustment regarding standard telephone cable in Chapter “Interconnection Cable”, PC
07.11.2006	First level approval with some formatting and relocation, TB
15.11.2006	AC connection pin description (Central Communication Box) added, PC
08.10.2007	Housing sizes inserted under pictures, TB

Table of Contents

Introduction

When interconnection is involved, more options are available in terms of connections, data flow, accessibility, and cost. One version is the Interconnected Recording Network which uses local recording. The three possible types of the Interconnected Recording Network are explained in detail in “TN # 85: Strong Motion Instrumentation Networks”. This document describes practical aspects concerning installation and their use.

1. Description and Functionality

The three types of the Interconnected Recording Network (Interconnection Network) are illustrated in Figure 1 and are described below. A brief functional comparison is also presented in Table 1.

1.1. Common Functionality

Connections: Several recorders with internal or external sensors are placed on site and are interconnected with one cable while galvanically isolated from each other. For convenient cabling external junction boxes are used. The interconnection between the stations can be carried out in ring, star, or net topology. Distances between the stations can be as much as 1 km. This is a favourable and cost effective solution for many applications.

Common Timing: One of the interconnected recorders (commonly referred to as the Software Master) is enabled to synchronise and update the internal clock of each of the other recorders (commonly referred to as Software Slaves) via the network to achieve Common Timing. All stations within the network use this common time information to synchronise their internal time. The time synchronisation is a permanent task for the Software Master. The stations within the network permanently check their synchronisation status. In case of not having the network time information available, the Slave stations base on their internal real time clock. The time of the last successful synchronisation is available in the status information of a Slave station and is written into every event header. A GPS time source can be connected to the Software Master to achieve the time synchronisation of the whole array to the absolute time, which allows easier correlation with recordings made by other arrays or recorders.

Common Trigger: Triggering functionality of each recorder can be controlled using three flags: 'Internal Trigger', 'Network Trigger Output' and 'Network Trigger Input'. By enabling or disabling these flags the behaviour of each station can be defined precisely as needed in the particular application. This functionality can be summarised as follows:

- Enable / disable self trigger:
  The station triggers if an internal trigger condition is fulfilled and the 'Internal Trigger' flag is enabled.

- Enable / disable sending trigger to network:
  The station transmits an active trigger message to the network if an internal trigger condition is fulfilled and the 'Network Trigger Output' flag is enabled.

- Enable / disable accepting trigger from network:
  The station triggers if an active trigger message arrives from the network and the 'Network Trigger Input’ flag is enabled.

If a station is not synchronised to the network it records based on the specified internal trigger condition. An output for Local Communication is available at each recorder for local data retrieval and setting of parameters. The reliability of the monitoring network is high, because a malfunction of a recorder would affect only the location of malfunction in the array. If the network is interrupted, each of the recorders will perform as a stand-alone recorder by recording whenever the instrument’s event-recording trigger level is reached.

1.1.1. Type A: CCL (Common Time, Common Trigger, Local Communication)

This type of array enables common triggering and common time in the simplest form. The data are stored locally in every recorder and have to be retrieved locally from each recorder separately, due to the availability of Local Communication only. Similarly, the setting of parameters of each recorder has to be performed on the site of each recorder.

☞ *A shielded cable with a single twisted pair is sufficient for this type.*

1.1.2. Type B: CCC (Common Time, Common Trigger, Central Communication)

A central communication module is utilised in this option. The module is connected to the network as a central, from which all of the recorders can be accessed for data retrieval and setting of the parameters.

☞ *Due to the communication option a shielded cable consisting of 3 twisted pairs is required.*

1.1.3. Type C: CCM (Common Time, Common Trigger, Multinode Communication)

The data of every recorder can be accessed and retrieved from any of the recorders in the array. Similarly the parameters of every recorder is adjustable from any of the accessed recorders. This provides an extremely versatile system to operate.

☞ *As for the previous type a shielded cable consisting of 3 twisted pairs is required.*

1.1.4. Comparison of Options

Table 1. Functional comparison of interconnected network options

Option	Common Timing	Common Triggering	Communication from: Local Recorder – To Local Recorder	Communication from: Local Recorder – To Every Recorder	Communication from: Central Module – To Every Recorder
CCL	✓	✓	✓		
CCC	✓	✓	✓		✓
CCM	✓	✓	✓	✓	(✓)

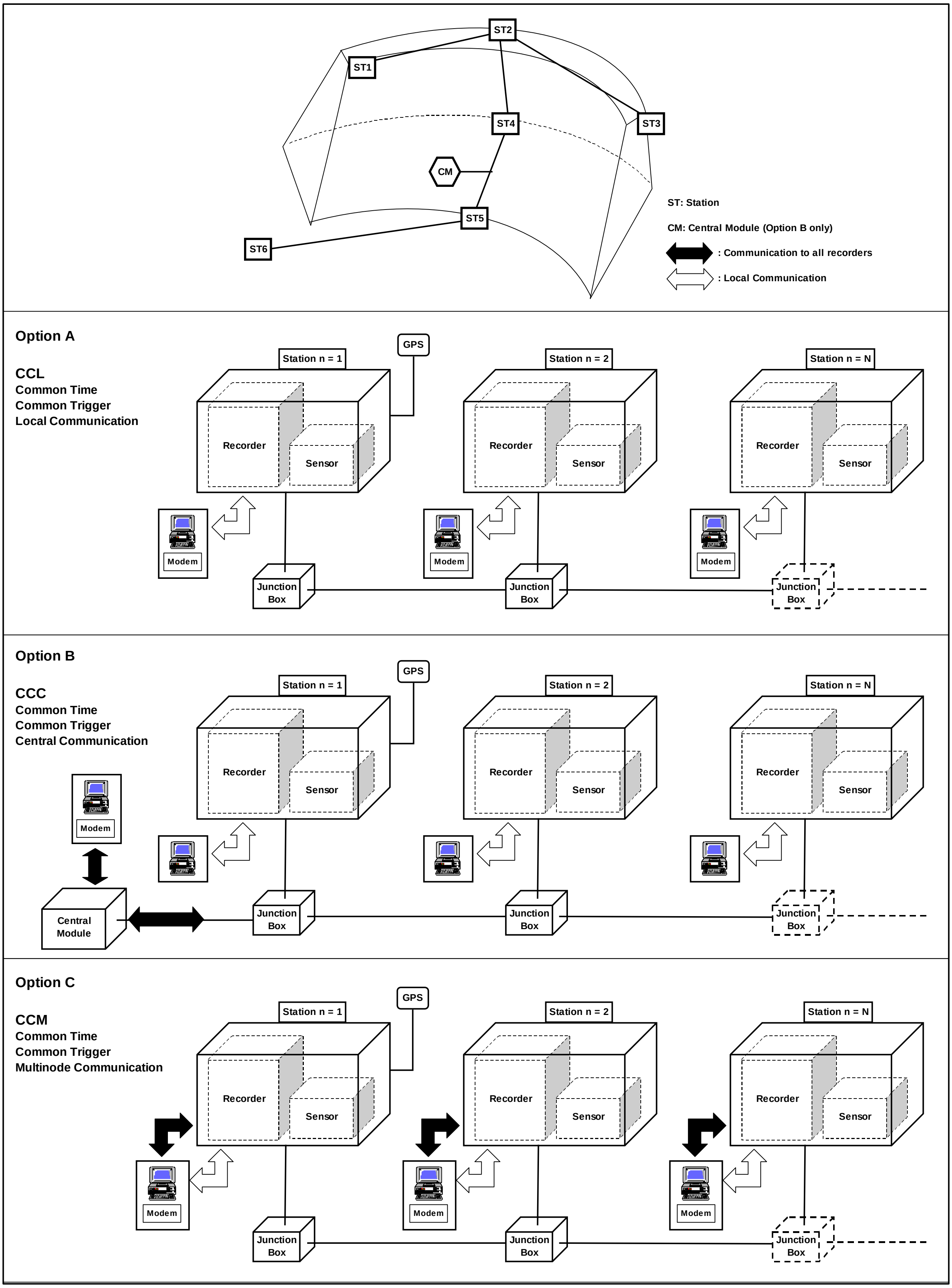

Figure 1. Topology of the Interconnected Recording Network Options

2. Installation

2.1. Physical Interconnection

The principle of the interconnection wiring of all types of networks described above is the same. Interconnection Junction Boxes are supplied in order to facilitate on-site wiring. Since these networks can extend over hundreds of meters involving long cables it is important to protect the recorders against over-voltages, such as electrostatic discharges and lightning, and differences in local earth potentials. The protection is realised in the following ways:

- Advanced Lightning and over-voltage protection is implemented in the Interconnection Junction Boxes
- An interconnection option board which takes care of the galvanic isolation is installed in the recorders

Figure 2 shows the Interconnection Junction Box which is used along with each recorder.

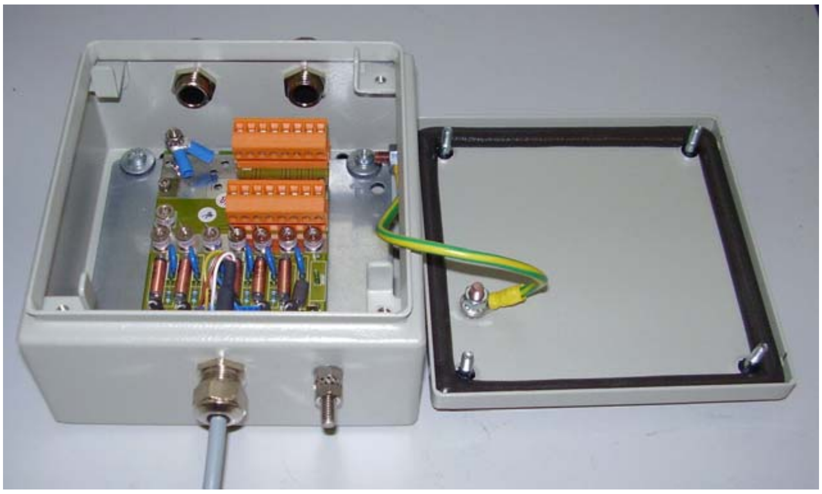

Figure 2. Interconnection Junction Box (150 x 150 x 80 mm)

The interconnection wiring is the only wiring, which is really site-specific, in other words carried out by the customer. The other wiring, such as INTERCON connection cable, RS-232 PC-connection cable, or AC cable is pre-assembled. The wiring of the interconnection cable is straight through which makes installation easy.

In order to achieve a maximum protection and system reliability, a couple of points are important to take care during installation, mainly earth and cable shield connections. These points are described in the following.

Figure 3 shows a recorder, the corresponding junction box (Interconnection Junction Box) and the connection of the bus (interconnection) cabling. Each recorder is connected to the bus cable via a junction box which goes with it.

☞ *Both, the recorder and the junction box, need to be connected to local earth. There is an earth screw on both housings which can be used for this purpose. The earth cable is connected first to the junction box and then goes on to the recorder.*

The Junction Box is connected to the recorder using the grey cable already assembled to the box. Its length is about 1 m.

The cable coming from the previous recorder and the cable going to the next recorder are connected as indicated in Figure 4.

The shields of the interconnection cables are connected to the yellow connectors as indicated in Figure 4. ***Do not connect them to the housing or local earth!***

There is one exception where the shield ***is*** *connected to local earth. It is in the junction box of the first recorder in Interconnection Networks of the type CCL and CCM (no Central Communication Box is used)!*

This way, the cable shield of the interconnection cable is only at one point connected directly to earth. At the other junctions it is connected via an over-voltage breaker. This makes sure that there are no electrical problems (no equalisation currents) in case the potentials of the local earths are not the same. This commonly occurs e.g. in dam installations.

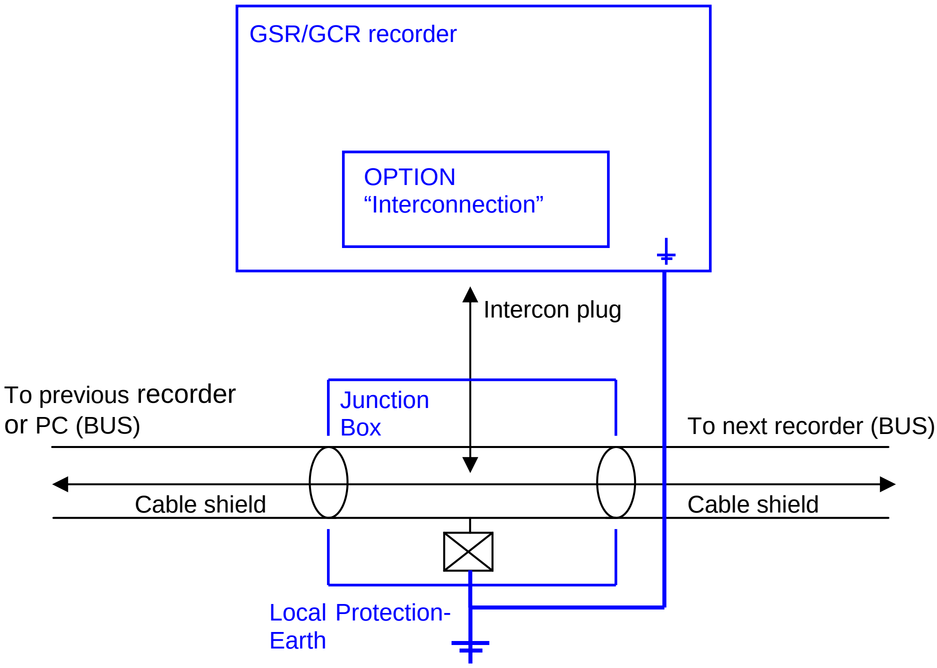

Figure 3. Interconnection wiring, including Junction Box

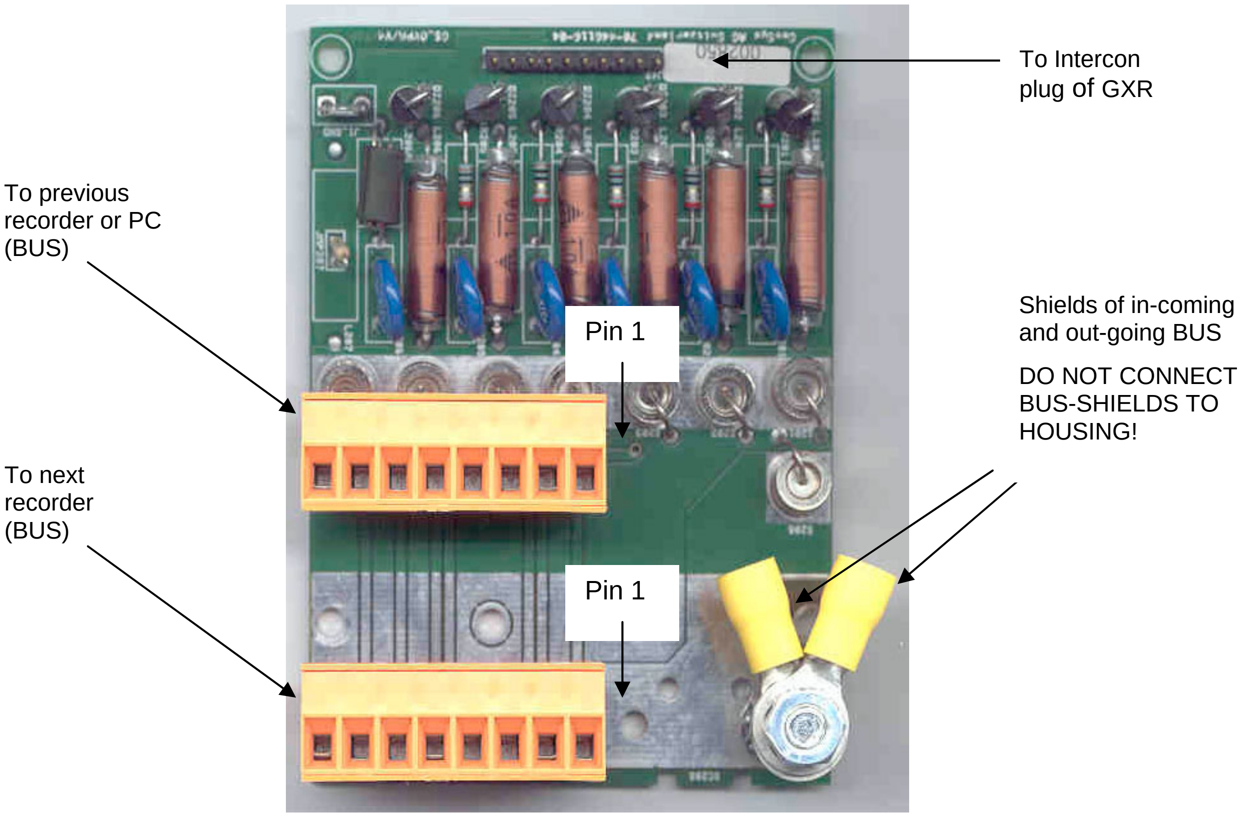

Figure 4. Connectors inside Junction Box

2.1.1. Central Communication Box

The Interconnection Network type CCC uses a Central Communication Box at which in general a Computer is connected (see Figure 5).

Figure 5. Central Communication Box (300 x 200 x 120/140 mm)

The Computer is connected using the standard RS-232 cable delivered with the shipment. The AC power cable is generally already assembled to the box. Figure 6 shows the connection diagram of the Central Communication Box.

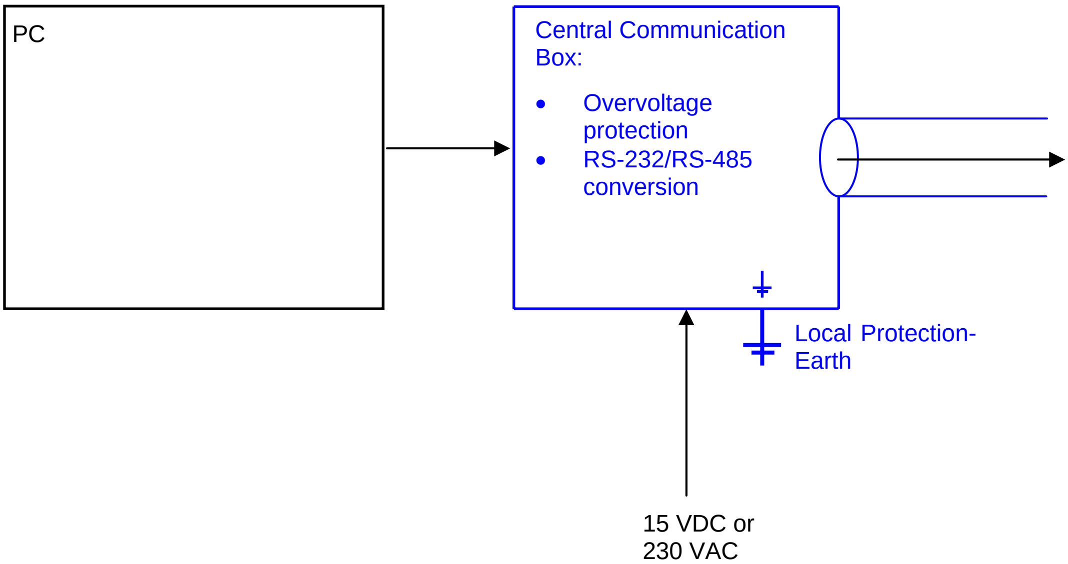

Figure 6. Interconnection Wiring, incl. Central Communication Box

The following table shows the connection of the AC power cable. Its location on the card is indicated in Figure 7. Connectors and fuses inside Central Communication Box.

Table 2. AC Connector Description

Signal	Colour	Pin
PE, Protection Earth	Yellow-green	1
--	--	2
--	--	3
L, Phase	Brown	4
--	--	5
--	--	6
--	--	7
N, Neutral	Light-Blue	8

☞ ***Make sure that the AC main supply is disconnected before starting to manipulate connections inside the box***

The interconnection cable is connected as indicated in Figure 7. It is the top connector, not to be confused with the main supply connector on the bottom.

☞ *The interconnection cable shield needs to be connected to the EMV-stuffing tube. It is here where the entire cable shield is connected to earth.*

The box itself is connected to earth with the earth signal (yellow-green) in the main supply cable or in newer instruments by the earth screw on the outside of the box.

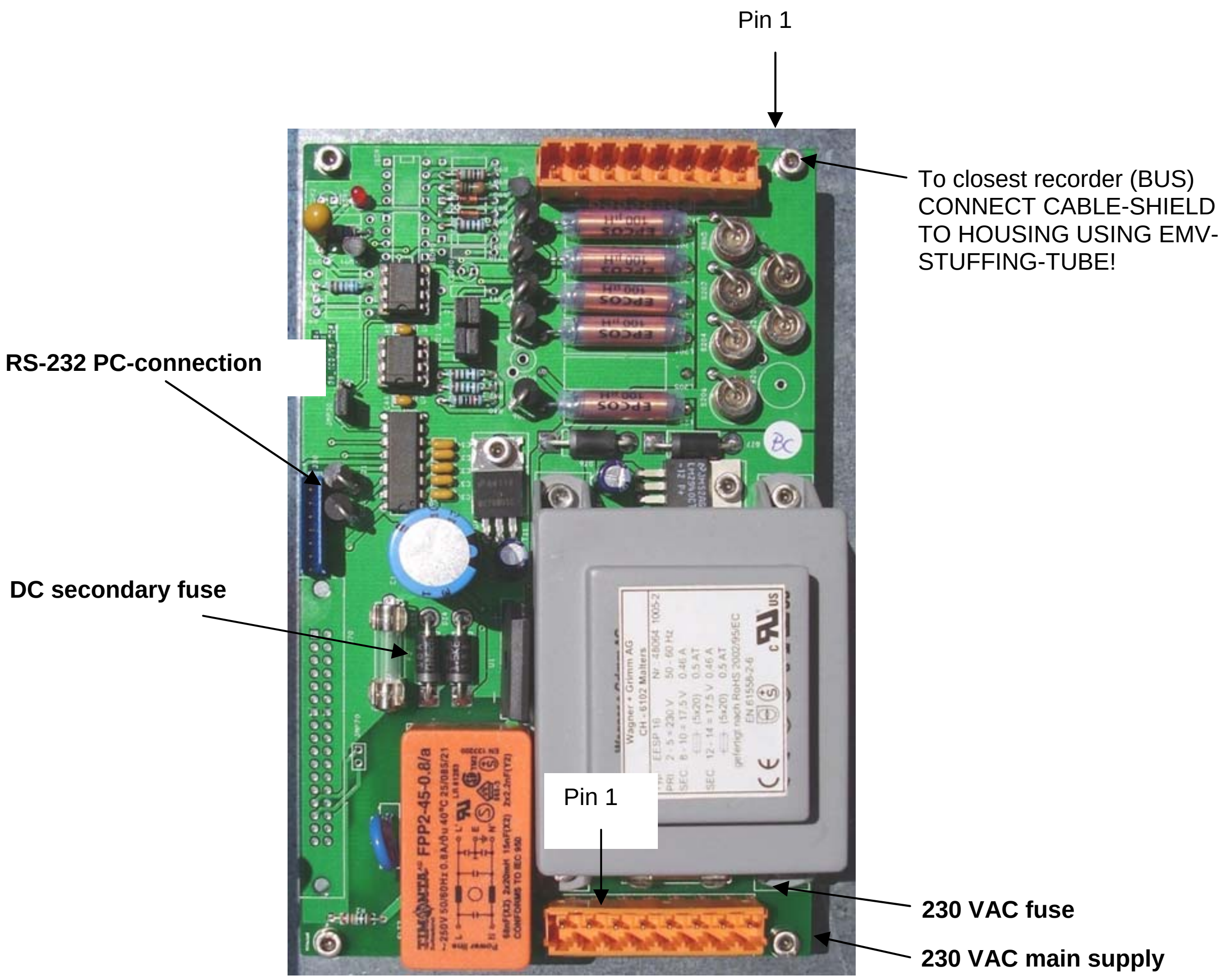

Figure 7. Connectors and fuses inside Central Communication Box

Figure 8 shows the way the cable shield needs to be connected to the Central Communication Box and to the junction boxes.

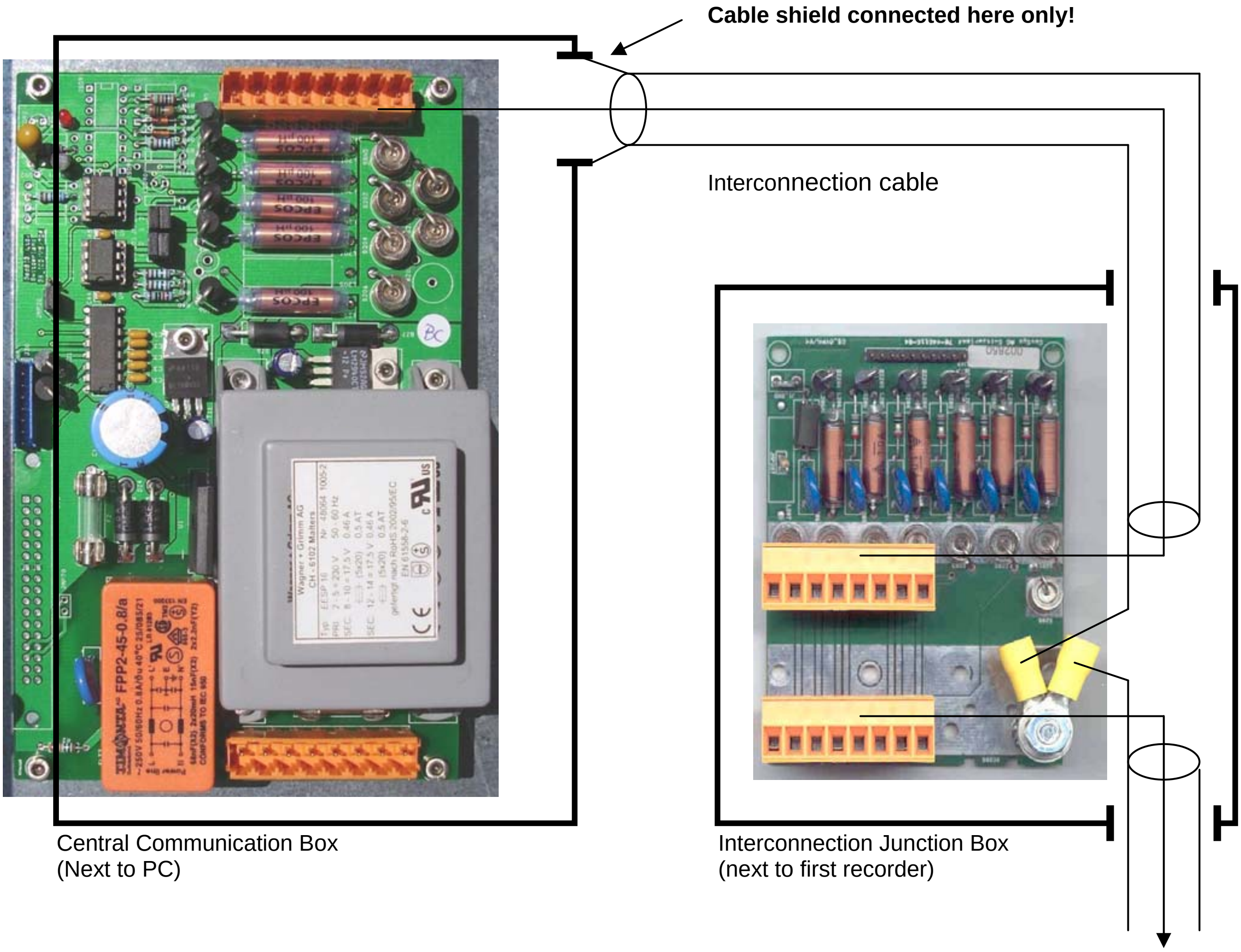

Figure 8. Shield connection

2.1.2. Interconnection Signals

The following table shows the Interconnection signals and their position on the orange connectors in the junction box and in the Central Communication Box.

The signals on pin 1 to 4 are only used for the network types CCC and CCM. In the case of CCC the names given indicate the signal directions from the Central Communication Box point of view. In a network of type CCM the four signals are used bi-directionally.

N_PWR is only used if the Centralised Power Supply Option has been selected.

Table 3. Interconnection Signals

Signal	Needed for Network Type	Central Communication Box or Junction Box	Next Junction Box
485_TX_H	CCC, CCM	1	1
485_TX_L	CCC, CCM	2	2
485_RX_H	CCC, CCM	3	3
485_RX_L	CCC, CCM	4	4
N_PWR	Optional	5	5
N_SYNC	CCC, CCM, CCL	6	6
N_GND	CCC, CCM, CCL	7	7
N_GND		8	8

2.1.3. Interconnection Cable

The appropriate choice of the interconnection cable is important for the functionality of the network. For all network types the cable has to have twisted-pairs and a shield in order to prevent it from picking up interference.

Another important aspect is the diameter required which is a trade off between total length of the bus network and cable diameter. Since the signal which takes care of *Common Time* and *Common Trigger* is a current signal (30 mA) it is the limiting factor. Therefore, the maximum total cable resistance (both ways) is 2 * 50 Ohm. Table 3 shows the relationship between cable cross-sections and maximum network lengths.

Table 4. Cable cross-sections vs. maximum network length

Cross-section [mm^2]	Resistance [Ohm/km]	Maximum network length [m]
0.20	89.0	500
0.25	71.2	700
0.35	50.9	900
0.5	36.6	1300

A way to reduce the cable resistance is to connect two pairs in parallel. This effectively halves the resistance and doubles the maximum length.

For network types which involve communication (CCC, CCM) the total network length is advised to be a maximum of 1000 m. However, lengths above 1000 m are possible but the maximum communication speed for reliable connections is decreasing with increasing distance. Please contact GeoSIG Ltd. in such a case. Another option for long-distance interconnection networks is a transmission based on fibre optics.

For a network of type CCL only one twisted-pair is required which is connected to N_SYNC (pin 6) and N_GND (pin 7) of the orange connectors. In the case of short in-door networks (up to 200 m) a standard telephone cable (without shield) is sufficient.

CCC and CCM require a cable with a minimum of 3 twisted-pairs. If 4 pairs are used, two of them can be used in parallel for N_SYNC and N_GND. In any case one pair is used for 485_TX_H / 485_TX_L (pin 1 and 2), and one for 485_RX_H / 485_RX_L (pin 3 and 4).

2.2. Interconnected Recorders

In an Interconnection Network not all recorders are configured in the same way from the hardware and from the software point of view. Figures 9, 10, and 11 show the setup and position of the individual recorders in the corresponding bus network. The text in the Figures below each recorder describes its configuration and role in the network. The recorders themselves are identified with labels containing the same text. The following Chapters describe this issue for the different types of networks.

The individual recorders are pre-configured (hardware and software) in the factory.

Do not change the interconnection network specific configuration as described below unless there is a strong reason to do so (check with GeoSIG Ltd.)!

The maximum number of recorders in an Interconnected Recorder Network is limited to 10.

2.2.1. CCL

The following different configurations are possible (see Figure 9):

- The first recorder in the bus is configured as Network Driver and has therefore jumpers J91 and J92 inserted on the internal interconnection card GS_ICC_V05. There can only be one Network Driver!
- The first recorder in the bus is configured as Software Master, whereas all the other recorders are configured as Software Slaves. Refer to Chapter “Software Configuration” below
- If a GPS is available it is connected to the Software Master (first instrument)

To summarise, there are two types of instrument configurations:
- GXR Interconnection Master (first)
- GXR Interconnection Slave (all, except first)

OVP boxes are not shown in Figure 9.

2.2.2. CCC

The following different configurations are possible (see Figure 10):

- The Central Communication Box serves as Network Driver. Since there is only one network driver required the jumpers J91 and J92 on the internal interconnection card GS_ICC_V05 of the recorders are not inserted.
- The first recorder in the bus is configured as Software Master, whereas all the other recorders are configured as Software Slaves. Refer to Chapter "Software Configuration" below
- If a GPS is available it is connected to the Software Master (first instrument)
- Communication through the network requires terminations in the first node of the network (Central Communication Box) and in the last one (last recorder)

To summarise, there are three types of instrument configurations:
- GXR Master without Termination (first recorder closest to Central Communication Box)
- GXR Slave without Termination (all, except first and last)
- GXR Slave with Termination (last instrument)

OVP boxes and Common Time / Common Trigger wiring is not shown in Figure 10.

2.2.3. CCM

The following configurations are possible (see Figure 11):

- The first recorder in the bus is configured as Network Driver and has therefore jumpers J91 and J92 inserted on the internal interconnection card GS_ICC_V05. There can only be one Network Driver!
- The first recorder in the bus is configured as Software Master, whereas all the other recorders are configured as Software Slaves. Refer to Chapter "Software Configuration" below.
- If a GPS is available it is connected to the Software Master (first instrument)
- Communication through the network requires terminations in the first and in the last recorder

To summarise, there are three types of instrument configurations:
- GXR Master with Termination (first)
- GXR Slave without Termination (all, except first and last)
- GXR Slave with Termination (last instrument)

OVP boxes and Common Time / Common Trigger wiring is not shown in Figure 11.

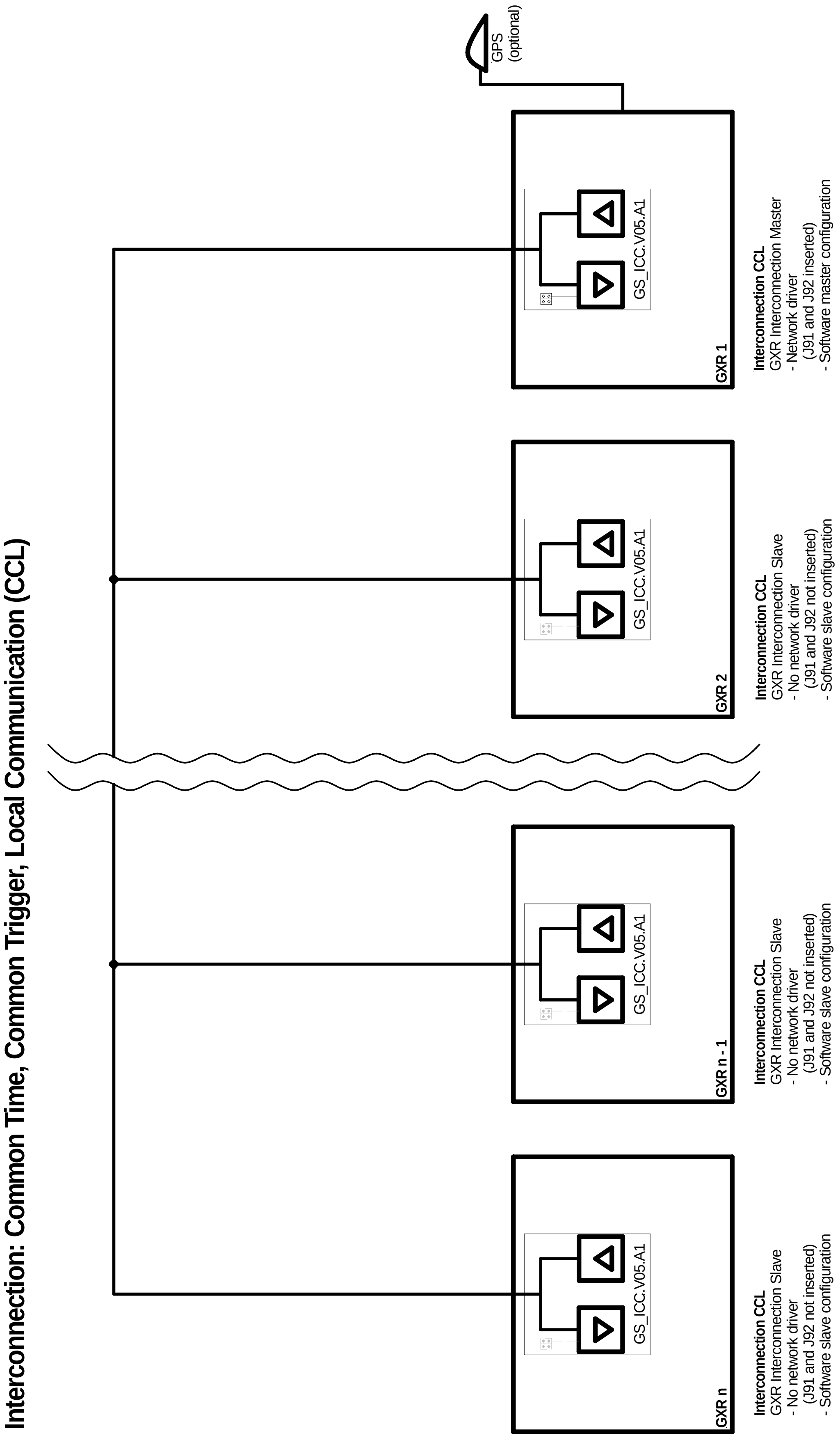

Figure 9. Interconnection Network setup CCL

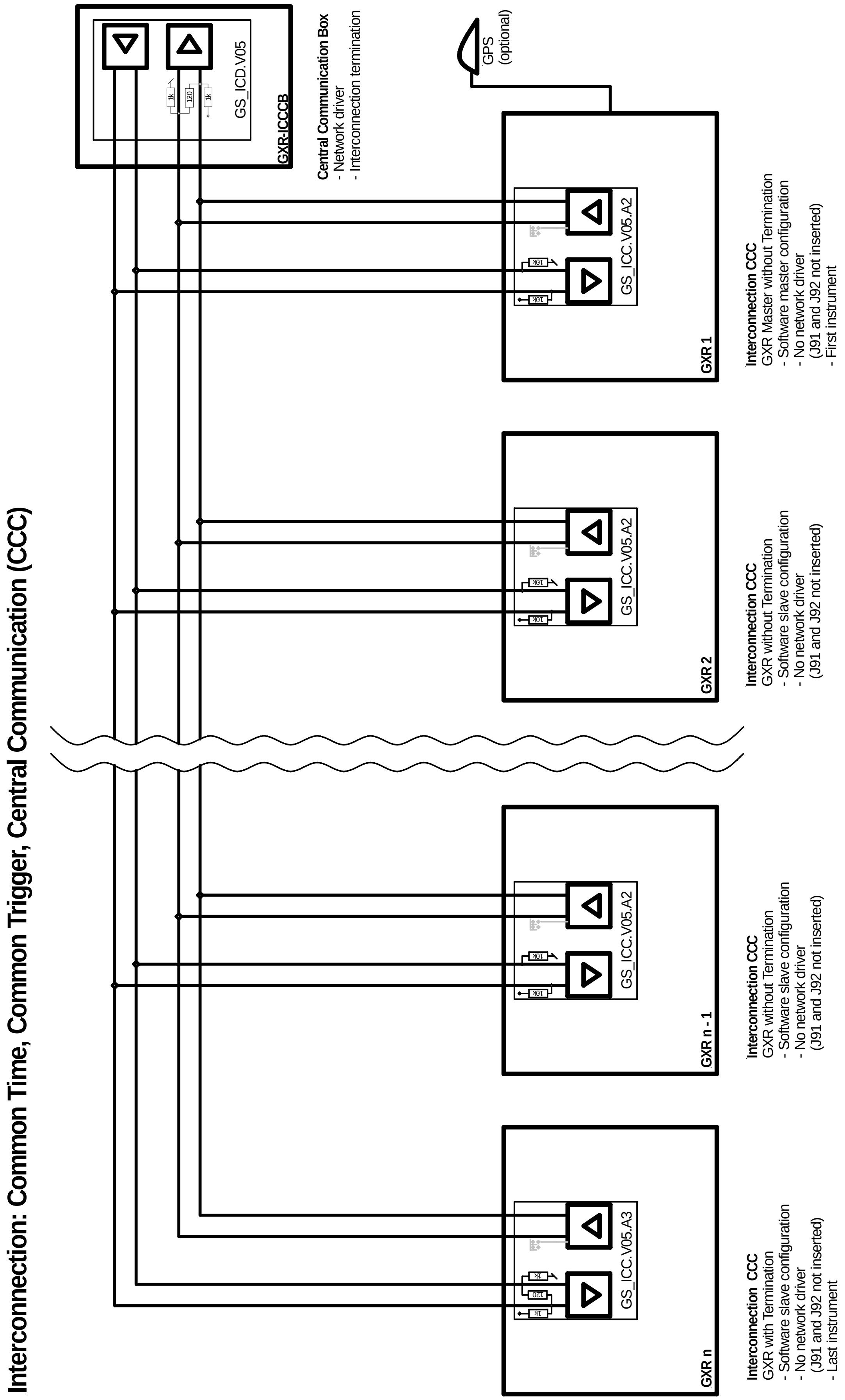

Figure 10. Interconnection Network setup CCC

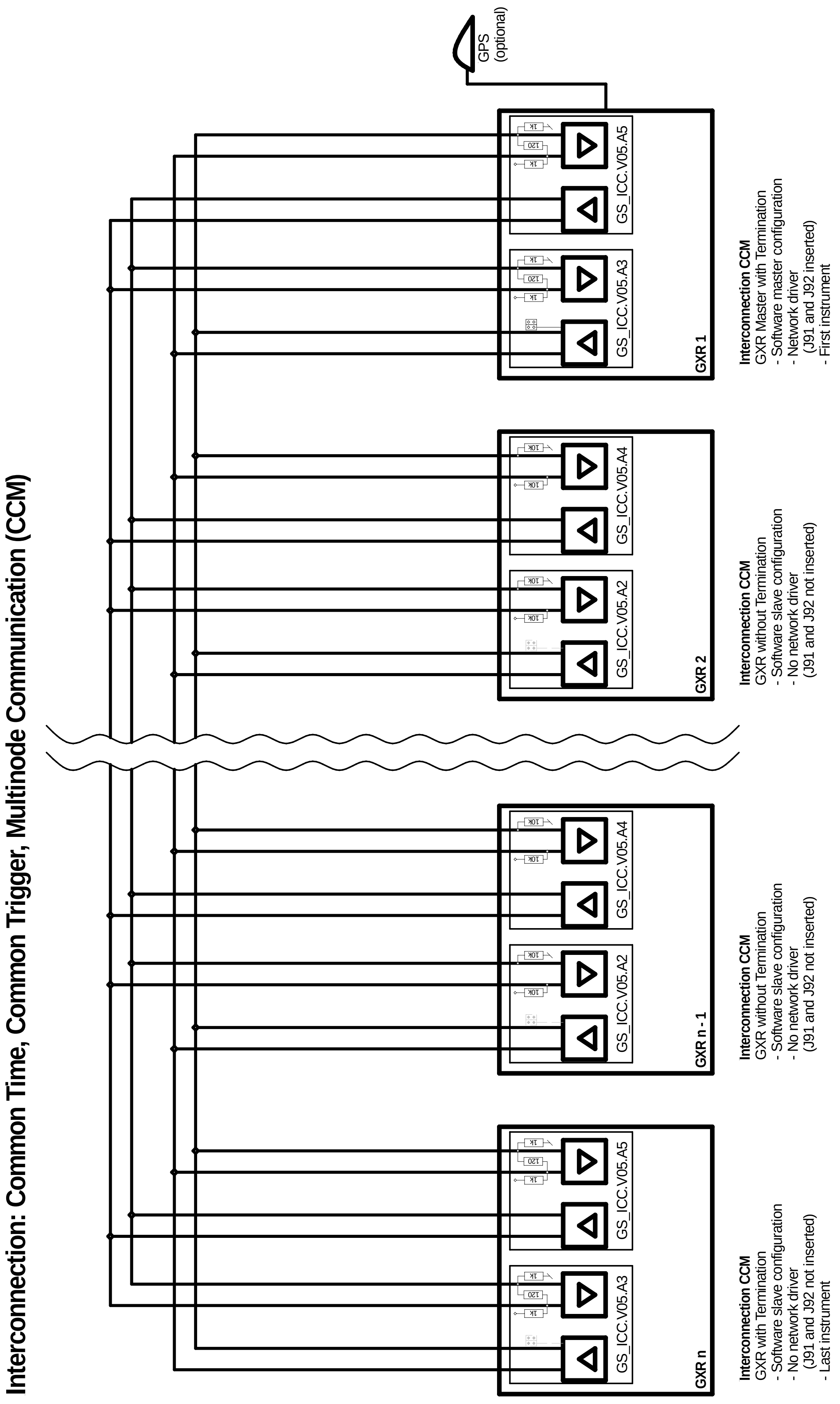

Figure 11. Interconnection Network setup CCM

2.2.4. Software Configuration

In order to allow Common Time and Common Trigger in the network the recorders need to be configured to this respect.

Figure 12 shows the configuration of the Software Master. The following ticks are fixed and cannot be changed.

Software Master:

- *Enable Network Synchronisation*
- *Network Master Mode*

Figure 13 shows the configuration of the Software Slave. The following ticks are fixed and cannot be changed.

Software Slave:

- *Enable Network Synchronisation*
- *Network Master Mode* IS NOT TICKED

Optional:
- *Input Network Trigger*
- *Output Network Trigger*
- *Synchronise Slave Clock to Network Clock*

For a description of the Synchronisation options please refer to Chapter 1. For more details on the use of GeoDAS please refer to the GeoDAS Software Manual.

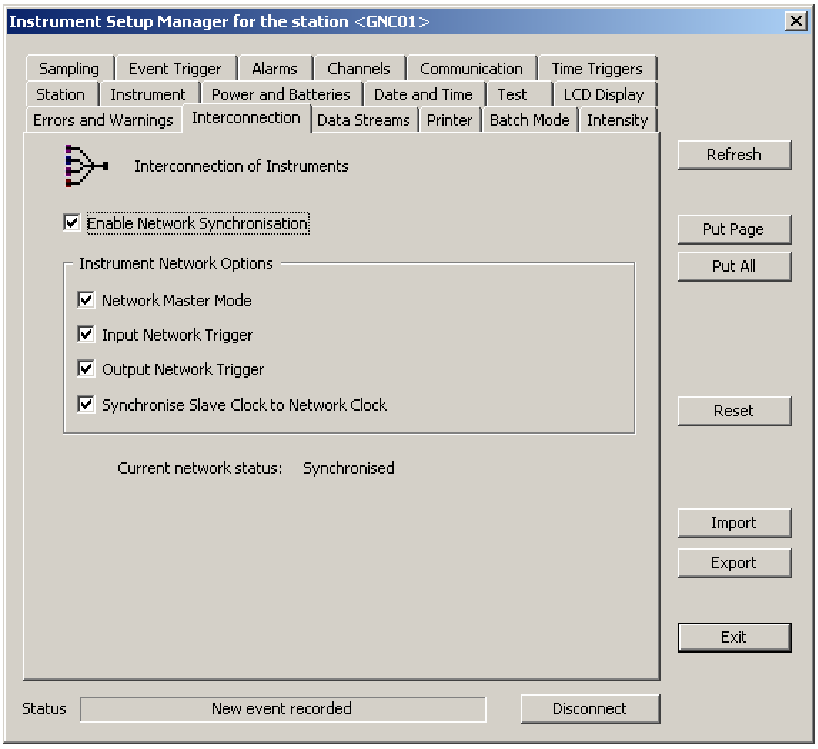

Figure 12. Software Master configuration in GeoDAS

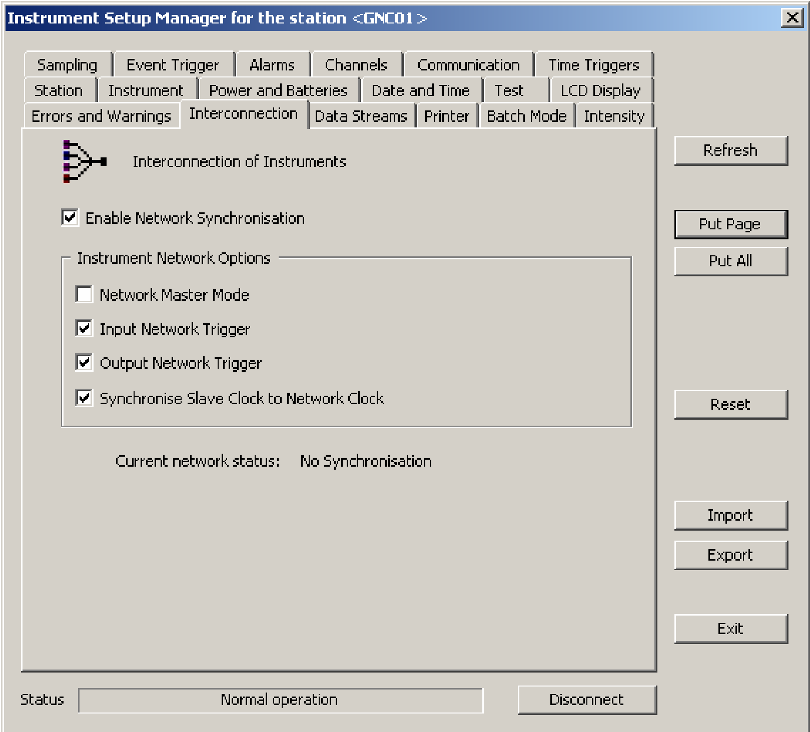

Figure 13. Software Slave configuration in GeoDAS

2.3. Verification of the Installation

If the network is synchronised (Common Time and Common Trigger are working) the network status of every recorder in the network, shows the word *Synchronised* (see above Figures 12 and 13 where the opposite is indicated) in GeoDAS. The synchronisation of the date and time of all Software Slaves to the Software Master should be verified and also the network triggering options.

A simple way to check the wiring during the installation is to verify the arrival of the network signals to an instrument. For this test the recorders need to be configured correctly. The following LED's can be found on the interconnection cards (GS_ICC_V5) inside the recorder (by removing the black plastic cover):

Caution: High Voltage!
If you remove the black plastic covering the base part of the recorder housing do not touch any electronics inside.

- LED90, yellow: Blinks in all recorders
- LED91, red: Blinks in the recorders configured as Network Drivers and in the Central Communication Box
- LED92, green: Blinks in the recorder configured as Software Master and during a trigger also in the corresponding Software Slave.

The communication option can be tested by simply trying to establish a connection to the instruments from a Computer running GeoDAS. The standard communication speed for Interconnection Networks is 38'400 Baud. If communication problems arise during installation the following LED's, found also on GS_ICC_V5, can be of help:

- LED60, yellow: Communication transmit signal
- LED61, green: Communication receive signal

Both LED's should blink during successful communication.