SERIAL COMMUNICATION MANUAL

March 2003

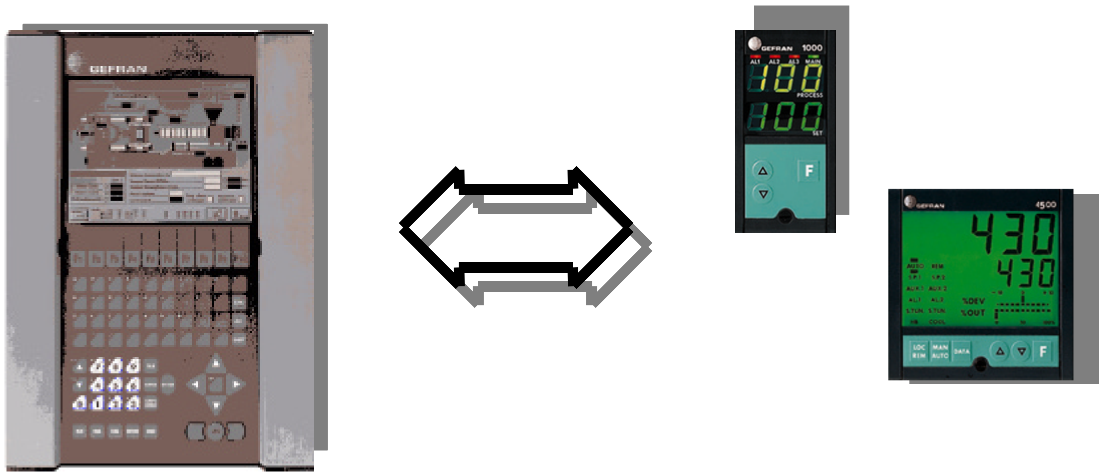
INDEX

CHAPTER 1

SERIAL COMMUNICATION INTRODUCTION

CONTENTS

Serial Communication Introduction



Industrial Personal Computer

Instruments
(Slave)

" Digital communication " means the complex of the operations through which the connection between electronic equipments, such as instruments, plc or industrial terminals, and a personal computer (then called PC) is carried out.
The PC (which works as a Master) interrogates the connected equipments (Slaves) and asks for
the requested information, such as the input measured value, the alarm state etc.
To implement this functionality it is necessary to check the following conditions:

PC (Master) and devices (Slaves) must be provided with the same Hardware interface, as there are many standard versions available with different electrical features (i.e. among the most used: RS232, RS485, RS422 and Current Loop).
Should the Master and the Slaves have different HW interfaces, it is necessary to connect a suitable converter (such as Gefran **CLB94**), **which also optoisolates the communication line**.

PC (Master) and devices (Slaves) have to use the same communication protocol (that is: " they have to speak the same language "). The protocol used by GEFRAN is a " proprietary " one, which means that it has been developed by GEFRAN itself to optimize the serial communication with its own instruments. Its name is CENCAL.
MODBUS protocol, an approved standard, is available on more advanced models.

HW Interface

GEFRAN uses the following serial communication standards:

- RS232
- RS 485
- 4-wire RS 485
- Current Loop (not provided in the new instruments)

Important Note:
Our instruments provide a 4-wire multi-point connection (4-wire RS485), as they can also support the RS422 standard, which differs from the 4-wire RS485 connection being only a transmission/receiving connection between two single units (a Master and a Slave) and not providing the condition of the line third status (open collector).
Only the RS485 connection (either 2 or 4 wires) allows to have more than a Slave.

From now on, the RS485 connection will define a 2-wire connection, while the 4-wire RS485 connection will define a 4-wire one.

Standard RS232 Serial Line

It is an EIA standard which defines the serial interface electro/functional features for the connection between two systems/equipments.
The information is transmitted through a voltage signal referred to a ground wire (the value of each bit is decodified by the receiver on the base of the measured voltage value).
This solution allows a PC direct connection with an instrument equipped with RS232 serial interface within short distances. Available transmission speeds are: 1200, 2400, 4800, 9600 and 19200 bauds.
Its limits concern max. speed, which does not exceed 20 Kb/sec, and max. distance between the equipments, which cannot be higher than 15 meters, due to the low immunity from electromagnetic disturbances. One only Slave unit can be connected. The unique advantage concerns the cheap price.

Standard RS485 and 4-wire RS485 Serial Communication

Voltage is the feature of the signal which “ carries ” the information, but, unlike RS232, where voltage is measured with respect to a ground wire, here it is measured in a “ differential ” way between two wires: one “ carries ” the signal and the other one “ carries ” the disabled signal. In this way a higher immunity from disturbances is reached and wider distances can be covered. For these two standards it is necessary to use PCs and instruments equipped with a proper RS485 or 4-wire RS485 interface, that is to use two CLB94 modules (4-wire only) or ADAM (2- and 4-wires), which convert, from one side (PC) the RS232 into a RS485 or a 4-wire RS485 towards the instrument side. Selectable transmission speeds are: 1200, 2400, 4800, 9600 and 19200 bauds.

The EIA RS485 standard features provided for half-duplex protocol can be considered valid:

- max. 10 Mbps data rate within 12 meters
- distances up to 1.2 Km with 100 Kb/sec speed
- max. 32 instruments connected on a single line
- line terminals with two 220 Ohm resistances at the edges
- differential transmission with low electromagnetic emission

" Passive " Current Loop Serial Connection

Current is the feature of the received signal which " carries " the information. This solution requires, for the connection with a supervision PC, a RS232/Passive Current Loop converter (i.e.: Gefran CLB94 module). The converter, which has to be placed within 2…3 meters from a PC and supplies the necessary current both in receiving and in transmission (for this reason the connection is called " passive "), can support up to 10 Slave units within a 100 meter distance. Standard bauderate is 1200 bauds.

Calculation of the **max. number of network-connectible instruments,** according to the electrical connection selected using a **CLB/94** converter.

CLB/94 Output	**CLB/94 V Outout**	**CLB/94 I max**	**CLB/94 Max. Impedence**	**Gefran Instrument RX+/RX- Input Impedence**	**Single Instrument I**	**Max. N° of Instruments**
4-wire RS485	10V	30mA	-	12Kohm	0.83mA	**36**
Parallel Current Loop	24V	240mA	-	1Kohm	24mA	**10**
Serial Current Loop	24V	20mA	1200ohm	90ohm	-	**13**

Voltage, current, impedence values listed in this table are to be used to evaluate other possibile serial converters to be used in the future, or which are already part of the network.

More Complex Configurations

If a higher number of instruments has to be connected, or if the distance to be covered is wider, the aim can be achieved in three different ways:

a) Serial Current Loop (**CLB**) : it is necessary to replace the 10th instrument with a CLB94 and connect the additional instruments from this point on.

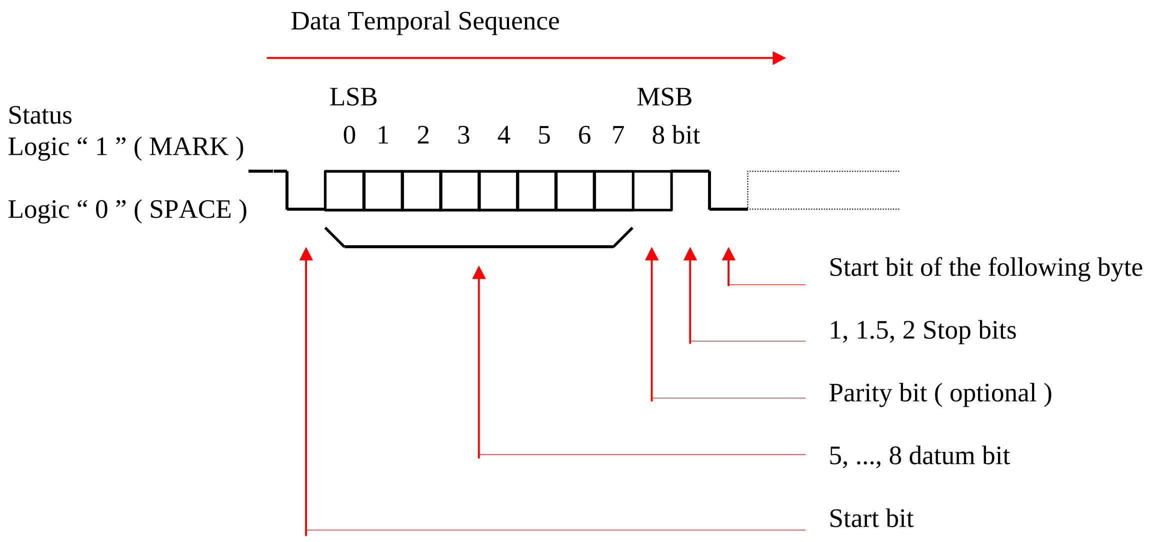
b) Parallel Current Loop (**CLB**): up to three cascade-connected CLB94s (the first one for the RS232/Current loop conversion and the other two in Current Loop), to cover an overall distance of 300 meters.

c) Up to 32 instruments can be connected via RS485 or 4-wire RS485 by using an **ADAM 4520** converter.
Should you have to connect more than 32 instruments, you can use an **ADAM 4510 repeater**, which extends the network to 32 more instruments, increasing the distance of 1200 meters.

Furthermore, different units equipped with different communication interfaces can also be connected in a single multidrop structure (that is, a structure made up by several objects serial-connected),
using the appropriate CLB conversion modules.

Asynchronous Protocol

The asynchronous transmission does not require the simultaneous transmission of a reference signal necessary to the receiver for the sampling of the signal itself. An asynchronous transmission system finds in the format itself a synchronization element (example: the always present Start bit).
Here is the format of an asynchronous transmission.
The structure of a byte with 5, 6, 7, 8 datum bit, with or without parity bit is represented in the following diagram.

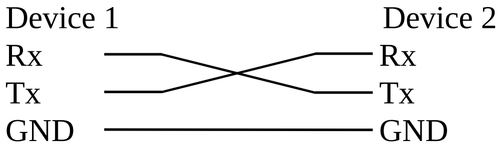


Communication Problems?

Here are some easy indications for a correct functioning quick check of RS232, RS485, 4-wire RS485, Current Loop communication lines.
A multimeter is required to check connections and voltage and resistance values.
On the contrary, an oscilloscope is necessary to make more specific inspections, such as the detection of wave-forms.

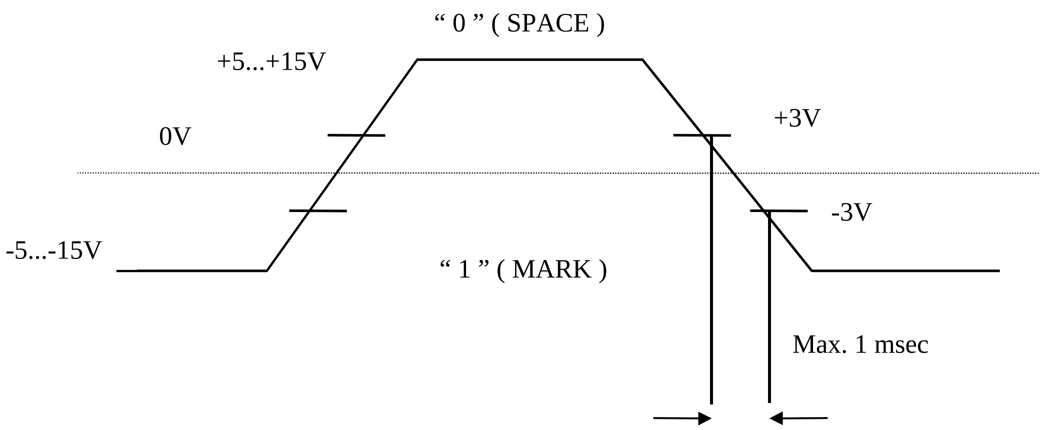
RS232

The line is made up of three conductors, a GND reference and two Rx and Tx.
The signal names are assigned and they refer either to the PC or to the instruments. The Rx signal receives and the Tx signal transmits data.
This statement justifies the connection between two units, where the Tx signal of a device is connected to the Rx signal of the other one.



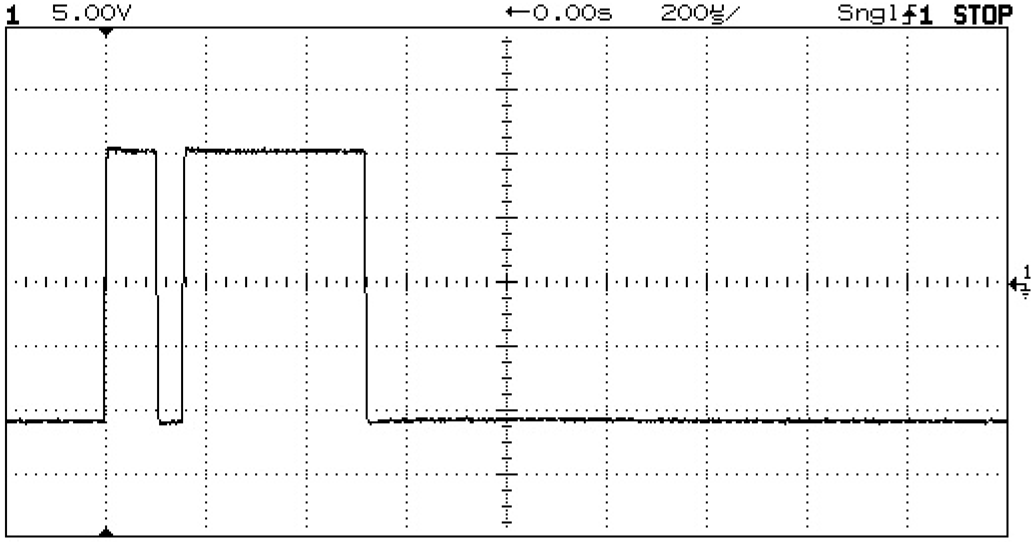
Main checks for a correct working:

a. Check the electrical connection and individuate the Tx, Rx, GND signals
b. If the line is not active, the “ 1 ” (MARK) logic state is present. It corresponds to a -5...-15V negative voltage and can be measured with a tester
c. By an active communication line, the wave-form presents logic state variations at “ 0 ” (SPACE), corresponding to a 5...15V voltage value
d. The conformity of the wave with the following model can be monitored with a standard oscilloscope:

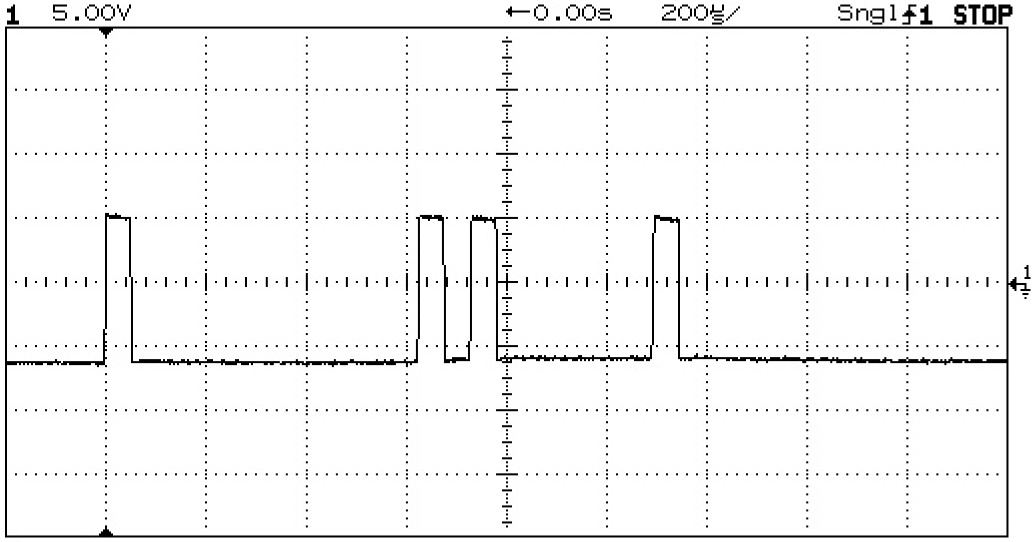


e. The input resistance measured between Rx and GND has to be lower than 3...7 KOhm

Signal measured between RX+ and RX- by a 600 instrument. (Probe earth on RX-)
No communication on the line = -12V
Analyzed message = $02 = 00000010B



Signal measured between TX+ and TX- by a 600 instrument. (Probe earth on TX-)
Instrument not selected = 0V
Instrument selected = -6V
Analyzed message = $FFFE = 11111111 11111110B



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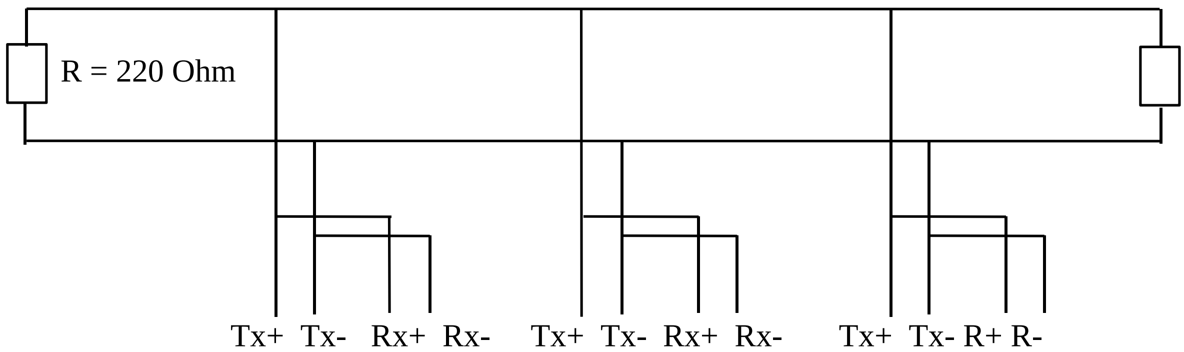
RS485

The line is made up of two conductors and of an additional ground reference optional one. The signal is differential.
This type of connection is apart from the task which has the device connected to the line.
It has to be noticed that the 2-wire RS485 connection can be obtained by a 4-wire interface, connecting Rx+ with Tx+ and Rx- with Tx-.
The line polarization is necessary to avoid an indeterminated status when this is in high impedance. The polarization type has to impose a MARK status.
In this case the Master unit transmits a message and all Slaves receive it. At the end, if a Slave has
to answer, it works like a Master and sends its own message. A peculiar feature of this connection is represented by the fact that all devices connected to the line receive everything passing on it.



The RS485 standard provides **a max. of 32 units** connected in parallel.

Each connected unit causes the Tx port high impedance, which means that no electrical status is imposed to the line itself. When an element has to transmit, it activates its own transmission line through a RTS signal (transmission request). The element which transmits receives the transmitted data, too.

Remarks:

The 2-wire RS485 connection with PC/AT cards is the following one:

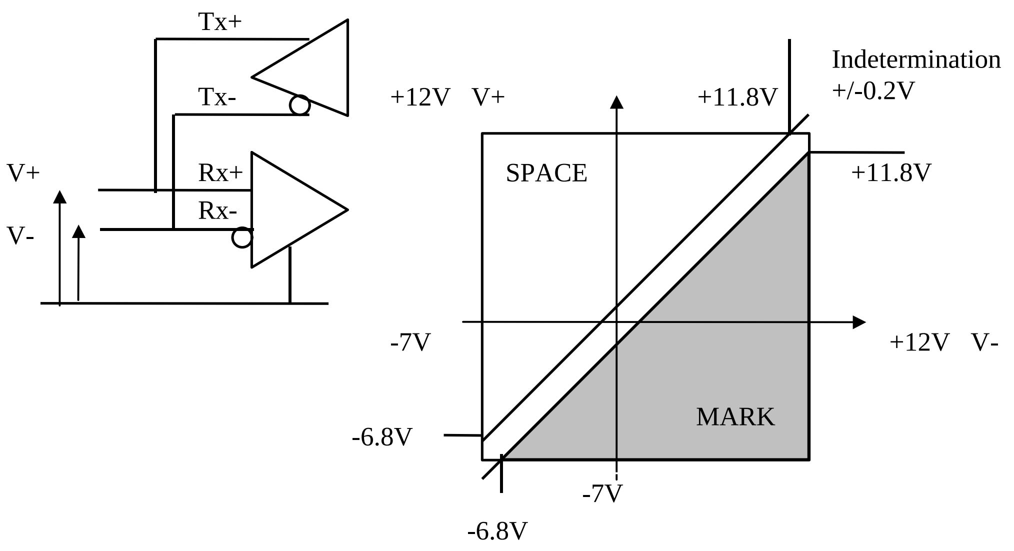
PC/AT (Master)		Gefran Instruments
A+ (RXD/TXD+)	↔	Tx/Rx-
B- (RXD/TXD-)	↔	Tx/Rx+

The 2-wire RS485 connection through an ADAM converter is the following one:

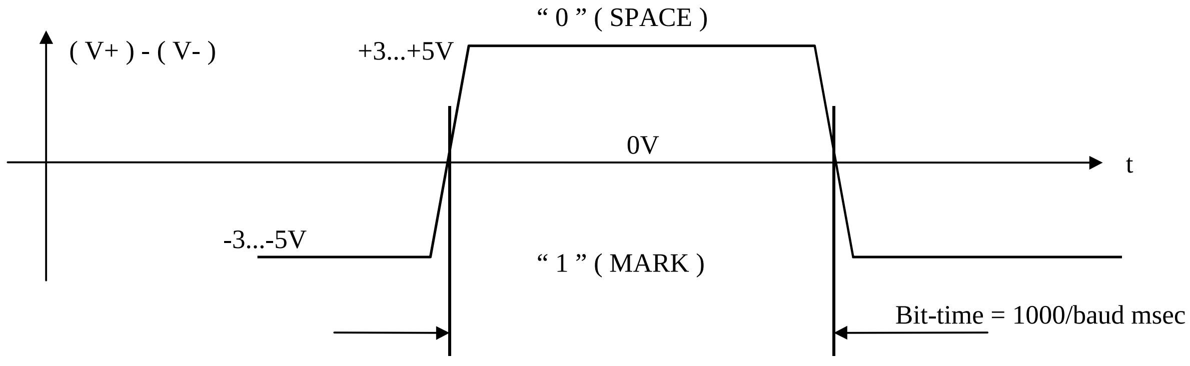
PC/AT (Master)		ADAM IN(RS232)	ADAM OUT(RS485)		Gefran Instruments
RX	←	TX	DATA +	↔	A
TX	←	RX	DATA -	↔	B
GND	—	GND			

Main checks for a correct working:
(Tx and Rx refer to Gefran instruments connections)

a. Check the electrical connection and find Tx+/Tx-, Rx+/Rx- signals
b. If the line is not active and if it is polarized, the “ 1 ” (MARK) logic state is present. It corresponds to a -3...-5V negative voltage (V+) - (V-) (which is in the -0.2...-19V allowed interval) and can be measured with a tester
c. By an active communication line, the wave-form presents logic state variations at “ 0 ” (SPACE), corresponding to positive voltage value (V+) – (V-)



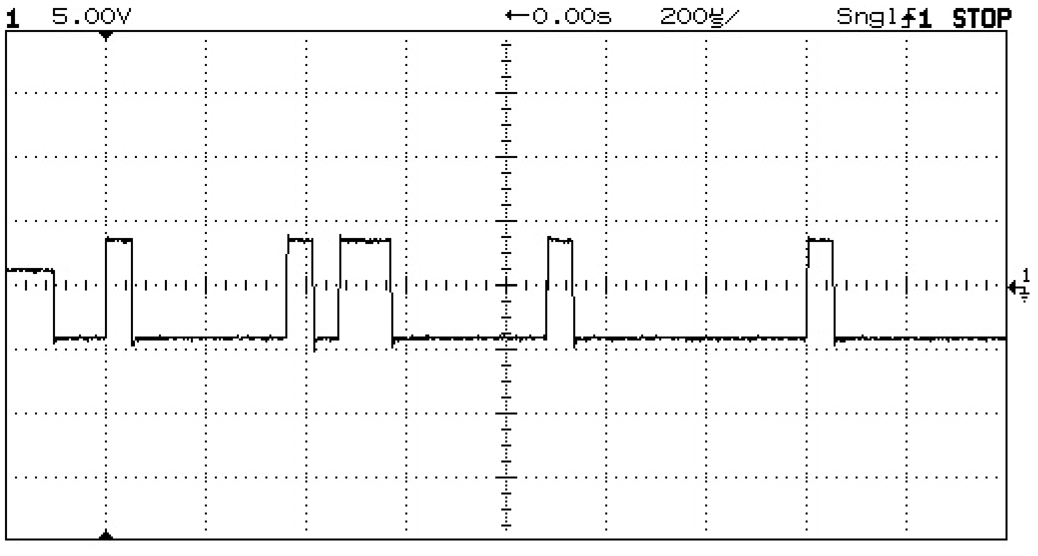
d. The conformity of the wave with the following model can be monitored with a standard oscilloscope:



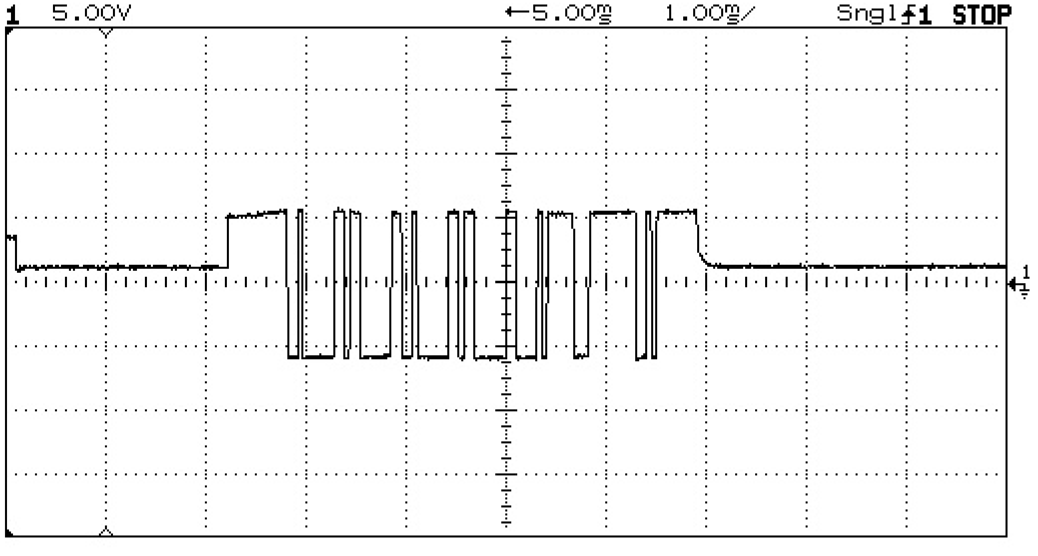
e. The line resistance measured between + and – has to be higher than 60 Ohm; without terminals it has to be higher than 12 KOhm/n. connected devices

Connection: PC->ADAM->600
Modbus Protocol:

Signal measured between A and B by a 600 instrument. (Probe earth on B)
No communication on the line = 1V
Analyzed message = $02-$03-$00 = 00000010B 00000011B 00000000B



Signal measured between A and B by a 600 instrument. (Probe earth on B)
Selected instrument = 1V
Analyzed message = $02-$03_$02… = 00000010 00000011 00000010B



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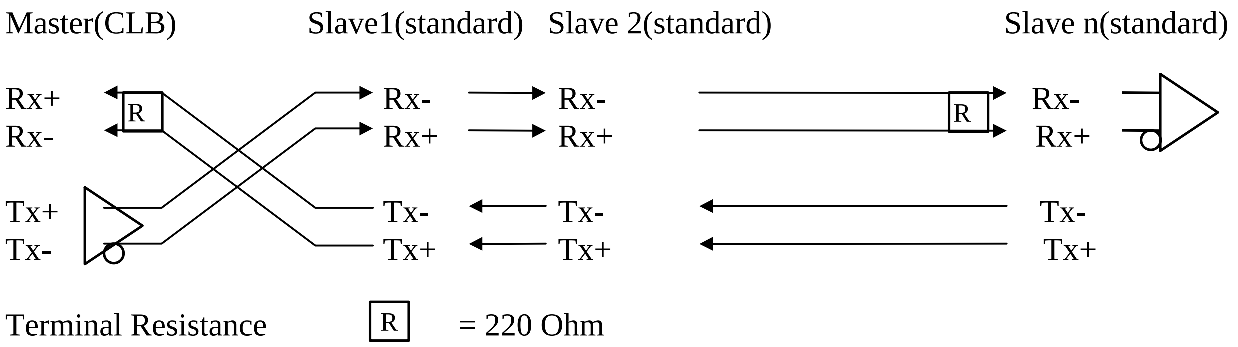
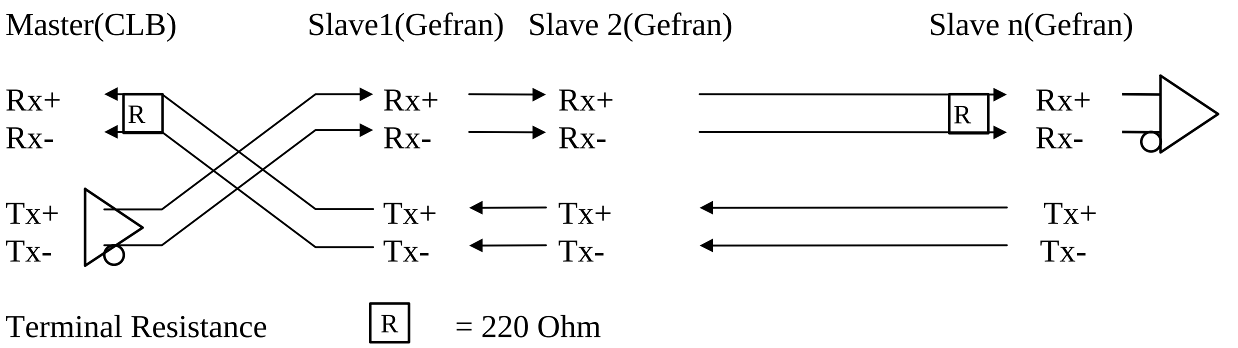
4-wire RS485

The line is made up of four conductors, of an additional ground reference optional one, of two differential signals Rx+/Rx- and Tx+/Tx-.
The signal names are assigned and they refer either to the PC or to the instruments. The Rx signal receives and the Tx signal transmits data.
This statement justifies the connection between the units, where the Master (PC) Tx signal is connected to the Slave (instruments) Rx signal and viceversa.
It has to be noticed that the RS422 connection concerns a transmission/receiving connection between two units only (a Master and a Slave); only the 4-wire RS485 connection allows to have more than one Slave.





Remarks:

The 4-wire RS485 connection with PC/AT cards is the following one:

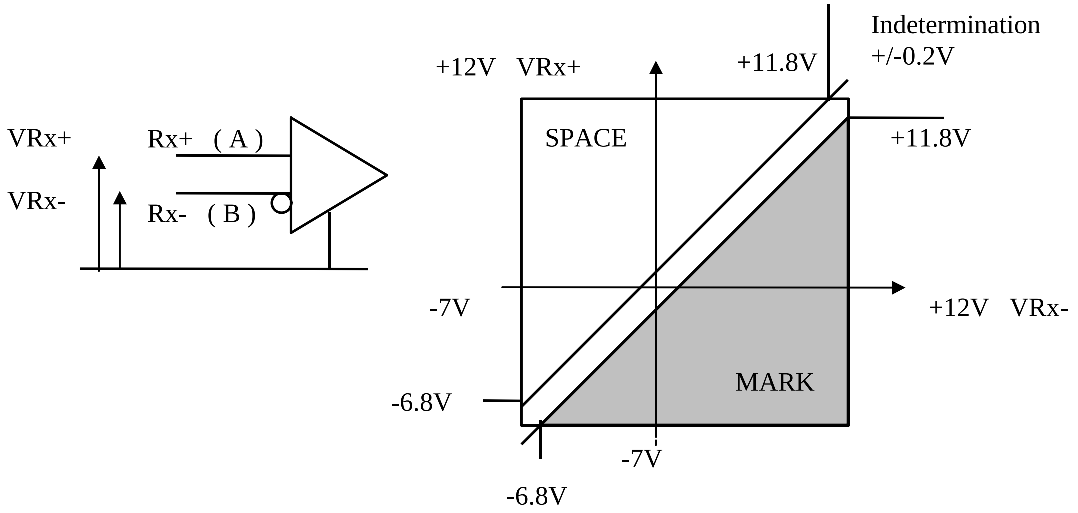
PC/AT (Master)		Standard Instruments	Gefran Instruments
RXD+	←	Tx+	Tx-
RXD-	←	Tx-	Tx+
TXD+	→	Rx+	Rx-
TXD-	→	Rx-	Rx+

Main checks for a correct working:
(Tx and Rx refer to connections with Gefran instruments)

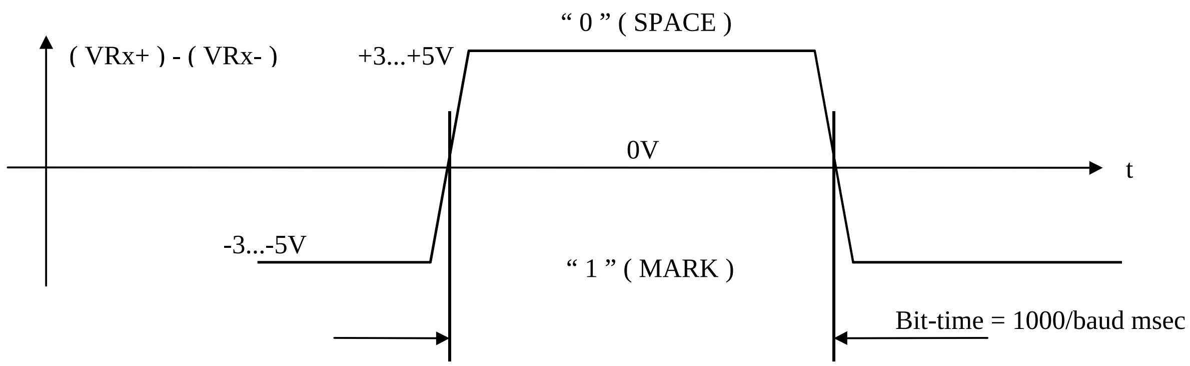
a. Check the electrical connection and individuate the Tx+/Tx-, Rx+/Rx- signals
b. If the line is not active, the “ 1 ” (MARK) logic state is present. It corresponds to a -3...-5V negative voltage (VRx+ - VRx-) (which is in the admissible interval -0.2...-19V) and can be

measured with a tester

c. By an active communication line, the wave-form presents logic state variations at “ 0 ” (SPACE), corresponding to a positive voltage value (VRx+ - VRx-)



d. The conformità of the wave with the following model can be monitored with a standard oscilloscope:

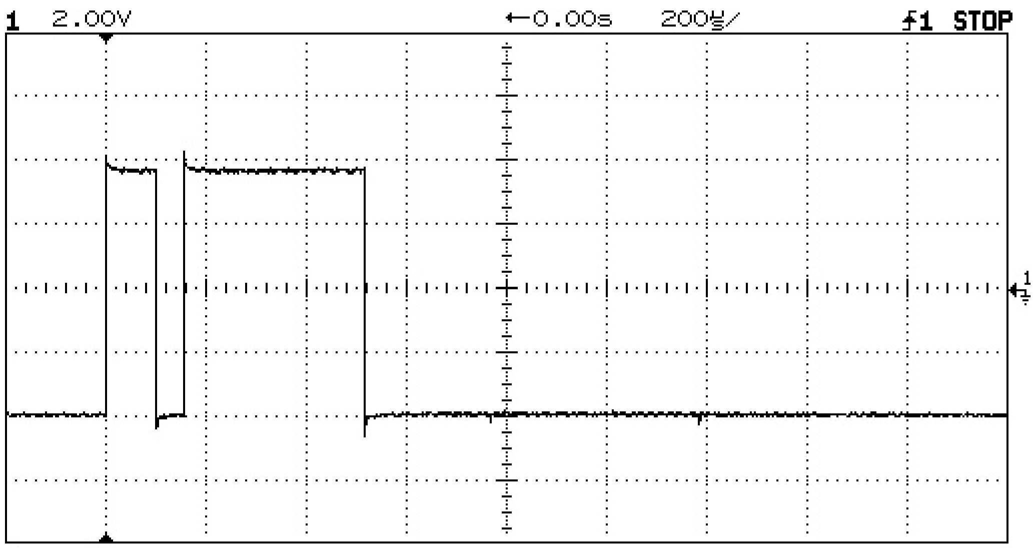


e. The input resistance of each receiver measured between Rx+ and Rx- has to be higher than 12 KOhm; without terminal resistance it has to be higher than 12 KOhm/n. connected equipments

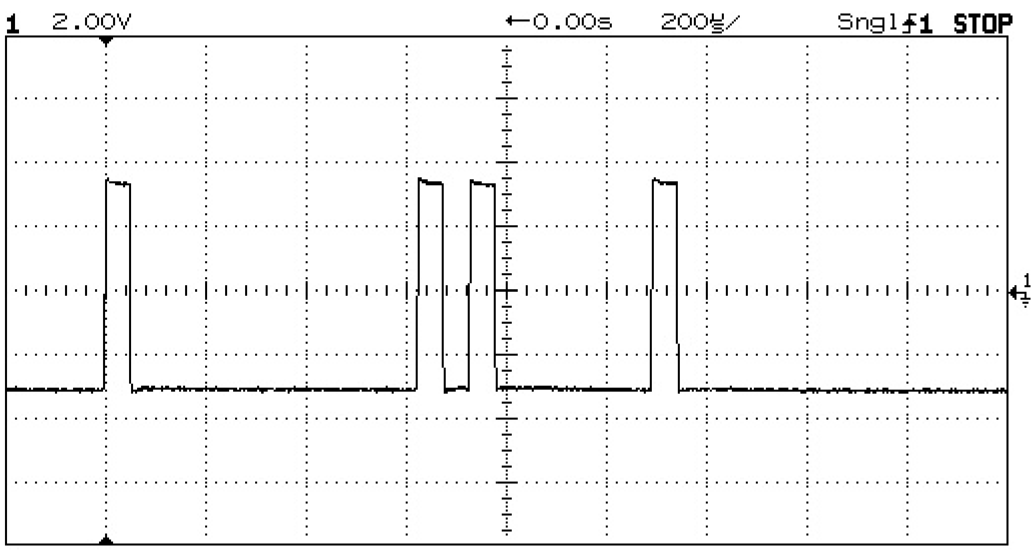
Connection: PC->CLB94->600
Cencal Protocol:
CLB94 jumper configuration:
Component side:

In the Cencal protocol, this polarization is used for signalling a possibile disabled line and it is the inverse of the stop bit level of trasnmitted data.

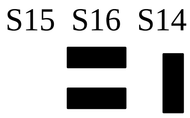
Signal measured between RX+ and RX- by a 600 instrument. (Probe earth on RX-)
No communication on the line = -4V
Analyzed message = $02 = 00000010B



Signal measured between TX+ and TX- by a 600 instrument. (Probe earth on TX-)
Instrument selected = -3V
Analyzed message = $FFFE = 11111111 11111110B



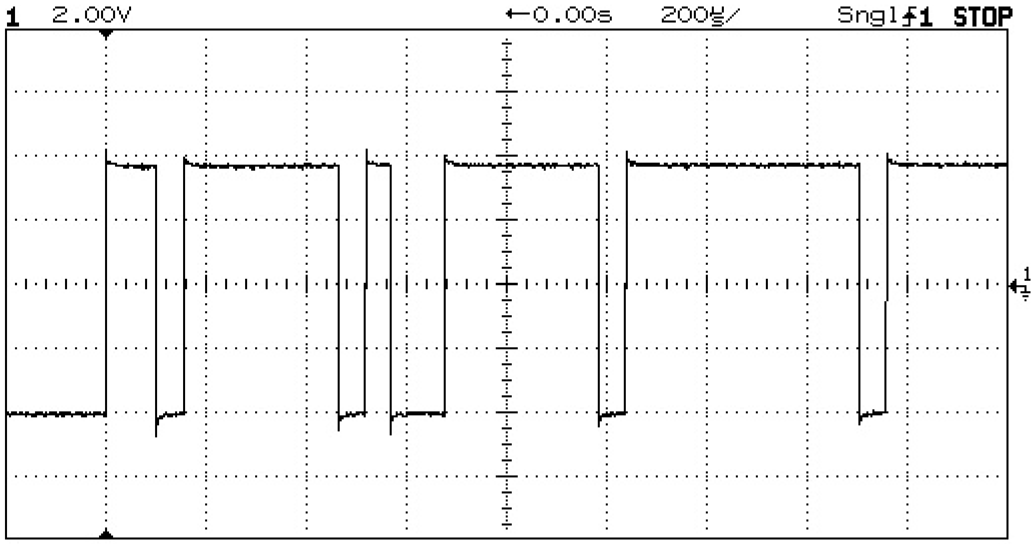
Modbus Protocol:
CLB94 jumper configuration:
Component side:



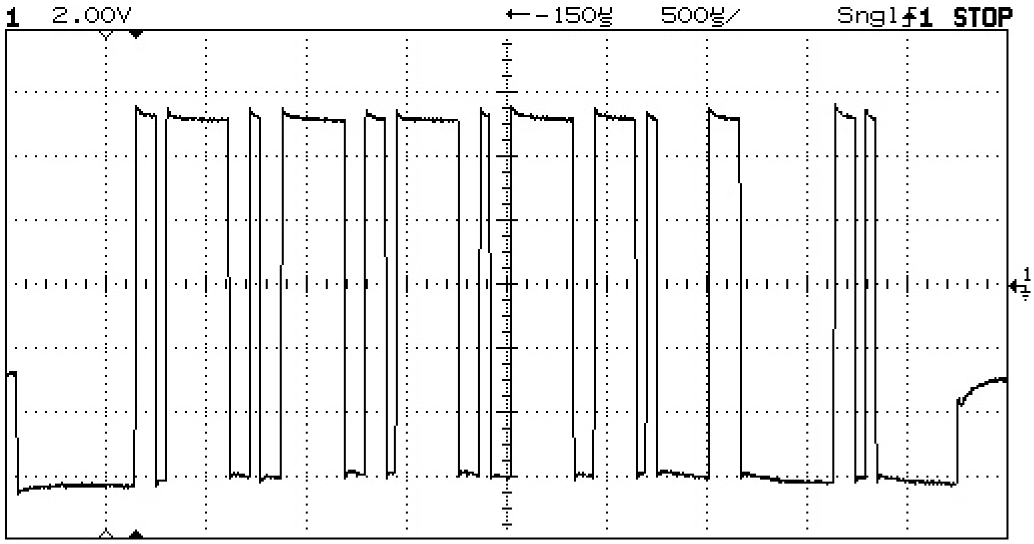
→ box bottom

In the Modbus protocol, in case of disabled line (**RTS** signal disabled), polarity has to follow data stop bit. An opposite polarity would cause a change of state at the end of a datum, which would generate an undesired start bit, sending an additional character on the line.

Signal measured between RX+ and RX- by a 600 instrument. (Probe earth on RX-)
No communication on the line = -4V
Analyzed message = $02-$03-$00 = 00000010B 00000011B 00000000B



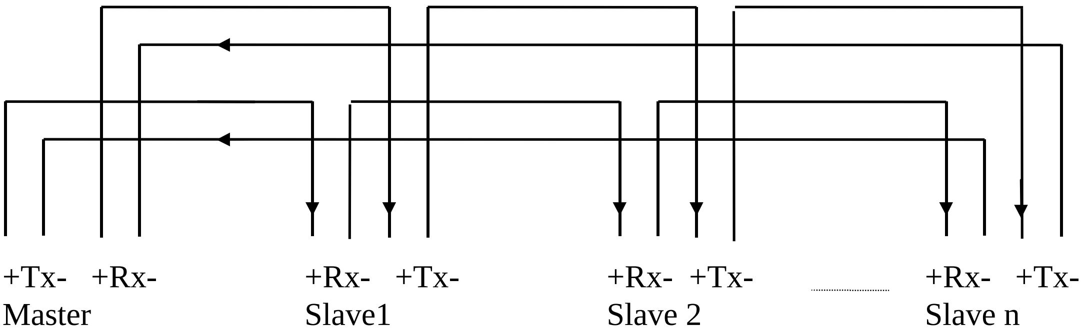
Signal measured between TX+ and TX- by a 600 instrument. (Probe earth on TX-)
Instrument selected = -3V
Analyzed message = $02-$03_$02… = 00000010 00000011 00000010B



Current Loop

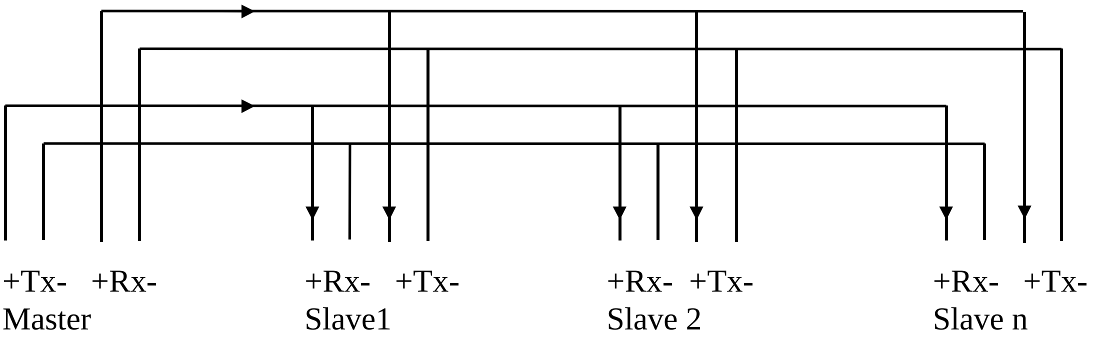
The line is made up of four conductors and of two Rx+/Rx- e Tx+/Tx- signals.
The signal names are assigned and they refer either to the PC or to the instruments. The Rx signal receives and the Tx signal transmits data.
This statement justifies the connection between the units, where the Master (PC) Tx signal is connected to the Slave (instruments) Rx signal.
Gefran instruments are equipped with current passive serial interface, the connection can be in series or parallel. The last one is suggested, in order to keep the continuity and works even if a Slave has been excluded:

Connection in series:



The Master active in transmission is an on-off current generator:
“ 1 ” (MARK) logic status, 20mA current
“ 0 ” (SPACE) logic status, 0mA current
The Master active in receiving has a 20mA current generator; the on-off modulation is made by the selected Slave; non-selected Slaves keep “ 1 ” (MARK) logic state and allow current circulation.

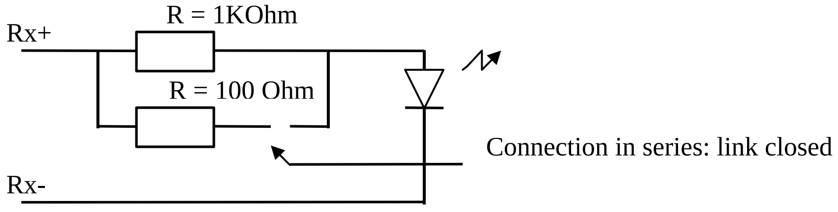
Parallel connection:



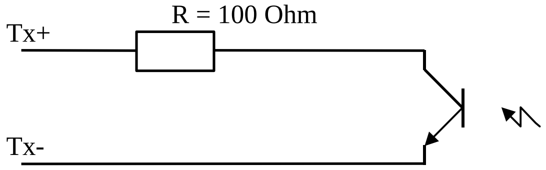
The Master active in transmission is an on-off voltage generator:
“ 1 ” (MARK) logic status, 20V voltage, (20mA * n.slave) current
“ 0 ” (SLAVE) logic status, 0V voltage, 0mA current
The Master active in receiving has a 20mA current generator; on-off modulation is made by the selected Slave; non-selected Slaves are in a high impedance state.

Current Loop Interface in Gefran Instruments

Two selectable resistances for series/parallel connection option are provided on the instruments, at the isolated passive input:



The transmission requires an isolated static switch:



Connection in series: jumper open, as shown in the manuals

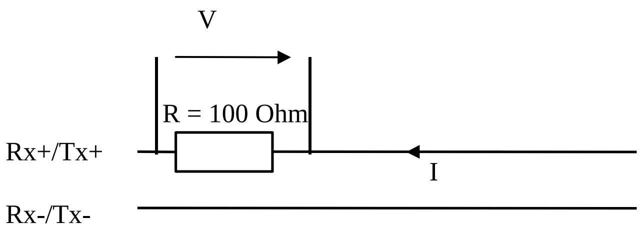
The Rx receiving line is isolated from the Tx transmission one.

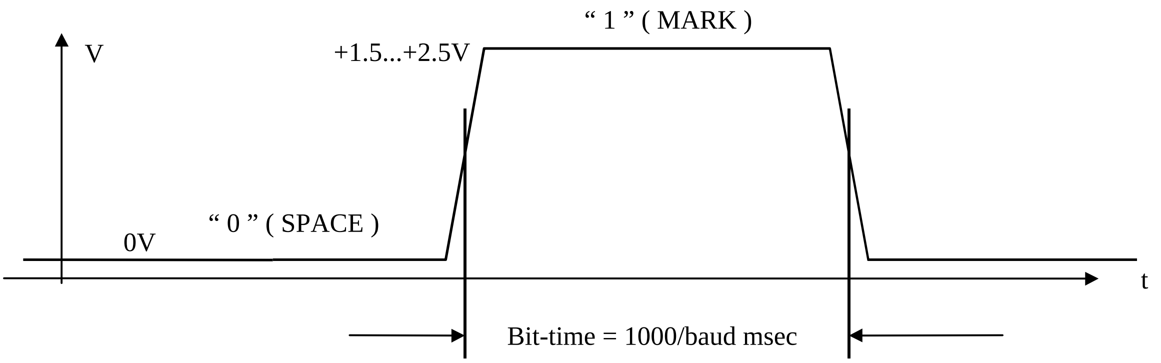
Gefran proposes the CLB94 converter for RS232/Current Loop matching.
Its main features are:

- electrical isolation between the RS232 line and the current line
- a 20V generator protection (in transmission) against short-circuits (max. 300mA) to supply a max. of 10 instruments connected in parallel
- a 20mA current generator (in transmission) on 600 Ohm max. load for connections in series
- a 20mA current generator (in receiving) on a 1.6 KOhm max. load

Main checks for a correct working:

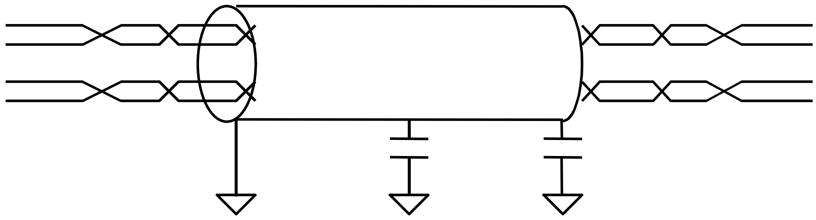
a. Check the electrical connection and find Tx, Rx signals
b. If the line is not active, the “ 1 ” (MARK) logic state is present, corresponding with current. It can be measured with a tester to be connected in series on the line
    - Connection in series: current is 20mA in the Master transmission line
    - Connection in parallel: current is 20mA* n.Slave in the Master transmission line
    - In the Master receiving line, current is 20mA
c. By an active communication line, the wave-form presents logic state variations at “ 0 ” (SPACE), corresponding to a null current
d. The conformity of the wave-form with the following model can be monitored with a standard oscilloscope, by measuring current through a shunt resistance to be put in series on the line connection terminals:





Connection

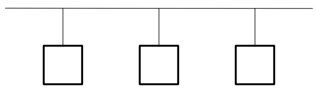
The connection can be made with a twisted pair cable, preferably screened



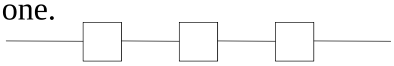
Connect the shield to the ground with clamps/bands, by one side only and, where possible, constrain it to the ground reference by means of capacities.
Do not insert serial connection cables in raceways where cables with high and pulse currents are present, such as, for example, motors with inverter drive.
Inside the electrical panel, where possible, use metal raceways and intersect power lines in an orthogonal way.

A-Z Glossary

baud – speed measure unit of a serial transmission. It corresponds to the number of bits transmitted in one second.
bit – base element of a binary numeric system (binary digit). It assumes value “ 0 ” or “ 1 ”
byte – set of 8 bits (8 binary digits). A byte assumes binary values between 0 and 255
capacity – physical element which mainly accumulates electric charge. If a direct voltage is applied at its poles, it works like an open circuit, if, on the contrary, an alternate high frequency voltage is applied, it works as a shortcircuit.
data rate – data transmission speed.
digital – it is associated to a physical event or quantity, which can be described by a finite number of states (i.e.: digital input, digital signal).
full duplex – transmission system which allows a device to transmit and receive data contemporaneously.
gnd - or ground, it identifies the reference potential of voltage measures in an electrical circuit.
half duplex - transmission system which allows a device to transmit and receive data transmission alternately.
impedance – ratio between voltage and current measurable at the poles of an electric network, composed by a real part and by a fictitious one.
logic status – element to describe digital quantities.
master – device which controls another one (Slave).
parallel (connection) – in a parallel connection the information reaches all connected devices contemporaneously.



parity – a serial transmission feature to control data integrity. It can be even or odd; from this depends the status of a bit added to the others to bring the number of bit = ” 1 ” to the declared parity value.
polarization – it gives a definite electrical status to a line when this is not given by elements connected to the line itself.
resistance (electric) – real/effective part of an impedance; element which dissipates active power when current is in phase with voltage applied across. It is measured in Ohms.
series (connection) – in a connection in series the information reaches the devices in a sequential way, it enters a device and comes out to enter the following one.



shunt – element to convert a current measure into a voltage one.
slave – device connected to another one (Master). “ Slave ” is controlled by Master.
terminal – element which imposes a definite impedance value to a transmission line.
voltage (electric) – quantity measurable as potential difference between two points of an electric network. It is measured in Volts.
wave-form – graphic representation (amplitude-time) of a physical quantity time flow.
word – set of two bytes (16 bit). A word assumes binary values within 0 and 65535

Electrical Connections (PC, converters, instruments**)**

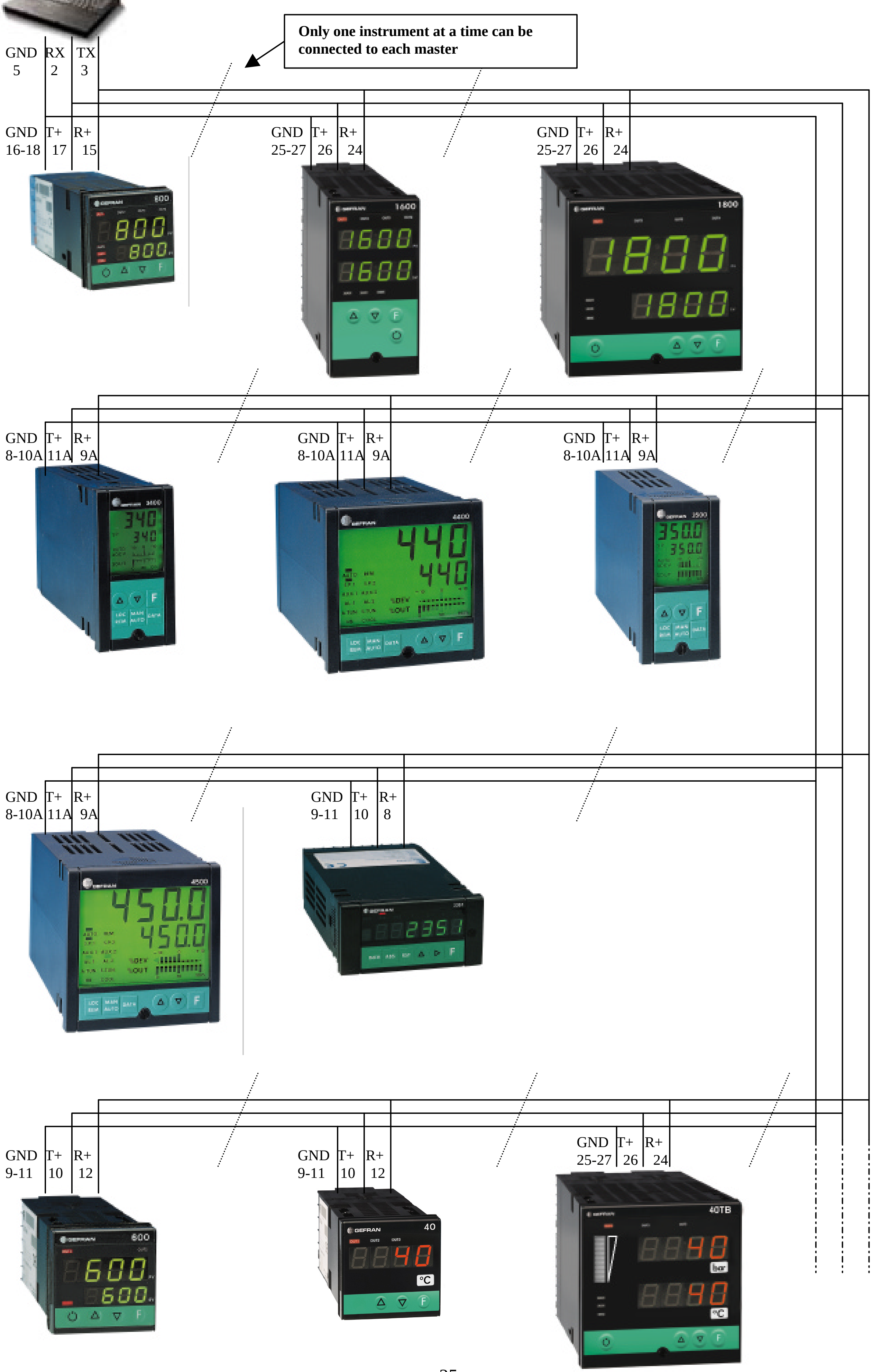
All available connections between a supervisory PC and Gefran instruments via RS232, RS485 and 4-wire RS485 are listed in the following pages.
The protocol used in the communication is independent on the electrical connection, apart from the RS485 connection, where Cencal protocol cannot be used.

Important Remark: when you use a CLB94 converter, you have to set the internal configuration jumpers accordino to input and output connections of the CLB itself. These settings are listed in the CLB94 manual.
If you use an ADAM converter, you have to select both the baudrate and the output connection (RS485 or RS422) simply by setting an internal dip-switch, which indication is given on the box of the converter itself.
ADAM converter RS422 output interfaces with the 4-wire RS485 interface of Gefran instruments, as indicated in the relating configuration described below.

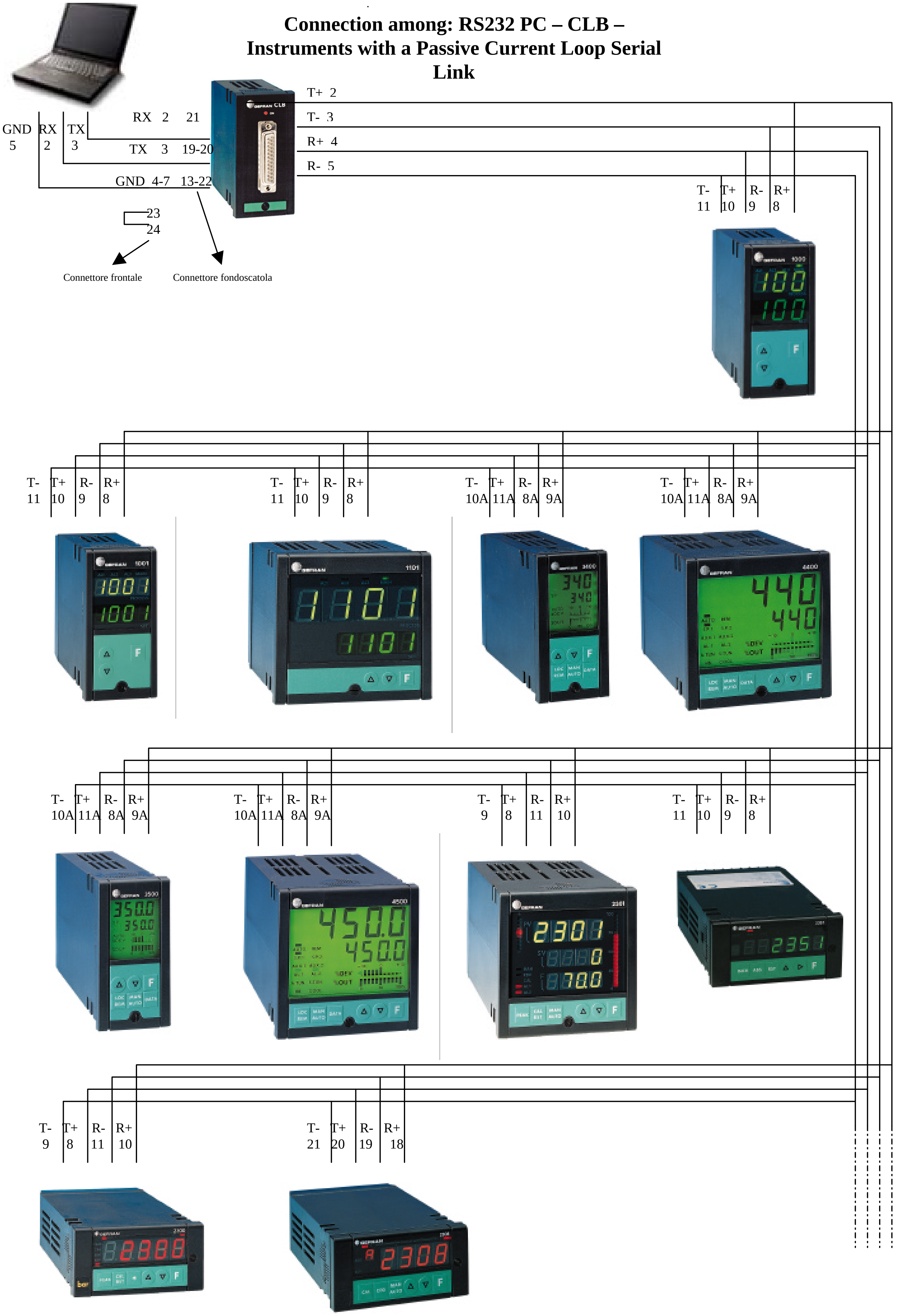
Gefran Instruments	**Default Serial Configuration (protocol-baud-parity-code)**	**RS232**	**RS485 (A-B)**	**4-wire RS485**	**Modbus Protocol**	**Cencal Protocol**	**Connector for Winstrum Cable**
600/601	Modbus-19200-none- 1	X	X	X	X	X	X
4-40T	Modbus-19200-none- 1	X	X	X	X	X	X
40TB	Cencal-1200- 1	X	X	X	X	X	X
GEFLEX	Modbus-19200-none- 1	X	X		X		
800	Cencal-1200- 1	X	X	X	X	X	X
1600	Cencal-1200- 1	X	X	X	X	X	X
1800	Cencal-1200- 1	X	X	X	X	X	X
2301	Cencal-1200- 1		X	X	X	X	
2300	Cencal-1200- 1		X	X	X	X	
2308	Cencal-1200- 1		X	X	X	X	
1000	Cencal-1200- 1			X		X	X
1001	Cencal-1200- 1			X		X	X
1101	Cencal-1200- 1			X		X	X
3500	Cencal-1200- 1	X	X	X	X	X	
4500	Cencal-1200- 1	X	X	X	X	X	
3400	Cencal-1200- 1	X		X		X	
4400	Cencal-1200- 1	X		X		X	
2351	Cencal-1200- 1	X		X		X	

N.B.: For 600 and 4-40T instruments ordered without serial interface, default configuration becomes : **Cencal-19200-code 1**.

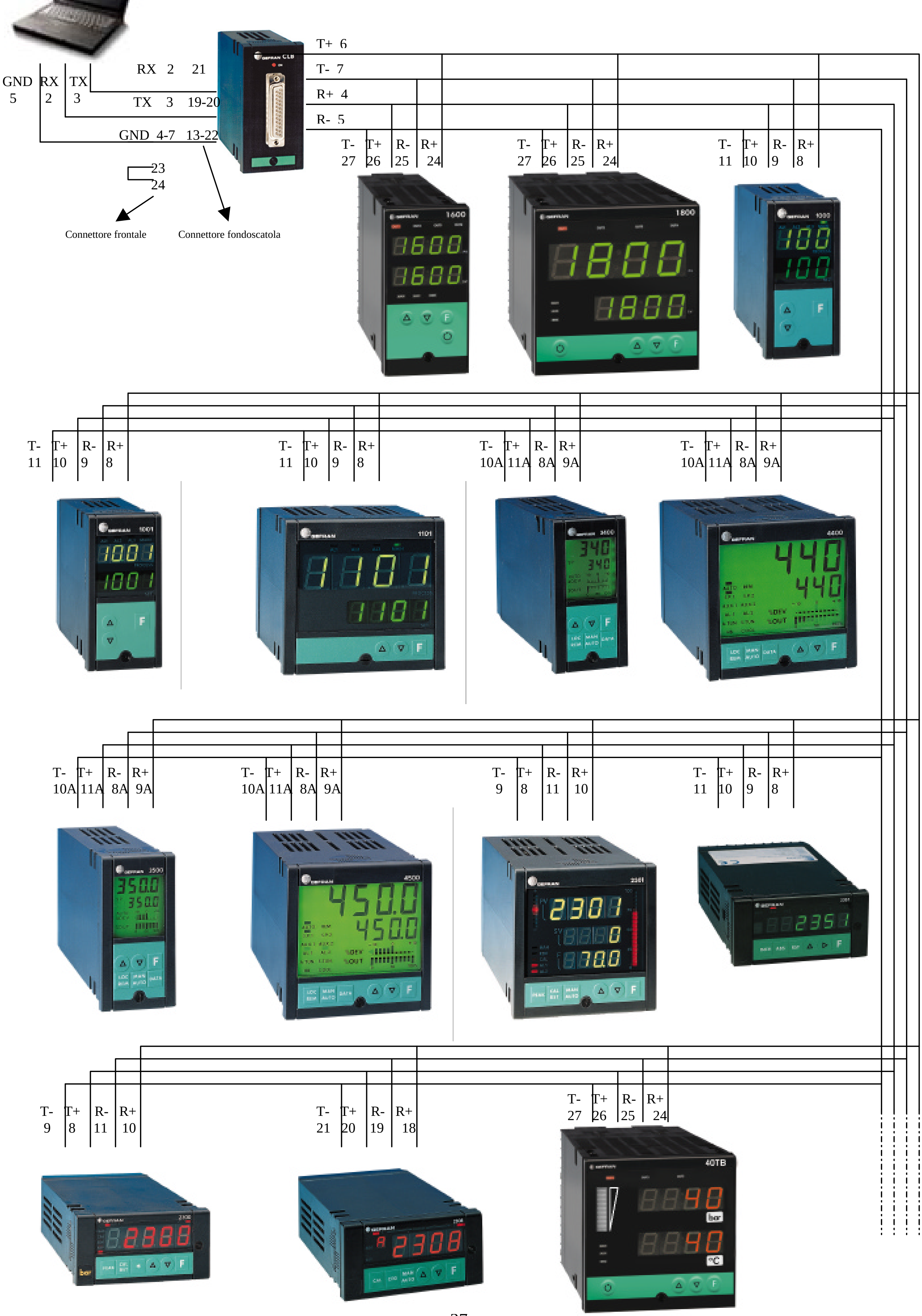
Point-to-point connection between: RS232 PC and Instruments with RS232C Serial Link



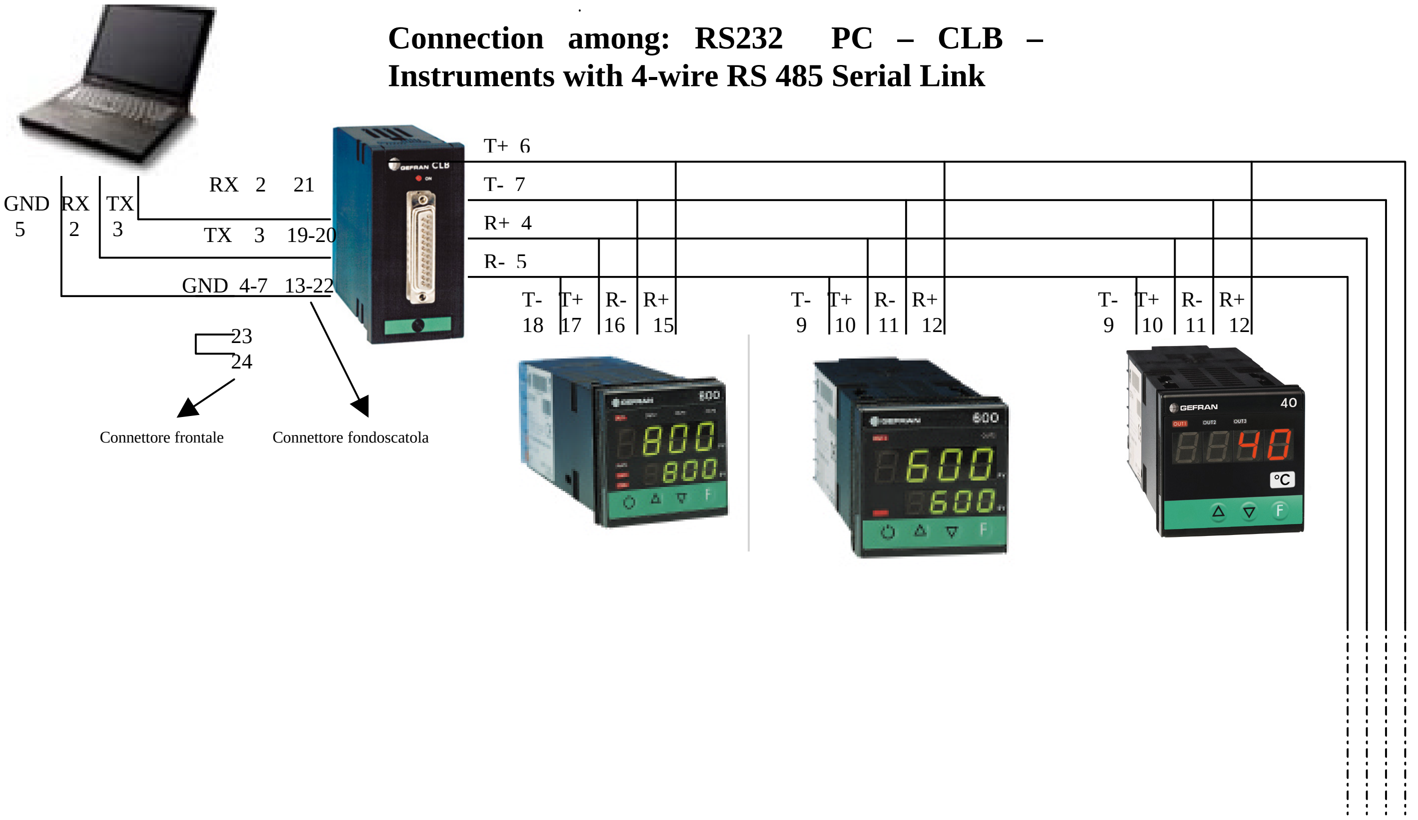
Connection among: RS232 PC – CLB – Instruments with a Passive Current Loop Serial Link



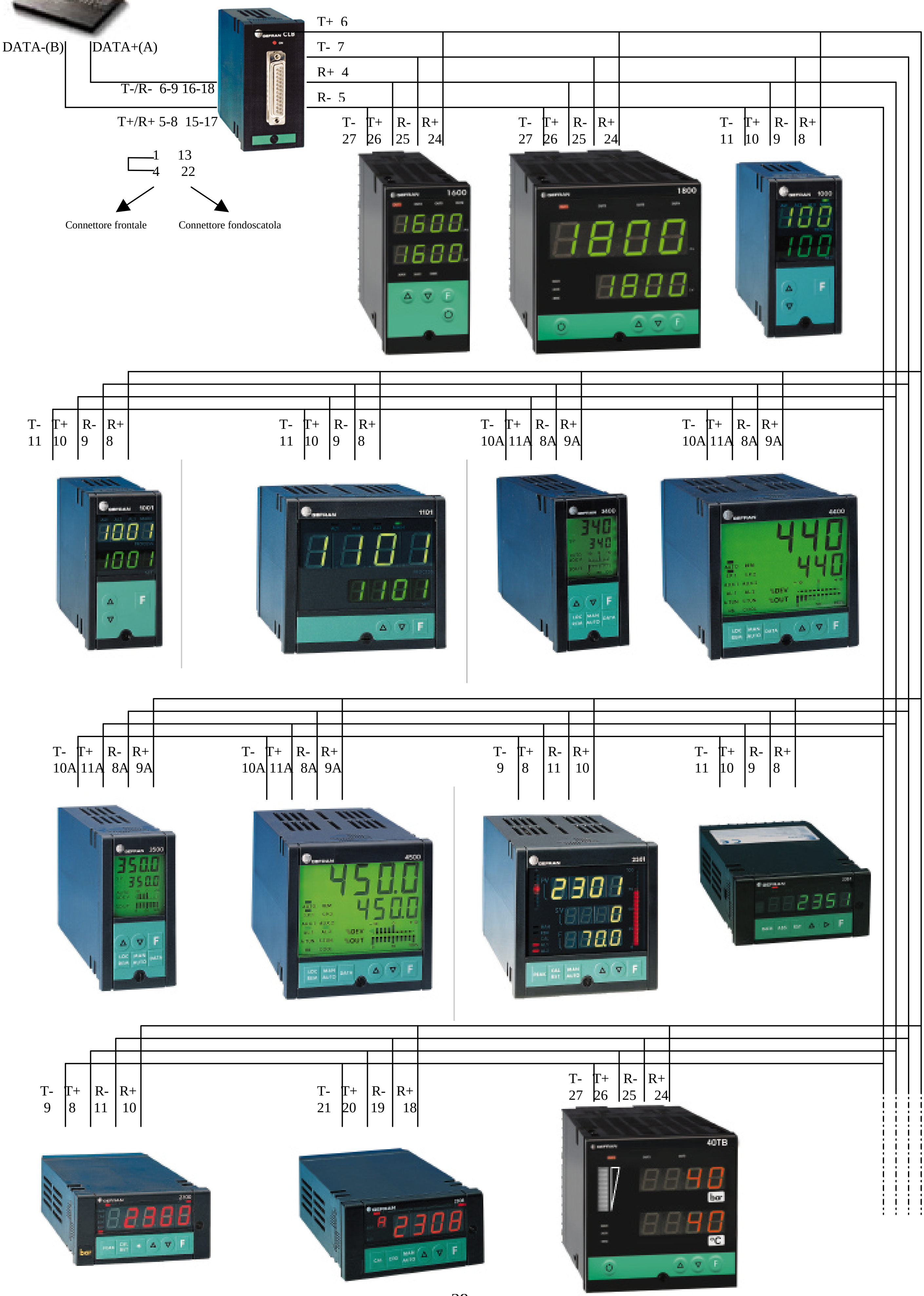
Connection among: RS232 PC – CLB – Instruments with a 4-wire RS 485 serial link



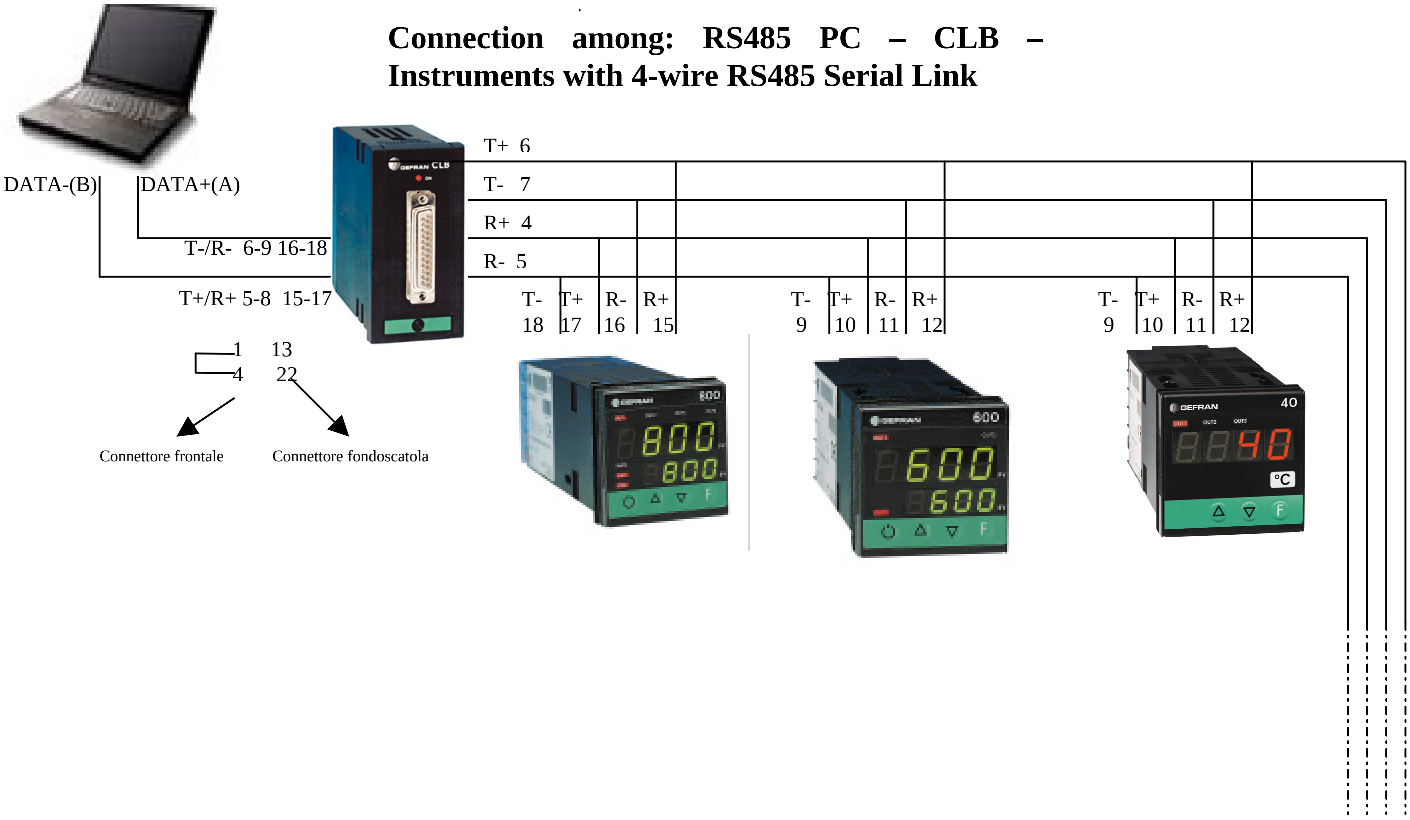
Connection among: RS232 PC – CLB – Instruments with 4-wire RS 485 Serial Link



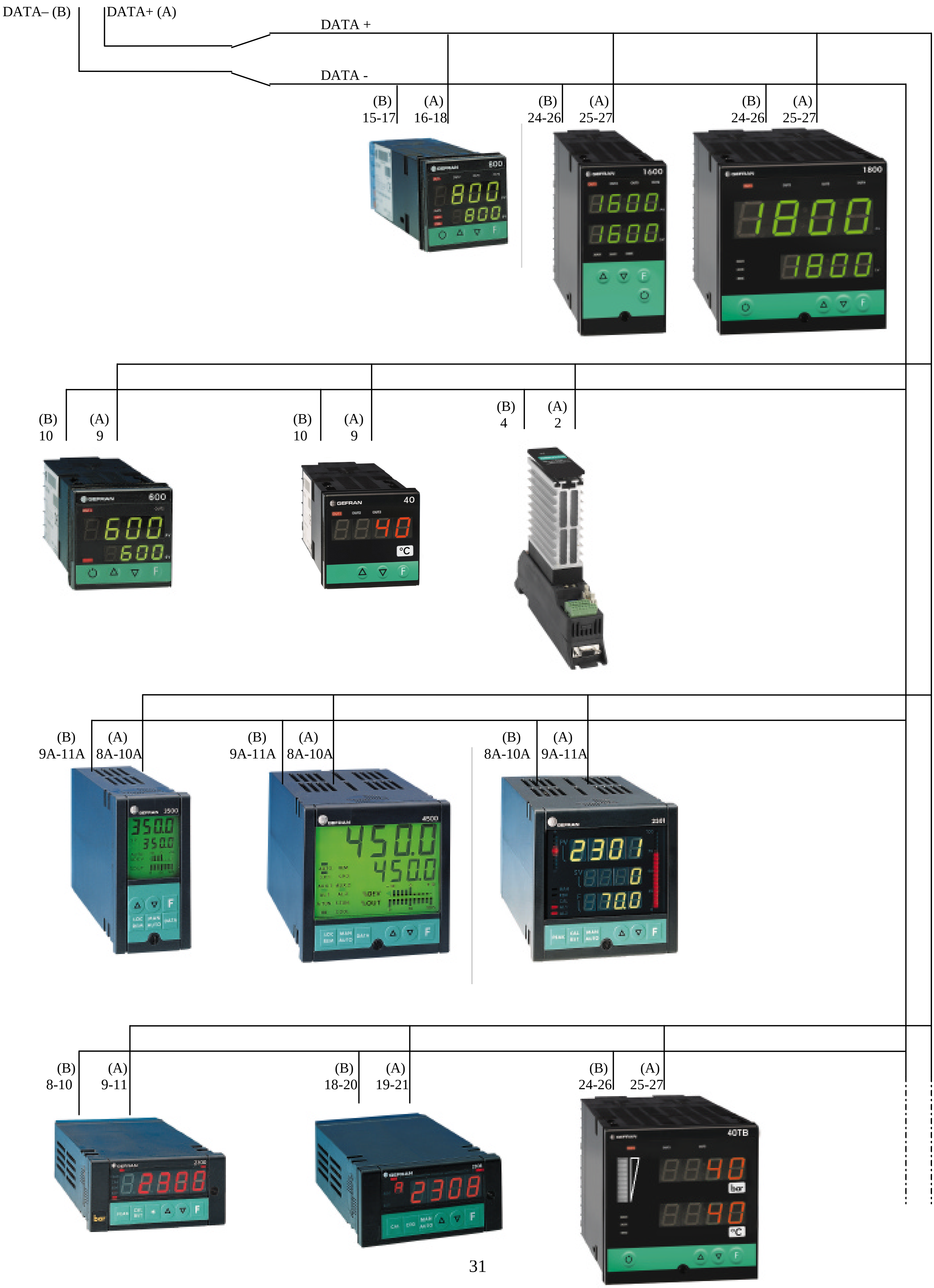
Connection among: RS485 PC – CLB – Instruments with 4-wire RS485 Serial Link



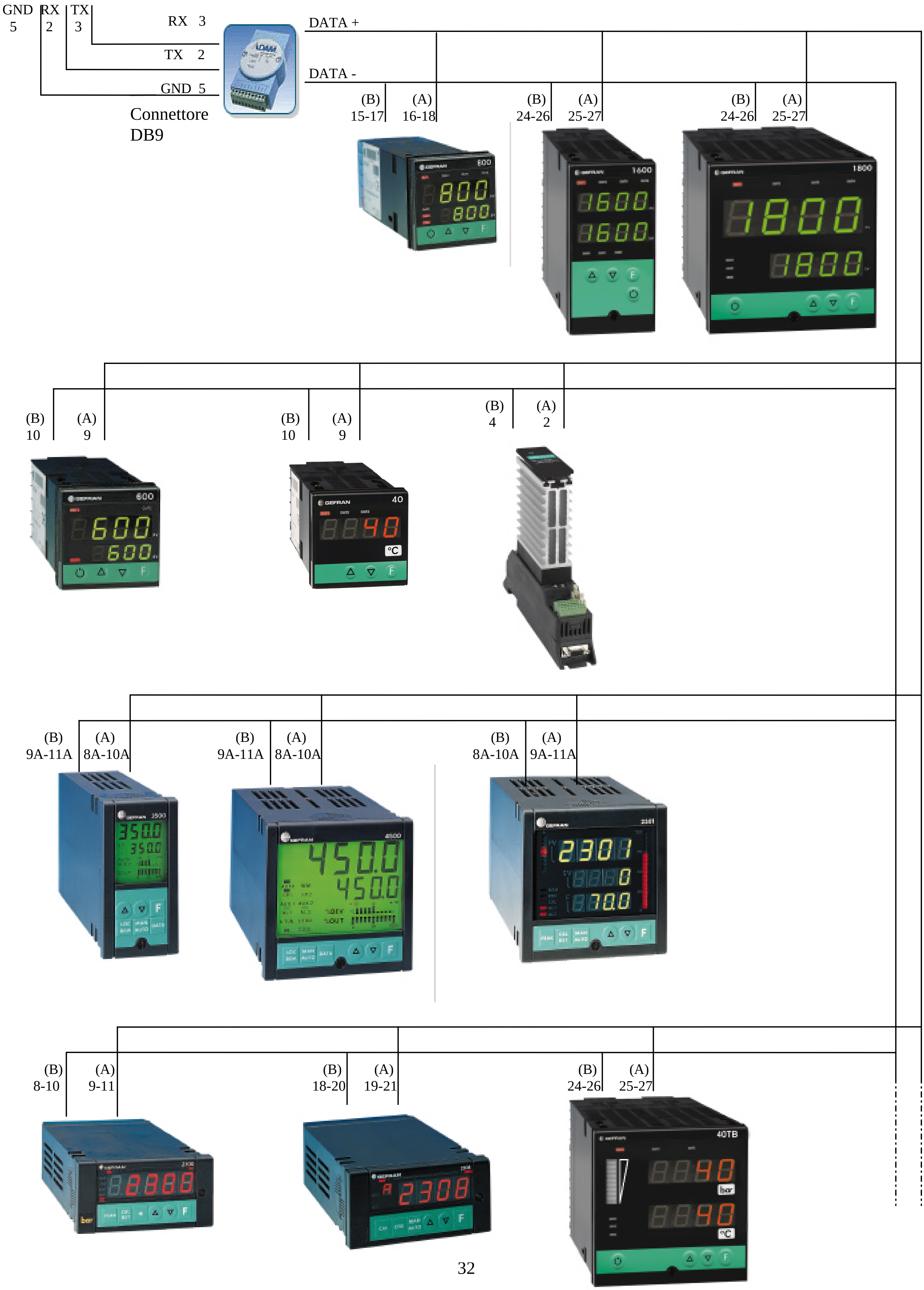
Connection among: RS485 PC – CLB – Instruments with 4-wire RS485 Serial Link



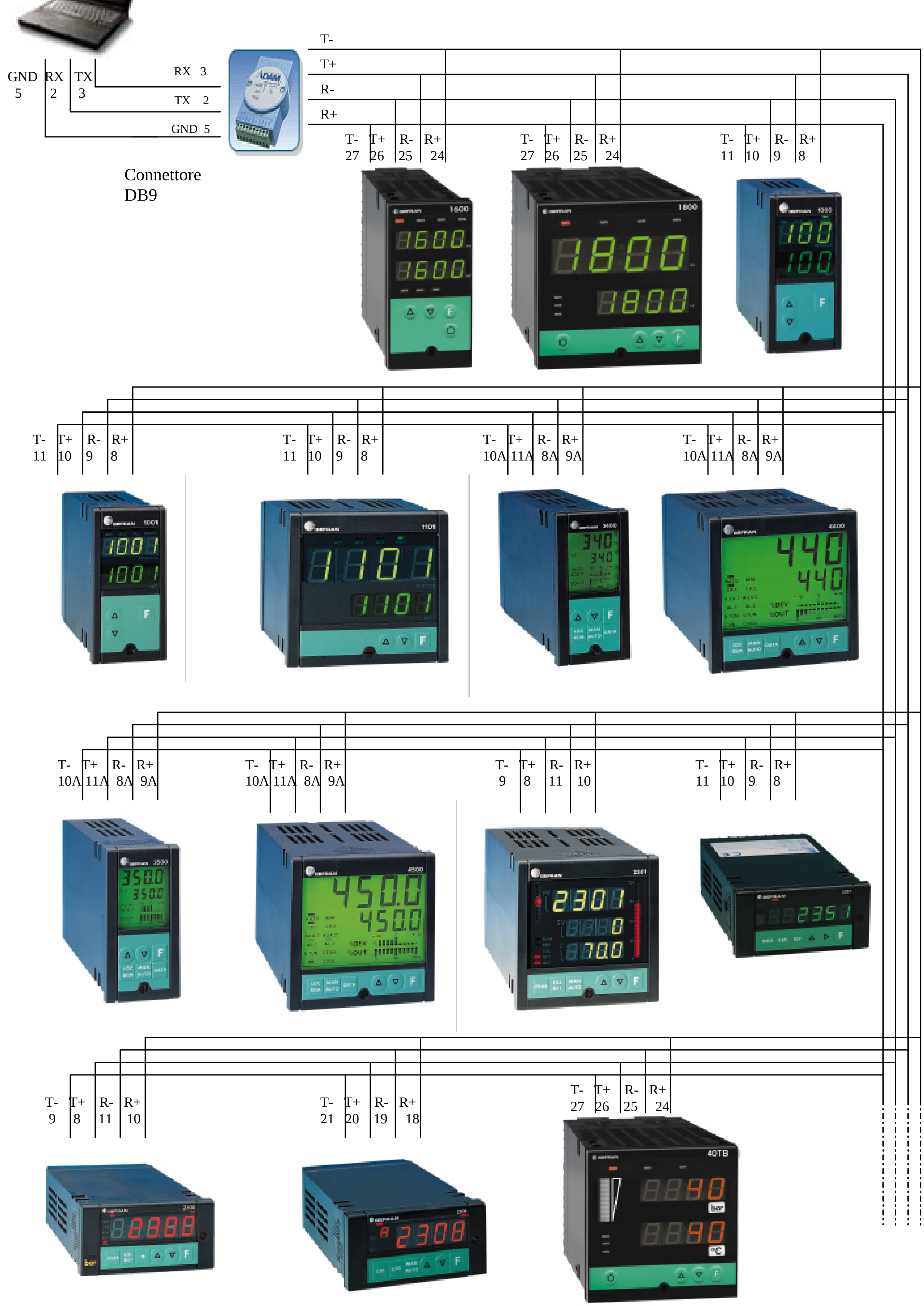
Connection: RS485 PC – Instruments with RS485 serial link



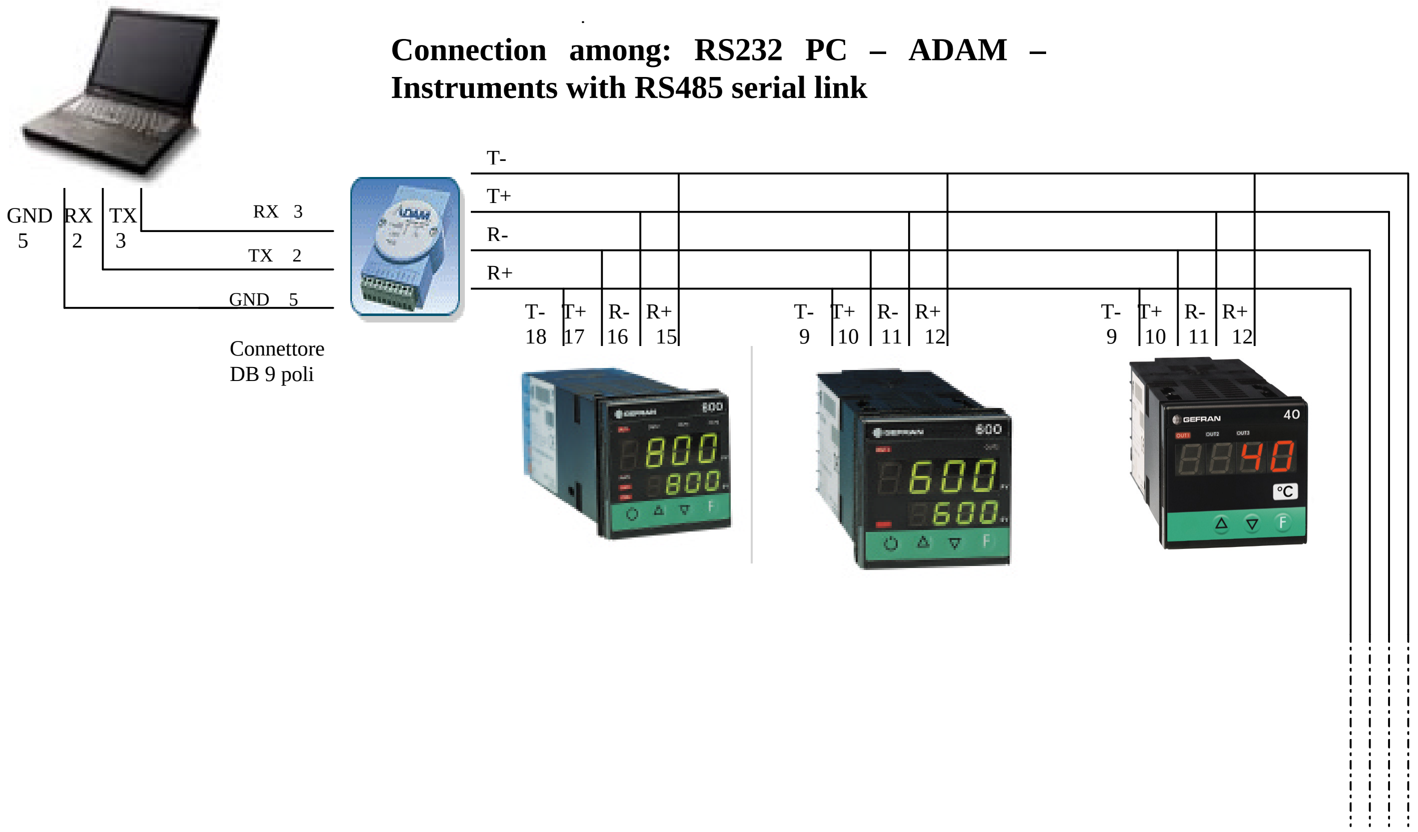
Connection among: RS232 PC – ADAM – Instruments with RS485 serial link



Connection among: RS232 PC – ADAM – Instruments with 4-wire RS485 serial link

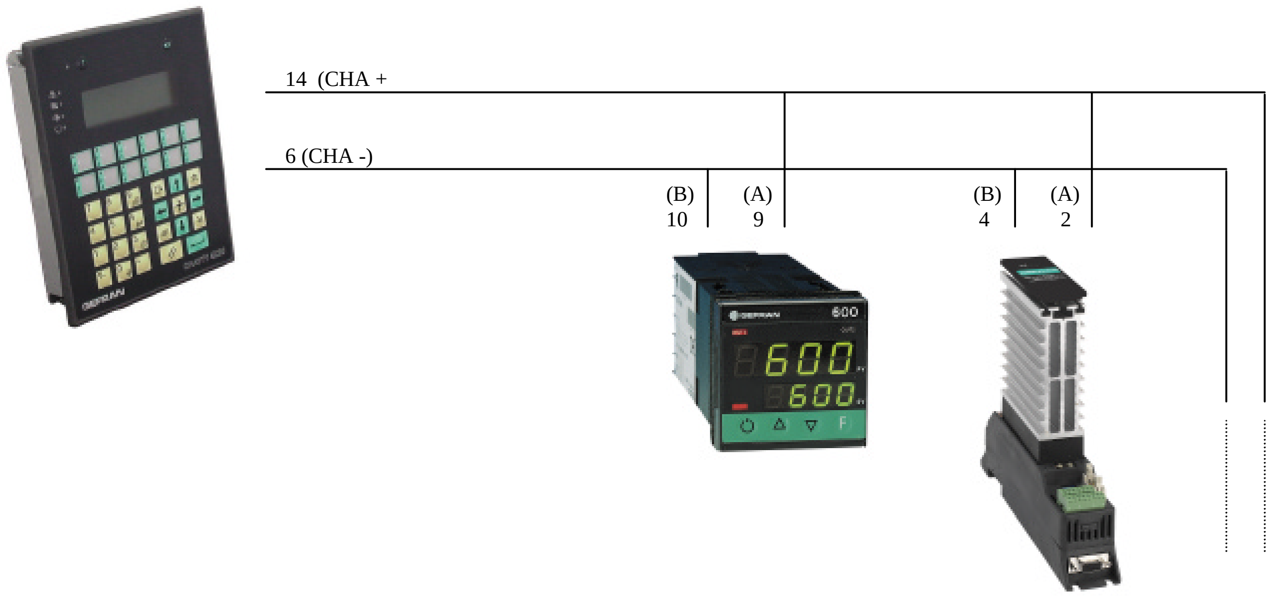


Connection among: RS232 PC – ADAM – Instruments with RS485 serial link



Chatty Connection – Instruments with seriale RS485 serial link

Chatty



CHAPTER 2

MODBUS

PROTOCOL

CONTENTS

MODBUS Protocol

Modbus is a standard protocol adopted by many manufacturers, which allows many different instruments to be interchangeable by the serial programming point of view.
The communication network is composed of a Master and of a max. of 255 Slaves on the same line. The Master only is enabled to initialize the communications, which can be: query/response, where one only Slave answers the Master, or no response, where all present Slaves are addressed.
Una transazione è composta da un frame (unità di informazione) di singola domanda e da uno di singola risposta o da un singolo frame di broadcast.
In the digital communication loop, the user can change only some parameters: interface (RS232, Current Loop, two or four wire RS485), baud rate (1200, 2400, 4800 or 9600 bauds) or Parità. On the contrary other parameters, are factory fixed by GEFRAN: the frame size, the transmission mode (RTU), the frame sequency, the error codes, the exception conditions etc.
In the case of Modbus protocol, each communication is considered finished when there are no communications on line for a time (called “ time out ”) equal to 3.5 times the time taken for a character transmission.
When some information has to be sent on the data line, the message has to be contained in an “ envelope ”. The envelope comes out through a “ port ” and it is transported on the line to the specified address. In the examined case, the Modbus defines the “ envelope ” as a message frame or as a byte structured sequence.

Message Size

The information included in the message is:

- The addressee (Slave address)
- What the addressee has to do (Function)
- The data necessari to carry out the task (Data)
- A test word (CRC) to check if any error is present (Error Check)

Range	Byte
Slave address	1
Function	1
Data	n
Error check (CRC-16)	2

When a Slave receives a message, the instrument returns a data frame of the same structure, but containing the requested information.

List of implemented controls:

01, 02	n Bit Reading
03, 04	n Word reading (memory location)
05	Bit writing
06	Word writing (memory location)
15	n Bit writing
16	n Word writing (memory location)

Transmission Mode:

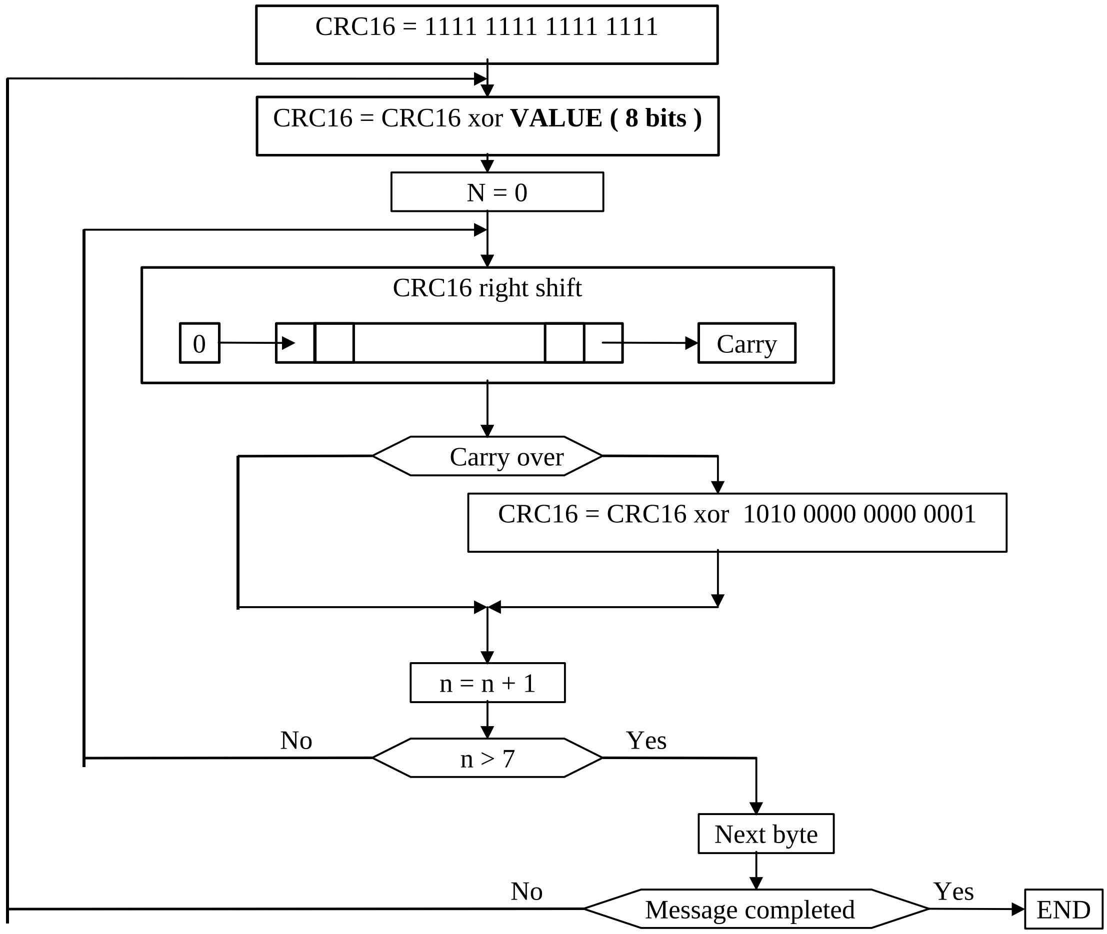
The transmission mode is the structure of the single information unit in a message. Between the two available Modbus standard modes (ASCII and RTU), Gefran has adopted the RTU one (Remote Terminal Unit), which foresees data binary codification. An error check is also available by means of CRC (Cyclic Redundancy Check)

Error Checking:

Generally, because of the electric noise, digital transmissions can contain errors. Two protection mechanisms are available to find and control error situations: the parity control which verifies each byte consistence and the CRC.
Through the CRC Error Check, frame incongruity situations are identified, in this case, the sent message is insubstantial and the receiving unit ignores it.

CRC Calculation: Data bits are considered as a continuous binary number, which most significant part (MSB) is transmitted as first. The message is first multiplied by x^{16} (that is shifted rights 16 times), then divided by $x^{16} + x^{15} + x^2 + 1$ expressed as binary number, that is 11000000000000101. The whole quotient is ignored and the remainder at 16 bit forms CRC. When the receiving unit will divide CRC by $x^{16} + x^{15} + x^2 + 1$ polynomial, it will have to obtain zero remainder with no errors.

The following flow chart shows how to organize a 16 bit CRC calculation algorythm:



Operazione				MSB	Carry
FFFF hex	1111	1111	1111	1111	
02 hex			0000	0010	
Or exclusive	1111	1111	1111	1101	
Shift (n. 1)	0111	1111	1111	1110	1
Polynomial	1010	0000	0000	0001	
Or exclusive	1101	1111	1111	1111	
Shift (n. 2)	0110	1111	1111	1111	1
Polynomial	1010	0000	0000	0001	
Or exclusive	1100	1111	1111	1110	
Shift (n. 3)	0110	0111	1111	1111	0
Shift (n. 4)	0011	0011	1111	1111	1
Polynomial	1010	0000	0000	0001	
Or exclusive	1001	0011	1111	1110	
Shift (n. 5)	0100	1001	1111	1111	0
Shift (n. 6)	0010	0100	1111	1111	1
Polynomial	1010	0000	0000	0001	
Or exclusive	1000	0100	1111	1110	
Shift (n. 7)	0100	0010	0111	1111	0
Shift (n. 8)	0010	0001	0011	1111	1
Polynomial	1010	0000	0000	0001	
Or exclusive	1000	0001	0011	1110	
07 hex			0000	0111	
Or exclusive	1000	0001	0011	1001	
Shift (n. 1)	0100	0000	1001	1100	1
Polynomial	1010	0000	0000	0001	
Or exclusive	1110	0000	1001	1101	
Shift (n. 2)	0111	0000	0100	1110	1
Polynomial	1010	0000	0000	0001	
Or exclusive	1101	0000	0100	1111	
Shift (n. 3)	0110	1000	0010	0111	1
Polynomial	1010	0000	0000	0001	
Or exclusive	1100	1000	0010	0110	
Shift (n. 4)	0110	0100	0001	0011	0
Shift (n. 5)	0011	0010	0000	1001	1
Polynomial	1010	0000	0000	0001	
Or exclusive	1001	0010	0000	1000	
Shift (n. 6)	0100	1001	0000	0100	0
Shift (n. 7)	0010	0100	1000	0010	0
Shift (n. 8)	0001	0010	0100	0001	0

CRC calculation example for hexadecimal 0207_{16} message:

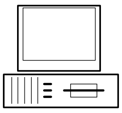
The final result is 41hex (MSB) 12 hex (LSB), the transmitted frame is:

0001 0010   0100 0001   0000 0111   0000 0010 (first byte transmitted) →

12   41   07   02

Reading Operations

n Bit reading

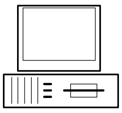

Master

Range	Byte
Slave address (1-255)	1
Function code (1-2)	1
Bit starting address (MSB)	1
Bit starting address (LSB)	1
Number of bits (MSB)	1
Number of bits (LSB)	1
Error check (CRC-16)	2


Slave

Range	Byte
Slave address (1-255)	1
Function code (1-2)	1
Byte count (n)	1
Data (LSb), ...	n
Error check (CRC-16)	2

n Word reading


Master

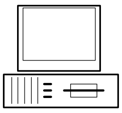
Range	Byte
Slave address (1-255)	1
Function code (3-4)	1
Word starting address (MSB)	1
Word starting address (LSB)	1
Number of words (MSB)	1
Number of words (LSB)	1
Error check (CRC-16)	2


Slave

Range	Byte
Slave address (1-255)	1
Function code (3-4)	1
Byte count (n)	1
Data (Word MSB)	n
Data (Word LSB)	
Error check (CRC-16)	2

Writing Operations

Bit writing



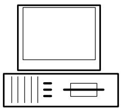
Master

Range	Byte
Slave address (1-255)	1
Function code (5)	1
Bit address (MSB)	1
Bit address (LSB)	1
Data (00 = OFF, 255 = ON)	1
Data (00)	1
Error check (CRC-16)	2

Slave

Range	Byte
Slave address (1-255)	1
Function code (5)	1
Bit address (MSB)	1
Bit address (LSB)	1
Data	1
Data (00)	1
Error check (CRC-16)	2

n Bit writing



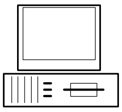
Master

Range	Byte
Slave address (1-255)	1
Function code (15)	1
Bit starting address (MSB)	1
Bit starting address (LSB)	1
Number of bits (MSB)	1
Number of bits (LSB)	1
Byte counter (n)	1
Data (LSB), ...	n
Error check (CRC-16)	2

Slave

Range	Byte
Slave address (1-255)	1
Function code (15)	1
Bit starting address (MSB)	1
Bit starting address (LSB)	1
Number of bits (MSB)	1
Number of bits (LSB)	1
Error check (CRC-16)	2

Word writing



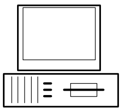
Master

Range	Byte
Slave address (1-255)	1
Function code (6)	1
Word address (MSB)	1
Word address (LSB)	1
Data (Word MSB)	1
Data (Word LSB)	1
Error check (CRC-16)	2

Slave

Range	Byte
Slave address (1-255)	1
Function code (6)	1
Word address (MSB)	1
Word address (LSB)	1
Data (Word MSB)	1
Data (Word LSB)	1
Error check (CRC-16)	2

n Word writing



Master

Range	Byte
Slave address (1-255)	1
Function code (16)	1
Word starting address (MSB)	1
Word starting address (LSB)	1
Number of words (MSB)	1
Number of words (LSB)	1
Byte counter (n)	1
Data (Word MSB)	n
Data (Word LSB)	
Error check (CRC-16)	2

Slave

Range	Byte
Slave address (1-255)	1
Function code (16)	1
Word starting address (MSB)	1
Word starting address (LSB)	1
Number of words (MSB)	1
Number of words (LSB)	1
Error check (CRC-16)	2

Memory Maps

Legend:

Addr.: address

Item: variable mnemonic name. The item name corresponds to the user' s manual instrument name, apart from any eventual "." point, which is not accepted by the supervision program syntax.

Description: comment to explain data meaning, **with reference to the instruments manual.**

R/W: access modality to read/write enabled variables. Another category of these only " R " variables is the set up one, which has to be made from the instrument keypad, according to the instrument itself and the devices connected to it (sensors, actuators, etc.). An example could be the parameters related to the type of probe.

Range: numeric interval of data acceptance. In some cases refers to other variables content.

Dp: (Decimal point), data decimal points number. In some cases refers to other variables content.

Def.: (Default) standard pre-defined setting.

Meas. Unit: Measure Unit
S.p.: scale points
cp: converter points
min: minutes
sec: seconds