

7SG18 Solkor N

Numeric Differential Protection

Document Release History

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Software Revision History

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Glossary

Baud Rate	See <i>bits per second</i> .
Bit	The smallest measure of computer data.
Bits Per Second (BPS)	Measurement of data transmission speed.
Data Bits	A number of <i>bits</i> containing the data. Sent after the <i>start bit</i> .
Half-Duplex Asynchronous Communications	Communications in two directions, but only one at a time.
Full-Duplex Asynchronous Communications	Communications in two directions, both at the same time.
Hayes 'AT'	Modem command set developed by Hayes Microcomputer products, Inc.
Master Station	See <i>primary station</i> .
Modem	MOdulator / DEModulator device for connecting computer equipment to a telephone line.
Parity	Method of error checking by counting the value of the bits in a sequence, and adding a parity bit to make the outcome, for example, even.
Parity Bit	<i>Bit</i> used for implementing parity checking. Sent after the <i>data bits</i> .
Primary Station	The device controlling the communication.
PSTN	Public Switched Telephone Network
RS232C	Serial Communications Standard. Electronic Industries Association Recommended Standard Number 232, Revision C.
Secondary Station	The device being communicated with.
Slave Station	See <i>secondary station</i> .
Start Bit	<i>Bit</i> (logical 0) sent to signify the start of a byte during data transmission.
Stop Bit	<i>Bit</i> (logical 1) sent to signify the end of a byte during data transmission.

1 Introduction

The relay has two communications channels:

- 1 Protection Communication Channel used to exchange power system current and other protection information between relays at each end of the protected feeder. The type of connection may be one of three types. The three types are: One pair of ST (RX&TX) type ports for various types of Fibre Optic ports; a four wire RS485 terminal or RS232 nine pin D type for connection to a Pilotwire Modem.
- 2 Auxiliary Communication Channel used to set, control and interrogate the relay and extract captured fault records. This may be either two wire RS485 or Fibre optic

The auxiliary communications channel can use either an IEC 60870-5-103 compliant protocol or MODBUS-RTU protocol, which allows the relay to communicate with a portable computer or a host computer in a SCADA scheme. The end to end protection communications uses a protocol based on IEC60870-5-103, but is a propriety protocol.

Access to the relay via the auxiliary communications port requires appropriate software in the interrogating computer, such as Reydisp Evolution. This software uses IEC60870-5-103 and therefore the relay must be set with this protocol active during setting and commissioning.

2 Protection Signalling Channel

2.1 CONNECTION SPECIFICATION AND RELAY SETTINGS

This section defines the connection medium used for the protection signalling channel.

The settings for the protection signalling channel can be found in the PROT. SIGNALLING MENU.

2.1.1 General

The relays work in pairs, one at each end of a protected zone or feeder, connected via the protection communications channel. This could be a direct end-to-end connection as shown in Figure 1 or it could be routed through a multiplexer as shown in Figure 2. The physical connection to the relay can be either electrical or optical, allowing twisted pair sections to be employed between the relay and multiplexer.

2.1.2 Recommended cable

The type of cables recommended for the various interface options are given in the table below. Details of transmission distances and signal budgets are given in the Performance Specification.

See Performance Specification for the available communication channels.

No other types of media are suitable for use with the protection signalling channel.

2.1.3 Connection Method

The relays are connected pairs consisting of a local end and a remote end. These pairs may be connected directly together (see figure 1) or through a digital multiplexer such as the UMUX 1500 from RFL Electronics Inc (see figure 2). The third connection method using RS 485 is shown in figure 3. A fourth type is connection over two pairs of screened twisted pilot wires.

The following table specifies the options available for communication between relays.

Transmitter Type	Wire/Fibre Type	Typical Attenuation Limits	Launch Power	Receive Power	Typical Distance
Electrical RS-485	Belden 9842 twisted pair		-	-	0-2km
Electrical Screened	Various	Total Pilotwire Resistance and	Requires Externally mounted RS232 to		0-10km with 1mm sq and above

Twisted Pair Pilotwire		Intercore Capacitance Product <300,000nFohms	Pilotwire Modem, 19200 Baud only		
Fibre Optic 1300nm Short Range	62.5/125µm multimode	-1.5dB at 1300nm per km of FO.	-10dB	-30dB	0-15km*
Fibre Optic 1300nm Long Range	9/125µm single mode	-0.35dB at 1300nm per km of FO.	-10dB	-30dB	0-49km*
	62.5/125µm multimode	-1.5dB at 1300nm per km of FO.	-7dB	-30dB	5-15km*

* assumes FO splices every 4km of -0.05dB to -0.1db each, but includes a 3dB safety margin for relay connector losses etc, based on minimum output levels. Typical distances may be greater. Loss estimates should be calculated for individual application studies using cable manufacturers data or measured after installation using specialised equipment.

Note all Fibre Optic type relays have a maximum Receive Power limit of -9dB, above which the input saturates.

The long range relays have the 1300nm transmitter set to have a launch power set to this level when a 9µm singlemode fibre is connected. When a 62.5µm multimode fibre is connected to the long range device the launch power will be above this level and therefore have a minimum as well as a maximum distance limit. The Launch power can be calibrated downwards at the rear of the relay using a suitable Fibre Optic Meter to allow the Signalling to become healthy.

The short range device is set to a launch power of -9dB when a 62.5µm fibre is connected and therefore are not restricted by a minimum length.

2.1.4 Transmission Method

Full duplex asynchronous communications is employed. The protocol is based on IEC60870-5-103 and uses frames assembled from individual characters. Each character consists of 11 bits:

1 start, 8 data, 1 parity, 1 stop.

Each frame consists of 10 characters:

1 Start flag, 7 Data, 1 Check sum, 1 End flag.

2.1.5 Transmission Rate (Baud Rate Setting)

Baud rates of 38400 and 19200 bits per second (BPS) are provided. Wherever possible use 38400 bps as this gives faster operate times. Use 19200 bps with external communications equipment (e.g. multiplexers) that do not support 38400 bps. When the signalling channel is non-standard and may introduce more noise than normal, a 19200 bps will provide more immunity. When using the relay with screened twisted pilotwires via the Pilotwire modem, the Protection Signalling baud rate **must be set to 19,200**.

2.1.6 Local Address Setting

The protection signalling address of the relay can be set to a value of between 0 and 31. The remote relay's address must be set so that the sum of both addresses is 31. I.e. if the local relay has an address of 5 then the remote relay's address must be set to 26. The lowest number in a pair is assigned as the master relay.

2.1.7 Propagation Delay

The protection can accommodate propagation delay up to the maximum specified in the Performance Specification. The Go and Return delays should be near identical, preferably to within 0.5 ms of each other.

3 IEC60870-5-103 INTERROGATION CHANNEL

3.1 CONNECTION SPECIFICATION AND RELAY SETTINGS

This section defines the connection medium as defined by IEC60870-5-103. Appendix B shows some typical communication connections.

The settings for the IEC60870-5-103 interrogation channel can be found in the COMMS INTERFACE MENU.

3.1.1 Recommended cable

Selection of fibre optic cable is critical. Fibres should be terminated with BFOC/2.5 (ST[®]) bayonet-style connectors. With this type of connector the recommended cable is 62.5 / 125µm glass fibre. This offers superior performance over SMA type connectors in terms of better coupling to the fibre and therefore has lower losses.

No other types of cable are suitable for use with the relays.

3.1.2 Connection Method

The relays can be connected in either a Star or Ring fibre-optic communications network. If star connected then a passive fibre optic hub must be used. A lower cost option is the ring configuration where the relays are 'daisy chained.' That is, the transmit output of the first relay is connected to the receive input of the second relay, and so on until the ring is complete.

Communication to the ring may be achieved either locally in the substation or remotely via the Public Switched Telephone Network (PSTN). If remote communication is desired, then additional modem equipment must be installed.

Reydisp Evolution is a PC based software package providing capability for both local and remote communication. It provides features such as download of disturbance and event records, upload of relay settings, real-time monitoring of measurands and remote control of plant.

3.1.3 Transmission Method

The transmission method is Half Duplex serial asynchronous transmission. In IEC60870-5-103 the line idle state is defined as Light ON. This can alternatively be selected as Light OFF in the Communications Interface menu of the relay if required for use with alternate hardware (See Section 3.1.5).

3.1.4 Transmission Rate

Rates of 19200, 9600, 4800, 2400, 1200, 600, 300, 150, 110 and 75 bits per second (BPS) are provided. Only 19200 and 9600 BPS are standard in IEC60870-5-103, the additional rates are provided for local or modem communications. The 19,200 BPS setting is normally used.

3.1.5 Line Idle Setting

The line idle setting can be set to be either ON or OFF and the setting must be compatible with the device connected to the relay. The IEC60870-5-103 standard defines a line idle state of Light On. If the device the relay is connected to does not have a compatible fibre-optic port then a suitable electrical to optical converter is required to connect it to a standard RS232C electrical interface. A suitable converter is the Sigma 4 type, which is available from Siemens.

Alternative converters are the Reyrolle Dual RS232 Port (Sigma 3) or Reyrolle Passive Fibre-Optic Hub (Sigma 1).

1. The Sigma 3 Dual RS232 port provides a fibre-optic interface to a relay and two RS232 ports. The RS232 system port is typically connected to a control system while the second port is a local port. When the local port is in use the system port is automatically disabled. The Sigma 3 has an internal link to switch between line idle Light ON or Light OFF. The default configuration is Light OFF.

2. The Sigma 1 Passive Fibre-Optic Hub provides fibre-optic interfaces for up to 29 relays. It has a fibre-optic port to the control system and multiple relay connections. Each of the 30 fibre-optic ports can be configured for either Light ON or Light OFF operation. Default for all is OFF.

3.1.6 Parity Setting

IEC60870-5-103 defines the method of transmission as using EVEN Parity. However, in some instances an alternative may be required. This option allows the parity to be set to NONE.

3.1.7 Address Setting

The IEC60870-5-103 address of the relay must be set to a value between 1 and 254 inclusive before any communication can take place. Setting the address to zero disables communications to the relay, although if it is in an optical ring it will still obey the Data Echo setting. All relays in an optical ring must have a unique address. Address 255 is reserved as a global broadcast address.

3.2 Modems

The communications interface has been designed to allow data transfer via modems. However, IEC60870-5-103 defines the data transfer protocol as an 11 bit format of 1 start, 1 stop, 8 data and 1 parity bit which is a mode most commercial modems do not support. High performance modems, for example, Sonix (now 3Com), Volante and MultiTech Systems MT series will support this mode but are expensive. For this reason a parity setting (see section 2.6) to allow use of easily available and relatively inexpensive commercial modems has been provided. The downside to using no parity is that the data security will be reduced slightly and the system will not be compatible with true IEC60870 control systems.

3.2.1 Connecting a modem to the relay(s)

The RS232C standard defines devices as being either Data Terminal Equipment (DTE) e.g. computers, or Data Communications Equipment (DCE) e.g. modems. To connect the modem to a relay requires a fibre-optic to electrical connector and a Null Terminal connector that switches various control lines. The fibre-optic converter is then connected to the relay in the following manner:

Fibre-Optic Converter	Relay Connection
Tx	Rx
Rx	Tx

3.2.2 Setting the Remote Modem

Most modems support the basic Hayes 'AT' command format, though different manufacturers can use different commands for the same functions. In addition, some modems use DIP switches to set parameters while others are entirely software configured. Before applying the following settings it is necessary to return the modem to its factory default settings to ensure that it is in a known state.

The remote modem must be configured as Auto Answer, which will allow it to initiate communications with the relays. Auto answer usually requires 2 parameters to be set. One switches auto answer on and the other, the number of rings after which it will answer. The Data Terminal Ready (DTR) settings should be forced on which tells the modem that the device connected to it is ready to receive data. The parameters of the modem's RS232C port need to be set to match those set on the relay i.e. baud rate and parity to be the same as the settings on the relay, and number of data bits to be 8 and stop bits 1.

Note: although it may be possible to communicate with the modem at e.g. 19200bps, it may not be possible to transmit at this rate over the telephone system which may be limited to 14400. A baud rate setting needs to be chosen which is compatible with the telephone system. Since 14400 is not available in the relay, the next lowest rate, 9600, would have to be used.

Since the modem needs to be transparent, simply passing on the data sent from the controller to the device and vice versa, the error correction and buffering must be turned off. In addition if possible force the Data Carrier Detect (DCD) setting to ON as the fibre-optic converter will use this control line.

Finally these settings should be stored in the modem's memory for power on defaults.

3.2.3 Connecting to the remote modem

Once the remote modem is configured correctly it should be possible to dial into it using the standard configuration from a local PC. As the settings on the remote modem are fixed, the local modem should negotiate with it on connecting and choose suitable matching settings. If it does not, however, set the local modem to mimic the settings of the remote modem described above.

3.3 Support Software

Reydisp Evolution is a PC based software package that provides access to the relay from a computer via the auxiliary communication channel. Its salient features are:

- Download, display and analysis of fault records and event records.
- Upload relay settings.
- Real-time measurements.
- Remote control of plant.

4 Introduction – Modbus RTU

This section describes how to use the Modbus Interface with a compliant control system. For further information regarding the interface, reference should be made to the Argus Modbus implementation report 434/TIR/14 available on website www.siemens.com.

The same communications interface is used to provide control system connections.

The relay complies with the physical requirements of Modbus using fibre-optics or an RS485 interface.

4.1 Medium

The communicating medium is optical fibre or electrical RS485. The device communicating with the Argus should have an interface optimised for 62.5/125 µm glass fibre-optics, or RS485 electrical connection.

4.2 Sigma Fibre-optic to RS232 Converters

See previous section 3

4.3 Recommended cable

Selection of fibre-optic cable is important. Fibres must be terminated with ST™ (BFOC/2.5) connectors. The recommended type is 62.5/125µm glass fibre. Communication distances over 1 km are achievable using this type of fibre.

The RS485 electrical interface can be connected using 120 ohm screened twisted pair wire i.e. Belden 9841 or equivalent.

4.4 Network Topology

Fibre optical communication networks can be connected singularly or in a star configuration. Modbus does not support a fibre optic ring configuration.

RS485 electrical connection can be used in a single or multi-drop configuration. The last device must be terminated correctly.

Appendix B illustrates typical network arrangements.

4.5 Settings

Communication parameters of Communications Interface: **Comms Baud Rate**, Communications Interface: **Comms Parity** and Communications Interface: **Line Idle** should match those of the communicating device.

4.6 Baud Rate

Rates of **19200**, **9600**, **4800**, **2400**, **1200**, **600**, **300**, **150**, **110** and **75** bits per second are provided. The Communications Interface:**Comms Baud Rate** setting should match that of the communicating device,

4.7 Comms Parity

The Communications Interface:**Comms Parity** setting allows parity of **Even** or **None** to be selected. This setting should match that of the communicating device.

4.8 Relay Address

Each relay on a network must have a unique address, between **1** and **247**, as set by the Communications Interface: **Relay Address** setting. A relay with the default address of **0** will not be able to communicate. The actual number of devices will be limited to 32 devices on any one RS485 connection. Note that the setting range available on the relay is 0-254 to suit IEC60870-5-103 but only 0-247 apply to Modbus-RTU.

4.9 Line Idle

If the communication medium is fibre-optic the Communications Interface: **Line Idle** setting defines the quiescent state. When set as **Light On** binary '0' is represented by light on, binary '1' is represented by light off and vice versa for **Light Off** mode. While in **Light On** mode and the device is not communicating it maintains the **Light On** mode to allow breaks in the cable to be detected. These potential breaks would not be detected when the device mode is set to **Light Off**.

This must be set to **OFF** when connected to the RS485 electrical connection.

4.10 Data Echo

All relays must have the Communications Interface:**Data Echo** setting to **OFF for Modbus-RTU**.

APPENDIX A – PROTECTION SIGNALLING COMMUNICATION CONNECTIONS

Figures 1 to 5 illustrate a number of methods of connecting the protection signalling communications channel.

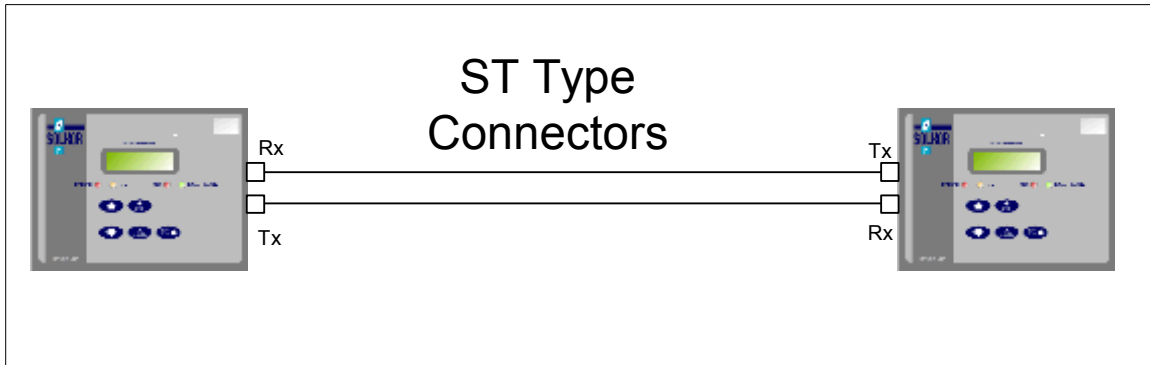


Figure 1 – Fibre Optic Signalling Connections

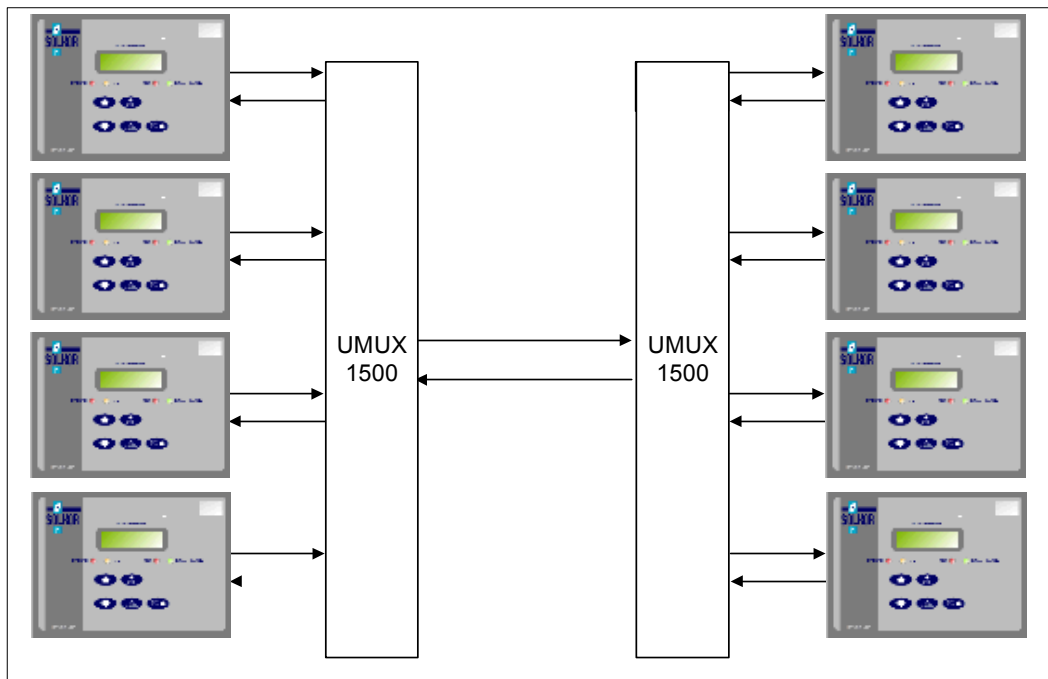


Figure 2 - Multiplexer Signalling Communications Configuration

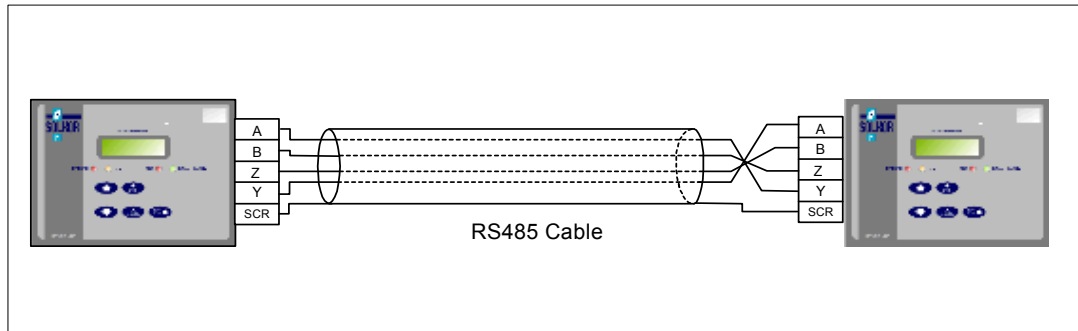


Figure 3 - RS485 Signalling Cable Connections

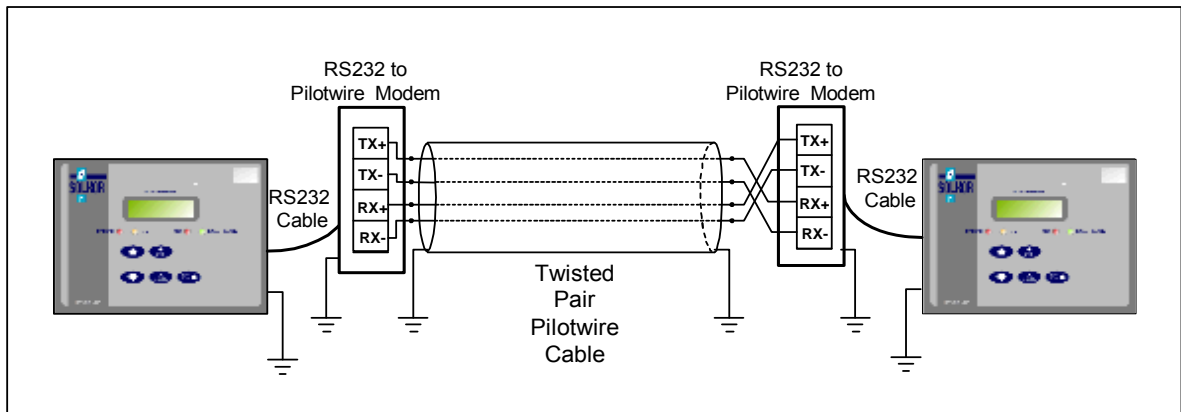


Figure 4 - Pilotwire Signalling Cable Connections

As shown above the pilot wires should be earthed at both ends, at the substation pilot wire terminations. The relay and Pilotwire Modem must be earthed separately at the relay panel. The Protection Signalling Baud Rate of the relay must be set to 19,200 when using pilot wire. The Pilotwire Modem has a mounting bracket that may be altered to suite the available panel space.

The Pilot wire modem is internally panel mounted.

APPENDIX B – IEC60870-5-103 COMMUNICATION CONNECTIONS

Figures 5 to 11 illustrate a number of methods of connecting relays in communications networks.

(Note that in the case of the optical ring configuration (figure 9 & 10), the Data Echo feature must be switched ON in the communications settings menu of the relay. In all other cases this setting should be set to OFF).

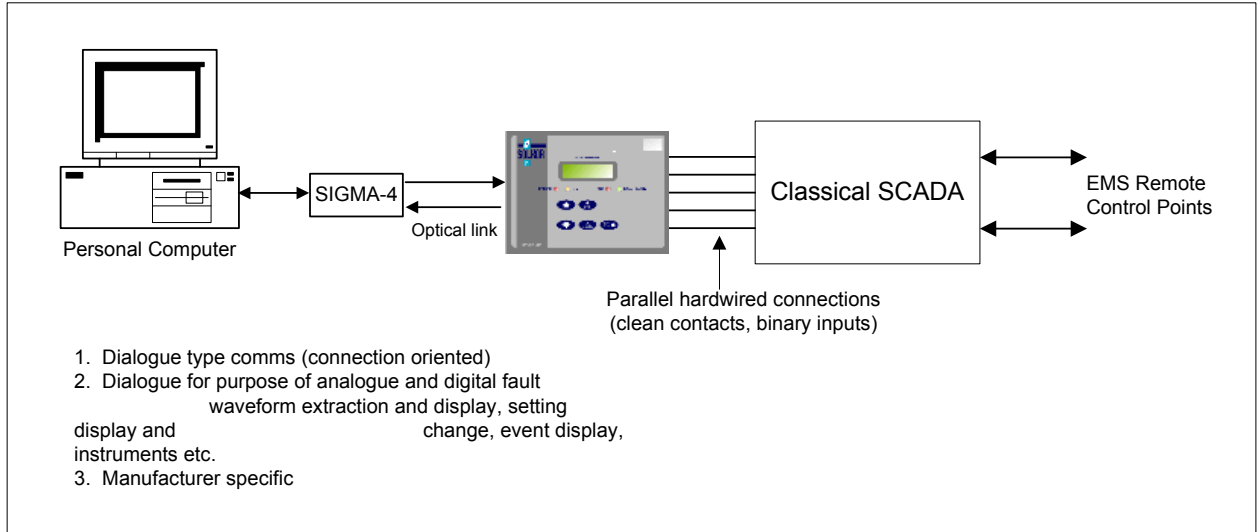


Figure 5 - Basic Fibre Optic Data Communications Configuration

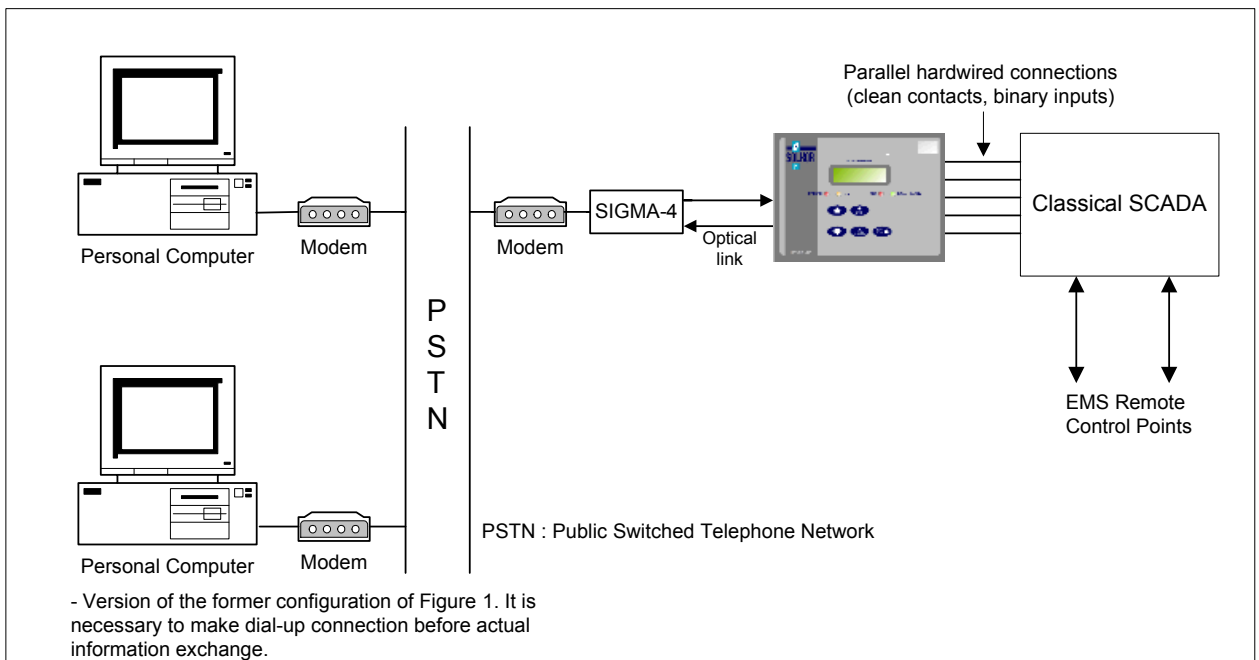


Figure 6 – Fibre Optic Data Communications Configuration (Remote)

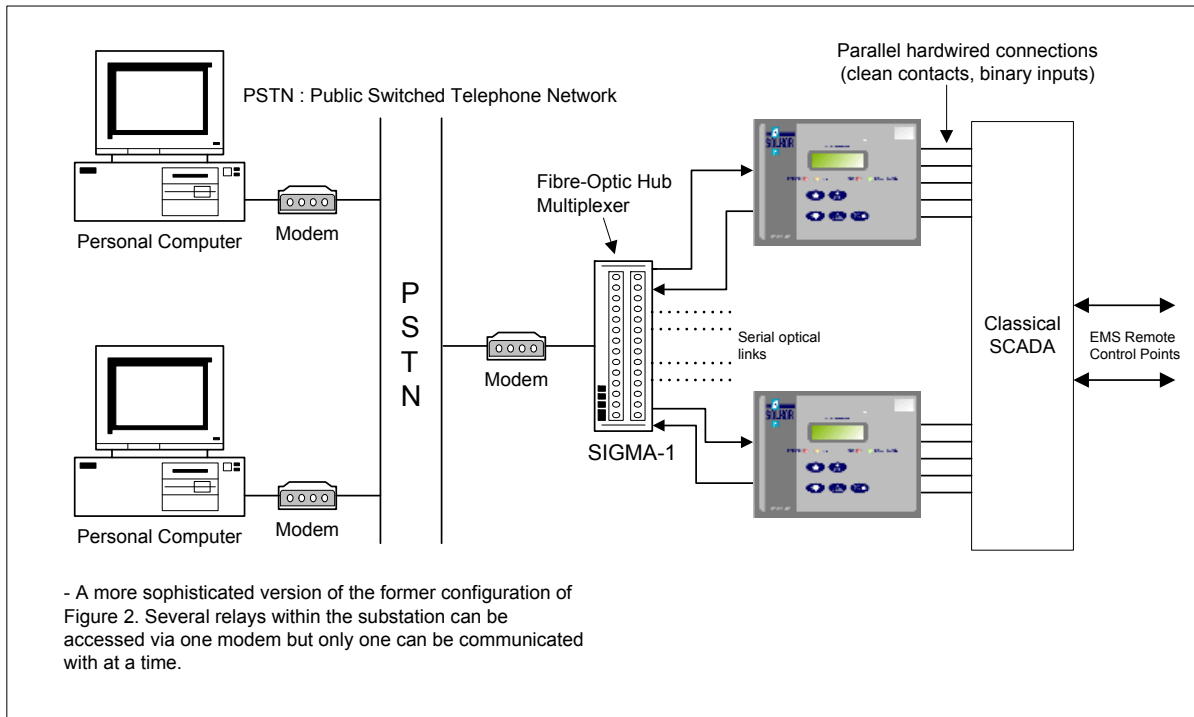


Figure 7 - Star Type Configuration (Multiplexer)

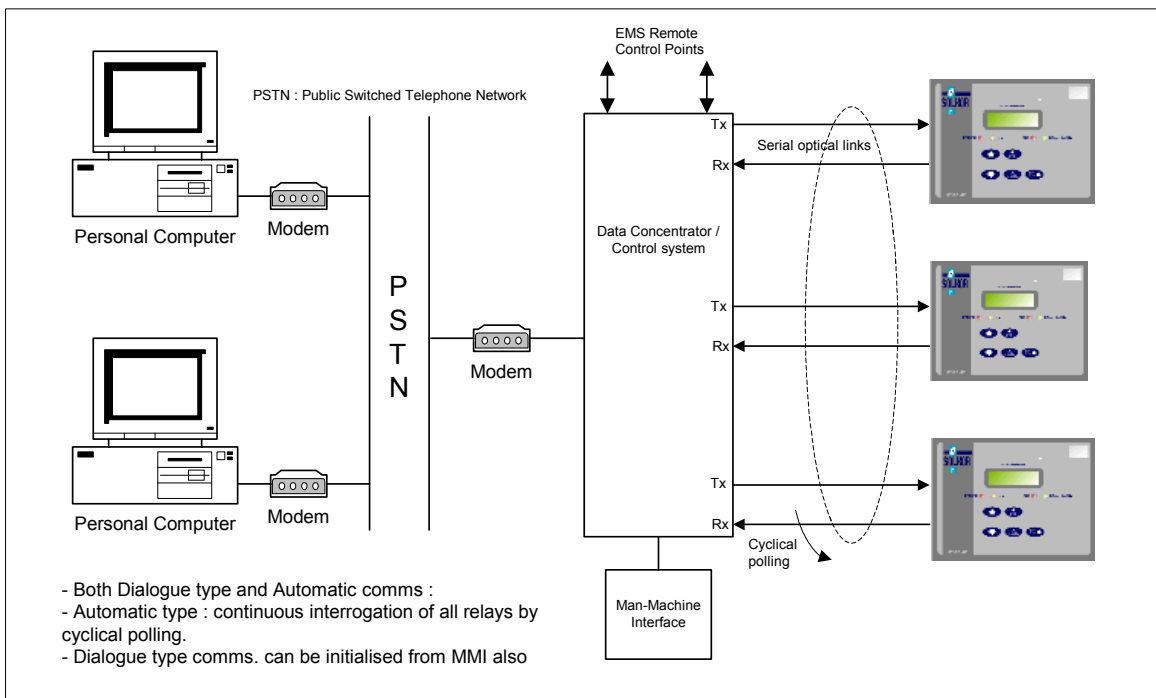


Figure 8 - Data Concentrator Configuration

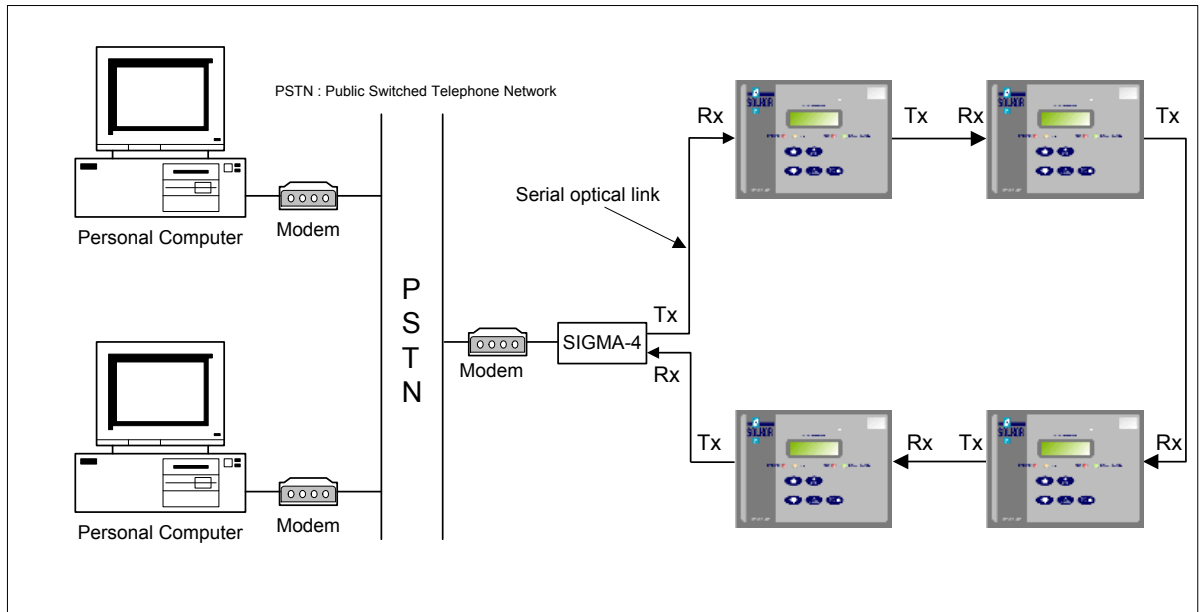


Figure 9 - Optical Ring Configuration (Data Echo - On)

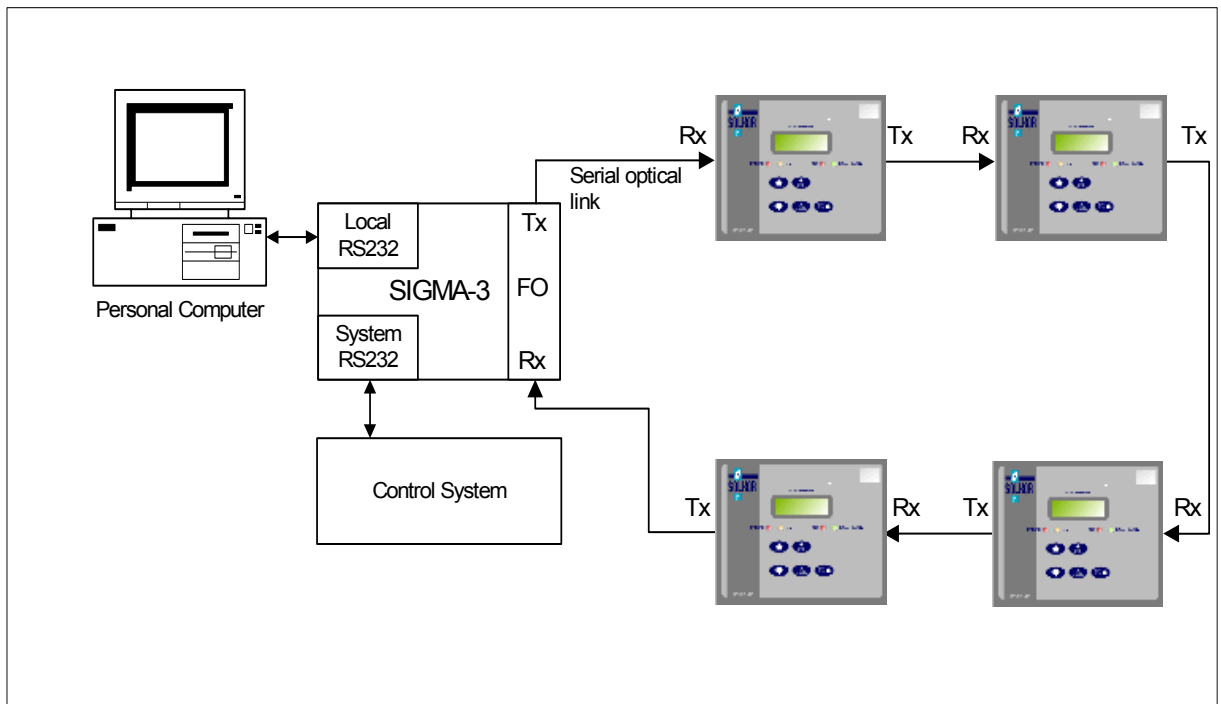


Figure 10 - Configuration using the Sigma 3 – Dual Port RS232 Device

Up to 254 relays may be connected in the above Fibre Optic ring.

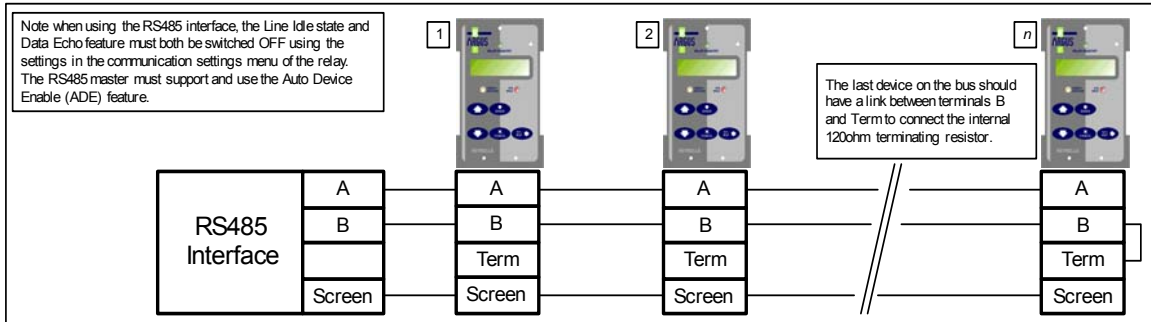


Figure 11 – Data Communication using the Two wired RS485 Interface

Up to 31 similar relays can be connected on the RS485 multi-drop bus per main interface.