

Substation Automation Products

# Communication set-up for Relion 670-series, version 1.2

## Differential protection and binary transfer in telecommunication networks

### Setting and application guide

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This is an Application Example for Communication set-up for RED670 Differential protection in telecommunication networks and the remaining IED 670 for binary signal transfer.

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## General

### 1

## RED670 Differential protection and telecommunication networks

### (Valid also for the other 670 series products)

There are two main application areas of telecommunication networks for the multiterminal current differential protection RED670 for up to 5 line ends.

**(I) Telecommunication networks with symmetric or fixed routes, where echo timing can be used, including back-to-back systems.**

**(II) Telecommunication networks with unspecified route switching, where the accurate global time in the Global Positioning System (GPS) is required.**

Echo-timing according to (I) can be used as fall back system if the GPS reference is lost in one or more RED670s in telecom networks type (II). The Echo-timer is activated by a setting, see *Figure 3*.

Note that for Echo-timing, the internal clock in each RED670 is used as a master and compared with the internal clocks in the remote RED670s as slaves. The difference and drift between the internal clocks are monitored continuously, and compensated for with echo messages between all ends with 40 ms intervals over the communication system. At start, it will take around 15 seconds to get full synchronization of the internal clocks. The deviation between the internal clocks are compensated to be within 1  $\mu$ s relative time.

Note also that the internal clock has an additional function as real time clock for other protection and monitoring functions such as event timing, but this is totally separate from the current differential function.

For networks with unspecified route switching, the reference for the internal clock is Global time, for example the global time in the GPS system from a built-in GPS receiver. The internal clock in each RED670 will be set according to the global time from the GPS system. The inaccuracy depends on connection time to the GPS system. After start-up (cold start) a software calibration procedure is carried out. After less than one hour, all internal clocks real time deviation from Global time has been decreased to 1  $\mu$ s.

Note also, there can only be one master clock in the telecommunication system for synchronization of the multiplexers, transceivers and the differential protection relays communication modems. (One master, the other slaves) This clock could also be a GPS clock but the telecommunication network synchronization is totally separate from the current differential protection internal clock synchronization.

The differential protection can be configured as master-slave or master-master. To configure the differential protection to slave, the differential protection is switched off. The configuration of the communication system is not affected by the protection configuration.

## 1.1

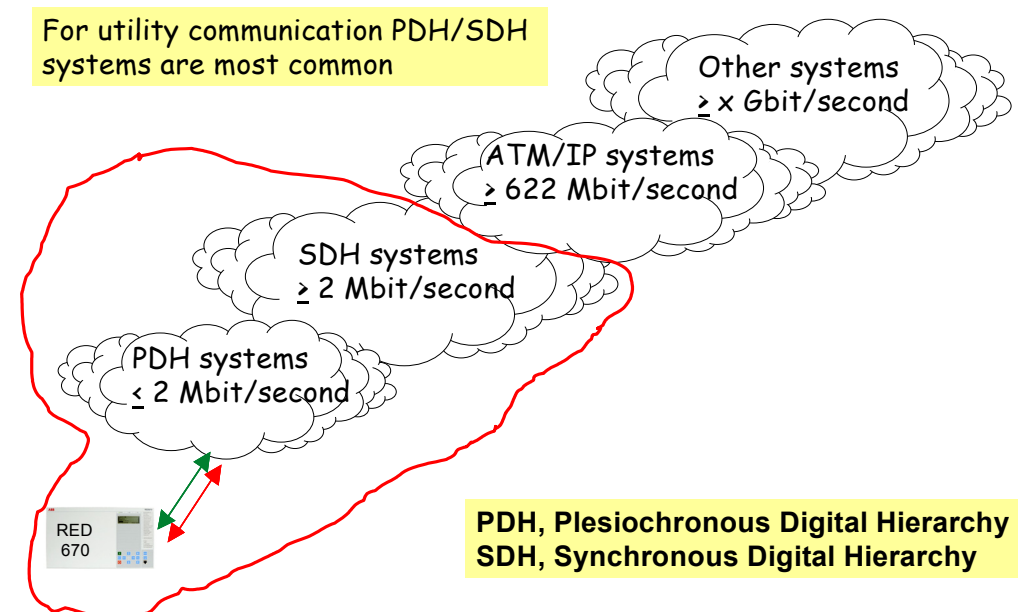
### Common telecommunication systems for power utilities.

There are mainly two types of telecommunication networks, which are used by electric power utilities. In most cases these networks are owned by the utility, but it can also be leased communication links from external companies.

The type used for 64 kbits channels are called PDH systems, Plesiochronous Digital Hierarchy. Plesio is greek and means almost. Thus proper synchronization of the PDH System must be provided to be used in protection applications.

Nowadays SDH systems are introduced in telecommunication networks for power utilities. SDH means Synchronous Digital Hierarchy, and is specified  $> 2\text{Mbit/second}$ .

The abbreviations PDH and SDH are used in the following text



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Figure 1: Telecommunication networks for differential protection.



## 1.2

**Telecommunication networks with symmetric or fixed routes with echo timing**

Networks with fixed routes for example with symmetric time delay or networks with fixed route switching, where both directions have symmetric time delay even after route switching has been performed. A different channel delay time is automatically compensated. For this type of networks echo-timing can be used. If there is a fixed route with specified asymmetry, the asymmetry can be compensated for by the setting parameter asymmetric delay, see section 5.3 Setting guidelines page 28.

**The maximum interruption time for route switching and echo timing, for example when the communication channel is lost, without affecting the synchronization of the internal clocks, is 2 seconds.** (The protection is blocked during the interruption.)

From protection point of view route switching interruptions should be <50ms. (In practice a route switching will normally take <100  $\mu$ s). The maximum allowed time delay in the telecommunication system is settable up to 2x40 ms. (Default is 2x20 ms = 40 ms) For longer channel delays, then the set value the differential function is blocked. The differential protection is also blocked if the virtual time deviation between the internal clocks in the RED670 (One to five ends) is more than the set value  $\pm 200\text{--}2000$   $\mu$ s for

*MaxtDiffLevel*, see Figure 3. The differential function is blocked until the internal clocks deviation are within the set value. The time to new synchronization will depend on the interruption time. (The slow drift between the internal clocks during normal operation is continuously compensated for.)

**Note:**

*The recommended setting for maximum time delay is 2x20 ms with echo timing or <40 ms for GPS applications.*

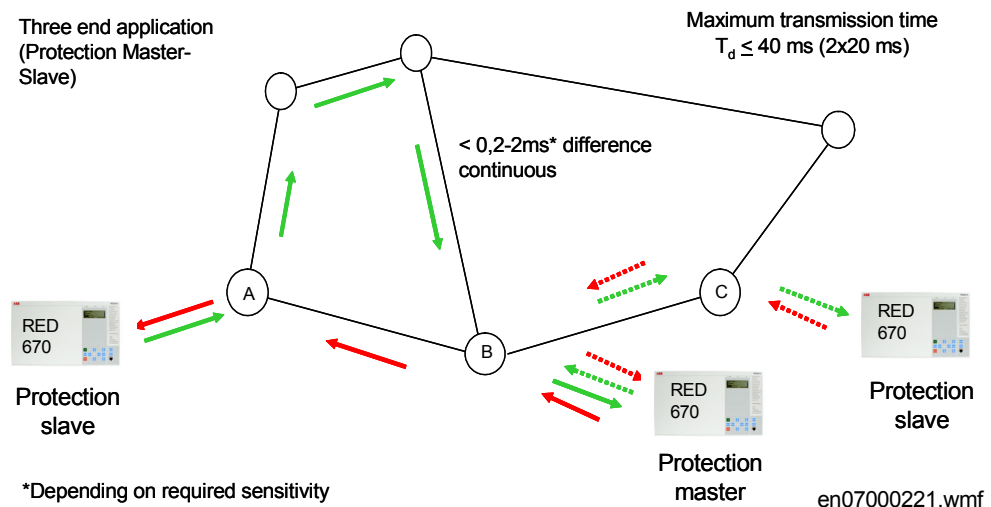


Figure 2: Three end application

### 1.3

#### Route switching criteria for telecommunication networks with specified (controlled) route switching

During route switching, a wider communication channel asymmetry can be accepted, as the clock in the two ends will only have a small deviation during the time the communication is switched from one route to another  $< 2$  seconds. However, route switching can only be handled correctly after complete start-up of the terminals (about 90 seconds), for example when the internal clocks are properly synchronized which will take an additional 15 seconds after the channel is restored. The 2 second limit is derived from the stability of the internal clocks. Longer route switching than 2 seconds will block the differential function until the clocks are synchronized again. The synchronisation time will depend on interruption time, see Section 1.5 page 11.

## 1.4

**Unspecified route switching can not be handled**

Setting of maximum deviation between internal clocks, *MaxtDiffLevel* in the respective RED670 (one to five). Setting range  $\pm 200$ -2000  $\mu$ s. The setting is made on the HMI or with PCM600PCM600, Protection and Control Manager for setting, engineering and disturbance handling of the 600-series. The abbreviation PCM600 will be used in the following text. The set maximum reference clock deviation is depending on the factors below.

- a Jitter and wander in the telecommunication system, typical  $\pm 50$   $\mu$ s in SDH systems and  $\pm 100$ -200  $\mu$ s in PDH systems ( $< \pm 100$   $\mu$ s according to the telecommunication standards, see Section 6 page 34.)
- b Acceptable small asymmetric delay, typical  $\pm 50$  to 100  $\mu$ s
  - A constant (fixed) asymmetric delay in the duplex channels can be adjusted by setting of the asymmetric delay on the built in HMI or by the PST (parameter setting tool) in the PCM600 tool.
- c Buffer memory in the telecommunication system, typical  $< +100$   $\mu$ s (Buffer memories should be avoided)
- d Clock drift during two seconds,  $< \pm 100$   $\mu$ s

Always use unique address for each LDCM on the local and remote terminal to avoid unwanted trip during loop - back in the communication system.

Group / Parameter Name	IED Value	PC Value	Unit	Min	Max
LDCMAnalog1_302					
NAMECH1		LDCM#-CH1			13 character(s)
NAMECH2		LDCM#-CH2			13 character(s)
NAMECH3		LDCM#-CH3			13 character(s)
NAMECH4		LDCM#-CH4			13 character(s)
ChannelMode		On			
TerminalNo		1		0	255
RemoteTermNo		2		0	255
DiffSync		Echo			
GPSSyncErr		Block/Echo			
CommSync		Slave			
OptoPower		LowPower			
TransmCurr		CT-GRP1			
ComFailAlmDel		100	ms	5	500
ComFailResDel		100	ms	5	500
RedChSwTime		5	ms	5	500
RedChRetnTime		100	ms	5	500
AsymDelay		0,00	ms	-20,00	20,00
AnalogLatency		2		2	20
remAinLatency		2		2	20
MaxTransmDelay		20	ms	0	40
CompRange		0-25kA			
MaxDiffLevel		600	us	200	2000
DeadbandDiff		300	us	200	1000
InvertPolK21		Off			

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Figure 3: Setting of *MaxtDiffLevel* in the PCM600 for Echo setting of block or Echo for GPSSyncErr

*MaxtDiffLevel* equals maximum individual time difference level between the internal clocks in the respective line ends. The setting range is 0.2-2 ms. The allowed time difference setting must be coordinated with reference to the sensitivity of the differential function.

This setting is only relevant for echo timing, for example when the GPS is lost.

*MaxtDiffLevel* is defined and measured at a sudden change in time difference between the line ends, induced by route switching.

If the *MaxtDiffLevel* is exceeded, the differential function is blocked. (The *MaxtDiffLevel* is assumed to be asymmetric, this is worst case.)

To avoid that a number of small changes below the *MaxtDiffLevel* give unwanted trip, these small changes are summated and checked to be below *MaxtDiffLevel*, see Section 2 page 12.

There is no supervising function in RED670, which can detect the difference between an asymmetric delay, buffer memory delay, telecommunication system jitter and wander and internal clock drift. The sum of these factors are supervised by observing the deviation between the internal clocks in all RED670s.

The GPS synchronization error, GPSSyncErr, is activated when the GPS global time and the internal differential clock time deviates  $>16 \mu\text{s}$ . The differential function can be set to be blocked, or the echo mode activated see figure 3.

With an SDH System ( $>2 \text{ Mbit}$ ), e.g. G.703 E1, and acceptable small asymmetric delay, the value  $2 \times \pm 300 \mu\text{s}$  can be used. With a PDH ( $\text{nx}64 \text{ kbit}$ ) system and a buffer memory of for example  $100 \mu\text{s}$ , a typical maximum deviation is  $2 \times \pm 400 \mu\text{s}$ . The setting should be calculated accordingly. For example increased minimum operate current for increased deviation.

Thus, a route switching, which causes a virtual difference between the internal clocks in the respective RED670s due to asymmetry in the communication channel delay, jitter and wander and buffer memory, below the set maximum clock deviation is not causing any communication failure alarm or blocking of the differential trip function. It is considered to be within the accuracy requirements and will be compensated for by the normal synchronization mechanism for the internal clocks.

If the route switching takes longer time than 2 seconds, the master and slave terminal will start to re-synchronize, after a delay of 4 seconds, with the new channel asymmetry incorporated. The synchronization will adjust the internal clock difference compared to the internal clocks in RED670 in other line ends within  $\pm 1 \mu\text{s}$ . The time synchronization messages are evaluated every 5 ms. With setting of  $\pm 200 \mu\text{s}$  maximum internal clock deviation between the respective RED670s, it will take around 10 seconds to reach a new synchronization. The synchronization will reach  $\pm 1 \mu\text{s}$  accuracy after additional 10-15 seconds.

**1.5****Reference clock deviation >set maximum deviation value  $\pm 200\text{-}2000\text{ }\mu\text{s}$** 

A route switching that causes a virtual difference between the internal clock in one RED670 compared with RED670 in other ends > set value due the asymmetry in the communication channel, jitter and wander in the communication system and buffer memory delay is supervised during 50 internal clock synchronization messages. The time synchronization messages are sent every 5 ms but evaluated every 40 ms, which gives a total stability time of 2 seconds. During this time the differential protection is still in operation, but the synchronization of the internal clocks is blocked. Thus the original accuracy between the internal clocks will be maintained during a communication interruption due to route switching. The route switching will typically be performed in <50 ms according to most communication standards. However, to make the system more robust, 2 seconds communication interruption can be tolerated without the loss of protection performance.

If the deviation between the internal clocks are outside the specified interval after 2 seconds, internal Comfail will be issued and the current differential trip blocked. After restoration of the communication channels, a new synchronization with a clock adjustment in steps of  $20\text{ }\mu\text{s}$  initially for each clock synchronization message will take place. The clock adjustment step will gradually decrease, when the internal clock differences is reduced.

If the communication channels in both directions are restored to the same time delay in both directions within 2 seconds, the difference between the internal clocks will be within set limits. Route switching within 2 seconds has no influence on the clock synchronization for the current differential protection with reference to differential function blocking. Thus, the differential function is available directly when the communication is restored.

**1.6****Route switching/interruptions >2 seconds, example****Application area (I) Echo timing**

If the route switching takes longer time, for example 4 seconds, the internal clocks will be synchronized with the asymmetric delay included. The influence of the asymmetry will then be:  $2\text{ seconds} / 40\text{ ms} \times 10\text{ }\mu\text{s}$  (average of 20 ms and  $1\text{ }\mu\text{s}$ ) = 0,5 ms, which can cause unwanted trip, depending on the set sensitivity of the differential function.

**Application area (II) Global time (GPS)**

Communication failure in the range of 10 to 30 seconds can cause the relay to lose the synchronization. Communication failure >30 seconds will always need a new synchronization of the internal clocks. If the synchronization has been lost, it takes 5 to 15 seconds of healthy communication to get the relays synchronized again and work with normal tripping times.

## 2 Echo timing function

An additional feature has been added in the echo timing function to detect accumulated dt changes below the set limit  $\pm 200\text{--}2000\ \mu\text{s}$ , to avoid that small changes will create an accumulated asymmetry, which can cause unwanted trip. Due to jitter and wander etc. this function is restricted to four dt changes.

The setting of the differential protection sensitivity must be coordinated with the setting of the *MaxtDiffLevel*. The influence of the *MaxtDiffLevel* on sensitivity is shown in Figure 4.

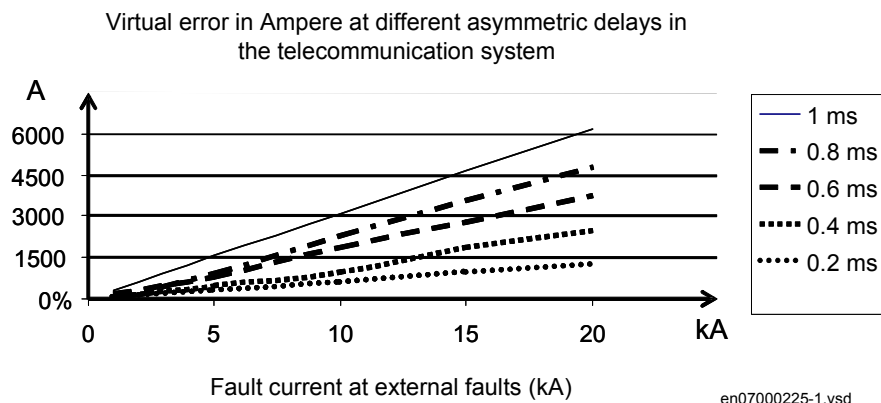


Figure 4: Virtual error

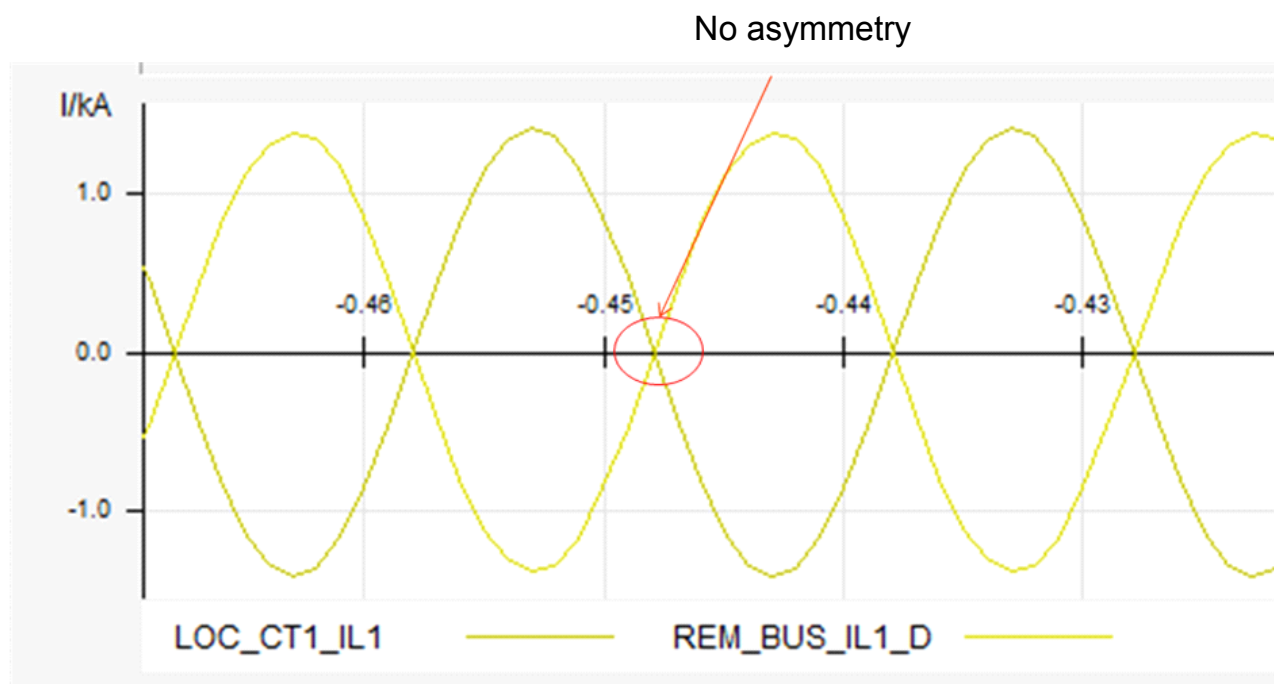
The dt detection has a setting for the dead band of  $\pm 200\text{--}2000\ \mu\text{s}$ . If the accumulated dt for up to four changes are greater than the set dead band, but below the set *MaxtDiffLevel*, no action is taken. When the fifth dt happens, the protection is blocked, even if the maximum deviation is not reached. (This restriction is included due to measuring inaccuracy, if too many consecutive dt changes are accumulated).

### 2.1 Detection of asymmetrical delay in telecommunication systems

The disturbance recorder can be used to check if the telecommunication system has an unwanted asymmetrical delay, which can cause unwanted trip if echo timing is used for RED670 differential protection.

#### Procedure:

- 1 Make a manual trig of the disturbance recorder in RED670 in the local end to record both local currents and remote currents
- 2 Check the zero crossings of the local and remote currents.
  - a. If there is no time delay between the zero crossings of the local and remote currents, the telecommunication system is without asymmetric delay, see disturbance recording 1 in Figure 5.



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Figure 5: Disturbance recording 1

- b. If there is a time difference in the zero crossing between local and remote current, the telecommunication system has an asymmetric delay, see disturbance recording 2 below.
- c. To verify that there is a correct detection of asymmetric delay, the procedure can be repeated at the remote end.

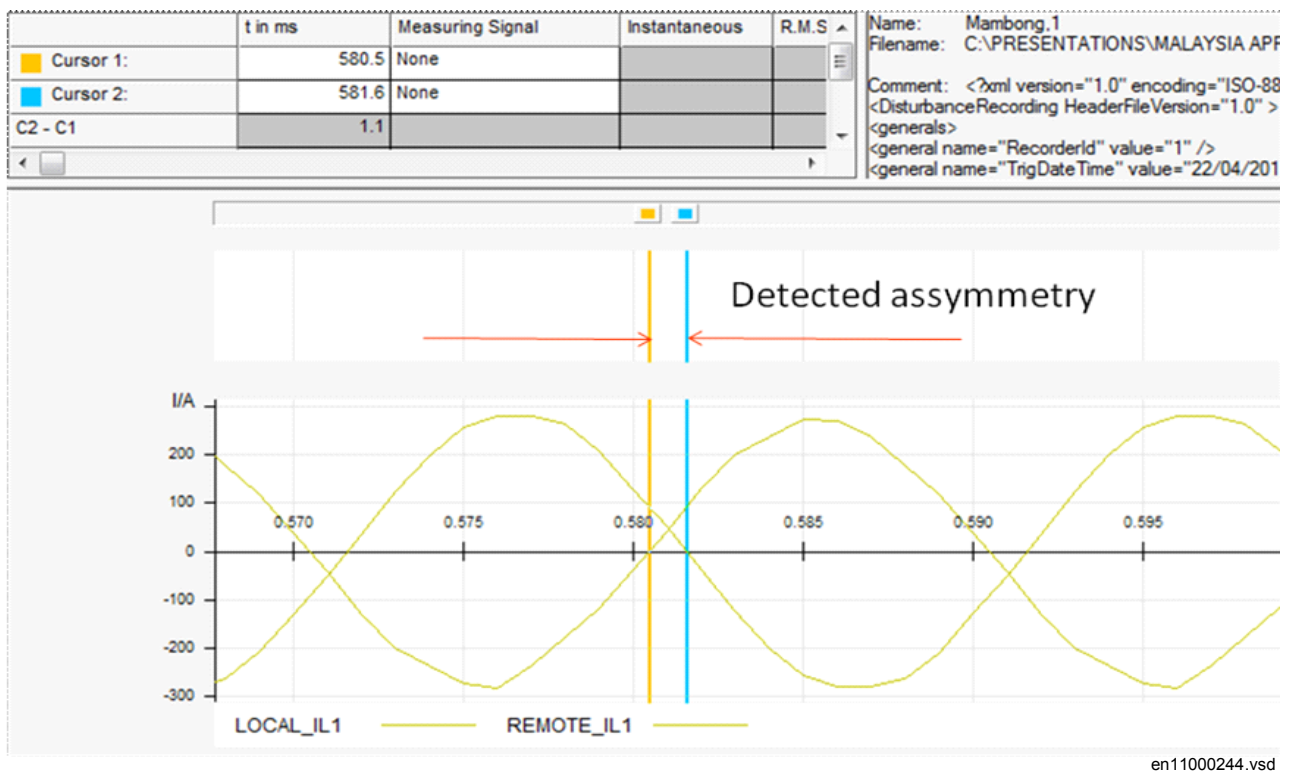


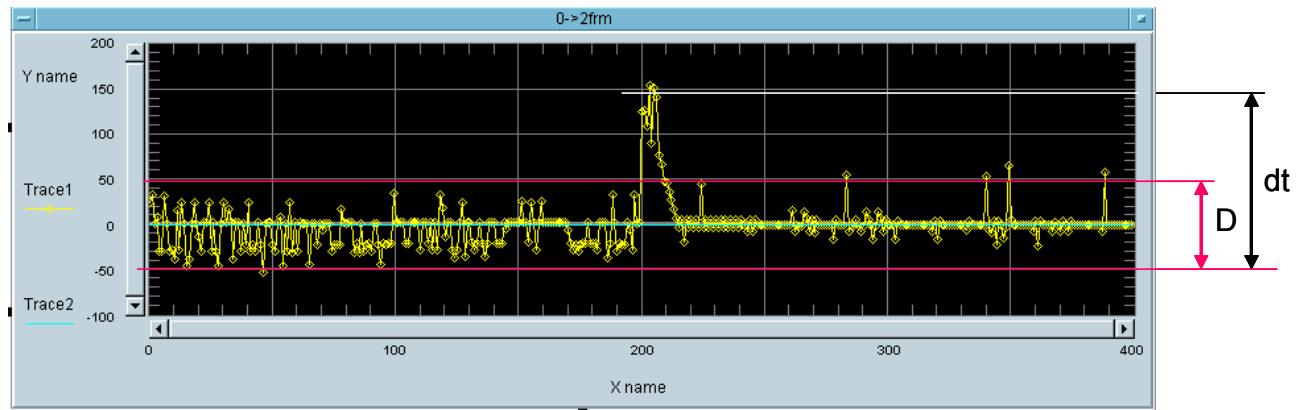
Figure 6: Disturbance recording 2

d. The influence of the asymmetric delay can be checked in Figure 6 above.

If the asymmetry is fixed, i.e. not fluctuating, the asymmetry can be compensated for by setting, see Section 5.5 page 39. If the asymmetry is fluctuating, GPS timing must be used.



See the oscillogram in *Figure 7* for explanations of dead band  $D$ , measured change  $dt$  and scattering (deviation in calculation), inside the set deadband.



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*Figure 7: Deadband*

$D$	$DeadbandtDiff \pm 200 \mu s$ (setting range $\pm 200$ - $2000 \mu s$ )
$dt$	Measured change $\pm 200 \mu s$ in this example
Scattering	Random fluctuations in delay time, due for example to varying switching time in multiplexers, which gives jitter and wander etc.

Group / Parameter Name	IED Value	PC Value	Unit	Min	Max
✓ LDCMAnalog1_302					
✓ NAMECH1		LDCM#-CH1			13 character(s)
✓ NAMECH2		LDCM#-CH2			13 character(s)
✓ NAMECH3		LDCM#-CH3			13 character(s)
✓ NAMECH4		LDCM#-CH4			13 character(s)
✓ ChannelMode		On			
✓ TerminalNo		1		0	255
✓ RemoteTermNo		2		0	255
✓ DiffSync		Echo			
✓ GPSSyncErr		Block			
✓ CommSync		Slave			
✓ OptoPower		LowPower			
✓ TransmCurr		CT-GRP1			
✓ ComFailAlmDel		100	ms	5	500
✓ ComFailResDel		100	ms	5	500
✓ RedChSwTime		5	ms	5	500
✓ RedChRtnTime		100	ms	5	500
✓ AsymDelay		0,00	ms	-20,00	20,00
✓ AnalogLatency		2		2	20
✓ remAinLatency		2		2	20
✓ MaxTransmDelay		20	ms	0	40
✓ CompRange		0-25kA			
✓ MaxtDiffLevel		600	us	200	2000
✓ DeadbandtDiff		300	us	200	1000
✓ InvertPotK21		Off			

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Figure 8: DeadbandtDiff

*DeadbandtDiff* equals dead band time difference. This setting is used to compensate for measuring inaccuracy due to scattering when accumulating changes smaller than *MaxtDiffLevel*.

After blocking by *MaxtDiffLevel* the communication set up must be checked before restarting.

## 3

**RED670 with built-in external GPS clock or with  
IRIGB-00X input for unspecified route switching**

For telecommunication networks with unspecified route switching RED670 with built in GPS clock must be used. Thus, the differential protection can operate correctly, independent of asymmetric delays in the communication channels. The maximum allowed time delay in the telecommunication system is settable,  $0-2 \times 20 \text{ ms} = 40 \text{ ms}$ , as the sum of the delay in both directions. It is also possible to make an asymmetric split, for example 10 ms in one direction and 30 ms in the other direction as the delay can be accurately measured when GPS timing is available. For longer delays, the differential function is blocked.

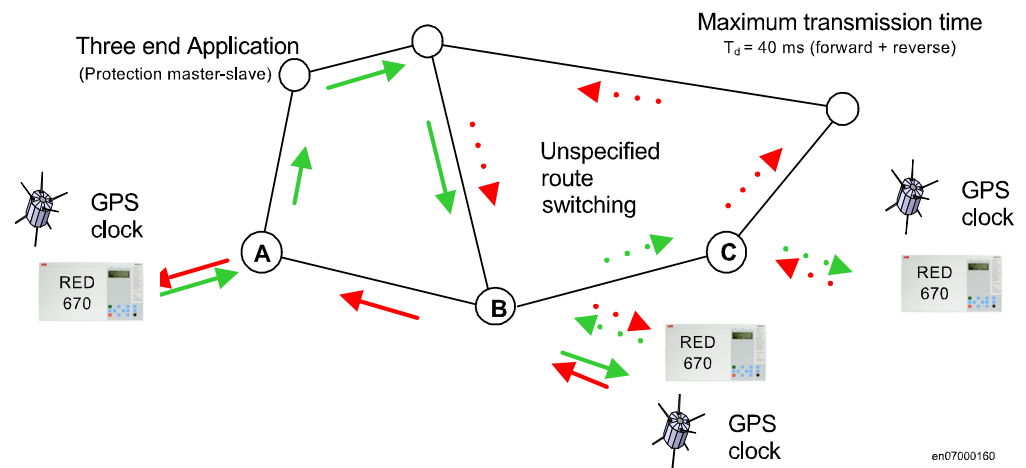


Figure 9: Three end application with GPS

## 3.1

**Start up of the GPS system (cold start)**

With the antenna placed for good visibility, the GPS system takes up to 15 minutes to find the satellites (minimum 4) and start synchronizing the internal clocks in the RED670 with the global time from the GPS system.

Group / Parameter Name		IED Value	PC Value	Unit	Min	Max
TIMESYNCHGEN: 1						
General						
✓ General						
✓ CoarseSyncSrc			Off			
✓ FineSyncSource			GPS			
✓ SyncMaster			Off			
✓ TimeAdjustRate			Slow *			
IEC61850-9-2						
General						
HwSyncSrc			GPS			
AppSynch			NoSynch			
SyncAccLevel			Unspecified			

\* At first start-up the TimeAdjustRate is automatically set to fast to reduce the adjustment time.

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Figure 10: Setting GPS clock

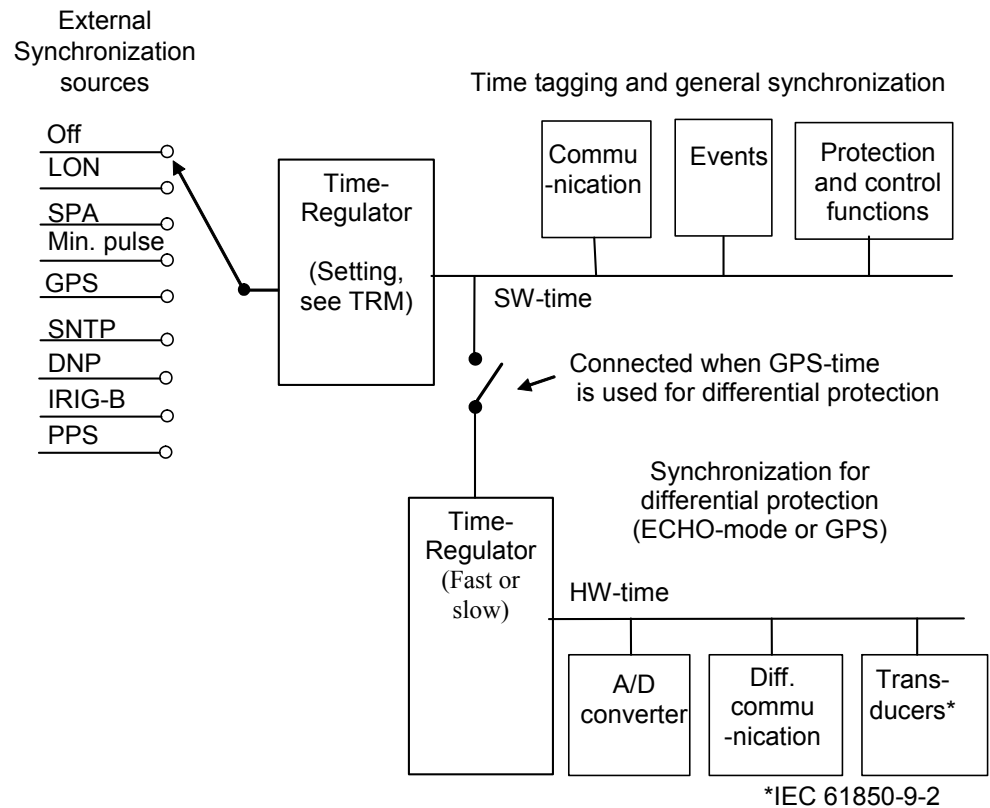
At the beginning of the synchronization procedure, the internal clocks in the RED670s are adjusted to have the correct global time in seconds, only integers are set. The remaining fractional part to reach global time, milliseconds (ms) and microseconds ( $\mu$ s), are used to slowly synchronize the RED670 internal clocks to global time.

The synchronization of the internal clock to the global time is done with a rate of 1 ms/s to reach the global time. When the RED670 internal clock is within 16  $\mu$ s from the global time, the differential function is enabled. Thereafter a soft calibration is performed, in which the RED670 internal clock is synchronized to maintain the global time + 1  $\mu$ s for a period of time, especially important during interruptions in the GPS system. When the internal clock and the global time deviates more than 16  $\mu$ s, the GPS timing is deactivated. If only GPS is used the differential protection is blocked or the back-up echo timing enabled.

## 3.2

### Time synchronization

The time system is based on a “software clock”, which can be adjusted from external time sources and a hardware clock. The protection and control modules will be timed from a “hardware” clock, which runs independently from the “software” clock. See figure below.



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Figure 11: Design of time system (clock synchronization)

All time tagging is performed by the “software” clock. When for example a status signal is changed in the protection system with the function based on “free running hardware” clock, the event is time tagged by the software clock when it reaches the event recorder. Thus the “hardware” clock can run independently.

The echo mode for the differential protection is based on the “hardware” clock. Thus, there is normally no need to synchronize the “hardware” clock and the “software” clock. If a GPS clock is used for other products in the 670-series than current differential RED670, i.e. the “hardware” and “software” clocks are not synchronized.

The synchronization of the “hardware” clock and the “software” clock is necessary only when GPS or IRIG B 00X with optical fibre, IEEE 1344 is used for the differential protection. The two clock systems are synchronized by a special clock synchronization unit with two modes, fast and slow. The setting *fast* or *slow* is available on the HMI or in PCM600.

*Fast* shall be used when GPS timing without echo back-up is selected to block the differential when the GPS is lost.

*Slow* shall be used when GPS timing with echo back-up or echo timing is selected.

#### **Fast clock synchronization mode**

At start-up and after interruptions in the GPS or IRIG B time signal, the clock deviation between the GPS time and the internal differential time system can be substantial. A new start-up is also required after for example maintenance of the auxiliary voltage system. The fast mode makes the synchronization time as short as possible during start-up or at interruptions/disturbances in the GPS timing.

When the time difference is  $>16\ \mu\text{s}$ , the differential function is blocked and the time regulator for the hardware clock is automatically using a fast mode to synchronize the clock systems. The time adjustment is made with an exponential function, i.e. big time adjustment steps in the beginning, then smaller steps until a time deviation between the GPS time and the differential time system of  $<16\ \mu\text{s}$  has been reached. Then the differential function is enabled and the synchronization remains in fast mode or switches to slow mode, depending on the setting. The "Fast" setting has 1 ms/s second adjustment rate.

#### **Slow clock synchronization mode**

During normal service, a setting with slow synchronization mode is normally used, which prevents the hardware clock to make too big time steps,  $>16\ \mu\text{s}$ , emanating from the differential protection requirement of correct timing.

At start up a special feature, an automatic fast clock time regulator is used to reduce the synchronization time. After the clock is synchronized to  $<16\ \mu\text{s}$  the slow clock mode is activated. The "Slow" setting has  $+50\ \mu\text{s/s}$  second adjustment rate.

If the echo timing has been enabled as back-up for the GPS system, the RED670 internal clock can not deviate more than  $\pm 50\ \mu\text{s/s}$ , which is the maximum adjustment rate of the internal clock, depending on the echo timing adjustment capability in a 64 kbit communication system.

This limitation is not valid for echo timing without GPS.

### **3.3**

#### **Setting of GPS via IRIGB00x for RED670 with PCM600**

- 1 Select the Fine SyncSource.

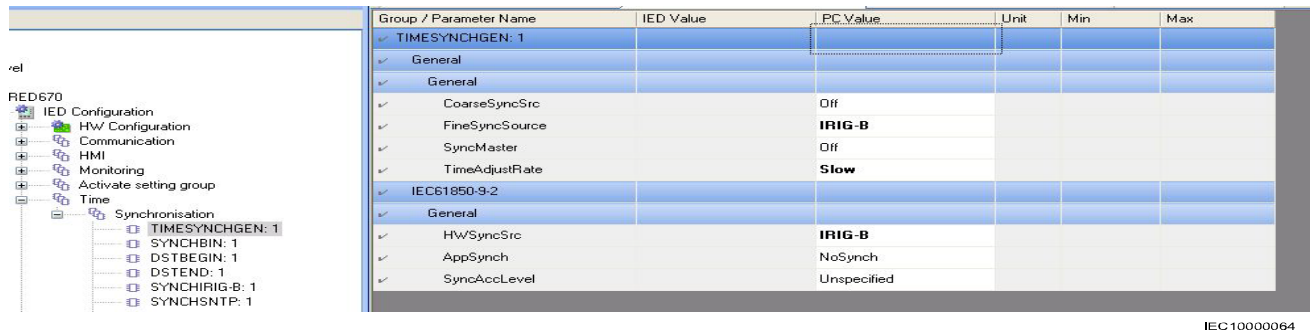


Figure 12: Select FineSyncSource

- 2 Set sync type to Opto (default).
- 3 Set the encoding to 1344.

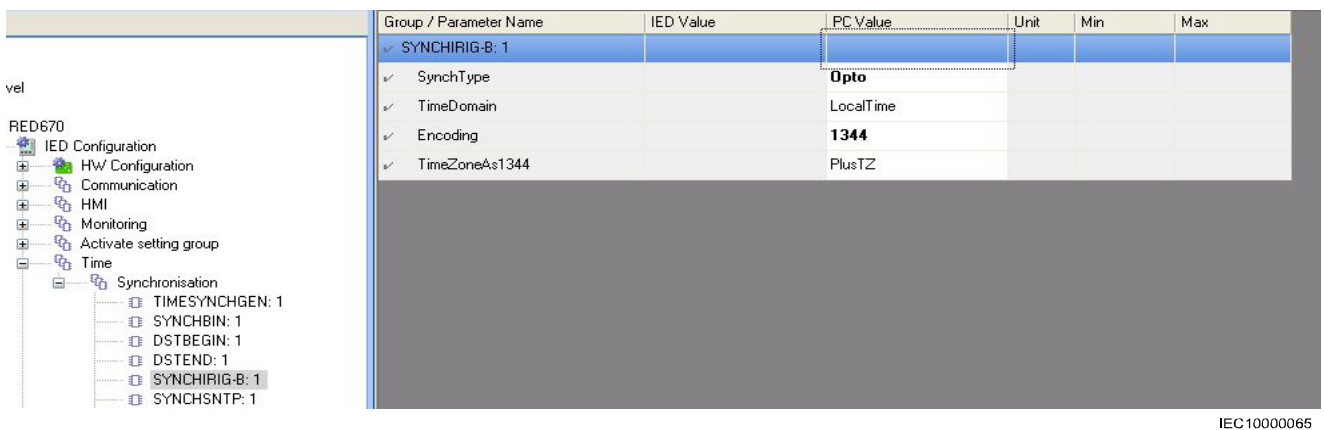


Figure 13: Set encoding

- 4 For the real time clock for example for tagging of events select the Time Sync Time zone under Synchronization.

### 3.4

### Accuracy of the GPS system

The accuracy of the soft calibration of the RED670 internal clocks is dependent of the time the GPS system has been in service. Thus, if the GPS system is lost directly after the differential protection has been enabled, the drift of the clock can be up to 16  $\mu$ s/second. However, by using software calibration this drift will be reduced to 1  $\mu$ s/second during a time span of < 1 hour. This reduced drift is also reducing the restart time after a short GPS interruption. If the time difference after the interruption is less than the set *MaxtDiffLevel*, the differential system can be enabled directly.

---

### 3.5 Enabling of the echo timing according to application (I)

The echo timing is enabled when the GPS is lost. The enabling of the echo timing will have a delay, depending on how long the GPS has been working after start.

Starting inaccuracy of the internal clock is 16  $\mu$ s and will go down to  $\pm 1 \mu$ s after some minutes.

### 3.6 Blocking of the echo-timing after GPS interruption

As the telecommunication system has unspecified route switching, the echo-timing can only be used with unchanged time delay in both directions (within set limits, see Section 1.2 page 7). As soon as the time delay is outside the set limits the differential function is blocked. Some additional features are included to increase the performance of the echo timing blocking, see below.

a) If redundant or alternative routes are available, these routes are also supervised for change in time delay. If there is no time delay difference in the redundant or alternative route, the echo-timing will continue with the reserve channel.

b) In telecommunication systems with unspecified route switching, time differences below the set limits are accumulated to handle multiple route switching, which together can reach the set time difference limit according to Section 1.2 page 7.

### 3.7 Selectivity planning

A missed protection message due to for example bit errors, prolongs the tripping time. Maximum interruption time and bit error rate should be part of the selectivity planning.



## 4

## Digital signal communication for line differential protection RED670

The line differential protection RED670 uses digital 64 kbit/s communication channels to exchange sampled current values between the ends every 5 ms. Each telegram contains current sample values, time information, trip-, block- and alarm signals and eight separate binary signals which can be used for any purpose, for example transfer trip from external protection equipment. Each 670 series equipment can have a maximum of four communication channels.

On a two ended line there is a need of one 64 kbit/s communication channel provided that there is only one CT in each line end as shown in *Figure 14*.

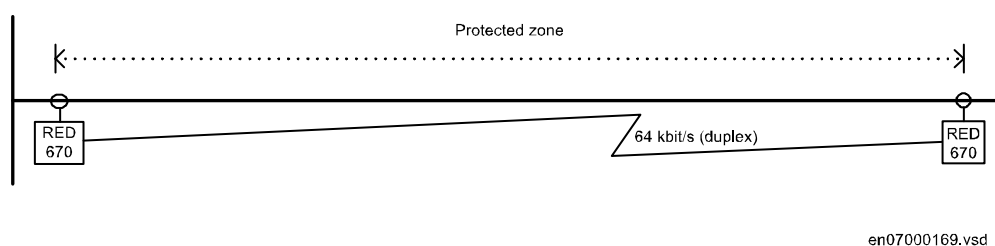


Figure 14: Two-terminal line

In case of a 1/2 breaker arrangements or ring buses, one line end can have two CTs as shown in *Figure 15*.

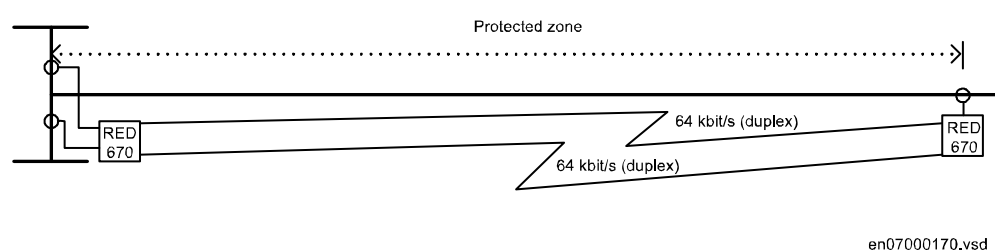


Figure 15: Two-terminal line with a 1/2 breaker

In this case, current values from two CTs in the double breakers, ring main or breaker-and-a-half systems end with dual breaker arrangement need to be sent to the remote end. As a 64 kbit/s channel only has capacity for one three-phase current (duplex), this implies that two communication channels will be needed, and this is also the normal solution.

Alternatively, it is possible to sum and check the two local currents before sending them and in that way reduce the number of communication channels needed. The evaluation is then made in software in the 670 series, but doing it in this way, there will be reduced information about bias currents in the two CTs.

In RED670, the bias current is considered the greatest phase current in any line end and it is common for all three phases. When sending full information from both local CTs to the remote end, as shown in *Figure 15*, this principle works, but when the two local currents are added together before sending the single resulting current on the single communication channel, information about the real phase currents from the two local CTs will not be available in the remote line end.

Whether it will be possible to use one communication channel instead of two (as shown in *Figure 15*) must be decided from case to case. It must be realized that correct information about bias currents will always be available locally, whilst only limited information will be available at the end, that receives the limited information over only one channel.

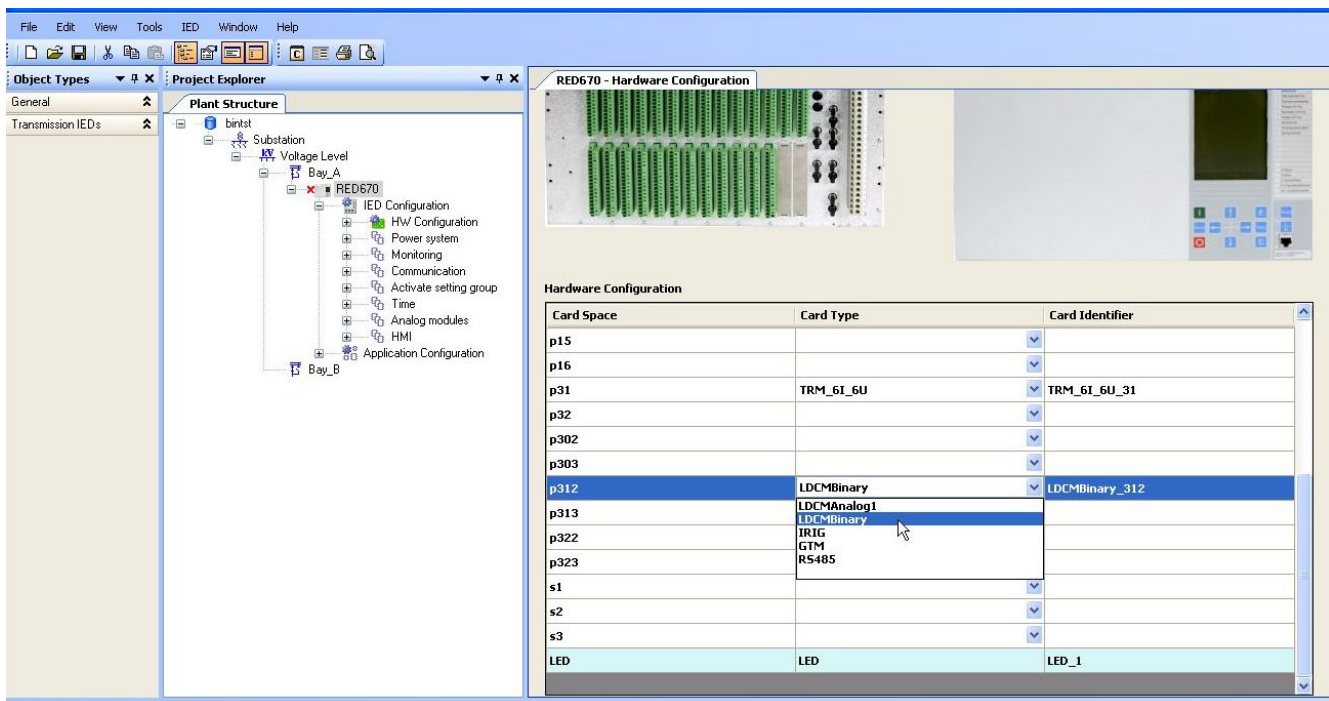
For the configuration of redundant channels see Section 4.5 page 27. For further information see Chapter Remote communication, in “*Application manual*”.

## 4.1

### Configuration of analog and binary signals - Line Data Communication Module (LDCM)

The communication between the 670 series protection and control products is provided by a Line Data Communication Module. The abbreviation LDCM is used in the entire text.

The selection of an analog or binary LDCM is made in PCM600.



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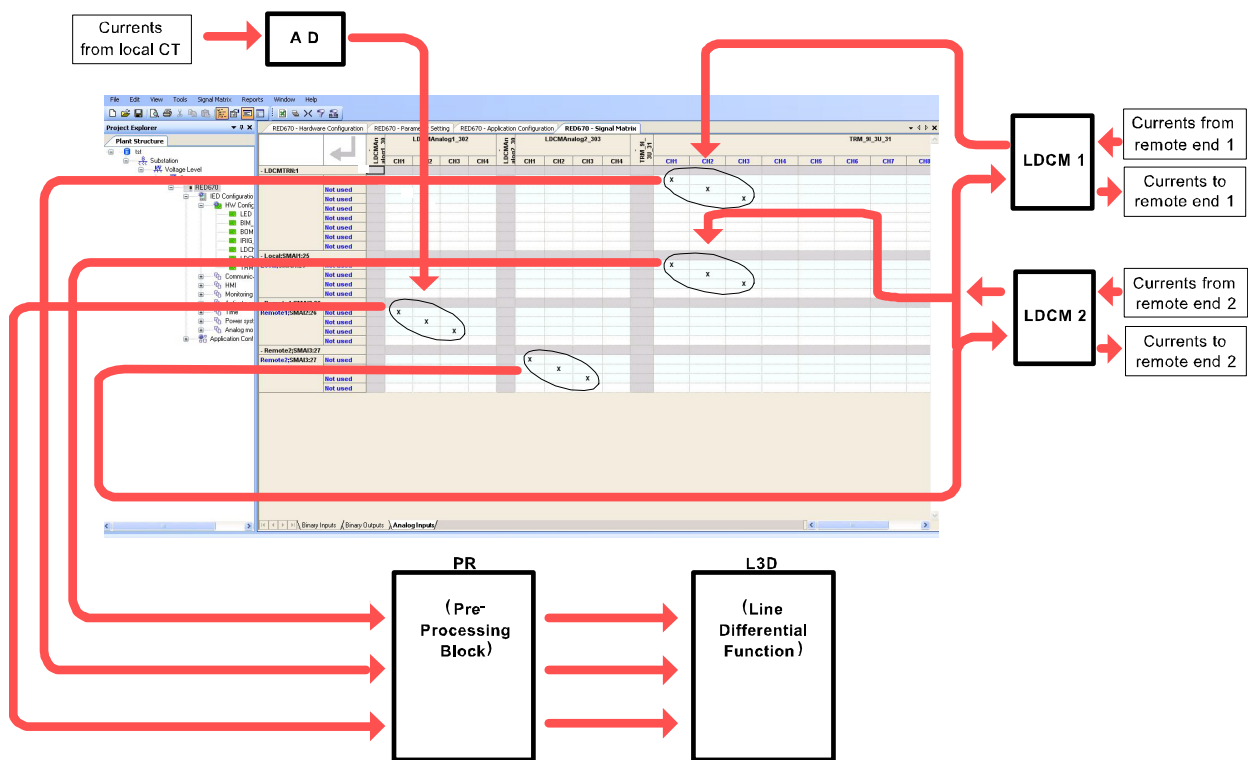
Figure 16: Selection of LDCM for analog or binary transfer

## 4.2

### Configuration of analog signals

The currents from the local end enter RED670 via the Analog Input Modules as analog values. These currents need to be converted to digital values and then forwarded to the line differential function in the local RED670, as well as being transmitted to a remote RED670 via a Line Data Communication Module with either fiberoptic C37.94 or galvanic X.21 at 64 kbit. The currents from a remote RED670 are received as digital values in the local RED670 via an LDCM and is thereafter forwarded to the line differential function in the local RED670.

The engineering tool PCM600, protection and control manager is used for the configuration and setting of the 670 series. The abbreviation PCM will be used in the following text. The Signal Matrix tool, SMT is used to configure and connect input and output signals. The abbreviation SMT will be used in the following text. The configuration of this data flow is made in the SMT tool in PCM600 which is principally shown in *Figure 17*, next page.



IEC10000066

Figure 17: Typical configuration of the analog signals for a three ended line

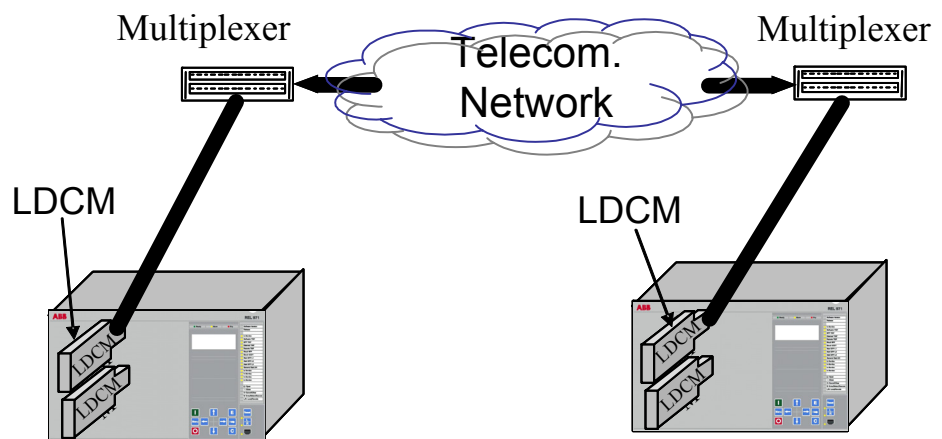
Figure 17 shows how one IED in a three ended line differential protection can be configured. Especially notice that there are two LDCMs, each one supporting a duplex connection with a remote line end. Thus, the same local current is configured to both LDCMs, whilst the received currents from the LDCMs are configured separately to the line differential function.



		LDCMAnalog1_302							
		REC06	REC07	REC08	COMFAIL	YBIT	NOCARR	NOMESS	ADDRERR
- Diff Com;SMBI:1									
Diff Com;SMBI:1	ldcm x302				X				
	ldcm x303								
	ldcm x312								
	ldcm x313								
	Not used								
	Not used								
	Not used								
	Not used								
	Not used								

IEC10000230

Figure 19: Example of LDCM signals as seen in the Signal matrix tool



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Figure 20: Typical LDCM application

## 4.5

### Configuration of redundant channels

LDCM installation sequence: slot 312, slot 313, slot 322, slot 323, slot 302 and slot 303.

2-4 LDCM can be included depending of availability of IRIG-B respective RS485 modules. IRIG-B will be seated in slot 302 and RS485 will be seated in slot 312.



### Warning:

*The redundant channels must be configured in the same way in both ends of the differential communication link, otherwise an unwanted trip may occur when the main channel fails and the redundant channel is enabled.*

*a) Thus it is not allowed to have a LDCM for the redundant channel only in one end.*

*b) The SMT configuration for the redundant channel must be left empty. The redundant channel will take over the signal matrix configuration from the main channel at enabling. If the redundant channel has, for example, been allocated current inputs with the SMT tool in one end or in both ends, an unwanted trip will occur.*

Slots 303, 313 and 323 can be set as redundant line differential communication channel in PCM600.

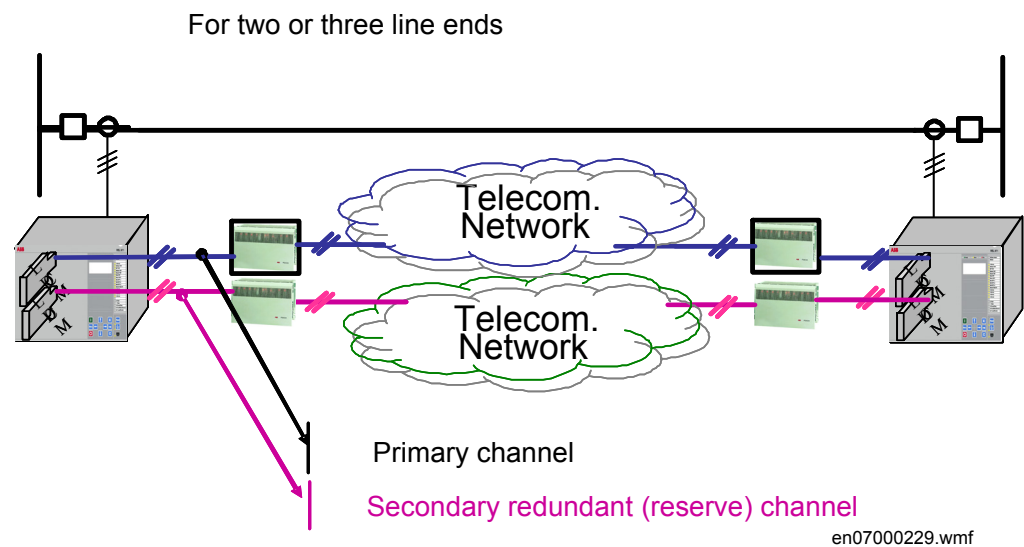
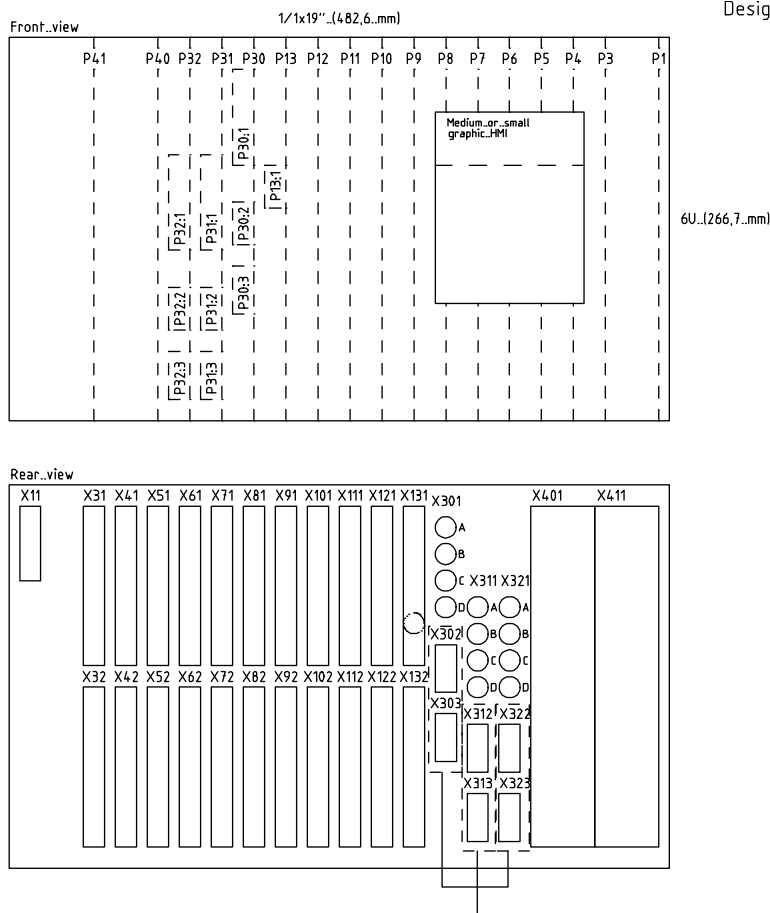


Figure 21: Typical application with redundant channels



**Note:**

Main and redundant channel is placed on the same base card in slot 303-302, 313-312 and 323-322. For more details, see Figure 22.



Designations for 1/1x19" casing with 2 TRM slots

Module	Slot	Terminal
PSM	P1	X11
1)	P3	X31,32
1)	P4	X41,42
1)	P5	X51,52
1)	P6	X61,62
1)	P7	X71,72
1)	P8	X81,82
1)	P9	X91,92
1)	P10	X101,102
1)	P11	X111,112
1)	P12	X121,122
2)	P13	X131,132
NUM	P30	-
SLM	P30:1	X301:A,B,C,D
3).6)	P30:2	X302
6)	P30:3	X303
ADM.5)	P31	-
OEM	P31:1	X311:A,B,C,D
4).6)	P31:2	X312
6)	P31:3	X313
ADM	P32	-
6)	P32:2	X322
6)	P32:3	X323
TRM.7)	P40	X401
TRM	P41	X411

- 1).BIM,..BOM,..SOM,..IOM..or..MIM
- 2).BIM,..BOM,..SOM,..IOM,..MIM..or..GSM
- 3).IRIG-B..installation,..when..included..in..seat..P30:2 \*
- 4).RS485..installation,..when..included..in..seat..P31:2 \*
- 5).First..location..of..ADM
- 6).LDCM..installation..sequence:..P31:2,..P31:3,..P32:2,..P32:3, P30:2..and..P30:3
- 7).First..location..of..TRM

NOTE.1

2-4..LDCM..can..be..included..depending..of  
availability..of..IRIG-B..respective..RS485..modules.

When..IRIG-B,..RS485..and..4..pc..of..LDCM..are..in..use,..needs..a..second..ADM.

- \* Note that IRIG-B, (slot 30:2) and RS485,  
(slot 31:2) modules have dedicated positions

en1mrk002801-AB\_6\_revA\_redundant channel.eps

Figure 22: Designation for 1/1x9" casing with 2 TRM slots

		LDCMAnalog1_302					TRM_9I_3U_31							
		LDCMAnalog1_302	CH1	CH2	CH3	CH4	TRM_9I_3U_31	CH1	CH2	CH3	CH4	CH5	CH6	CH7
- LDCMTRN:1														
LDCMTRN:1	Not used							X						
	Not used								X					
	Not used									X				
	Not used													
	Not used													
	Not used													
	Not used													
- Local:SMAI:25														
Local:SMAI:25	Not used							X						
	Not used								X					
	Not used									X				
	Not used													
- Remote1:SMAI:26														
Remote1:SMAI:26	Not used		X											
	Not used			X										
	Not used				X									
	Not used													

Binary Inputs

Binary Outputs

Analogue Inputs

IEC10000068

Figure 23: Signal Matrix for one LDCM

		LDCMAnalog1_302				LDCMAnalog2_303				TRM_9I_3U_31											
		LDCMAnalog1_302	CH1	CH2	CH3	CH4	LDCMAnalog2_303	CH1	CH2	CH3	CH4	TRM_9I_3U_31	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8	CH9
- LDCMTRN:1																					
LDCMTRN:1	Not used												X								
	Not used													X							
	Not used														X						
	Not used																				
	Not used																				
	Not used																				
	Not used																				
- Local:SMAI:25																					
Local:SMAI:25	Not used												X								
	Not used													X							
	Not used														X						
	Not used																				
- Remote1:SMAI:26																					
Remote1:SMAI:26	Not used		X																		
	Not used			X																	
	Not used				X																
	Not used					X															
	Not used																				

IEC10000069

Figure 24: Signal Matrix for two channels, one redundant

The position for the main and redundant channels are predefined in the basic configuration, in other words they can not be shifted. The signal matrix for the redundant channel must be empty. It is automatically updated when the main channel is lost. See Figure 24, above.



Project Explorer

Plant Structure

tst2

Substation

Voltage Level

Bay

RED670

IED Configuration

HV Configuration

LED

BIM\_3

BDM\_4

TRM\_9I\_3U\_31

LDCMAnalog1\_302

LDCMAnalog2\_303

IRIG\_313

Time

Power system

Communication

Analog modules

HMI

Monitoring

Activate setting group

Application Configuration

RED670 - Parameter Setting

Group / Parameter Name	IED Value	PC Value	Unit	Min	Max
LDCMAnalog2_303					
NAMECH1		LDCM#-CH1			13 character(s)
NAMECH2		LDCM#-CH2			13 character(s)
NAMECH3		LDCM#-CH3			13 character(s)
NAMECH4		LDCM#-CH4			13 character(s)
ChannelMode		On			
TerminalNo		3		0	255
RemoteTermNo		4		0	255
DiffSync		Echo			
GPSSyncErr		Block			
CommSync		Slave			
OptoPower		LowPower			
TransmCurr		RedundantChannel			
ComFailAlrmDel		100	ms	5	500
ComFailResDel		100	ms	5	500
RedChSwTime		5	ms	5	500
RedChRtnTime		100	ms	5	500
AsymDelay		0,00	ms	-20,00	20,00
AnalogLatency		2		2	20
remAinLatency		2		2	20
MaxTransmDelay		20	ms	0	40
CompRange		0-25kA			
MaxDiffLevel		600	us	200	2000
DeadbandDiff		300	us	200	1000
InvertPolK21		Off			

IEC10000070

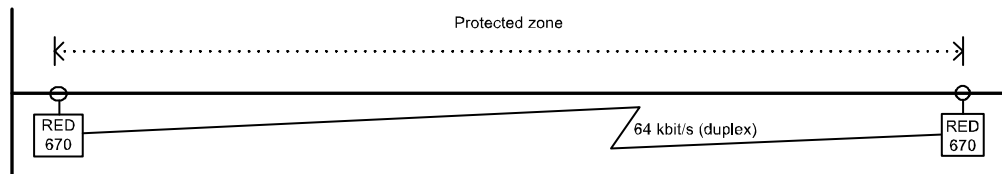
Figure 25: Setting example of RED670 with redundant channel (two duplex channels)

## 5

## Binary signal transfer for the 670 series

REL 670, REC 670, REB 670 and REG 670 can utilize the same 64 kbit communication facilities for binary signal transfer of up to 192 external or internal logical signals, for example Carrier Send, Carrier Receive, block signals, control signals etc.

The line differential protection RED670 can transfer 8 binary signals.



en07000169.vsd

Figure 26: Two-terminal line

The start and stop flags are the 0111 1110 sequence (7E hexadecimal), defined in the HDLC standard. The CRC is designed according to the standard CRC16 definition. The optional address field in the HDLC frame is not used. Instead a separate addressing is included in the data field. The address field is used for checking that the received message originates from the correct equipment. There is always a risk that multiplexers occasionally mix the messages up. Each point in the system is given a number. The 670 series is then programmed to accept messages from a specific IED number. If the CRC function detects a faulty message, the message is thrown away and not used in the evaluation. When the communication is used exclusively for binary signals, the full data capacity of the communication channel is used for the binary signal purpose which gives the capacity of 192 signals

Group / Parameter Name	IED Value	PC Value	Unit	Min	Max
LDCMBinary_302					
ChannelMode		On			
TerminalNo		1		0	255
RemoteTermNo		2		0	255
CommSync		Slave			
OptoPower		LowPower			
ComFailAlrmDel		100	ms	5	500
ComFailResDel		100	ms	5	500
InvertPolK21		Off			

IEC10000071

Figure 27: Setting example of RED670 with one communication channel for binary transfer

## 5.1

## Function block

**Note!**

*There is no function block for the LDCM they are instead represented as hardware channels in ACT and in SMT. Where they can be found in the top margin. The signals appear only when a LDCM is included in the Hardware Configuration Tool. It is possible to use either ACT or SMT to configure the LDCM signals.*

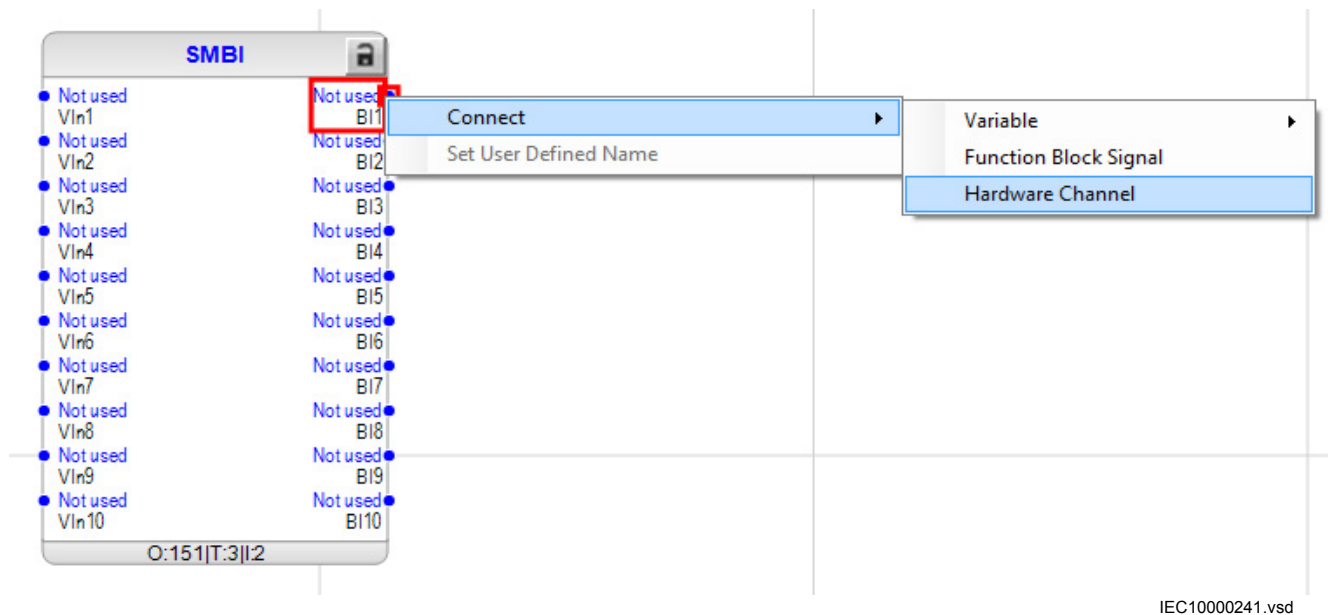
## 5.2

**ACT Configuration of binary inputs and outputs for binary signal transfer**

In ACT LDCM Hardware Channels can be connected by putting the pointer (arrow) over the connection point. The arrow will then change to a pointing hand, right click and select Connect/Hardware Channel.

**Note**

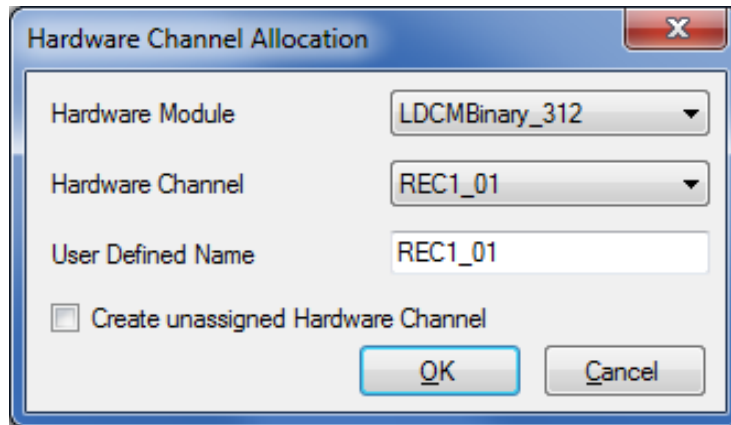
*If a LDCM is not used, it shall be disabled with the hardware configuration too. Otherwise parallel LDCMs can be blocked.*



IEC10000241.vsd

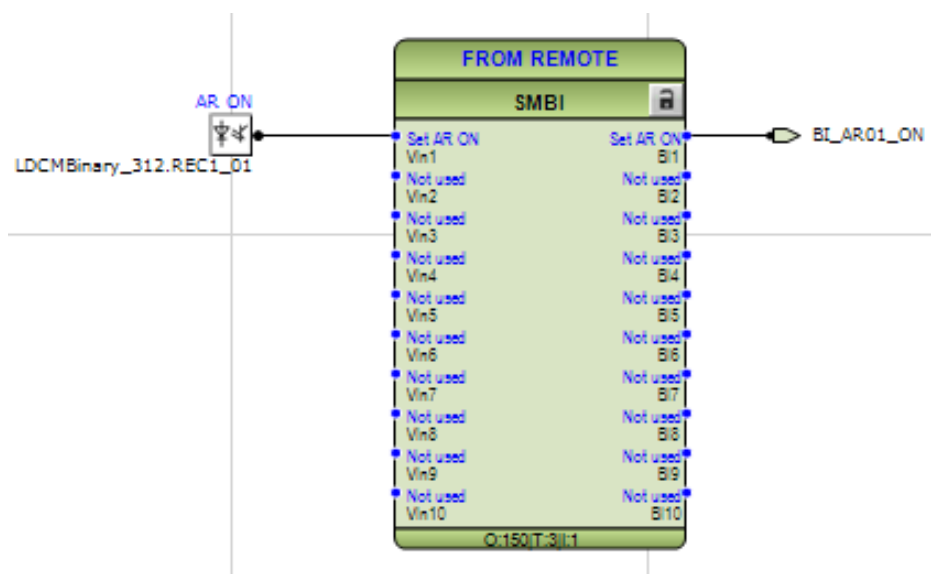
Figure 28: ACT configuration of binary inputs and outputs

In the dialog Hardware Channel Allocation it is possible to select: Hardware Module, Hardware Channel and User Define Name where the channel name is given.



IEC10000242.vsd

Figure 29: Dialog Hardware Channel Allocation



IEC10000243.vsd

Figure 30: The result of selected Hardware Channels might look like

When User Define Name for the Hardware Channel is given it will also be visible in SMT.

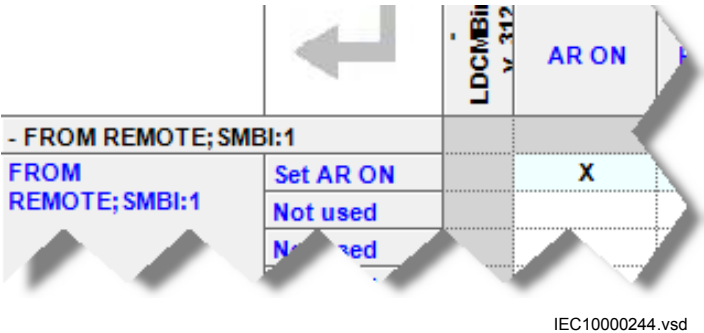


Figure 31: User define name is visible in SMT

5.3

Configuration of binary output (SMBO) and input (SMBI) signals in Signal Matrix Tool (SMT).

The configuration of binary signals for binary signal transfer in SMT is basically done by selecting accurate TAB.

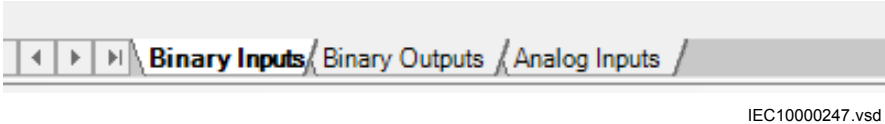


Figure 32: TAB selecting in SMT

This example shows configuration of SMBI input and LDCM Hardware Channel in the Binary Inputs tab. The intercross between software (SMBI) and hardware (LDCM) is marked with an X indicating that a connection is done.

RED670 - Application Configuration		RED670 - Signal Matrix							
		←	+ LDCMAnalo α1_322	+ LDCMAnalo α2_303	+ LDCMAnalo α2_313	+ LDCMAnalo α2_323	- LDCMBinar α2_312	AR ON	AR OFF
- FROM REMOTE; SMBI:1									
FROM REMOTE; SMBI:1	Set AR ON							X	
	Not used								
	Not used								
	Not used								
	Not used								
	Not used								
	Not used								
	Not used								

IEC10000245.vsd

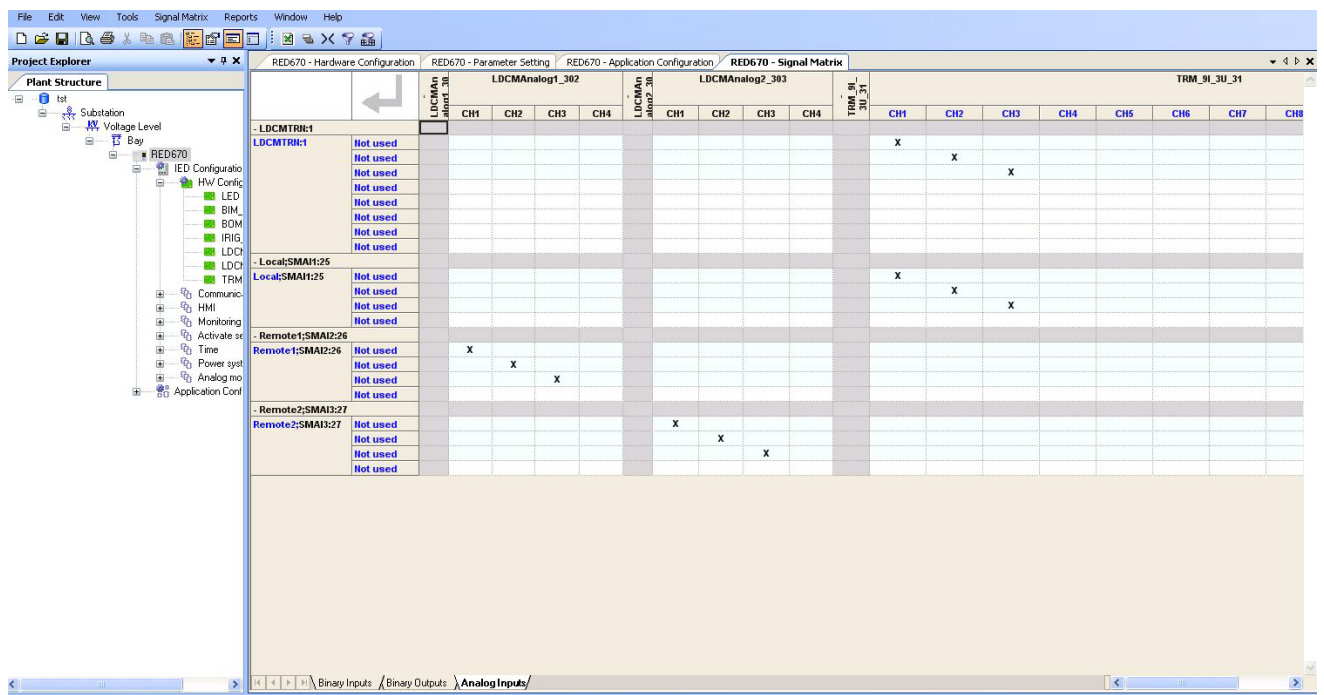
Figure 33: X indicates that a connection is done between SMBI and LDCM

The possibility to set names on Hardware Channels in ACT is also possible in SMT. Simply by selecting the channel to rename and open Object Properties. In the field User Defined Name: change to preferred name and save.

The screenshot shows the SMT software interface. On the left, the 'RED670 - Signal Matrix' is visible, showing a connection (X) between 'FROM REMOTE; SMBI:1' and 'AR ON'. On the right, the 'Object Properties' window is open, showing the 'Designation' tab. The 'User Defined Name' field is highlighted with a red circle, and the 'AR OFF' button is also circled in red.

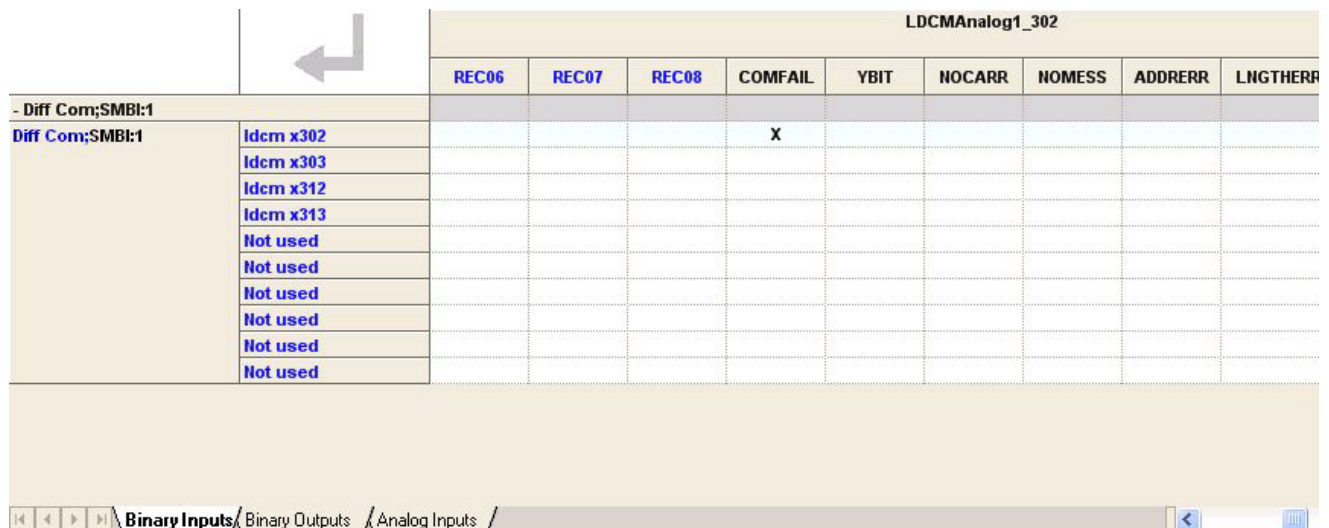
IEC10000246.vsd

Figure 34: Figure shows where to change name in SMT



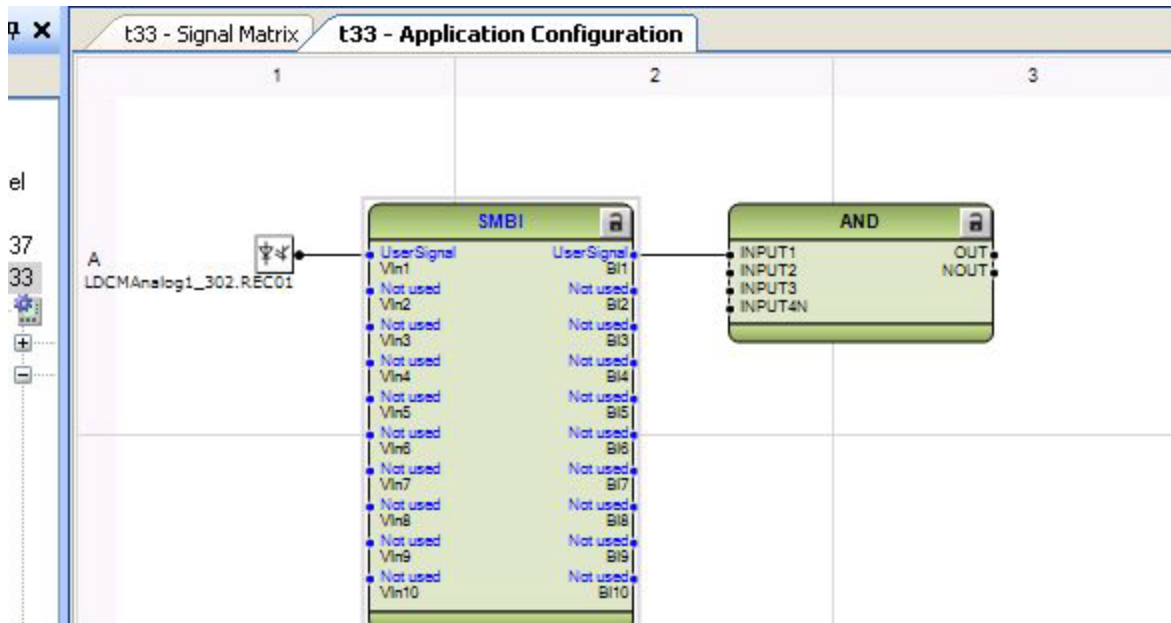
IEC10000237

Figure 35: Configuration of received signals



IEC10000238

Figure 36: Configuration of communication alarms



IEC10000239

Figure 37: Disconnection of analogue signals for binary signal transfer set-up

## 5.4

### Analog and binary input and output signals

In the PCM600 configuration and setting tool, the communication module (LDCM) has an affix, either CRM or CRB, which defines actual type of signal transfer.

CRM 1-6; **Remote Communication Multi** is used to send both analog and binary signals (RED670).

CRB 1-6; **Remote Communication Binary** is used to send binary signals (remaining IED 670).

CRM and CRB number 1-6 has predefined slots in the IED 670 hardware. **Only four slots can be used simultaneously.**

Table 1: Predefined slots for analog and binary signals

Analog and binary signals	Binary signals	Communication slot
CRM- 1	CRB- 1	302
CRM- 2	CRB- 2	303
CRM- 3	CRB- 3	312
CRM- 4	CRB- 4	313
CRM- 5	CRB- 5	322
CRM- 6	CRB- 6	323



**Table 2: Output signals for the LDCMRecBinStat (CRM1-) function block in analog mode (see also section 11, fault tracing)**

Signal	Description
COMFAIL	Detected error in the differential communication
YBIT	Detected error in remote end with incoming message
NOCARR	No carrier is detected in the incoming message
NOMESS	No start and stop flags identified for the incoming message
ADDRERR	Incoming message from a wrong terminal
LNGTHERR	Wrong length of the incoming message
CRCERROR	Identified error by CRC check in incoming message
TRDELERR	Transmission time is longer than permitted
SYNCERR	Indicates when synchronisation is not correct
RECOMF	Remote terminal indicates problem with received message
REMGPSER	Remote terminal indicates problem with GPS synchronization
SUBSTITU	Link error, values are substituted
LOWLEVEL	Low signal level on the receive link

**Table 3: Binary output signals for the LDCMRecBinStat (CRB1-) function block in binary mode (see also section 11, fault tracing)**

Signal	Description
COMFAIL	Detected error in the differential communication
YBIT	Detected error in remote end with incoming message
NOCARR	No carrier is detected in the incoming message
NOMESS	No start and stop flags identified for the incoming message
ADDRERR	Incoming message from a wrong terminal
LNGTHERR	Wrong length of the incoming message
CRCERROR	Identified error by CRC check in incoming message
RECOMF	Remote terminal indicates problem with received message
LOWLEVEL	Low signal level on the receive link

## 5.5

### Setting guidelines

*Channel mode:* This parameter can be set *ON* or *OFF*. If *OFF* is set with locally measured currents (analog inputs) trip and transfer trip will be issued. Besides this, it can be set *OutOfService* which signifies that the local LDCM is out of service. Thus, with this setting, the communication channel is active and a message is sent to the remote IED that the local IED is out of service, but there is no COMFAIL and the analog and binary values are sent as zero.



#### Note:

*Only applicable for no-load conditions; for example during maintenance of a HV-breaker.*

*TerminalNo*: This setting assigns a number to the local REX 670. Up to 256 REX 670 can be assigned unique numbers. For a line differential protection, maximum 6 IEDs can be included. The possibility to use the large number of IED designations is reserved for the case where a high security against incorrect addressing in multiplexed systems is desired.

*RemoteTermNo*: this setting assigns a terminal number to the remote IED.

*DiffSync*: Here the method of time synchronization, Echo or GPS, for the line differential function is selected.

*GPSSyncErr*: If GPS synchronization is lost, the synchronization of the line differential function will continue during 16 s. based on the stability in the local 670 units clocks. Thereafter the setting *Block* will block the line differential function or the setting *Echo* will make it continue by using the *Echo* synchronization method. It shall be noticed that using *Echo* in this situation is only safe as long as there is no risk of varying transmission asymmetry.

*CommSync*: This setting decides the Master/Slave relation in the communication system and shall not be mistaken for the synchronization of line differential current samples. When direct fibre is used, one LDCM is set as Master and the other one as Slave. When a modem and multiplexer is used, the REX 670 is always set as Slave, as the telecommunication system will provide the clock master.

*OptoPower*: The setting *LowPower* is used according to table 7, page 37.

*TransmCurr*: This setting decides which of 2 possible local currents that shall be transmitted, or if and how the sum of 2 local currents shall be transmitted, or finally if the channel shall be used as a redundant channel.

In a 1 ½ breaker arrangement, there will be 2 local currents, and the grounding on the CTs can be different for these. CT-SUM will transmit the sum of the 2 CT groups. CT-DIFF1 will transmit CT group 1 minus CT group 2 and CT-Diff2 will transmit CT group 2 minus CT group 1.

CT-GRP1 or CT-GRP2 will transmit the respective CT group, and the setting *RedundantChannel* makes it possible to use the channel as a backup channel.

*ComFailAlrmDel*: Time delay of communication failure alarm. In communication systems, route switching can sometimes cause interruptions with a duration up to 50 ms. Thus, a too short time delay setting might cause nuisance alarms in these situations.

*ComFailResDel*: Time delay of communication failure alarm reset.

*RedChSwTime*: Time delay before switchover to redundant channel in case of primary channel failure.

*RedChRturnTime*: Time delay before switchback to the primary channel after channel failure.

*AsymDelay*: the asymmetry is defined as transmission delay minus receive delay. If a fixed asymmetry is known, the Echo synchronization method can be used if the parameter *AsymDelay* is properly set. From the definition follows that the asymmetry will always be positive in one end, and negative in the other end.

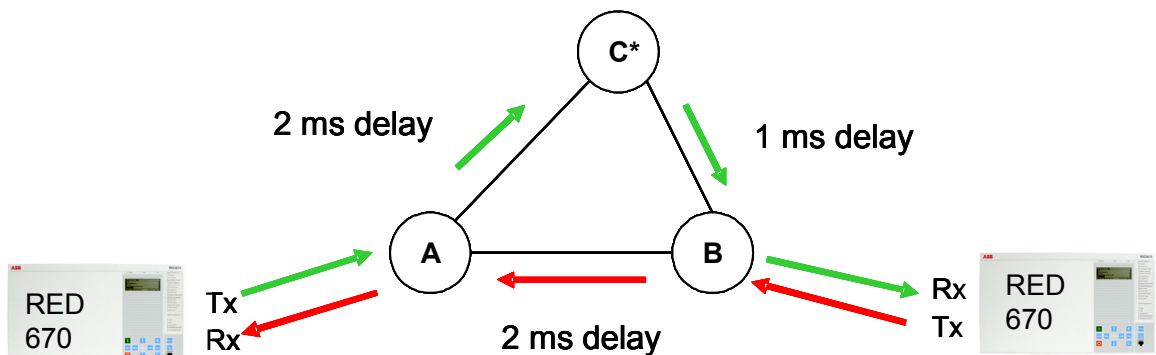
*LocAinLatency*: a parameter which specifies the time delay (number of samples) between actual sampling and the time the sample reaches the local communication module, LDCM. The parameter shall be set to 2 when transmitting analogue data from the local transformer module (TRM). When a merging unit according to IEC 61850-9-2 is used instead of the TRM this parameter shall be set to 5.

*RemAinLatency*: this parameter corresponds to the *LocAinLatency* set in the remote IED.

#### Setting example:

AsymDelay for RED 670 in end A is set  $3 \text{ ms} - 2 \text{ ms} = 1 \text{ ms}$

AsymDelay for RED 670 in end B is set  $2 \text{ ms} - 3 \text{ ms} = -1 \text{ ms}$



\*The 3 ms delay in route A-C-B includes the delay in the multiplexer in end C. The setting can be found under LDCM configuration/CRM-CRB/AsymDelay

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Figure 38: Setting example of AsymDelay for RED670

*MaxTransmDelay*: Data for maximum 40 ms transmission delay can be buffered up. Delay time in the range of some ms are common. It shall be noticed that if data arrive in the wrong order, the oldest data will just be disregarded.

*CompRange*: the set value is current peak value over which truncation will be made. To set this value, knowledge of the fault current levels should be known. The setting is not overly critical as it considers very high current values for which correct operation normally still can be achieved.

## 5.5.1

## Setting parameters

**Table 4: Basic general settings for the LDCMRecBinStat (CRM1-) function**

Parameter	Range	Step	Default	Unit	Description
ChannelMode	Off ON OutOfService To be used in multiterminal lines for example maintenance in one end to avoid communication failure and different protect blocking in remaining RED670.	-	ON	-	Channel mode of LDCM, 0=OFF, 1=ON, 2=OutOfService
TerminalNo	0 - 255	1	0	-	Terminal number used for line differential communication
RemoteTermNo	0 - 255	1	0	-	Terminal number on remote terminal
DiffSync	ECHO GPS	-	ECHO	-	Diff Synchronization mode of LDCM, 0=ECHO, 1=GPS
GPSSyncErr	Block Echo	-	Block	-	Operation mode when GPS synchroniation signal is lost
CommSync	Slave Master	-	Slave	-	Com Synchronization mode of LDCM, 0=Slave, 1=Master
OptoPower	LowPower HighPower	-	LowPower	-	Transmission power for LDCM, 0=Low, 1=High
TransmCurr	CT-GRP1 CT-GRP2 CT-SUM CT-DIFF1 CT-DIFF2	-	CT-GRP1	-	Summation mode for transmitted current values
ComFailAlrmDel	5 - 500	5	10	ms	Time delay before communication error signal is activated
ComFailResDel	5 - 500	5	10	ms	Reset delay before communication error signal is reset
RedChSwTime	5 - 500	5	5	ms	Time delay before switching in redundant channel
RedChRturnTime	5 - 500	5	100	ms	Time delay before switching back from redundant channel
AsymDelay	-20.00 - 20.00	0.01	0.00	ms	Asymmetric delay when communication use echo synch.
MaxTransmDelay	0 - 40	1	20	ms	Max allowed transmission delay

**Table 4: Basic general settings for the LDCMRecBinStat (CRM1-) function**

Parameter	Range	Step	Default	Unit	Description
CompRange	0-10kA 0-25kA 0-50kA 0-150kA	-	0-25kA	-	Compression range
MaxtDiffLevel	200 - 2000	1	600	µs	Maximum time diff for ECHO back-up
DeadbandtDiff	200 - 1000	1	300	µs	Deadband for t Diff
InvertPolX.21	Off ON	-	Off	-	Invert polarization for X.21 communication

**Table 5: Basic general settings for the LDCMRecBinStat (CRM2-) function**

Parameter	Range	Step	Default	Unit	Description
ChannelMode	Off ON OutOfService	-	ON	-	Channel mode of LDCM, 0=OFF, 1=ON, 2=OutOf-Service
TerminalNo	0 - 255	1	0	-	Terminal number used for line differential communication
RemoteTermNo	0 - 255	1	0	-	Terminal number on remote terminal
DiffSync	ECHO GPS	-	ECHO	-	Diff Synchronization mode of LDCM, 0=ECHO, 1=GPS
GPSSyncErr	Block Echo	-	Block	-	Operation mode when GPS synchroniation signal is lost
CommSync	Slave Master	-	Slave	-	Com Synchronization mode of LDCM, 0=Slave, 1=Master
OptoPower	LowPower HighPower	-	LowPower	-	Transmission power for LDCM, 0=Low, 1=High
TransmCurr	CT-GRP1 CT-GRP2 CT-SUM CT-DIFF1 CT-DIFF2 RedundantChannel	-	CT-GRP1	-	Summation mode for transmitted current values
ComFailAlrmDel	5 - 500	5	100	ms	Time delay before communication error signal is activated
ComFailResDel	5 - 500	5	10	ms	Reset delay before communication error signal is reset
RedChSwTime	5 - 500	5	5	ms	Time delay before switching in redundant channel
RedChRturnTime	5 - 500	5	100	ms	Time delay before switching back from redundant channel

**Table 5: Basic general settings for the LDCMRecBinStat (CRM2-) function**

Parameter	Range	Step	Default	Unit	Description
AsymDelay (Refers to fixed routes with known asymmetric delay)	-20.00 - 20.00	0.01	0.00	ms	Asymmetric delay when communication use echo synch.
LocAinLatency	2-20	1	2	samples	Time delay between actual sampling and the time the sample reaches the local communication module (LDCM)
RemAinLatency	2-20	1	2	samples	Time delay between actual sampling and the time the sample reaches the local communication module (LDCM)
MaxTransmDelay	0 - 40	1	20	ms	Max allowed transmission delay
CompRange	0-10kA 0-25kA 0-50kA 0-150kA	-	0-25kA	-	Compression range
MaxtDiffLevel	200 - 2000	1	600	µs	Maximum time diff for ECHO back-up
DeadbandtDiff	200 - 1000	1	300	µs	Deadband for t Diff
InvertPolX.21	Off ON	-	Off	-	Invert polarization for X.21 communication

**Table 6: Basic general settings for the LDCMRecBinStat (CRB1-) function**

Parameter	Range	Step	Default	Unit	Description
ChannelMode	Off On OutOfService	-	On	-	Channel mode of LDCM, 0=OFF, 1=ON, 2=OutOfService
TerminalNo	0 - 255	1	0	-	Terminal number used for line differential communication
RemoteTermNo	0 - 255	1	0	-	Terminal number on remote terminal
CommSync	Slave Master	-	Slave	-	Com Synchronization mode of LDCM, 0=Slave, 1=Master
OptoPower	LowPower HighPower	-	LowPower	-	Transmission power for LDCM, 0=Low, 1=High
ComFailAlrmDel	5 - 500	5	10/100 <i>depending on version</i>	ms	Time delay before communication error signal is activated
ComFailResDel	5 - 500	5	10	ms	Reset delay before communication error signal is reset

**Table 6: Basic general settings for the LDCMRecBinStat (CRB1-) function**

Parameter	Range	Step	Default	Unit	Description
InvertPolX.21	Off On	-	Off	-	Invert polarization for X.21 communication

**Note:****ComfailAlrmDel; COMFAIL Alarm Delay:**

ComFailAlrmDel should be set  $\geq 100$  ms, in normal service. Route switching in telecommunication networks normally takes  $< 50$  ms. ComFailResDelay should be set at 10 ms.

*(For fault tracing it can be advantageous to set the ComFailAlrmDel at 5 - 10 ms.)*

## 6

## Communication channels

Each 670 series device can be configured with up to four remote communication interfaces. The communication configuration for each channel is individually set.

Application examples:

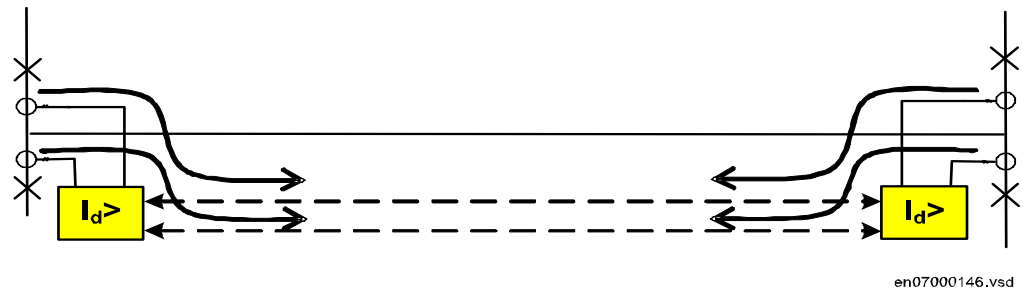


Figure 39: Two ended line with 1 1/2 breaker

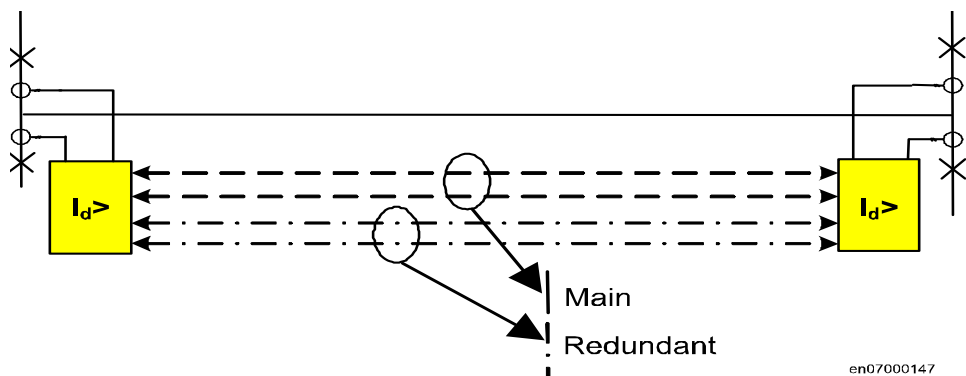


Figure 40: Two ended line with 1 1/2 breaker, redundant channels



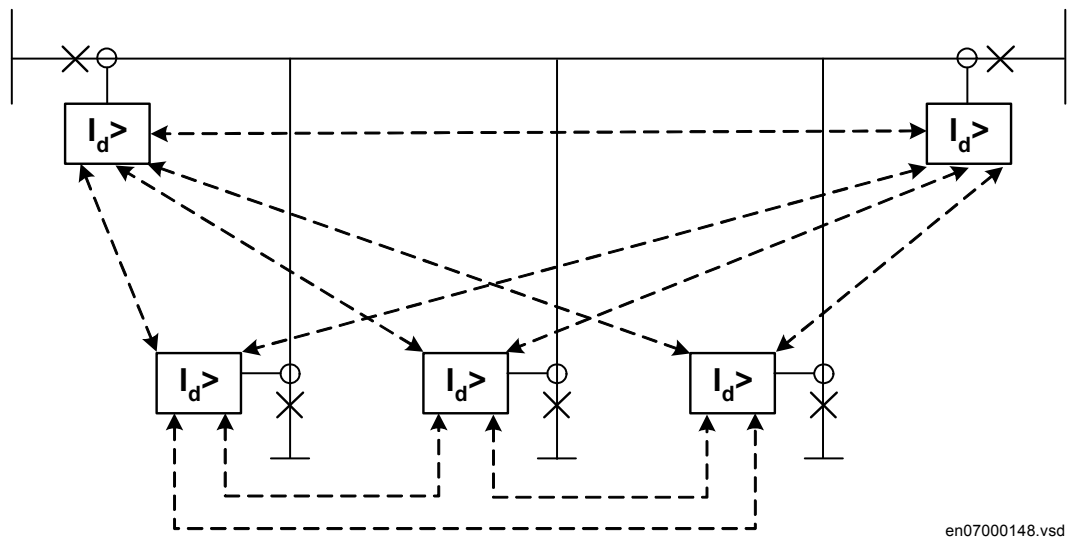


Figure 41: Multiterminal line for 5 line-ends, master-master

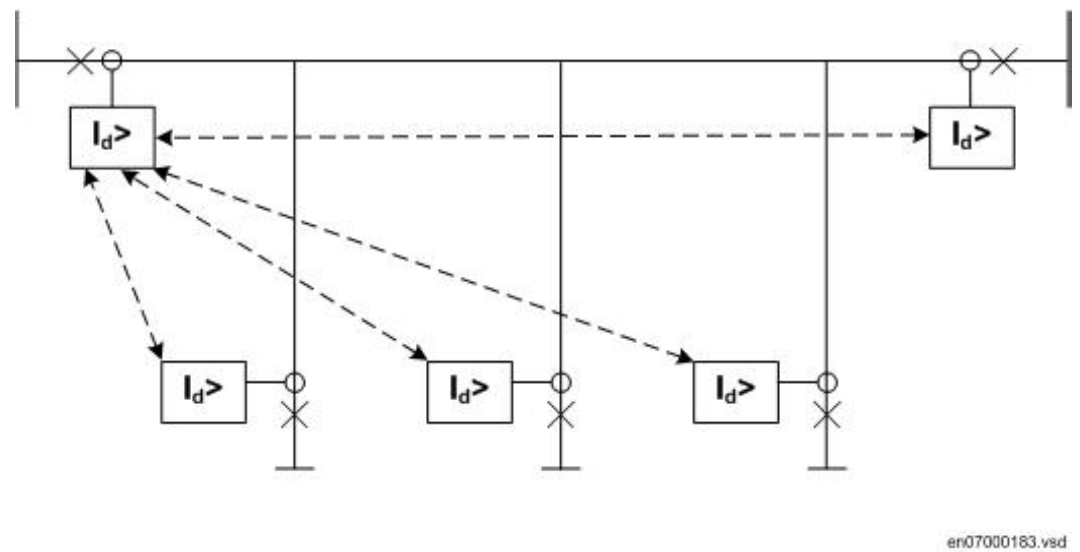
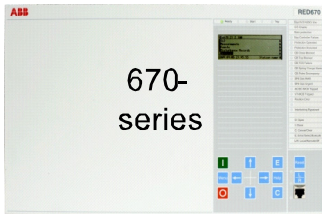


Figure 42: Multiterminal line for 5 line-ends, master-slave

## 7

## Communication alternatives



Fibre-optics

- C 37.94 64 kbit/s communication module up to four ports

- Possibility for redundant channels (for 2 and 3 terminals)
- Fibre optical module for dedicated single mode fibers, typical 70/130 km

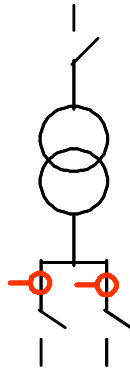
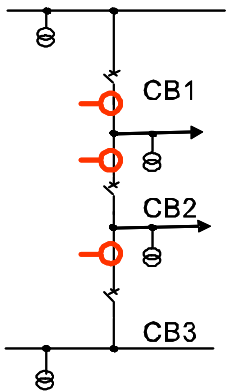
- C37.94 direct to PCM/MUX

- External G.703 converter, 64 kbit/s PDH or 2 Mbits SDH

- Galvanic X21 interface

- Two local analogue inputs for differential protection

- Additional local inputs for complementary protection



No external summation

Figure 43: Communication alternatives for 670 series

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## 7.1

## Fiberoptic communication interfaces with IEEE C37.94 international standard protocol

The 670 series can be configured with 1-4 fiberoptic interfaces according to IEEE C37.94 1. with 12 x 64 bits channels (only one 64 kbits channel LDCM is used).



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Up to 4 modules type LDCM can be included. Three different types are available.

- For Multimode fiberoptic 50/125  $\mu\text{m}$  or 62,5/125  $\mu\text{m}$  for 2-3 km to telecommunication equipment (Can also be used for back-to back applications 2-3 km), (850 nm)
- For single mode fiberoptic 9/125  $\mu\text{m}$  for back to back applications < 70 km (1300 nm)
- For single mode fiberoptic 9/125  $\mu\text{m}$  for back to back applications < 110 km (1550 nm)
- Selection of high or low optical power, see *Table 9*.

Table 7: Optical budget for 670 series: 64 kbit communication with C37.94 interface				
Fiberoptic communication	850 nm	850 nm	1310 nm	1550 nm
	Multimode fiber Glass 50/125 $\mu\text{m}$	Multimode fiber Glass 62,5/125 $\mu\text{m}$	Single mode Glass 9/125 $\mu\text{m}$	Single mode Glass 9/125 $\mu\text{m}$
Modem type	1MRK002122-AB	1MRK002122-AB	1MRK0002311-AA	1MRK0002311-BA
Contact type	ST	ST	FC/PC	FC/PC
Minimum output power	-21 dBm	-17 dBm	-7 dBm	- 3dBm
Minimum receiver sensitivity	-30 dBm	-30 dBm	-29 dBm	-29 dBm
<b>Optical budget*</b>	<b>9 dB</b>	<b>13 dB</b>	<b>22 dB</b>	<b>26 dB</b>

\* The optical budget includes a satisfactory margin for aging in transmitter and receiver during 20-30 years.

<b>Table 8: Example of input data for calculation of optical power budget: Maximum distance</b>				
Fiberoptic communication	850 nm	850 nm	1310 nm	1550 nm
	Multimode fiber Glass 50/125 µm	Multimode fiber Glass 62,5/125 µm	Single mode Glass 9/125 µm	Single mode Glass 9/125 µm
Modem type	1MRK0002211-AB	1MRK0002122-AB	1MRK0002311-AA	1MRK0002311-BA
Typical attenuation in fiberoptic cables	3 db/km	3 db/km	0,32 dB/km	0,21 db/km
Attenuation	1,0 dB	1,0 dB	0,3 dB	0,3 dB
Factory splice attenuation	0,25 dB/splice 0,1 splices /km	0,25 dB/splice 0,3 splices /km	0,08 dB/splice 0,1 splices /km	0,08 dB/splice 0,3 splices /km
Repair splices attenuation	0,5 dB/splice 0,1 splices /km	0,5 dB/splice 0,1 splices /km	0,1 dB/splice 0,05 splices /km	0,1 dB/splice 0,05 splices /km
Fiber margin for aging	0,1 db/km	0,1 db/km	0,01 db/km	0,01 db/km

<b>Table 9: Example calculation of optical power budget: Maximum distance</b>				
Fiberoptic communication	850 nm	850 nm	1310 nm	1550 nm
	Multimode fiber Glass 50/125 µm	Multimode fiber Glass 62,5/125 µm	Single mode Glass 9/125 µm	Single mode Glass 9/125 µm
Modem type	1MRK0002122-AB	1MRK0002211-AB	1MRK0002311-AA	1MRK0002311-BA
<b>Maximum distance depending of attenuation in actual fibre</b>	<b>2 km</b>	<b>3 km</b>	<b>60 km</b>	<b>110 km</b>
Attenuation in fiberoptic cables	6 dB	9 dB	19,2 dB	23,1 dB
Attenuation 2 Contacts	2 dB	2 dB	0,6 dB	0,6 dB
Factory splice attenuation	0,1 dB	0,15 dB	0,48 dB	0,48 dB
Repair splices	0,3 dB	0,3 dB	0,7 dB	0,7 dB
Margin for fiber aging	0,2 db	0,3 dB	0,7 dB	0,7 dB
Attenuation	8,6 dB	11,9 dB	21,68 dB	25,58 dB
Optical budget	9 dB	13 dB	22 dB	26 dB
Extra margin	0,4 dB	1,1 dB	0,036 dB	0,42 dB
If extra margin > values in table 9 set low power	6 dB	8 dB	15 dB	15 dB

## 7.2

### Galvanic interface type X.21

#### Introduction

The galvanic X.21 line data communication module is used for connection to telecommunication equipment, for example leased telephone lines. The module supports 64 kbits/s data communication between IEDs.

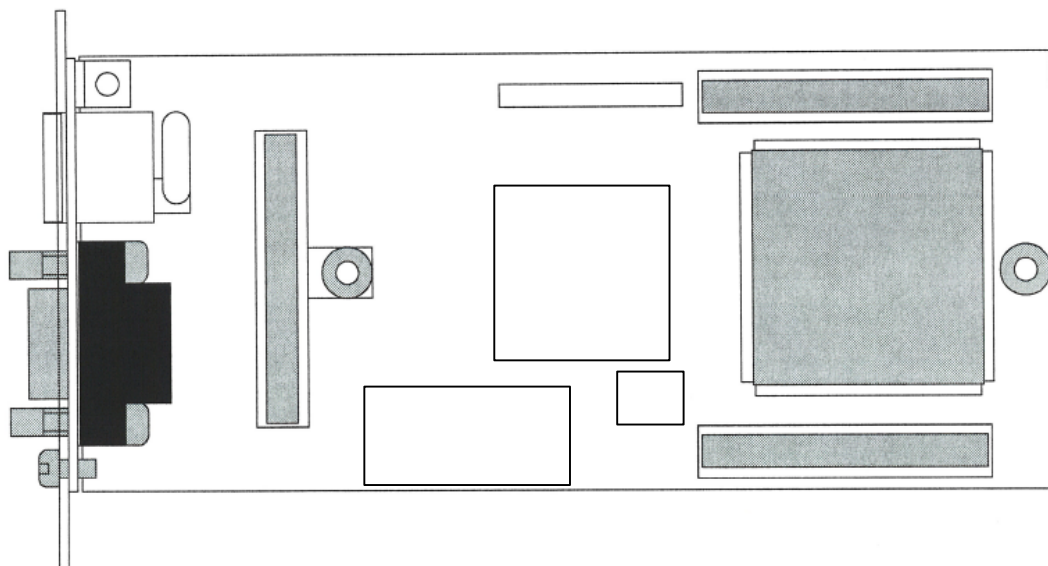
Example of applications:

- Line differential protection
- Binary signal transfer

### 7.2.1

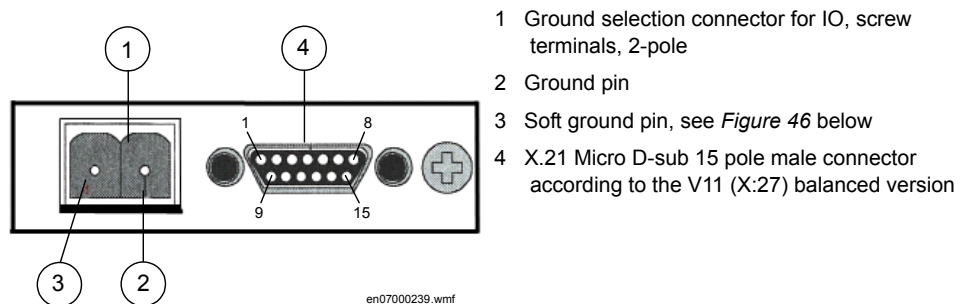
#### Design

The galvanic X.21 line data communication module uses a ABB specific PC\*MIP Type II format.



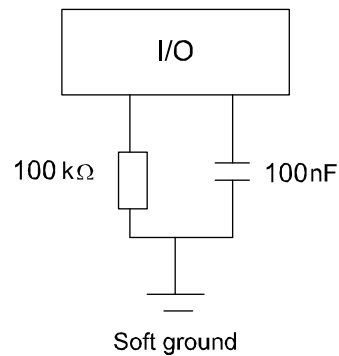
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Figure 44: Overview of the X.21 LDCM module



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Figure 45: The X.21 LDCM module external connectors



en07000242

*Figure 46: Schematic view of soft ground*

### Grounding

At special problems with ground loops the soft ground connection for the IO-ground can be tested.

Three different kinds of grounding principles can be set (used for fault tracing):

- 1 Direct ground - The normal grounding is direct ground, connect terminal 2 direct to chassi.
- 2 No ground- Leave the connector without any connection
- 3 Soft ground - connect soft ground pin (3), see *Figure 46* above

## X.21 Connector

Table	Pin-out for the X.21 communication connector
Pin number	Signal
1	Shield (ground)
2	TXD A
3	Control A
4	RXD A
6	Signal timing A
8	Ground
9	TXD B
10	Control B
11	RXD B
13	Signal timing B
5, 7, 12, 14, 15	Not used

### 7.2.2

#### Functionality

The data format is HDLC. The speed for the transmission of the messages used is 64 kbit/s.

A maximum of 100 meter of cable is allowed to ensure the quality of the data (deviation from X.21 standard cable length).

#### Synchronization

The X.21 LDCM works like a DTE (Data Terminal Equipment) and is normally expecting synchronization from the DCE (Data Circuit equipment). The transmission is normally synchronized to the Signal Element Timing signal when a device is a DTE. When the signal is high it will read the data at the receiver and when the signal is low it will write data to the transmitter. This behaviour can be inverted in the control register.

Normally an external multiplexer is used and it should act like the master.

When two X.21 LDCM is directly communicating with each other one must be set as a master generating the synchronization for the other (the slave). The DTE signal Element Timing is created from the internal 64 kHz clock.

The Byte Timing signal is not used in ABB devices.

---

**7.2.3****Technical data**

Quantity	Range of value
Connector, X.21	Micro D-sub, 15-pole male, 1.27 mm (= .050") pitch
Connector, ground selection	2 pole screw terminal
Standard	CCITT X.21
Communication speed	64 kbit/s
Insulation	1 kV
Maximum cable length	100 m



## 8 PDH telecommunication system

PDH telecommunication system set-up with 64 kbit/s C37.94 interface to transceiver type 21-216, or X.21 directly to telecommunication systems.

For PDH telecommunication systems with 21-219, see section 10.

### 8.1 General communication requirements

There is a short delay in alarm time, normally 100 ms, for the communication fail in the relay, derived from the dependability of the differential protection function. This will require a high quality communication system, see “Appendix 1” on page 69.

If the telecommunication system is disturbed more than 100 ms, an alarm will be correctly issued.

### 8.2 Communication structure for IEEE C37.94 fiberoptic interface in 670 series and 21-216 with G.703 64 kbit/s in a PDH-system

REL 670 Line differential relay or other 670 series for binary signal transfer

Transceiver 21-216 Optical/electrical interface converter

MUX = Multiplexer or PCM = Pulse Code Multiplexer is two different names for the same thing.

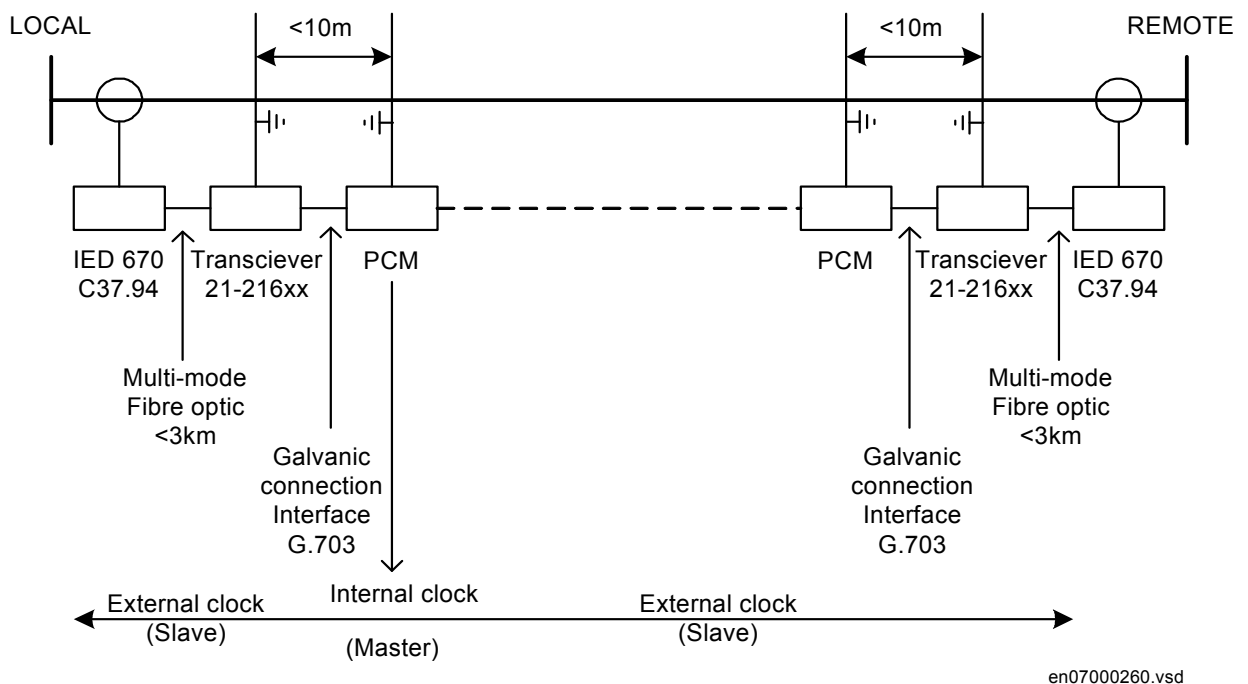
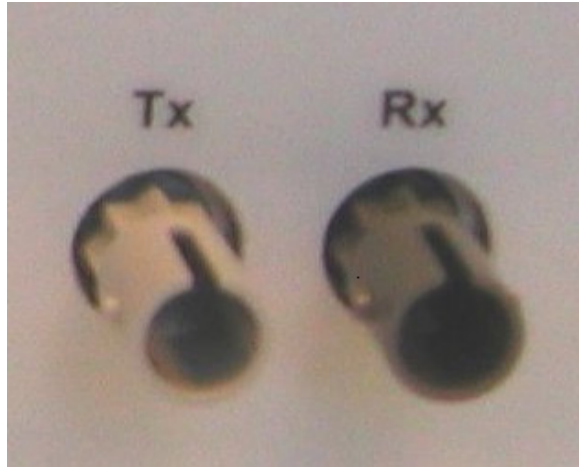


Figure 47: PDH Communication structure

## 8.3

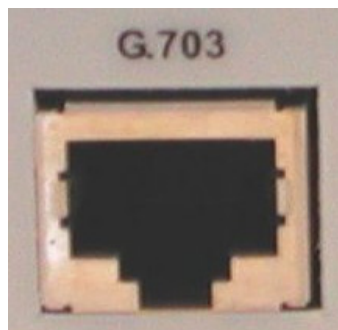
**Service settings of 21-216****Fiber Optic Port**

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*Figure 48: The fiber optic connector is of ST type.*

Confirm the attenuation of the fiber optic cable, including splices and patch cables, does not exceed the system budget. Do not forget to add a safety margin. Minimum safety margin is 3dB.

Make sure that the local fiber optic transmitter, marked Tx, is connected to the remote units fiber optic receiver, marked Rx.  
Local Rx shall be connected to remote Tx.



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*Figure 49: G.703 64kbit/s Codir Port*

---

RJ45 pin	Name	Direction
1	Tx+ (TIP-out)	From 21-216 to multiplexer
2	Tx- (RING-out)	From 21-216 to multiplexer
4	Rx+ (TIP-in)	From multiplexer to 21-216
5	Rx- (RING-in)	From multiplexer to 21-216
Metal house	Shield	Cable shield must be connected

Use a cable with twisted pairs and a high quality shield. Only foil shielding is not enough.

Rx+ and Rx- should form one twisted pair - Tx+ and Tx- another twisted pair.

A Cat5 S/FTP-cable, /Shielded/Foil Twisted Pair) used for example in Ethernet communication is a good cable. The outer shield is a braided mesh around the cable. In addition every twisted pair has a foil-shielding.

If a S7FTP patchcable for Ethernet is used, be aware that a cross-connected cable has only the pairs on pin 1-2 and 3-6 cross-connected, the two remaining pairs are not cross-connected.

### Clock configuration switch

From 21-216 revision 2 and later, a rotary switch is added to the front panel, to ease installation and testing.

When two 21-216 are used in a PDH or a PDH/SDH system the two 21-216 shall be set as slaves, i.e. when external clock is used.

### Back-to-back testing

For testing back-to-back with the G703 ports directly connected, one of the 21-216 shall be set as Master (internal clock).

## 8.3.1

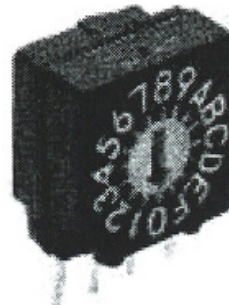
**Clock synchronization configuration**

A rotary switch on the front panel can be used for clock synchronization configuration.

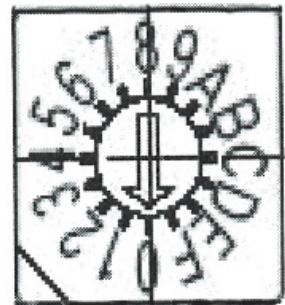
The rotary switch has 16 positions, (HEX-switch).



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en07000251.wmf



en07000252.wmf

Figure 50: Clock configuration switch

At position 0 the switch's arrow, visible through the adjusting hole, points straight down. In position 0, external clock is selected (default).

Position	Function
0	External clock is selected (Slave)
1	External clock is selected and inverted (Slave)
2	Internal clock is selected (Master)
3	Internal clock is selected and inverted (Master)
4-7	Reserved for future use
8-15	Reserved for factory testing

*When a "not used" channel is selected or if both codir and fiber clock are selected, the ERR-LED on the front panel is lit.*

## 8.4

### Start and usage

#### Power on

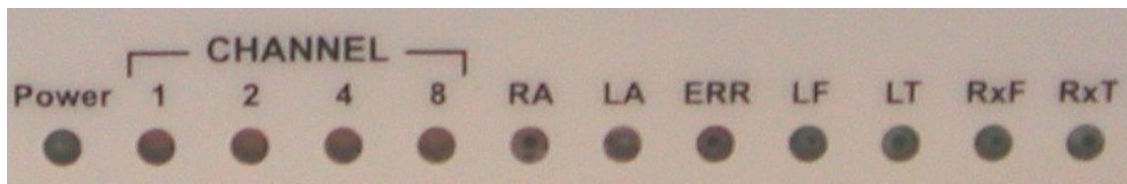
Connect the power cord to the 21-216 and then connect to mains.

If the link doesn't work, try to cross-connect the fiber at one end.

#### 8.4.1

#### LED-status

There are 12 LED-indicators at the front panel.



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Figur 51: Front panel

#### Power

A green LED lit when power is connected to the unit.

#### RA

Remote Alarm. A red LED indicating that the remote unit has encounter a fault condition and has set A red LED indicating that the remote unit has encounter a fault condition and has set the "Yellow Alarm bit" in the IEEE C37.94 protocol.

#### LA

Local Alarm. A red LED indicating that the 21-206 has encounter a fault in the IEEE C37.94 protocol -LOS Loss Of Signal. The "Yellow Alarm bit" is set in the outgoing IEEE C37.94 protocol

#### ERR

Error. A red LED indicating that the 21-216 has detected an internal error. The ERR-LED also indicates that not allowed setting of jumpers is made.

#### LF

Link Fiber. A green LED indicating that the 21-216 receives correct IEEE C37.94 frames, (no LOS).

#### LT

Link Twisted pair/G.703 codir. A green LED indicating that 21-216 receives G.703 codir 64kbit/s protocol.

**RxF**

Receive data on Fiber. A green LED indicating that 21-216 receives data in IEEE C37.94 format.

**RxT**

Receive data on twisted pair/G.703 codir. A green LEED indicating that 21-216 receives data in G.703 codir protocol.

**Channel**

For yellow LED's representing the channel chosen by jumpers at installation.

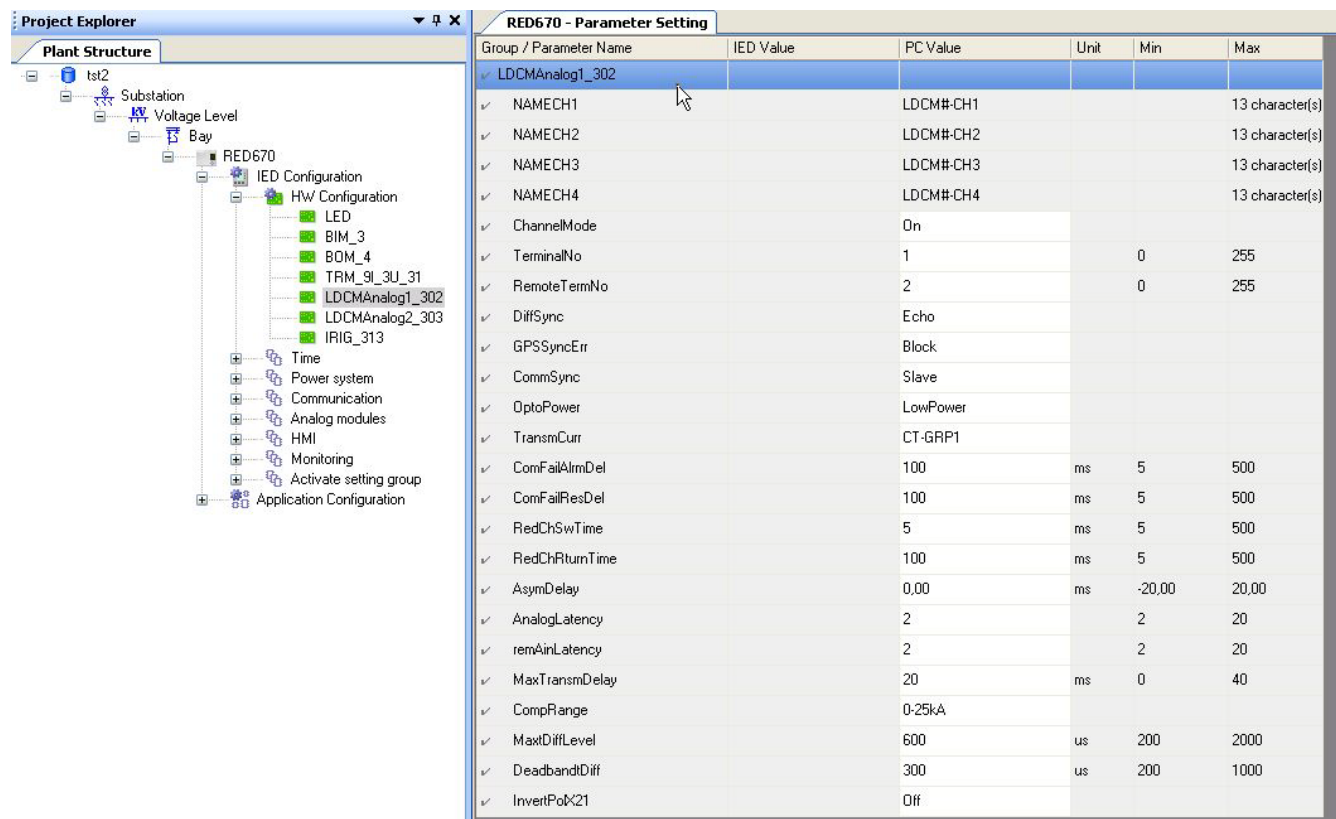
The channel is "calculated" by adding the lit LED's.

for example if LED 1 and LED 2 are lit  $1+2=3$  Channel 3 is chosen.

This means that data to/from G.703.codir-port is sent and received on the IEEE C37.94 protocol on the fiber.

**Clock synchronization configuration**

Clock synchronization configuration can be done "on the fly" with the rotary switch on the front panel. Se chapter "Service settings of 21-216"

**8.5****Service settings of 670 series with G.703 co-directional**


Group / Parameter Name	IED Value	PC Value	Unit	Min	Max
✓ LDCMAnalog1_302					
✓ NAMECH1		LDCM#-CH1			13 character(s)
✓ NAMECH2		LDCM#-CH2			13 character(s)
✓ NAMECH3		LDCM#-CH3			13 character(s)
✓ NAMECH4		LDCM#-CH4			13 character(s)
✓ ChannelMode		On			
✓ TerminalNo		1		0	255
✓ RemoteTermNo		2		0	255
✓ DiffSync		Echo			
✓ GPSSyncErr		Block			
✓ CommSync		Slave			
✓ OptoPower		LowPower			
✓ TransmCurr		CT-GRP1			
✓ ComFailAlrmDel		100	ms	5	500
✓ ComFailResDel		100	ms	5	500
✓ RedChSwTime		5	ms	5	500
✓ RedChRtnTime		100	ms	5	500
✓ AsymDelay		0.00	ms	-20.00	20.00
✓ AnalogLatency		2		2	20
✓ remAnLatency		2		2	20
✓ MaxTransmDelay		20	ms	0	40
✓ CompRange		0-25kA			
✓ MaxDiffLevel		600	us	200	2000
✓ DeadbandDiff		300	us	200	1000
✓ InvertPolx21		Off			

IEC10000072

Figure 52: CRM3 set as slave

## 8.6

## Service settings of Transceiver 21-216 G.703 64 kbit



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Figure 53: 21-216 Fiber optic G.703 Codir - IEEE C37.94 Converter

There is only one setting that is required. The transceiver has to be set to external clock. The rotating dip switch in position 0. For back-to-back testing one 21-216 has to be set as master internal clock, rotary switch in position 2, (overrides settings of jumpers 8 and 9).

## 8.7

## Grounding

The recommended grounding is - direct grounding (default setting). At ground loop problems, the soft ground mode can be advantageous, see Figure 54 and Figure 55.

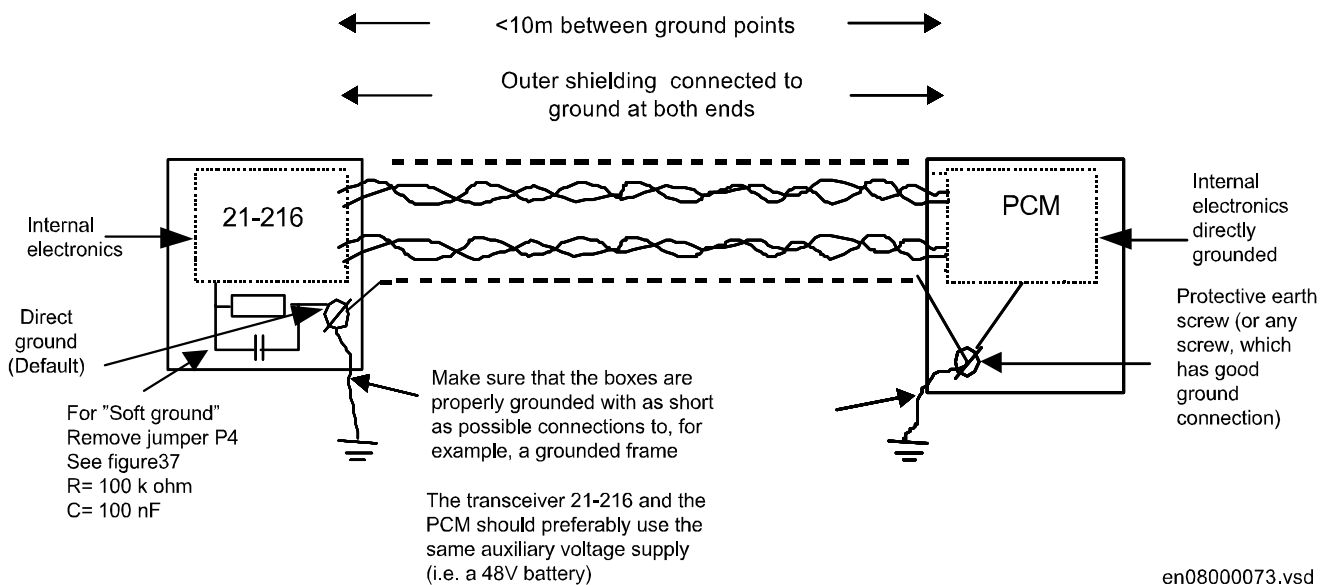


Figure 54: Grounding principles

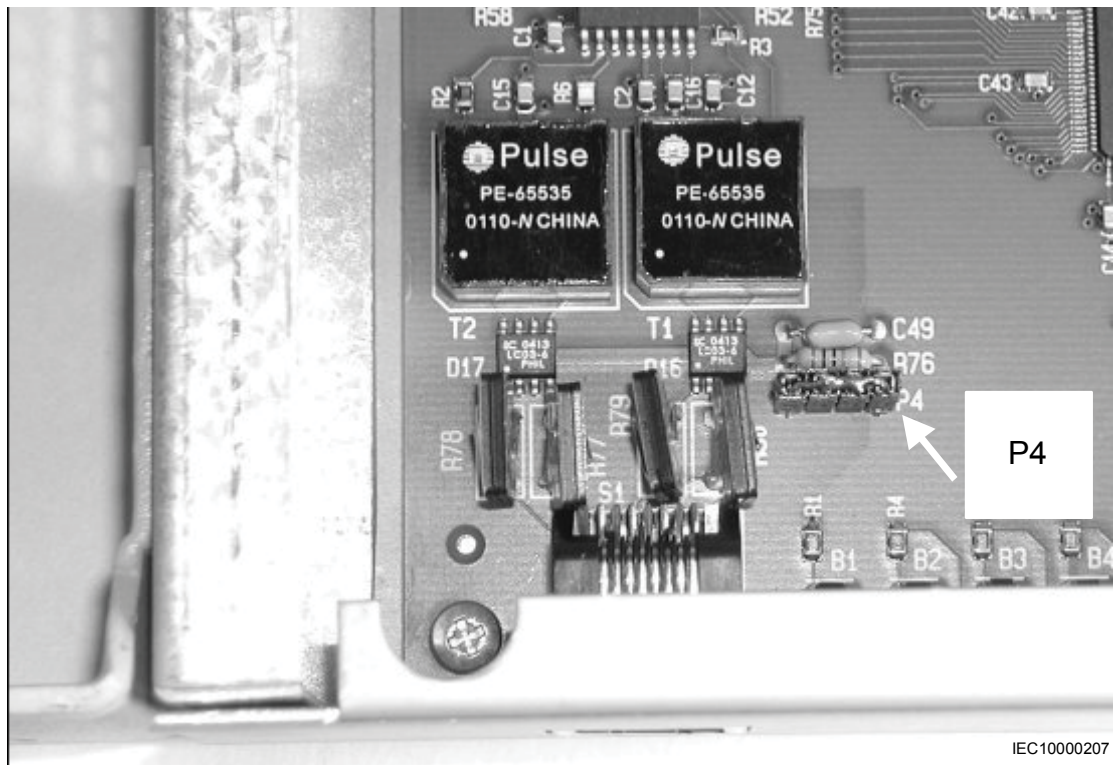


Figure 55: Ground select jumper

The strapping area/jumper P4 selects how internal signalground and chassisground are referenced together.

With a jumper between P4's terminals chassisground and signalground are directly tied together.

Without a jumper on P4 chassisground and signalground are connected together with a 100 k $\Omega$  resistor in parallel with a 100nF capacitor.

#### Reassemble

After jumper selecting, reassembling is done in the reversed order as described above. Do not forget to reconnect protective ground cables.

### 8.7.1

#### Detection of communication faults on 21-216

There is a supervision on the 21-216 which can be used for fault tracing.

#### RA

Remote Alarm. A red LED indicating that the remote unit has encountered a fault condition and has set A red LED indicating that the remote unit has encountered a fault condition and has set the "Yellow Alarm bit" in the IEEE C37.94 protocol.



**LA**

Local Alarm. A red LED indicating that the 21-206 has encountered a fault in the IEEE C37.94 protocol -LOS Loss Of Signal. The “Yellow Alarm bit” is set in the outgoing IEEE C37.94 protocol

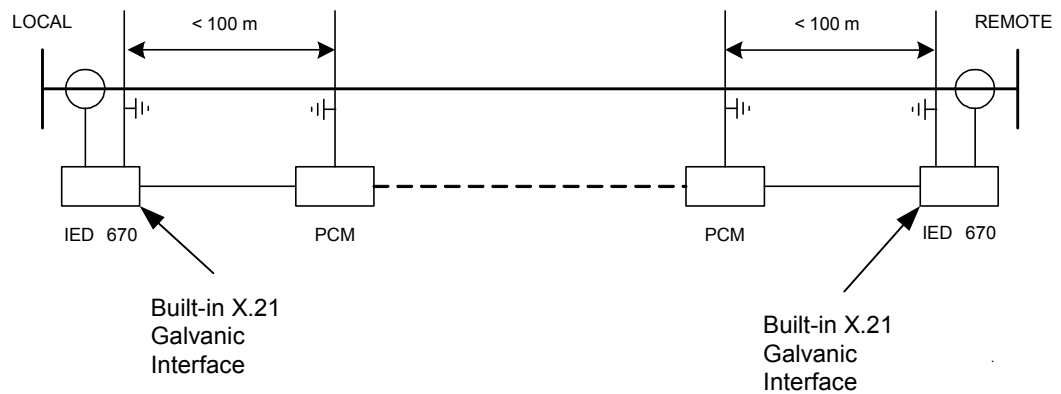
If IED 670 has a communication fail alarm and there is no indication for RA or LA on the 21-216 then the communication interruption is in the telecommunication system.

## 9 Communication structure for the X.21 built-in galvanic interface

REL 670 Line differential relay or 670 series for binary transfer

Built-in interface type X.21

PCM = Pulse Code Multiplexer = MUX



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Figure 56: Communication structure for X.21

### 9.1 Connection and Service settings of 670 series with X.21 galvanic interface

#### X.21 connector

The connector used for the X.21 communication is a 15-pole male Micro D-sub according to the V11 (X.27) balanced version. See section 7.2 page 41.

### 9.2 Check of settings on 670 series HMI and communication status

Table 10: Basic general settings for the LDCMRecBinStat (CRM1-) function

Parameter	Range	Step	Default	Unit	Description
ChannelMode	Off ON OutOfService	-	ON	-	Channel mode of LDCM, 0=OFF, 1=ON, 2=OutOf-Service
TerminalNo	0 - 255	1	0	-	Terminal number used for line differential communication
RemoteTermNo	0 - 255	1	0	-	Terminal number on remote terminal

**Table 10: Basic general settings for the LDCMRecBinStat (CRM1-) function**

Parameter	Range	Step	Default	Unit	Description
DiffSync	ECHO GPS	-	ECHO	-	Diff Synchronization mode of LDCM, 0=ECHO, 1=GPS
GPSSyncErr	Block Echo	-	Block	-	Operation mode when GPS synchroniation signal is lost
CommSync	Slave Master	-	Slave	-	Com Synchronization mode of LDCM, 0=Slave, 1=Master
OptoPower	LowPower HighPower	-	LowPower	-	Transmission power for LDCM, 0=Low, 1=High
TransmCurr	CT-GRP1 CT-GRP2 CT-SUM CT-DIFF1 CT-DIFF2	-	CT-GRP1	-	Summation mode for transmitted current values
ComFailResDel	5 - 500	5	10	ms	Reset delay before communication error signal is reset
RedChSwTime	5 - 500	5	5	ms	Time delay before switching in redundant channel
RedChRturnTime	5 - 500	5	100	ms	Time delay before switching back from redundant channel
AsymDelay	-20.00 - 20.00	0.01	0.00	ms	Asymmetric delay when communication use echo synch.
MaxTransmDelay	0 - 40	1	20	ms	Max allowed transmission delay
CompRange	0-10kA 0-25kA 0-50kA 0-150kA	-	0-25kA	-	Compression range
MaxtDiffLevel	200 - 2000	1	600	µs	Maximum time diff for ECHO back-up
DeadbandtDiff	200 - 1000	1	300	µs	Deadband for t Diff
InvertPolX.21	Off ON	-	Off	-	Invert polarization for X.21 communication

After making these settings check the result on the HMI of the IED 670.

Look under Test/Function Status/Communication/Remote communication/LDCM312/CRM3/ on both end terminals and verify that the result is OK. Received 100%, transmit 100%.

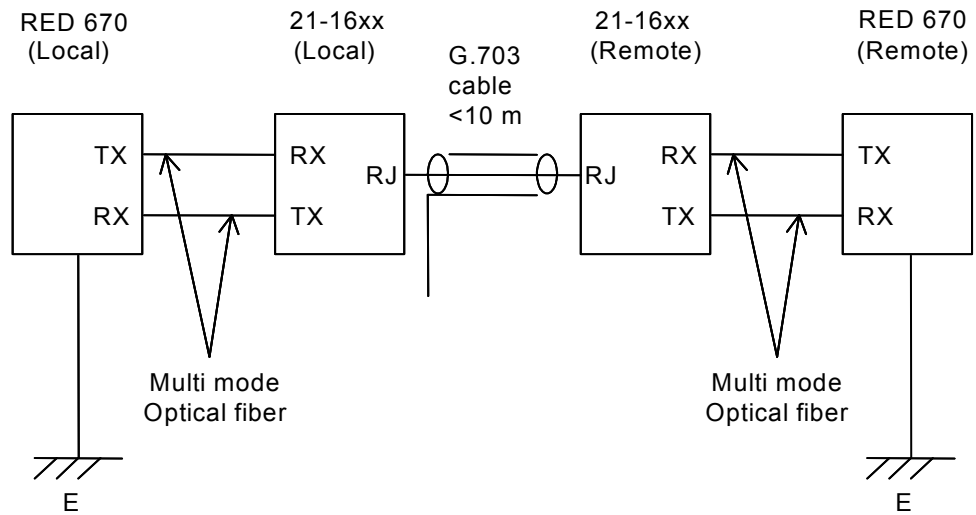
## 9.3

## Supervision of the communication on the 670 series HMI

### 9.3.1

#### Communication structure for laboratory testing

During laboratory testing one of the 21-216 has to provide the timing. This is done by removing the jumper on S14 EXT CLK in one of them. Remember to restore after testing.



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Figure 57: Communication structure for laboratory testing

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## 10 PDH/SDH telecommunication system set-up with 670 series 64 kbit/s C37.94 interface to transceiver type 21-219

The transceiver 21-219 can be used for both SDH or PDH systems.

### 10.1 Transceiver 21-219 service settings for SDH systems

Normally the SDH system with an accurate Master clock gives a high quality communication with very low Bit Error Rate (BER $10^{-9}$ ).

#### 10.1.1 Service settings with the port for 21-219 synchronized to the SDH system master clock

Setting up of a SDH system requires that the port for 21-219 is synchronized from the actual SDH network master clock. Thus the SDH telecommunication multiplexer (MUX) must be set to fulfil this. These settings are vendor dependent, but normally the SDH MUX has to be set for retiming and the format according G.704 framed, structured, unstructured etc.

The format transparent cannot be used in SDH systems because no synchronization on the 21-219 SDH port is available.

#### Communication structure:

670 series

Transceiver 21-219 Optical/electrical interface converter

SDH MUX = Multiplexer in the SDH system

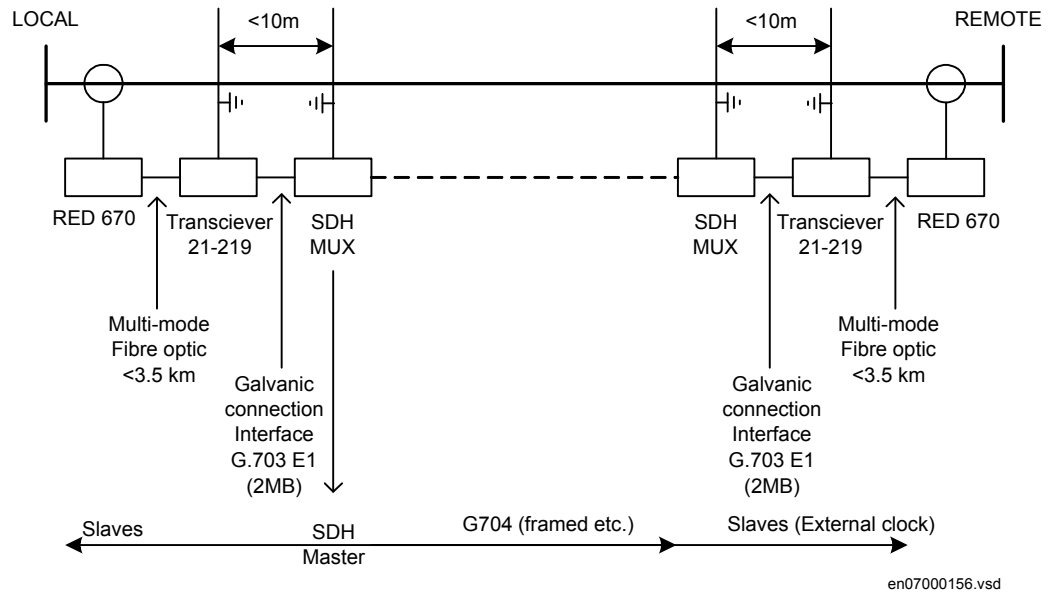


Figure 58: Communication structure

### Setting of clock source (slave mode)

In normal operation the 21-219 at both end of a line shall be configured for External clock, thus the configuration switch at the front shall be in position 0, the led 1, 2, 4, 8 shall all be off.

## 10.1.2

### Service settings with the SDH/PDH port synchronized from one of the 21-219 transceivers (PDH system)

The communication quality in PDH systems are normally not as good as in SDH systems due to less stable clocks as Master. The bit error rate is normally BER  $10^{-6}$ .

Set-up as PDH system requires that the synchronization is provided from an external source, for example one of the 21-219 transceivers. Thus the SDH MUX must be set not to interfere with the synchronization. This setting is normally fulfilled by setting the SDH MUX in transparent mode.

### Communication structure:

670 series Protection/control relay  
Transceiver 21-219 Optical/electrical interface converter  
SDH MUX = Multiplexer in the SDH system

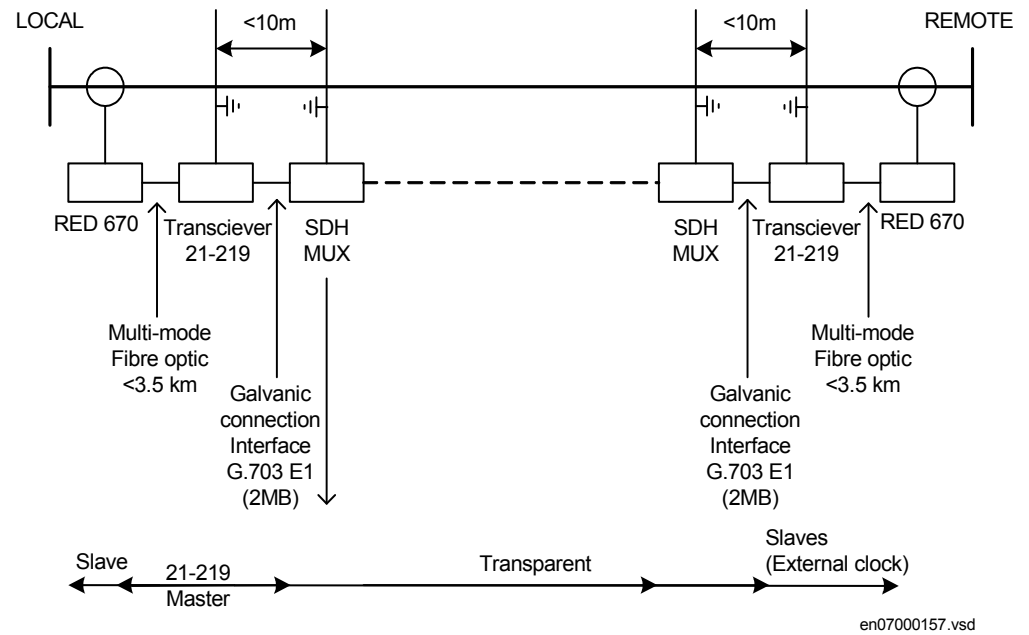


Figure 59: Communication structure

#### Setting of clock source (Master - slave mode)

**Local end Master 21-219;** In normal operation the 21-219 master should be set for *Internal clock*. Thus the configuration switch at the front shall be in position 1 and LED 1 shall be lit. The LED 2, 4, 8 shall all be off.

**Remote end Slave 21-219;** In normal operation the 21-219 slave shall be configured for *External clock*. Thus the configuration switch at the front shall be in position 0. The LED 1, 2, 4, 8 shall all be off.

Both 670 series devices shall be set as slaves.

Note that the differential protection clock is a separate issue not involved in communication and always is set as Master for the differential protection, even if the differential protection is configured Master - Slave.

### 10.1.3

#### Service settings of transceiver 21-219 G.703 E1 2 Mbit

There is only one setting that is required. The 21-219 has to be set for external or internal clock, depending on configuration of the telecomsystem.

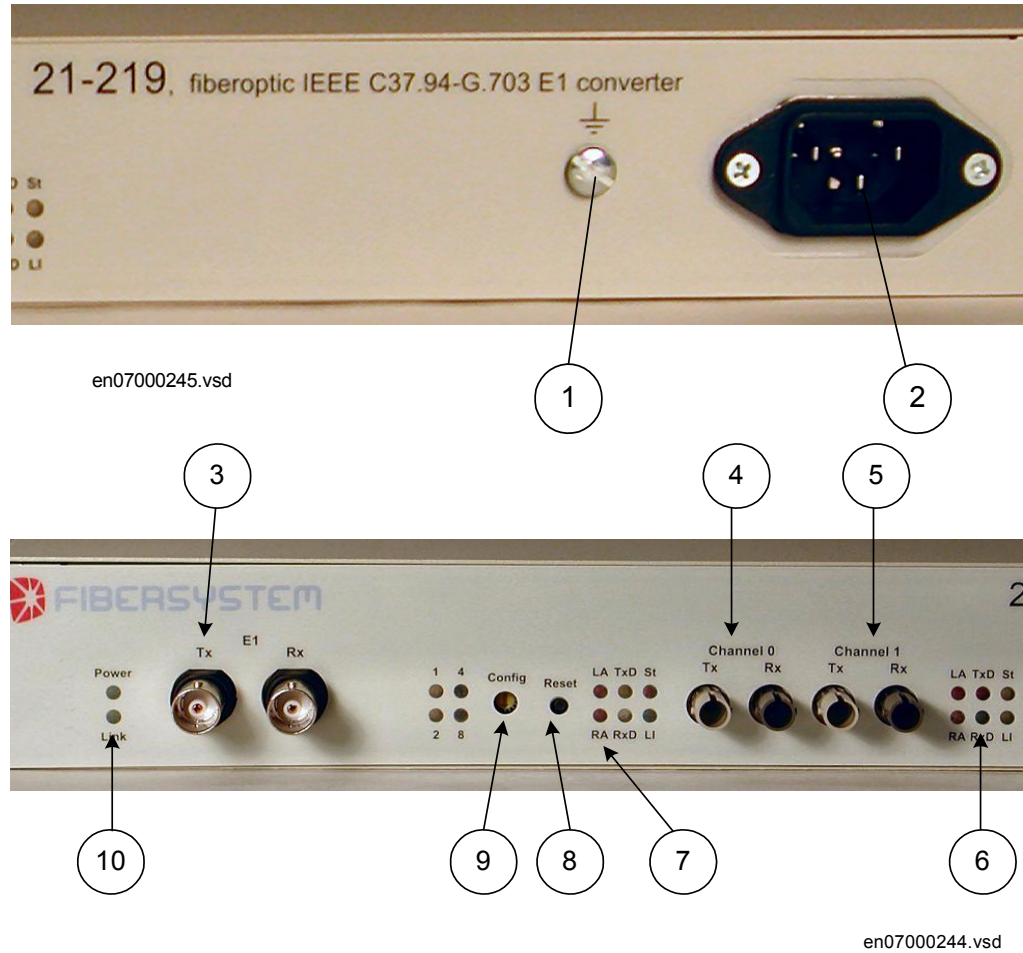
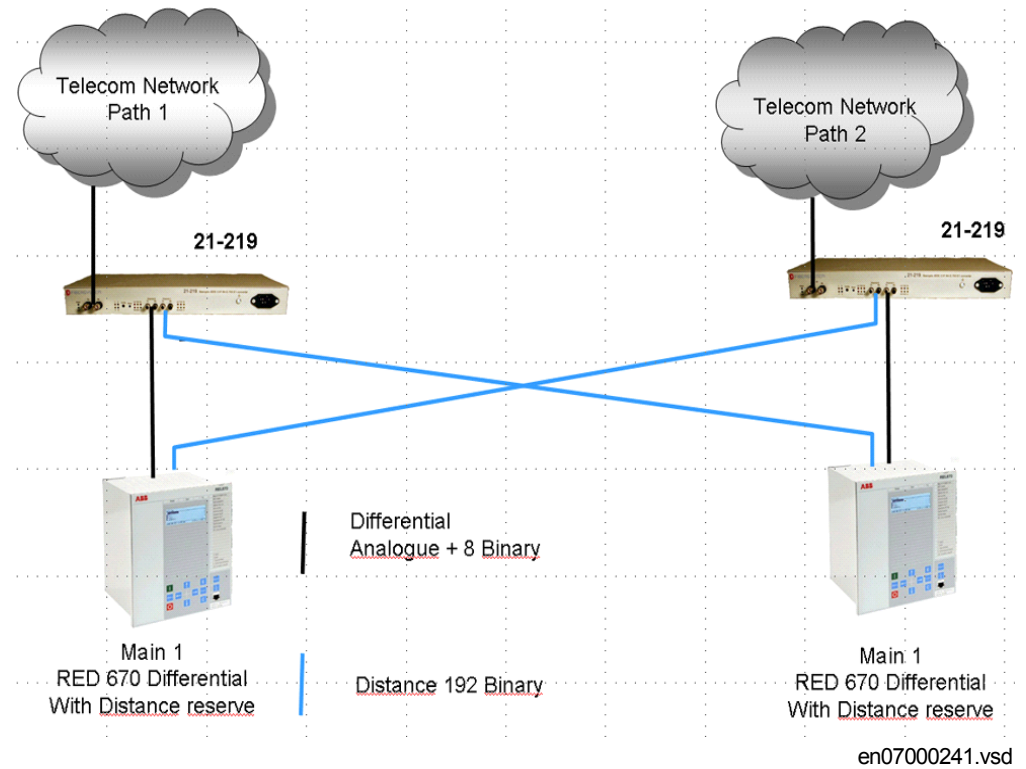


Figure 60: 21-219 Fiber optic IEEE C37.94 G.703 E1 Multiplexor

- 1 Functional ground
- 2 Power Supply IEC 320 connector
- 3 G.703 port
- 4 Fiber Optic Ports "Channel 0"
- 5 Fiber Optic Ports "Channel 1"
- 6 Status LEDs Fiber Optic Port "Channel 1"
- 7 Status LEDs Fiber Optic Port "Channel 0"
- 8 Reset button
- 9 Config-switch
- 10 Status LEDs G.703 and configuration



Transceiver 21-219 has two channels which can be used for redundant communication, see *Figure 61* below.



*Figure 61: Protection system with redundant communication channels*

#### 10.1.4

#### Configuration

##### Normal use

Normally no configuration is needed!

When two 21-219 are connected back-to-back, (E1 ports connected to each other), one of the 21-219 should be set to “Master mode”.

### Config rotary switch

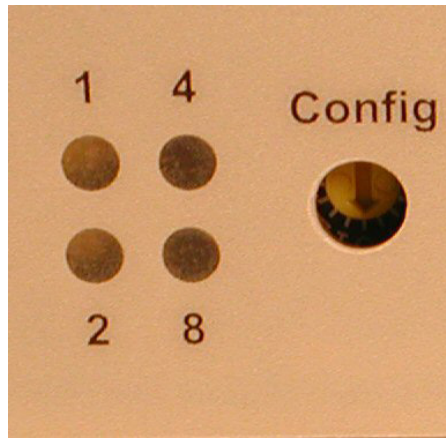
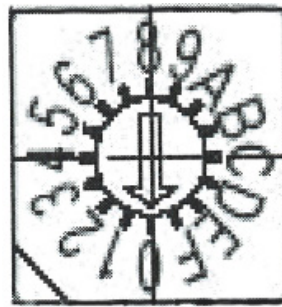


Figure 62: Rotary Switch

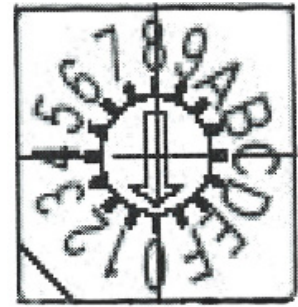
The rotary switch has 16 positions, (HEX\_switch).



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en07000252.wmf



en07000252.wmf

Figure 63: Rotary switch enlarged

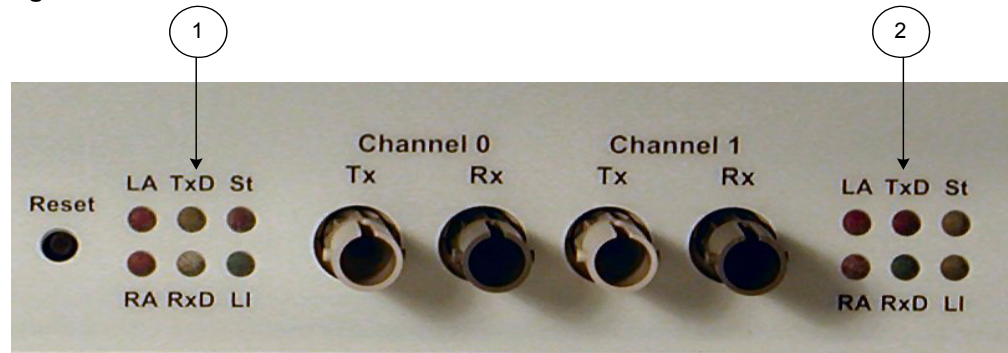
At position 0 the arrow in the switch, visible through the adjusting hole, points straight down.

All configuration is done by setting the position of the “Config” rotary switch on the front panel. The “Config”-switch is operated with a small screwdriver. The switch has 16 positions. Every switch position is presented by the four LEDs 1, 2, 4, and 8, see figure 48. The LEDs forms a corresponding binary-value of the switch position. In the table below “X” marks a lit LED.

LED 1	LED 2	LED 3	LED 4	FUNCTION
				(0H) External clock selected. “Slave mode”
X				(1H) Internal clock selected. “Master mode”

### 10.1.5

#### Signals on front



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Figure 64: LED indicators

- 1 LED indicators for “Channel 0”
- 2 LED indicators for “Channel 1”

**LA = Local Alarm.** A red LED indicating that the 21-219 has encountered a fault in the received IEEE C37.94 protocol - LOS Loss Of Signal. The “Yellow Alarm bit” is set in the outgoing IEEE C37.94 protocol.

Is red when the 21-219 has detected an error. This indication has a memory function. When the local-error is no longer present, the LA-LED will blink until the “Reset”-button is pressed.

**RA = Remote Alarm.** A red LED indicating that the remote unit has encountered a fault condition and has set the “yellow Alarm bit” in the IEEE C37.94 protocol.

Is red when the remote unit of the fiber optic link has detected an error. This indication has a memory function. When the remote-error is no longer present, the RA-LED will blink until the “Reset”-button is pressed.

**ST = Status.** A red LED is lit when the 21-219 has set outgoing data on fiber to AIS-condition.

**LI = Link Fiber.** A green LED indicating that the 21-219 receives correct IEEE C37.94 frames, (No Loss). Blinks when the fiber optic receiver indicate low signal amplitude. Low amplitude is indicated when received optical signal power is between -35dBm and -40dBm.

The IEEE C37.94 standard specifies: “The receiver shall operate error-free (BER <1E-9) for mean optical power between -32dBm and -11dBm”.

**TxD.** Received data from E1 sent out to IEEE C37.94. A yellow LED indicating that 21-219 sends data in IEEE C37.94 format.

**RxD.** Receive IEEE C37.94 data on fiber. A yellow LED indicating that the 21-219 receives data in IEEE C37.94 protocol.

## 10.1.6

### Detection of communication faults on 21-219

There is supervision on the 21-219 which can be used for fault tracing.

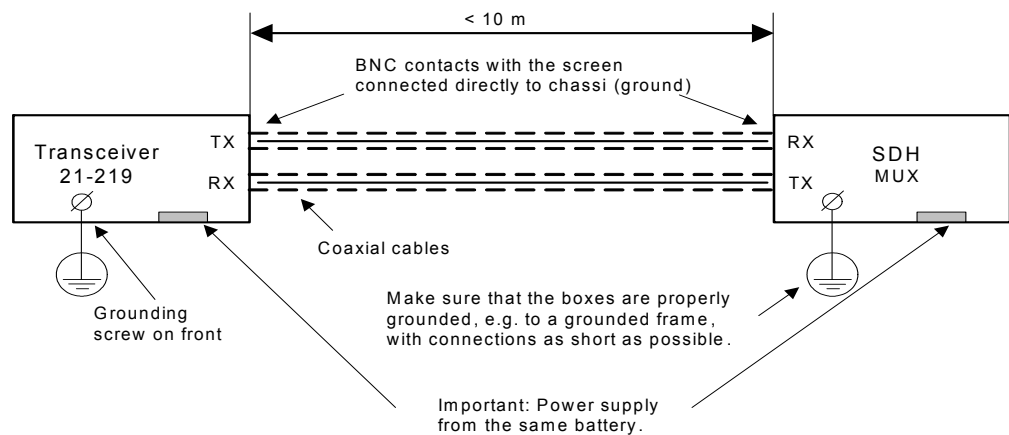
There are two red light emitting diodes on the front of the 21-219, LA (Local Alarm) if there is some problem in 21-219, and RA (Remote Alarm) which is supervising the fiber optic link from the 21-219 to the 670 series, see section 10.1.5 page 67.

If 670 series has a communication fail alarm and there is no indication for LA or Ra on the 21-219, then the communication interruption is in the telecommunication system.

### Grounding of 21-219

The interface protection circuitry in the 21-219 is based on the requirement that the telecommunication multiplexer (MUX) interface is directly or low resistive grounded to the same ground as the grounding screw on the front of the 21-219. There is no over-turned protection in 21-219. If there is a potential difference between the 21-219 ground and the MUX ground it will result in a current flowing in the outer shield of the connecting cable that may damage the cable and degrade the system functionality with bite errors as a consequence.

Thus a correct grounding is essential, with the coaxial cables outer shield grounded to the chassis via the BNC contacts at both ends, see *Figure 65*.



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*Figure 65: Coaxial cables outer shield grounded to the chassis at both ends*

### **Communication settings of 670 series connected to 21-219**

The same setting as for 21-216 are used, see Section *10.1.3* page 70.

### **Communication structure for laboratory testing**

During laboratory testing back-to-back one of the 21-219 must be set as Master. This is done by turning the configuration switch to pos 1 "EXT CLK" on one of them, LED 1 shall be lit and LED 2, 4, 8 shall be off.

## 11 Communication check/fault tracing

### 11.1 Information available on the HMI

On the HMI of RED670 and the 670 series, the status of the remote communication can be supervised. The available information is also useful at fault tracing.

The information on the HMI can be found in the following HMI tree on the RED670 front.

Enter

-Test

- Function status

-Communication

-Remote communication

-LDCM (slot); Line Differential Communication Module

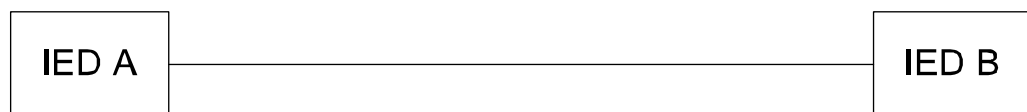
- CRM (no 1-4) Communication remote multi (analogue + binary)

or

- CRB (no 1-4) Communication remote binary (only binary-192 BI/BO)

SMT/ CRM and CRB: Signal Matrix Tool connection number to connect information to for example the event recorder.

#### 11.1.1 Example of HMI info for transmission delay and asymmetry.



0,4 ms Transmission delay, 3,5 ms Asymmetric delay in test set-up

en08000440

ECHO mode			
Settings in IED A		Settings in IED B	
asymDelay	-3.10 ms	asymDelay	3.10

ECHO mode			
Service value in IED A		Service value in IED B	
transmDelay	0.400 ms	transmDelay	3.50
asymDelay	-3.10 (same as setting)	asymDelay	3.10 (same as setting)

#### In GPS mode the actual values are shown

GPS mode			
Service values in IED A		Service values in IED B	
transmDelay	0.4 ms	transmDelay	3.500 ms
asymDelay	-3.1 ms	asymDelay	3.100 ms

### Window

Remote communication/LDCM(slot)/CRM for RED670 and /CRB for the 670 series

HMI Info				Signal Name	SMT-CRM	SMT-CRB
	Normal (Example)	Faulty (Example)	Specification			
TransmDelay in Echo mode 1)	2 ms	-	Time	Round trip delay/2 + set asymmetric delay		
Transmission delay in GPS mode 1)	2 ms		Time	Actual transmission delay + measured asymmetric delay (+or -)		
NoOfShInterr	50	-	Counter	No of short interruptions, 20-50 ms		
NoOfMEDInterr	10	-	Counter	No of medium interruptions, 50-200 ms		
NoOfLongInterr	5	-	Counter	No of long interruptions, >200 ms		
CommStatus	OK	NoRXD	Status	Communication status/no of received messages		
COMFAIL	0	1	Status	Communication failure (>set delay 100 ms in service, 5-10 ms for fault tracing.)	19	19
NoOfTXD	100.000	<100	Status %	No of sent messages		
NoOfRXD	100.000	<75*	Status %	No of received messages		
Ybit	0	1	Status	Detected error in incoming message in remote end	13	13
AsymDelay 1)	0,5 ms	-	Setting/GPS ms	Asymmetric delay (Setting in echo mode or measured with GPS timing.)		

HMI Info				Signal Name	SMT-CRM	SMT-CRB
NOCARR	0	1		No carrier is detected in the incoming message. Group signal - Logical OR for: <ul style="list-style-type: none"> <li>• LINK_LOST No input data stream at the optical receiver</li> <li>• SYNC_LOST The clock synchronization is lost</li> <li>• C37 ERROR Error at the C37.94 fiberoptic receiver (Faulty format)</li> </ul>	25	25
NOMESS	0	1	Status	No start and stop flags in incoming message	24	24
ADRERR	0	1	Status	Incoming message from non-valid address	14	14
LNGTHERR	0	1	Status	Incorrect length for the incoming message	23	23
CRCERROR	0	1	Status	CRC-error in incoming message	15	15
TRDELERR**	0	1	Status	Transmission delay error, > 40 ms	16	N.A**
SYNCERR**	0	1	Status	Error in echo timing synchronization	17	N.A**
RECOMFAIL	0	1	Status	Error in received message at remote end	18	18
REMGPSER**	0	1	Status	Error in GPS synchronization at local or remote end	20	N.A**
SUBSTITU**	0	1	Status	Link error, differential protection blocked. Analogue values are substituted with zero, ref. disturbance recorder.	21	N.A**
LOWLEVEL	0	1	Status	Low signal level in the receive link	26	26

\* Around 75 % RXD is typical if for example two Master clocks are present in the communication system

\*\* Only in RED670

## 11.2

### Detection of communication faults on Fibersystem transceiver type 21-216 C37.94/G.703 64 kbit/s modem.

There is supervision on the 21-216 which can be used for fault tracing, see section 8.7.

There are two red light emitting diodes on the front of the 21-216, LA (Local Alarm), there are some problem in 21-216 and RA (Remote Alarm) which is supervising the fiber optic link from the 21-216 to the 670 series.



If IED 670 has a communication fail alarm and there is no indication for LA or Ra on the 21-216, then the communication interruption is in the telecommunication system.

### 11.3

#### **Detection of communication faults on Fibersystem transceiver type 21-219 C37.94/G.703 G.703 E1 2 Mbit/s modem**

There is supervision on the 21-219 which can be used for fault tracing, see section 8.7.

There are two red light emitting diodes on the front of the 21-219, LA (Local Alarm), there are some problem in 21-219 and RA (Remote Alarm) which is supervising the fiber optic link from the 21-219 to the 670 series.

If IED 670 has a communication fail alarm and there is no indication for LA or Ra on the 21-219, then the communication interruption is in the telecommunication system.

### 11.4

#### **Detection of communication faults by loop back tests.**

A very efficient way to trace the origin of communication problems is to make so called loop-back tests, that is to make a loop back to the local RED670 or 670 series products at various points in the communication system. The loop back tests involve both fiberoptic loop-back and galvanic cable loop-back, depending on actual point in the communication system.



#### **Note:**

*After loop back test, always restore the original terminal numbers. The same terminal number in both ends can cause an unwanted trip. If the relay has been in testmode, please check that local trip is reset before leaving test mode*

#### **Loop back test sequence.**

Block the trip circuits.

Set the local relay and the remote relay with the same address.

Setting of the Line Differential Communication module- LDCM

- general settings

- communication

- LDCM communication

-LDCM (slot no)

- CRM(no) or CRB(No) for the 670 series

Terminal No [ ]

Remote terminal No same [ ]

Echo Synchronization On or Off

GPS synchronization Off or On

The synchronization method shall be the same in the loop-back tests as in actual service.

Perform Loop back tests at consecutive points in the communication system. The number of test will depend on the actual communication system, and number of channels.

Fibersystem transceiver 21-216 will be connected to a 64 kbit PDH Multiplexer.

Fibersystem 21-219 is normally connected directly to a 2 Mbit SDH multiplexer, reducing the number of interface points for the loop-back test.

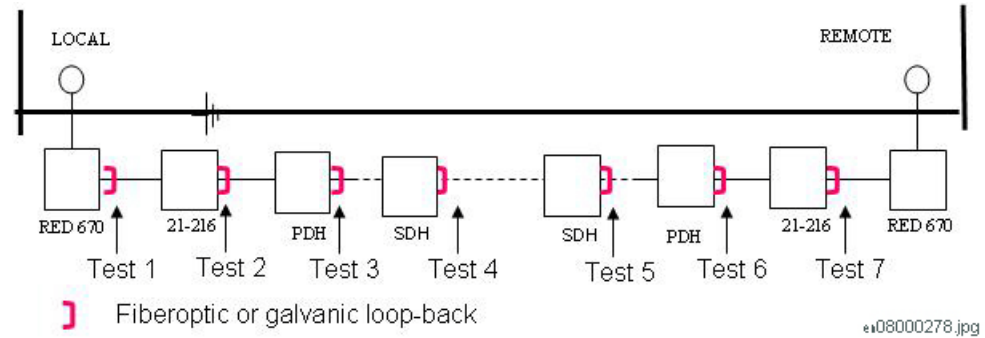


Figure 66: Fiberoptic or galvanic loop-back

Test 1. Connect RX and TX directly on the actual LDCM with a fiberoptic loop. Check that the communication is OK on the HMI, see 11.1 page 70.

If there is more then one LDCM (max 4) on the local RED670, the test must be repeated for each channel

Test 2- to Test N. Loop back RX+ to TX+ and RX- to TX-. Loop back in respective interface points one by one in the communication system. Check the communication information on the HMI for each interface point, see 11.1 above. If no fault is found, Test 1 and Test 2 should be repeated in inverse order from the remote end.



### Note:

For loop-back tests with X21 galvanic interface special procedures and equipment is needed. Contact your local ABB representative.

## Sample specification of communication requirements for differential protection RED670 and the 670 series protection and control terminals in digital telecommunication networks

The communication requirements are based on echo timing.

### Bit Error Rate (BER) according to ITU-T G.821, G.826 and G.828

- $<10^{-6}$  according to the standard for data and voice transfer

### Bit Error Rate (BER) for high availability of the differential protection

- $<10^{-8}$ - $10^{-9}$  during normal operation
- $<10^{-6}$  during disturbed operation

During disturbed conditions, the trip security function in RED670 can cope with high bit error rates up to  $10^{-5}$  or even up to  $10^{-4}$ . The trip security can be configured to be independent of COMFAIL from the differential protection communication supervision, or blocked when COMFAIL is issued after receive error  $>100$ ms. (Default)

### Synchronization in SDH systems with G.703 E1 or IEEE C37.94

The G.703 E1, 2 Mbit shall be set according to ITU-T G.803, G.810-13

- One master clock for the actual network
- The actual port Synchronized to the SDH system clock at 2048 kbit
- Synchronization; bit synchronized, synchronized mapping
- Maximum clock deviation  $<\pm 50$  ppm nominal,  $<\pm 100$  ppm operational
- Jitter and Wander according to ITU-T G.823 and G.825
- Buffer memory  $<250$   $\mu$ s,  $<100$   $\mu$ s asymmetric difference
- Format: G 704 frame, structured etc.Format.
- No CRC-check

### Synchronization in PDH systems connected to SDH systems

- Independent synchronization, asynchronous mapping.
- The actual SDH port must be set to allow transmission of the master clock from the PDH-system via the SDH-system in transparent mode
- Maximum clock deviation  $<\pm 50$  ppm nominal,  $<\pm 100$  ppm operational
- Jitter and Wander according to ITU-T G.823 and G.825
- Buffer memory  $<100$   $\mu$ s
- Format: Transparent
- Maximum channel delay

- Loop time <40 ms continuous (2 x 20 ms)

**IED 670 with echo synchronization of differential clock (without GPS clock)**

- Both channels must have the same route with maximum asymmetry of 0,2-0,5 ms, depending on set sensitivity of the differential protection.
- A fixed asymmetry can be compensated (setting of asymmetric delay in built in HMI or the parameter setting tool PST).

**IED 670 with GPS clock**

- Independent of asymmetry.

## Related documents

<b>Documents related to RED670</b>	<b>Identity number</b>
Operator's manual	1MRK 505 184-UEN
Installation and commissioning manual	1MRK 505 185-UEN
Technical reference manual	1MRK 505 183-UEN
Application manual	1MRK 505 186-UEN
Buyer's guide	1MRK 505 188-BEN
Connection diagram, Single breaker arr. Three phase tripping arr.	1MRK 002 801-BA
Connection diagram, Single breaker arr. Single phase tripping	1MRK 002 801-CA
Connection diagram, Multi breaker arr. Three phase tripping arr.	1MRK 002 801-DA
Connection diagram, Multi breaker arr. Single phase tripping arr.	1MRK 002 801-EA
Configuration diagram A, Single breaker with single or double busbars	1MRK 004 500-82
Configuration diagram B, Single breaker with single or double busbars	1MRK 004 500-83
Configuration diagram C, Multi breakers such as 1 1/2 or ring busbar arr.	1MRK 004 500-84
Configuration diagram D, Multi breakers such as 1 1/2 or ring busbar arr.	1MRK 004 500-85
Setting example 1, 230 kV Short cable line with 1 1/2 CB arr	1MRK 505 175-WEN

<b>Documents related to REL 670</b>	<b>Identity number</b>
Operator's manual	1MRK 506 276-UEN
Installation and commissioning manual	1MRK 506 277-UEN
Technical reference manual	1MRK 506 275-UEN
Application manual	1MRK 506 278-UEN
Buyer's guide	1MRK 506 280-BEN
Connection diagram, Single breaker arr. Three phase tripping arr.	1MRK 002 801-BA

Connection diagram, Single breaker arr. Single phase tripping arr.	1MRK 002 801-CA
Connection diagram, Multi breaker arr. Three phase tripping arr.	1MRK 002 801-DA
Connection diagram, Multi breaker arr. Single phase tripping arr.	1MRK 002 801-EA
Configuration diagram A, Single breaker with single or double busbar, 3 pole tripping (A31)	1MRK 004 500-86
Configuration diagram B, Single breaker with single or double busbar, 1/3 pole tripping (A32)	1MRK 004 500-87
Configuration diagram C, Multi breaker such as 1 1/2 or ring busbar arr. 3 pole tripping (B31)	1MRK 004 500-88
Configuration diagram D, Multi breaker such as 1 1/2 or ring busbar arr. 1/3 pole tripping ( <b>B32</b> )	1MRK 004 500-89
Setting example 1, 400 kV Long overhead power line with 1 1/2 CB arr. Quadrilateral characteristic.	1MRK 506 267-WEN
Setting example 2, Setting example 1, 400 kV Long overhead power line with 1 1/2 CB arr. Mho characteristic.	1MRK 506 291-WEN
Setting example 3, 230 kV Extremely long overhead power line, double bus, single CB arr. Quadrilateral characteristic.	1MRK 506 268-WEN
Setting example 4, 230 kV Extremely long overhead power line, double bus, single CB arr. Mho characteristic.	1MRK 506 292-WEN
Setting example 5, 132 kV Short overhead power line, double bus, single CB arr. Quadrilateral characteristic.	1MRK 506 269-WEN
Setting example 6, 132 kV Short overhead power line, double bus, single CB arr. Mho characteristic.	1MRK 506 290-WEN
Setting example 7, 70 kV power line on a resonance earth system. Double bus, single breaker arrangement.	1MRK 506 293-WEN
Setting example 8, 400 kV long series compensated line. 1 1/2 breaker arrangement.	1MRK 506 294-WEN

#### **Documents related to REC 670**

#### **Identity number**

Operator's manual	1MRK 511 188-UEN
Installation and commissioning manual	1MRK 511 189-UEN
Technical reference manual	1MRK 511 187-UEN
Application manual	1MRK 511 190-UEN
Buyer's guide	1MRK 511 192-BEN

Connection diagram, Single breaker	1MRK 002 801-FA
Connection diagram, Double breaker	1MRK 002 801-MA
Connection diagram, 1 1/2CB	1MRK 002 801-NA
Configuration diagram A, Single breaker arr. with single or double busbar	1MRK 004 500-90
Configuration diagram B, Double breaker arrangements	1MRK 004 500-91
Configuration diagram C, 1 1/2 breaker arr. for a full bay	1MRK 004 500-92

<b>Documents related to RET 670</b>	<b>Identity number</b>
Operator's manual	1MRK 504 087-UEN
Installation and commissioning manual	1MRK 504 088-UEN
Technical reference manual	1MRK 504 086-UEN
Application manual	1MRK 504 089-UEN
Buyer's guide	1MRK 504 091-BEN
Connection diagram, Two winding transf. Single breaker arrangements	1MRK 002 801-LA
Connection diagram, Two winding transf. Multi breaker arrangements	1MRK 002 801-HA
Connection diagram, Three winding transf. Single breaker arrangements	1MRK 002 801-KA
Connection diagram, Three winding transf. Multi breaker arrangements	1MRK 002 801-GA
Configuration diagram A, Two winding transf. with single or double busbar but with a single breaker arr. on both sides (A30)	1MRK 004 500-93
Configuration diagram B, Two winding transf. in multi breaker arr. on one or both sides (A40)	1MRK 004 500-94
Configuration diagram C, Three winding transf. with single or double busbar but with a single breaker arr. on both sides (B30)	1MRK 004 500-95
Configuration diagram D, Three winding transf. in multi breaker arr. on one or both sides (B40)	1MRK 004 500-96
Configuration diagram E, Two or three winding transf., back-up protection package (A10)	1MRK 004 500-135
Configuration diagram F. Tap changer control package for two parallel transformers. (A25)	1MRK 004 500-140

Configuration diagram F. Tap changer control package for four parallel transformers. (A25)	1MRK 004 500-140
Setting example 1, 400/230 kV 500 MVA Transformer, YNyn connected	1MRK 504 083-WEN
Setting example 2, 132/230 kV 40 MVA Transformer, YNd1 connected	1MRK 504 084-WEN

#### **Documents related to REB 670**

#### **Identity number**

Operator's manual	1MRK 505 179-UEN
Installation and commissioning manual	1MRK 505 180-UEN
Technical reference manual	1MRK 505 178-UEN
Application manual	1MRK 505 181-UEN
Buyer's guide	1MRK 505 182-BEN

#### **Documents related to REG 670**

#### **Identity number**

Operator's manual	1MRK 502 014-UEN
Installation and commissioning manual	1MRK 502 015-UEN
Technical reference manual	1MRK 502 013-UEN
Application manual	1MRK 502 016-UEN
Buyer's guide	1MRK 502 019-BEN
Setting example	1MRK 502 020-WEN

#### **Documents related to all IEDs**

#### **Identity number**

Connection and Installation components	1MRK 013 003-BEN
Test system, COMBITEST	1MRK 512 001-BEN
Accessories for IED 670	1MRK 514 012-BEN
Getting started guide IED 670	1MRK 500 080-UEN
SPA and LON signal list for IED 670, ver. 1.1	1MRK 500 083-WEN
IEC 61850 Data objects list for IED 670, ver. 1.1	1MRK 500 084-WEN
Generic IEC 61850 IED Connectivity package	1KHA001027-UEN



Protection and Control IED Manager PCM600 Installation sheet	1MRS755552
Engineering guide IED 670 products	1MRK 511 179-UEN
Buyer's guide REG 216	1MRB520004-BEN



**Note:**

*Latest versions of the described documentation can be found at [www.abb.com/substationautomation](http://www.abb.com/substationautomation).*

Fibersystem 21-216 manual at [www.fibersystem.se](http://www.fibersystem.se)

Fibersystem 21-219 manual at [www.fibersystem.se](http://www.fibersystem.se)



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