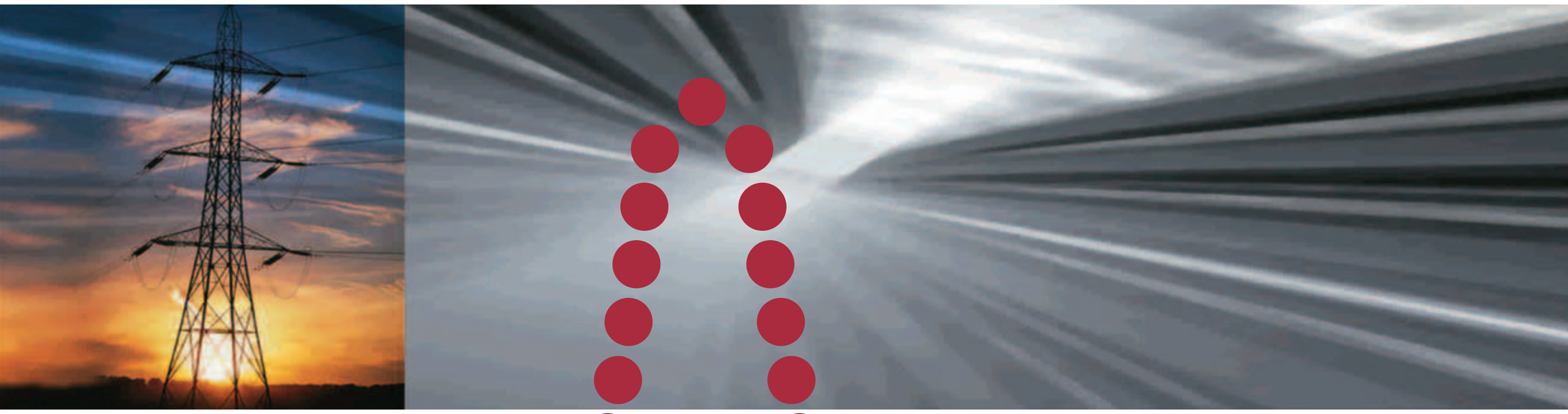

1CPX

Substation Central Unit

Instruction Manual

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BCPX407Av03

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Notes:

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CHAPTER 1

Description

The **CPX** families of equipment, along with the PCD unit, form part of what is known as the Substation Central Unit (SCU), which in turn forms part of the Substation Integrated Protection and Control System (SIPACS). Together with these we find the Level 1 protection and control equipment.

Among the general functions of the **CPX** are the following:

- **Communication with Level 1 equipment.**
- **Integration of all substation control information in a common real-time database.**
- **Communication with equipment of the same or higher level with protocol emulation.**
- **Execution of programmable control functions at the substation level.**
- **Ability to execute maneuvers with interlocking management at the substation level.**

1.1 General

The Central Unit of protection and Control of Substation are made up of two independent units that operate as a whole. The **CPX** is designed to solve all communication and data processing needs with a substation's protection, control and metering equipment, providing new functions that make most of the information available to these units. The **CPX** is responsible for communications with level 1 equipment and for real-time database maintenance. The **PCD** is primarily the interface between the user and the installation.

Although they form a whole, the **CPX** can operate autonomously without having a **PCD** connected. The reverse situation is not possible. In this situation, where there is no **PCD**, the interface between the user and the installation takes place through other external equipment (remote control, SCADA, etc.).

The entire system can be configured through ***Zivergraph*** software. This program enables the system to be configured to adapt to the substation's characteristics: equipment connected, signals associated with each unit, representation of the information on displays, logic functions at the substation level, desired functionality, etc.

1.2 CPX Functions

The main functions of the central unit or **CPX** are described below:

- **Communications**

The **CPX** communicates with the protection and control equipment that monitors the substation through the standard protocol **PROCOME**. The equipment is connected to the **CPX** by plastic or glass fiber optics, or by a serial cable. Equipment with the following protocols may be connected to the **CPX**: **PROCOME**, **DNP 3.0**, **MODBUS**, **IEC 103**, **SPABUS**.

It also communicates with the control station, emulating the necessary protocol in each case, to inform the same of the events occurring at the substation and enable it to maneuver on its active elements.

The technical office also communicates with the **CPX** through a modem connected to the remote port. By using the manufacturer's program, protection data can be transparently accessed, so that queries can be made regarding the status of the protections, etc. This connection is also possible from the local port. This functionality is included in all **CPX** models for equipment using the **PROCOME** protocol. For equipment with other protocols, it will depend on the model.

In addition, the **CPX** is connected to the operating console through a local network. All the data transfers between both units takes place via this connection. Likewise, a remote operating console, which may be in the company's technical office, can also be connected to the **CPX** via modem.

Finally, the **CPX** has an interface to obtain the standard GPS clock signal, with the ability to, on the one hand, receive the signal delivered directly through a GPS antenna, and on the other hand, also offer a connection to a GPS receiving device.

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- **Synchronization**

The **CPX** is responsible for keeping the entire system synchronized with a single clock source. This source may be external or internal. If external synchronization is not possible, the **CPX** uses the internal real-time clock (RTC) as a standard to synchronize the clocks of the different equipment connected to it.

Several non-exclusive synchronization methods can be used as a source of external synchronization. Using the particular communications protocol, the **CPX** is synchronized periodically from the control office via the control program..

If a GPS clock is used, the **CPX** has several communications interfaces with this clock. Thus, the **CPX** allows synchronization with a GPS clock using IRIG-B, serial and parallel interfaces. These interfaces will be explained further on.

- **Databases**

The **CPX** collects data from the substation's IED, control and metering units and maintains a database with this data, updated in real time (the update cycle will depend on the number of units connected, on the communication parameters and on the protocol used). This database is the data medium for the operating console (local and remote) and all other applications that communicate with the central unit, such as remote controls, internal tasks, etc.

The **CPX** database is stored in an internal format and is volatile, i.e., it is a copy of the level 1 equipment data. No log of this information is kept.

The **CPX** not only emulates higher-level communications protocols; it also maintains a database in the particular format of the protocol emulated, so that it makes the higher-level equipment think that it is communicating with a unit from the original manufacturer.

- **Commands**

The **CPX** allows commands to be executed on the installation's configurable elements. The command may originate internally (control functions, logic) or externally (operating console, remote control). The **CPX** modifies the format of commands between the different protocols so that the command reaches the equipment that must execute it, regardless of the manufacturer of the equipment. Likewise, it closes the communication loop, if the communications protocol supports this, by sending the unit's response to an order to the equipment from which the order originated.

There is a blocking logic that prevents performing dangerous or forbidden maneuvers in certain situations.

- **Logic**

The **CPX** has an internal task responsible for executing a fully programmable logic program by means of certain functions: logic gates (AND, OR, NOT, etc.), flip-flop (RS, JK), commands, etc.

This logic program may be used to implement control functions at the substation level, group signals to send to the control office, etc.

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- **Event Management**

Information of the level 1 equipment is collected by first asking for a “snapshot” of the status of all signals available in the equipment, and then asking for changes in these signals in a cyclical manner. All of these changes are sent to the internal tasks that have requested this information from the database.

However, not all signal changes occurring at the substation will be useful to the user; in other words, not all will be defined as events. The **CPX** filters and sends to the **PCD** those changes that the client considers interesting.

Similarly, each database client task will receive all signal changes collected from the equipment, and it will be its job to filter them, keeping those that are to its interest and discharging those that are not.

- **Alarm Management**

The same as with the events, not all signal changes are alarms. The **CPX** is responsible for managing the alarms occurring at the substation, indicating the **PCD** which of the changes that have been sent are alarms and which are not.

Alarm management for the control office is one of its tasks; the only thing the **CPX** does is filter the changes and send along only those that are of interest.

- **Control Functions**

The **CPX** can execute certain control functions at the substation level, in which signals from different equipment take part. These control functions can be of two types: fixed or programmable. The former category includes those whose functionality is fixed and cannot be altered; they may only be configured and set. The latter includes those that are programmed within control logic.

- **Redundancy**

A redundant system must be installed in some key installations. The **CPX** may have two types of redundancy: Hot Standby (HSB) and Full. In both cases, the **primary CPX** performs the functions inherent to a **CPX**, and monitors certain critical variables, while the **secondary CPX** is on standby, ready to take control of the substation if a fault is detected. The difference lies in the fact that with Full redundancy, the database of both **CPXs** is up-to-date at all times, while with HSB redundancy, the secondary **CPX’s** is not.

- **Log Management**

Another optional functionality of the **CPX** is to log changes in signals, measurements and meters. These logs are daily records, saved on disk, of the information you wish to save. These records are collected from the **PCD**, which will later process them.

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- **Self-checking**

The central unit periodically checks the integrity of the hardware and the software stored on its permanent memory devices. It also has a system that picks up any error that occurs when the unit's hardware is accessed, so that the system can continue operating in an emergency mode if necessary, until the problem can be solved.

- **Human-Machine Interface**

There is an operator interface that allows to obtain information regarding the equipment's functionality, as well as information that will enable the supervision of the central unit's performance and operability at all times. This interface has an LCD display, a keypad with basic functions and a series of configurable LEDs which show the status of certain system control signals.

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1.3 Identification of the Model

The hardware model can be determined from the table below:

1CPX - ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ W ☐

RESERVE	
To be defined	

COMMUNICATIONS HARDWARE OPTIONS	
None	0
Indatic Remote	1
TRW Remote	2

INTEGRATED HARDWARE OPTIONS	
None	0
Flash Disk + Display + Front Keypad	3
Option 3 + IRIG-B123 GPS	B

POWER SUPPLY VOLTAGE	
24 - 48 Vdc	1
110 - 125 Vdc	2
250 Vdc	3
220 Vdc	4

LANGUAGE	
Spanish	0
English	2
Portuguese	E
French	G

TYPES OF F.O. – LEVEL 1 PORTS	
Plastic	0
ST (glass + bayonet)	1
SMA (glass + screw)	2

NUMBER OF LEVEL 1 PORTS	
6 ports 1 176 + 1 177	0
12 ports 2 176 + 2 177	1

RESERVE	
To be defined	

RESERVE	
To be defined	

TYPE OF CASE	
Standard case	W

RESERVE	
To be defined	

MARKET ADAPTER	
See specific list with last letter of relay model	

Figure 1.1: Hardware Model Selection.

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CHAPTER 2

Technical Data

Power Supply Voltage

CPXs have a power supply whose voltage can be selected, depending on the specific model:

48	**Vdc (±20%)**
110 - 125	**Vdc (±20%)**

Hardware Data

- Industrial CPU card with 233 MHz or higher Pentium microprocessor (includes chip for Ethernet network with 10Base-T connection and VGA video controller).
- 32 Mb of RAM (minimum).
- 64 Mb static Flash Disk and/or 1 Gb hard disk or higher
- Video and keyboard connector.
- Hub with four 10Base-T type connections.
- Parallel connection for GPS clock receiver, isolated by means of optical couplers.
- Coaxial connector for IRIG-B123 signal.
- Multiport serial communications card with optical coupler interface for fiber optics (maximum 2 cards).
- Card with 4 RS-232 serial ports with optical coupler interface.
- 8 digital status contact inputs and 4 digital status contact outputs
- Front panel with MMI (keyboard and display) and LEDs (optional)

Status contact inputs

The number of digital status contact inputs depends on the model.

Rated voltage for status contact inputs	**24-125 Vdc ±20%**
Current drain	**< 5mA**

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Double contact outputs

Power Make and carry: (with resistive load)	**30 A** for **1 s**
Power in Continuous service: (with resistive load)	**8 A**
Connection capability:	**2500 W**
Break (resistive):	**150W** -max. **8A**- (up to **48 Vdc**)
	55W (**80Vdc** - **250Vdc)**
	1250 VA
Break (L/R = 0.04 s):	**60 W** to **125 Vdc**
Switching voltage:	**250 Vdc**

- **Communication Data**

Glass Fiber Optics Transmission:

Type:	**Multimode**
Wavelength:	**820 nm**
Connector:	**ST**
Transmitter minimum power:	
50/125 fiber:	**-20 dBm**
62.5/125 fiber:	**-17 dBm**
100/140 fiber:	**- 7 dBm**
Receiver sensitivity:	**- 25.4 dBm**

Plastic Fiber Optics (1 mm):

Wavelength:	**660 nm**
Transmitter minimum power:	**- 16 dBm**
Receiver sensitivity:	**- 39 dBm**

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RS232C Port Signals

dB-9 connector, signals used: (COM1, COM2, COM3, COM4, COM5) (LOC, REM)	Pin 1 - DCD Pin 2 - RX Pin 3 - TX Pin 4 - DTR Pin 5 - GND Pin 6 - DSR Pin 7 - RTS Pin 8 - CTS Pin 9 - RI
dB-25 connector, signals used: (Q0)	Pin 2 - TX Pin 3 - RX Pin 4 - RTS Pin 5 - CTS Pin 7 - GND Rest – N/C

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dB-37 connector for parallel synchronizer clock
(PP0)

Signals used:	Pin 1 - IRQ
	Pin 3 - Bit 15
	Pin 4 - Bit 14
	Pin 5 - Bit 13
	Pin 6 - Bit 12
	Pin 7 - Bit 11
	Pin 8 - Bit 10
	Pin 9 - Bit 9
	Pin 10 - Bit 8
	Pin 30 - Bit 7
	Pin 31 - Bit 6
	Pin 32 - Bit 5
	Pin 33 - Bit 4
	Pin 34 - Bit 3
	Pin 35 - Bit 2
	Pin 36 - Bit 1
	Pin 37 - Bit 0

RJ45 connection
(LAN0, LAN1, LAN2, LAN3, LAN4)

Signals used:	Pin 1 - TX+
	Pin 2 - TX-
	Pin 3 - RX+
	Pin 4 - N/C
	Pin 5 - N/C
	Pin 6 - RX-
	Pin 7 - N/C
	Pin 8 - N/C

Coaxial connector for synchronizer clock with IRIGB-123 interface

Internal Connection - Signal
External Connection - GND

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VGA connector for composite video signal:

Signals used:	Pin 1 - Video R (75 ohm / 0.75 V pp) Pin 2 - Video G (75 ohm / 0.75 V pp) Pin 3 - Video B (75 ohm / 0.75 V pp) Pin 4 - ID2 (Monitor ID bit 2) Pin 5 - GND Pin 6 - RGND (Red GND) Pin 7 - GGND (Green GND) Pin 8 - BGND (Blue GND) Pin 9 - N/C Pin 10 - SGND (Sync GND) Pin 11 – ID0 (Monitor ID bit 0) Pin 12 – ID1 (Monitor ID bit 1) Pin 13 - HSYNC or CSYNC (Horizontal Sync) Pin 14 - VSYNC (Vertical Sync) Pin 15 – ID3 (Monitor ID bit 3)

Keyboard Connector (QWERTY-type keyboard)

Signals used:	Pin 1 - CLOCK Pin 2 - DATA Pin 3 - N/C Pin 4 - GND Pin 5 - +5 VDC

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CHAPTER 3

Standards and Type Tests

The equipment satisfies the standards indicated below. When not specified, the standard is **UNE 21-136 (IEC-255)**.

Insulation Test	*IEC -255-5*	
Between all circuit terminals and ground:		**2 kV**, **50 Hz**, for 1 minute
Between all circuit terminals:		**2 kV**, **50 Hz**, for 1 minute

1 MHz Burst Test	*IEC-255-22-1 Class III (UNE 21-136-92/22-1)*	
Common Mode:		**2.5 kV**
Differential mode:		**1.0 kV**
Fast Transient Disturbance Test	*IEC -255-22-4 Class IV (UNE 21-136-92/22-4) (IEC 1000-4-4)*	**4 kV ± 10 %**
Electrostatic Discharge Test	*IEC 255-22-2 Class III (UNE 21-136-92/22-2) (IEC 1000-4-2)*	**8 kV ± 10 %**

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CHAPTER 4

Physical Architecture

IV

4.1 Modularity

- **CPX**

The **CPX** is made up of several cards with different functions. The cards are arranged in two groups joined by a card-bus located in the central part of the unit. The remaining cards are placed in the front or back part. Those located in front provide hardware functions, and the ones located in the back provide the physical interface and isolation.

The cards located in the front are:

- **CPU card.**
- **Multiport communications card.**
- **Multifunction card: GPS, Indactic, etc.**
- **Front panel with display, keyboard and LEDs**

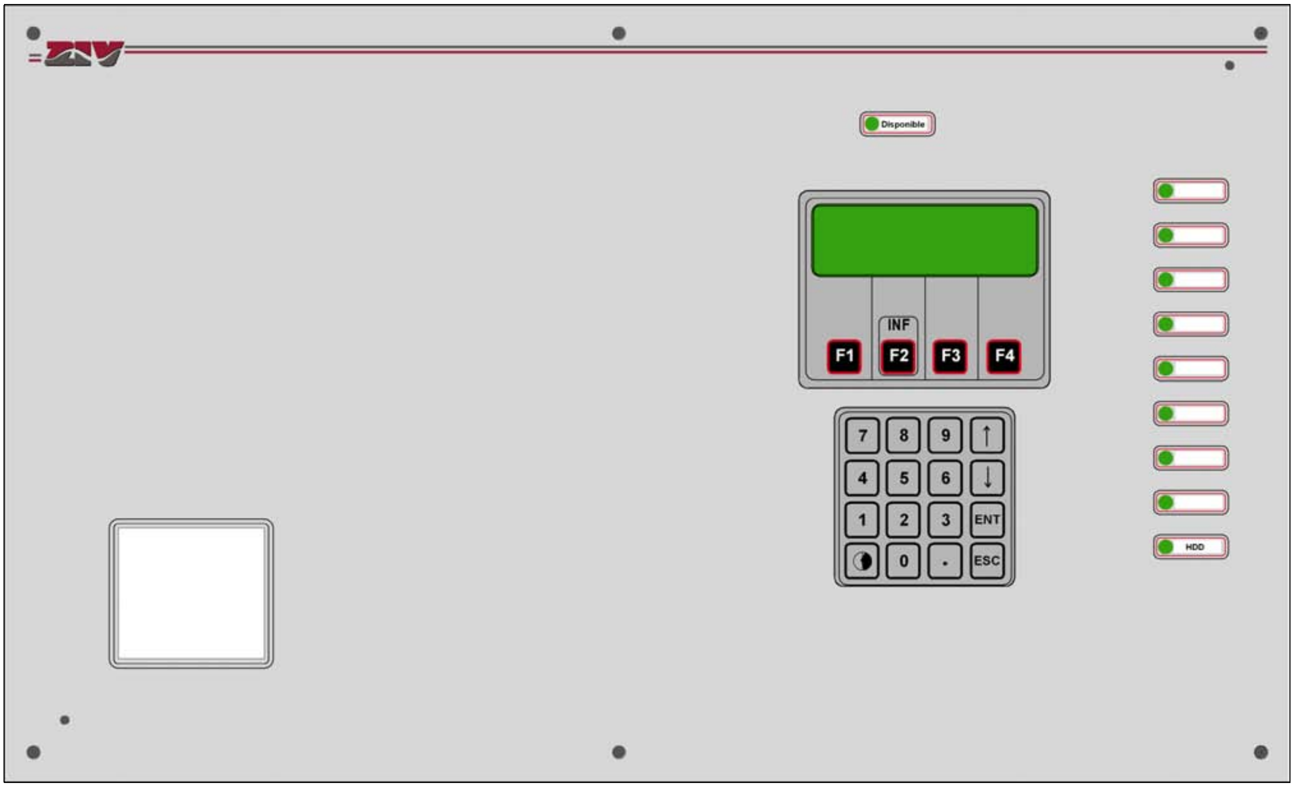

Figure 4.1: Front View of a CPX.

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The cards located in the back are:

- **Power supply.**
- **Serial port card, Ethernet network and video hub.**
- **I/O, GPS, Indactic and keyboard card.**
- **Cards for F.O., local and remote ports.**

Depending on the model, up to the following may be included:

- 2 multiport communications cards with their corresponding F.O. port cards. 1 DB9F RS232 serial port for local connection with ***Zivercom*** (located in the back).
- 1 DB9F RS232 serial port for remote connection with ***Zivercom.***
- 6 fiber optic ports (glass or plastic) for connections with level 1 equipment (can be expanded to 12 ports).
- 1 DB25F serial port for connection with special equipment.
- 4 DB9F RS232 multipurpose serial ports (their functions depend on model and configuration).

Figure 4.2 illustrates the back of a generic IED.

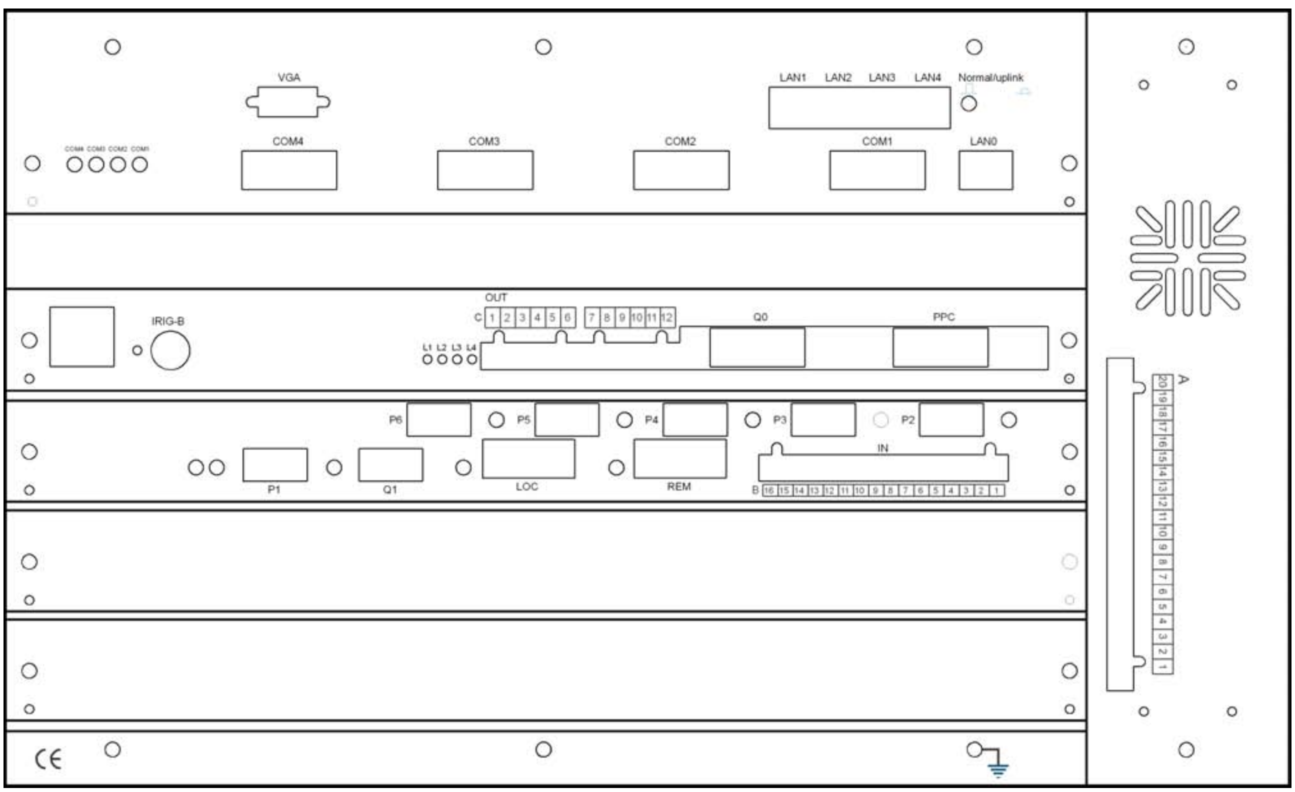

Figure 4.2: Rear View of a CPX.

There are also some LEDs on the back that indicate: communications port activity and storage disk access.

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4.2 Dimensions

The IEDs are fixed to enclosures of 1 19" *rack* width and 6 rack heights. They are designed to be installed semi-flush mounted in panels. The enclosure is graphite grey.

4.3 Connection Elements

- **Terminal blocks**

The terminal blocks are arranged horizontally as shown in figure 4.2 and are distributed as follows:

- Terminal block with contact outputs, labeled OUT. It has 4 contact outputs in 12 terminals, and contact may be generally open or closed.
- Terminal block with contact inputs, labeled IN. It has 8 contact inputs in 16 terminals.

The association of each terminal with the corresponding signals will depend on the IED settings.

The terminals can take wire up to #14 AWG. We recommend pin terminals for these connections.

- **Removing printed circuit boards**

The IED's electronic boards are removable.

The electronic cards have screws that must be taken out before removing them. Note that whenever this operation is performed, the unit's power supply must be disconnected.

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CHAPTER 5

Settings

The **CPX** is a highly configurable unit, with a large number of parameters. The functions available depend on the software model.

The **CPX** gets configuration data from some files in text mode, explained in the annexes, which are generated through ***Zivergraph*** software. Through this software, a central unit can be customized to an installation, configuring all the necessary parameters for each function.

Except for the programmable control functions, the **CPX** has no parameters whose execution time can be adjusted. Any modification of the parameters must be done from the ***Zivergraph*** software, after which the **CPX** can be reconfigured with the newly modified files. As this is a complex procedure, the parameter variation ranges and settings will not be discussed here; they will be indicated in the ***Zivergraph*** manual and in the annexes describing the configuration files.

The adjustable parameters for the control functions are described in Chapter 6, in the section corresponding to each one of them.

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CHAPTER 6

Description of Operation

VI

6.1 Introduction

The **CPX's** software is made up of several independent tasks that perform specific functions which are executed on a multitask basis. Many of these tasks are fixed and make up what is known as the core of the **CPX**. Other tasks will be available depending on the **CPX** model.

The main task is to collect information from other equipment at a lower conceptual level, process it and serve it to a higher conceptual level equipment. To do this, it uses communications protocols which are emulated and adapted to the **CPX**'s internal structure.

There are also other tasks that provide additional functionality, giving the **CPX** great potential for processing data from the installation.

This chapter will discuss the various functions that can be found in a **CPX**.

6.2 Concept of the Equipment

In the **CPX**'s internal structure, all signals (digital and analog) come from a specific unit and are uniquely identified by a pair of numbers: **unit** and **signal**. The **Unit** identifier is, in general terms, the address of the unit in the communications protocol. The **Signal** identifier is a signal's index within a group of signals from a unit: digital inputs, digital outputs, analog inputs, etc.; in other words, each group of signals is made up of signals identified by a consecutive number from 0 to 1023.

Each of these groups has a mnemonic that distinguishes it: ISC, digital inputs; MEA, analog inputs; ISE, commands; CON, counters; ISS, digital output writing signals; ISM, analog output writing signals. These identifiers are taken from the PROCOME protocol, but thanks to the emulation of other protocols, they can be applied to all equipment connected to the **CPX**.

As an example, we can say that the open breaker signal corresponds to ISC 52 from unit 22, or that the voltage of a bus is MEA 3 from unit 12.

- **Virtual Units**

In order to incorporate into the system the signals generated by the **CPX's** different functions, a number of internal units have been created which have no physical correspondence (i.e., virtual), which have these signals associated with them.

The virtual units that may be present in the **CPX** are the ones shown in table 6.1. Both the model and the configuration of the **CPX** determine what virtual units will be present in a certain installation.

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Table 6.1 also indicates the range of signals that each of the virtual units has. Each one will be described further on when its functionality is discussed.

Table 6-1

Address	Signals	Description
256	ISC: 0...1023 ISE: 0...1023	Logic. This task that is responsible for executing the logic program generates its own signals as a result of that execution.
257	ISC: 0 ... 324 ISE: 0 ... 33	Central. Groups the signals generated by the central unit itself considered as a unit. These signals are, among others, communications failures with equipment, internal signals, status of the CPX's digital inputs, etc.
258	ISC: 0	Remote control. Indicates the status of communications with the control office.
259	ISC: 0...7 + NPos	Control function to detect resistive grounds. The number of signals depends on the number of IEDs configured.
260	ISC: 0...28 ISE: 0...13	H Control function.
261	ISC: 0...23 + 40 * Terminal ISE: 0 ... 3	ERAS control function.
262	ISC: 0...7 + NPos	Control function to detect resistive grounds. Module 2.
263	ISC: 0...7 + NPos	Control function to detect resistive grounds. Module 3.
264	ISC: 0...7 + NPos	Control function to detect resistive grounds. Module 4.
265	ISC: 0...7 + NPos	Control function to detect resistive grounds. Module 5.
266	ISC: 0 … 1023 ISE: 0 …1023 MEA: 0 … 255 CON:0 … 255	Communications task with a PLC.
267	-	Spare
268	-	Spare
269	ISC: 0 ... 12 ISE: 0 ... 3	Task responsible for the redundancy of the CPX.
270	ISC: 0	Communications task with a PLC in MODBUS.

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6.3 General Functions

6.3.1 Synchronization

The **CPX** is responsible for keeping all lower-level equipment present in the installation synchronized with a reference date and time. The frequency of the synchronization can be carried out with a periodicity configurable with the **Synchronization Time** parameter. If the protocol allows it, the synchronization message is broadcast, i.e., all relays for one port are synchronized at once.

Related to this function is a parameter which indicates whether the time is sent to the equipment with a resolution of milliseconds, or whether it is rounded off to the hundredth of a second by default.

In addition, in order to ensure that the equipment is synchronized with reliable data, the **CPX** itself is synchronized from different sources. The origin of these sources depends on the configuration and on the status of the sources; there are several possibilities.

- **Synchronization from the operating console**

The **CPX**'s internal clock is synchronized by the user from the operating console. To do this, the **Synchronize CPX** option from the Engineering display is used. The data entered is sent to the **CPX**, which uses it to change its internal time and then synchronize the equipment.

- **Synchronization from the control office**

The control office periodically sends the time to the **CPX** using the appropriate communications protocol. The **CPX** uses this data to change its internal time and then synchronize the equipment.

- **GPS clock synchronization**

If there is an external GPS synchronizer, the data it supplies will be used for synchronization. Depending on the interface connecting to the clock, the sync method and the necessary parameters will be different. In all cases, using a certain protocol, the GPS clock sends, updated date, time and status data at periodic intervals; the **CPX** uses this data to synchronize its internal clock.

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First of all, there is a parameter (**GPS Clock**) that indicates whether a GPS clock is connected to the **CPX**, and if so, what type it is. The types available are the following:

- **IKOR PC Parallel**: specific to the IKOR company and used on a 17-line parallel interface. A DB37F connector is used.
- **IRIG-B123**: this interface accepts a connection with any clock that complies with the IRIG-B123 protocol. A coaxial connector is used.
- **IKOR 232 serial** (also **ZIV 1GPS 232 serial**): this option is used to connect a clock specific to the IKOR company, or a **ZIV** clock, using their RS232 serial interface. The clock sends time data in a serial frame with a certain format. One of the communications ports labeled COM1-4 is used. The format of the frame is as shown in the table below.

Table 6-2	
[STX]D:dd.mm.aa;T:n;U:hh.mm.ss;#*S![ETX]	
[STX]	Start of frame (0x02)
D	Block indicator
dd	Day of the month (2 digits)
mm	Month (2 digits)
aa	Year (2 digits)
T	Block indicator
n	Day of the week
U	Block indicator.
hh	Hours (2 digits)
mm	Minutes (2 digits)
ss	Seconds (2 digits)
#/Space	Possible sync error greater than 3ms/OK
*/Space	Internal clock failure/OK
S/Space	Daylight savings time / Standard time
!/Space	Less than one hour until standard-daylight savings change/NO
[ETX]	End of frame (0x03)

- **GC14 232 serial**: this option is similar to the previous one. The difference is the manufacturer of the clock (GlobalClock) and the serial frame used to send the time data. One of the communications ports labeled COM1-4 is used. The format of the frame is as shown in the table below.

Table 6-3	
[STX]08:45:16.001_23.09.97_4UL_258[ETX] or LFCR	
1. Block	Time including milliseconds
2. Block	Date (DD.MM.YY)
3. Block	Status block
4	Day of the week (Thursday)
U	Time Zone (U = UTC, Z = Local time, S = Local daylight savings time)
L	Synchronization (L = Lock, Q = Quarztime)
_	Space (0x20)
258	Day of the year

All of these types of clocks are mutually exclusive and only one may be connected to the **CPX** at one time.

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From a software standpoint, all of the interfaces are available, and the one desired is chosen through configuration. From a hardware standpoint, the two 232 serial interfaces and the IKOR PC parallel interface are standard on all **CPX** models; however, the IRIG-B123 interface is only available on some models.

For the IKOR PC parallel and IRIG-B123 interfaces, a jumper must be configured on card 4TL191/XXXX to assign IRQ 12 to the appropriate interface. Thus, for the IKOR parallel clock, the jumper in jumper block JP2 in the INP row must be closed with the IRQ12 column, while for the IRIGB clock, the one in the IRIGB row must be closed with the IRQ12 column. Only one jumper should be closed in the IRQ12 column.

For the serial interfaces, the communications parameters must also be configured: serial port, speed, parity, stop bits. This is done with the ***Zivergraph*** software.

Communications problems with the GPS clock are indicated through the generation of a change in the PROCOME 256 signal from the central virtual unit (address 257). If there is no communication with the clock or if the data being received is not correct, a signal change with status of 1 is generated; when communication is restored, a change to 0 is generated. During this entire time, the system behaves as if no GPS clock were connected, allowing synchronization from other sources (office, console). The parameter **Time allowed with no interruptions** controls the time passed from the moment an error situation is detected until the respective signal is generated.

Under certain circumstances, the time difference between the **CPX**'s internal time and the GPS clock's time may be more than 20 ms. In this case, there is considered to be a sync error, and a change (activation) is generated in the PROCOME 257 signal from the central unit (257). When this difference is less than 20 ms., another change (deactivation) is generated for that signal. This function is configurable and can be enabled / disabled with the **Deviation Error** parameter.

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If the function is enabled, this sync error situation is maintained for the time marked by the parameter **Time with GPS error before considering it incorrect**. Once this time has elapsed, the **CPX**’s internal clock is updated with the GPS time, and the new time is considered to be the correct one.

If the synchronization system is via GPS clock and it is working properly, the **CPX** will not accept another type of synchronization: operating console, control office.

There is an additional synchronization system function relating to the emulator of the PID1 remote control protocol, which will be explained in the chapter dealing with this emulator.

6.3.2 Daylight Savings / Standard Time Change

The **CPX** can manage the daylight savings / standard time change if it is configured to do so. In general, the external synchronization system is responsible for making this change and notifying the **CPX**. However, in some installations without GPS and with a certain type of remote control, this procedure must be performed by the **CPX**.

The daylight savings / standard time change function consists of moving the **CPX**’s time forward or backward on a specific date at a specific time. This function is configurable and can be disabled / enabled. The number of hours that the time must go forward / backward can also be configured, as well as when the change should take place.

There are two parameters that relate this function to the GPS clock. One of them indicates whether the GPS is managing the time change, or whether the **CPX** must do it, while the other indicates whether the GPS indicates the current time period.

All of these parameters are configured through the ***Zivergraph*** software, from the general settings display.

6.3.3 Audible Warning

The audible warning function is closely linked to the alarms. It consists of an audible warning going off every time an alarm is received in the **CPX**. This function has been implemented as a generic command on a unit. Every time an alarm is received, this command is executed. When configuring the signals for each unit, the user can indicate, on an individual basis, which alarms will make the audible warning sound.

The audible warning will be connected to the digital output of a unit (level 1, **CPX**) so that when the latter receives the command it will close the contact that will turn on the warning. This contact will remain closed for a certain amount of time.

There is a parameter indicating whether the audible warning is enabled or not. There is no additional functionality for acknowledgment of the warning or time settings. If necessary, this will have to be implemented with external logic.

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6.4 Communications

As we discussed earlier, communications are the key element of the **CPX**. The **CPX** is responsible for collecting information from level 1 equipment and distributing it to a higher or same level equipment.. In order to perform this task, a series of communications protocols is used to adapt to the existing or required arquitecture in each installation..

6.4.1 Physical Medium

The connection between the **CPX** and the IEDs is primarily via fiber optics. There are two reasons why this physical medium is used: one, to isolate the **CPX** from possible damage from overvoltages in the rest of the equipment; and two, to prevent possible interference with communications caused by existing wires at the installations. Depending on the model, the **CPX** has between 6 and 18 fiber optic ports.

The RS232C interface is also used to communicate with other equipment, especially when modems are used. All of the **CPX**'s ports are isolated by means of optical couplers.

To connect the **CPX** to level 3 systems (remote control, SCADA, etc.), there are several RS232C serial ports with DB9F connectors, with all lines available (RX, TX, CD, DTR, RTS, CTS, etc.). Radio or telephone modems, converters (RS232-FO, RS232-RS485), etc. may be connected to these ports.

The **CPX** is connected to the **PCD** via a twisted-pair Ethernet cable. This same interface may be used to communicate with level 3 equipment if the protocol so requires.

6.4.2 Communication with Level 1 Equipment

The **CPX** forms part of the Integrated Protection and Control System. This is a distributed system, and the tasks of capturing and processing information are performed by IEDs, which can perform other functions: protection, measuring, supervision, etc. From the standpoint of the **CPX**, the task that interests us is the collection and processing of information obtained from field elements, as well as the internal functions.

All of this data is accessible from the outside through a communications protocol.

6.4.2.a Interrogation Cycle

In the **CPX**, there are several tasks responsible for communicating with the IEDs. These tasks have been designed to ensure a certain level of speed and security in collecting information.

There is a continuous interrogation cycle for IEDs so that the CPX's database can be updated as quickly as possible. This monitoring cycle has high priority, although it can be sporadically interrupted by protection messages.

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The messages that make up this monitoring cycle depend to a large degree on the protocol used to communicate with the equipment. However, in basic terms, a generic interrogation cycle can be established, divided into three parts: **initialization**, **continuous cycle** and **periodic requests**.

- **Initialization**: This procedure is used every time communication begins with a unit for the first time or after a communications failure.
  - Communications initialization.
  - Time synchronization.
  - Change request.
  - Refresh request.

- **Continuous cycle**: This is the normal procedure for updating information at the substation.
  - Change request.

- **Periodic requests**: These procedures are used periodically; the period is configurable.
  - Counter request.
  - Synchronization.
  - Refresh request.

In addition to these procedures, there are other asynchronous procedures that are launched in response to an external “event.” Thus, procedures for commands or writing outputs will take place asynchronously, as soon as possible within the continuous cycle. The procedure for transparent communication will also take place asynchronously, interrupting the monitoring cycles described above as little as possible.

There are variations on this interrogation cycle, resulting from the different protocols that the **CPX** uses to communicate with the equipment.

If a unit does not respond to a message sent by the **CPX** before a configurable period of time has elapsed, the **CPX** will generally try to resend. However, this depends on the protocol, so this will be explained further on.

6.4.2.b Communications Parameters

The **CPX** lets the user configure all of the parameters that typify serial communication: speed, parity, number of bits, stop bits, delay times, etc. The ***Zivergraph*** software lets the user configure all communications port parameters: speed, parity, stop bits, number of bits, times. Some of these parameters are associated with the port, and will be configured from the display corresponding to communications and port cards.

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6.4.2.c Communication Times

As we have already indicated, the **CPX** establishes a continuous interrogation cycle for IEDs in order to update its database as quickly as possible. At times, this means a very heavy processing load for the equipment, so the interrogation rate must be decreased by introducing delays before sending a new message.

There is a configuration parameter which indicates whether this delay should be introduced or not. The number of milliseconds in the delay can also be configured.

If a unit is the only one connected to a port, the delay is introduced before each message is sent to the unit, even if the function is not enabled.

6.4.3 Transparent Communication with Protection Equipment

The **CPX** is designed to communicate with control equipment. However, it can also be connected to protection equipment. The **CPX** provides a mechanism for accessing protection data, but only for equipment using PROCOME as their protection protocol. This communication is not possible for any other equipment.

The only thing the user needs to do is use the communications program with the PROCOME unit and connect to the **CPX** by one of the methods it allows: local port, remote port and TCP/IP Ethernet network connection or SLIP serial connection. Once the connection with the **CPX** is made, the user can communicate with the unit desired. The **CPX** routes the messages it receives from this program towards the port where the unit in question is connected, and sends the latter's responses towards the program.

This function is called **Transparent communication**, because from the standpoint of the user and the manufacturer's program, the **CPX** behaves as if it were just a cable.

6.4.4 Communication with Level 3 Systems

An important part of the **CPX**'s communications is being able to communicate outside of the substation. This makes it possible to remotely monitor and control the substation using the appropriate medium.

The CPX has up to four RS232C serial ports to communicate with external equipment. This communication takes place through a communications protocol specific to each installation. The one that is used depends on the client's requirements.

Communication with the level 3 system takes place through the emulation of the protocol in question. Not only are the protocol's own messages emulated, but to the extent possible, the behavior of the original equipment using the protocol is emulated. In this way, the level 3 system is made to believe that it is communicating with an original unit instead of an emulated one.

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This is not always possible, because in some cases, the protocol is designed to communicate with a unit (RTU type), while in the case of an installation with **CPX**, it would be communicating with a distributed system.

When emulating these protocols, the **CPX** behaves like a remote terminal, responding to information requests from the master terminal and carrying out the commands it receives from the latter.

In addition, the **CPX** device has an Ethernet interface that can be used to communicate with equipment at Level 3, maintaining the same functionality that the one through serial ports. Only some protocols allow the use of such Etherntet interface: IEC-60870-5-104, MODBUS and DNP3.

6.4.5 Routing functions

The **CPX-B**, unlike the **CPX-A**, holds a routing table that is generated automatically when re-started. This table is used to handle the incoming connections and to decide if they are accepted or no.

In addition, the **CPX-B** has a functionality to add registers to this table so that it is extended or restricted those networks from where the access is allowed to the **CPX**. This functionality is configured through the program ***ZIVergraph***© and the configuration file used is “route.cfg” (see annex A).

In that configuration file it is possible to include up to four entrances that will be added to the routing table of the **CPX** device.

The configuration of new generic connections must be done through that file. Simply set 0.0.0.0 parameters as much for the destination IP address like for the network mask, and use that IP address for the gateway IP address too.

6.5 Level 1 Protocols

Information is transmitted between the IEDs and the **CPX** using different communications protocols. The standard protocol, which is on all **CPX** models, is PROCOME. In addition to this protocol, the **CPX** can communicate with level 1 equipment using the following: DNP 3.0, IEC 103, MODBUS, SPABUS, WISP+. All of the protocols cannot be used at the same time in the same unit; the types of equipment that can be connected depend on the model.

The PROCOME, DNP 3.0 and IEC 103 protocols allow equipment to be connected at fiber optic ports. The MODBUS and SPABUS protocols only allow equipment to be connected to one of the **CPX**'s ports through a serial cable. All accept more than one unit at each port, although equipment with different protocols cannot be mixed at the same port.

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6.5.1 PROCOME

PROCOME is a protocol based on European standards which is specifically designed to handle data in electrical substation protection and control systems. All **CPX** models are equipped with this protocol.

Equipment with the PROCOME protocol is configured as normal equipment using ***Zivergraph*** or the *DBASE.CFG* file. This equipment can only be connected at fiber optic ports.

There are certain parameters that only affect equipment with the PROCOME protocol.

If a unit does not respond to a message sent by the **CPX** before a certain (configurable) amount of time has elapsed, given by the **Communications timeout** parameter (in ***Zivergraph***, in the equipment properties display; in *DBASE.CFG*, **Time** parameter in General equipment data), the **CPX** tries to resend. If it does not respond to this retry, an internal signal is generated from virtual unit 257, indicating a communications failure with that unit, and the **CPX** goes on to the next unit.

When it is once again the turn of the unit with the communications failure, the initialization procedure is used instead of the procedure that gave rise to the failure. If it fails to respond in five consecutive cycles, it is removed from the continuous cycle and its rate of interrogation is decreased. This is done to prevent a unit with communications failure from slowing down the entire interrogation cycle. During these attempts to recover a unit in failure, a shorter response timeout is used, given by the **Communications in failure timeout** parameter (in ***Zivergraph***, in the equipment properties display; in *DBASE.CFG*, **ReconnectTime** parameter in General equipment data).

At times, the continuous interrogation cycle means a very heavy processing load for the equipment, so the interrogation rate must be decreased by introducing delays before sending a new message. There is a configuration parameter which indicates whether this delay should be introduced or not (**Delay sending messages** in ***Zivergraph*** and **BitDelay** in *CENTRAL.CFG*). The number of milliseconds in the delay can also be configured (**Time between interrogations** in ***Zivergraph*** and **QuesTime** in *CENTRAL.CFG*). This time is general and is applied to all ports with PROCOME equipment.

If a unit is the only one connected to a port, the delay is introduced before each message sent to the unit, even if the function is not enabled.

Finally, after a broadcast message (message directed to all units at one port), a certain waiting period is required before another message is sent so the equipment can process the first one. There is a fixed parameter (70 ms) which indicates how long the next query should be delayed to the next unit. This time is general and is applied to all ports with DNP3 equipment.

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6.5.2 DNP3

DNP3 is a generic control communications protocol widely used in the industry (www.dnp.org). This protocol is standard on some **CPX** models.

Equipment with the DNP3 protocol is configured as normal equipment using ***Zivergraph*** or the *DBASE.CFG* file. This equipment can be connected at fiber optic ports or at a serial port (COMx). However, the **CPX** only allows one DNP3 unit to be connected to a COMx serial port.

There are certain parameters that only affect equipment with DNP3 protocol; these are configured in ***Zivergraph*** in the **Specific DNP3 protocol data** display or in the *DNP3MS.CFG* file.

6.5.2.a Interrogation Cycle

The equipment interrogation cycle can be configured by port, and a different cycle can be used for each port. The parameters that are configurable by port are the ones shown in the table below. Whether one type or another is chosen will depend on the equipment connected to each port. The information necessary to correctly configure these parameters will be obtained from the control profile for the DNP3 unit.

By default, ***Zivergraph*** enables the InterC0, InterC1 and InterC2 parameters, leaving the rest disabled.

Table 6-4

Parameter	Description
InterC0	If the value is 1, the type of interrogation is via the CLASS0 data request message. If the value is 0, this interrogation does not take place.
InterC1	If the value is 1, the type of interrogation is via the CLASS1 data request message. If the value is 0, this interrogation does not take place.
InterC2	If the value is 1, the type of interrogation is via the CLASS2 data request message. If the value is 0, this interrogation does not take place.
InterC3	If the value is 1, the type of interrogation is via the CLASS3 data request message. If the value is 0, this interrogation does not take place.
InterBI	If the value is 1, the type of interrogation is via the Binary Input request message. If the value is 0, this interrogation does not take place.
InterBIC	If the value is 1, the type of interrogation is via the Binary Input Change request message. If the value is 0, this interrogation does not take place.
InterAI	If the value is 1, the type of interrogation is via the Analog Input request message. If the value is 0, this interrogation does not take place.
InterAIC	If the value is 1, the type of interrogation is via the Analog Input Change request message. If the value is 0, this interrogation does not take place.
HUSC1	If the value is 1, unsolicited messages are enabled for Class1 data. If the value is 0, this enabling does not take place.
HUSC2	If the value is 1, unsolicited messages are enabled for Class2 data. If the value is 0, this enabling does not take place.
HUSC3	If the value is 1, unsolicited messages are enabled for Class3 data. If the value is 0, this enabling does not take place.

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For example, for equipment connected to one port, a cycle of interrogation by classes may be used, and in that case, InterC0=InterC1=InterC2=1 would be used with the rest at 0. The InterBI, InterBIC, InterAI and InterAIC parameters are provided because some equipment does not accept interrogation by classes, and does accept requests for specific data. The HUSCx parameters are used to indicate that spontaneous data sending is used by the equipment at that port, instead of polling the **CPX**; the latter only performs periodic status interrogation. If spontaneous data is used, the polling cycle should not be used: InterC1, InterC2, InterC3, InterBIC and InterAIC.

6.5.2.b Communication Times

The DNP3 protocol is divided into layers or levels that are independent from each other. As it is a protocol that adds many control bytes and checksums to the data, it can be implemented in several ways, although one is recommended in order to improve refresh times. In the link layer, messages can be sent with confirmation (SEND/CONFIRM function) or without it (SEND/NO_REPLY function). **ZIV** has chosen this last method in order to improve refresh times.

In the configuration file, the times and parameters referring to the link layer (Level 2) have been maintained for compatibility reasons, although they are not used. The ones that are used are the ones affecting the application layer (Level 7). There is one exception, and this is that during initialization of the unit, the first message that is sent is a link layer initialization message. This message corresponds to the Reset Remote Link procedure (SEND/CONFIRM function). This procedure involves a link layer response from the equipment.

The time waited for the arrival of this message is given by the **L2ConfWaitTime** parameter (in the *DNP3MS.CFG* file).

For all other messages, no response is expected at the link level, because there is none; however, there should be one at the application level. If a unit does not respond to a message sent by the **CPX** before a certain (configurable) amount of time has elapsed, given by the **Maximum delay time for application level response** parameter (in ***Zivergraph***; in the *DNP3MS.CFG* file, **L7ConfWaitTime**), the **CPX** tries to resend it a number of times given by the **Number of retries** at the application level parameter (in *DNP3MS.CFG*, **NumRetriesL7**). If it does not respond to any of these retries, an internal signal is generated from virtual unit 257, indicating a communications failure with that unit, and the **CPX** goes on to the next unit. This time should be on the order of several seconds, because if the unit's configuration is large, or if several queries are strung together in the interrogation cycle (several active InterCx or InterBIC and InterAIC activated), the time it takes the data sent by a unit to reach the **CPX**'s application layer is on this order; thus, this fact must be taken into account.

When it is once again the turn of the unit with the communications failure, the initialization procedure is used instead of the procedure that cause the failure.

After a broadcast message (message directed to all units at one port), you should wait a while so that the equipment can process said message before sending another message.. There is a configuration parameter (**BrdcstMsgDel** in the *DNP3MS.CFG* file) which indicates in milliseconds how long the next query should be delayed to the next unit. This time is general and is applied to all ports with DNP 3 equipment.

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6.5.3 IEC103

The IEC 870-5-103 protocol is a European communications standard for protection equipment. This protocol is included on some **CPX** models.

Equipment with the IEC103 protocol is configured as normal equipment using ***Zivergraph*** or the *DBASE.CFG* file. This equipment can only be connected at fiber optic ports.

For units with the PROCOME and DNP3 protocol, their data is directly assigned to the **CPX**'s internal data. For equipment with the IEC103 protocol, data types must be converted, because this protocol is specifically for protection and the **CPX** uses control data. This assignment is performed with the *IEC103MS.CFG* file.

There are certain parameters that only affect equipment with the IEC103 protocol, and which are configured with the *IEC103MS.CFG* file.

6.5.4 SPABUS

The SPABUS protocol is used by equipment manufactured by ABB. This protocol is included on some **CPX** models. Equipment with this protocol is configured with an additional file named *SPABUSMS.CFG*. This equipment can only be connected to a COM-X serial port.

In this case, the information provided by the equipment must be transformed. The task that communicates with this equipment is responsible for making this conversion. To do this, it uses the configuration file called *MODULSPA.CFG.* This file indicates what data will be collected from each of the units, and how it will be mapped in the **CPX**’s internal configuration.

As we have already said, all of the equipment with this protocol will be connected to the same port. This means that, if a large number of units is connected, the interrogation cycle will be slow.

6.5.5 MODBUS RTU

The MODBUS RTU protocol is a de facto communications standard for protection and control equipment. It was initially developed to communicate with control equipment in industrial environments (PLC’s), but it has spread and is now used for protection as well as control. This protocol is included on some **CPX** models.

With this protocol, data must be converted from the MODBUS format to the **CPX**’s format. The data required to integrate MODBUS equipment into the **CPX** are in the *MODBUSMS.CFG* file.

Several MODBUS units can be connected to the same serial port (COM-X).

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6.6 Level 3 Protocols

The information that the database collects from the substation equipment (virtual or real) is available to be used by other systems, internal or external. Depending on the client and on the geographic area where the installation is located, a certain communications protocol is used to transfer this information to level 3 systems.

The different protocols emulated by the **CPX** to communicate with Level 3 or Level 2 equipment are the following:

- PID1
- Sevco 6802
- Indactic
- DNP3
- SINEC 3964R/RK512 (in master mode)
- CEI-870-5-101 (NoBal I, cei101). - Chilectra (OBS).
- CEI-870-5-101 (Bal/NoBal cei101b). - Endesa (Chilectra, ERZ...); REE
- CEI-870-5-101 (NoBal II, cei101d) - COELBA
- Extended Wisp+
- CEI-870-5-101 (NoBal III cei101c) - CERJ
- CEI-870-5-101 (NoBal IV cei101a) - Electropaz
- CEI-870-5-101 (NoBal V cei101e) - ENERSUL
- COSINOR
- MODBUS RTU
- GESTEL
- CEI-870-5-101 (NoBal VII, cei101g) - COSERN
- TRW2000
- CEI-870-5-101 (NoBal VIII, cei101i) - Iberdrola
- PROCOME SLAVE
- MODBUS TCP/IP

The operating principle of these emulators is similar in all cases. The emulation task collects the information from the internal database and adapts it to the data format of the remote command. When the master terminal interrogates the **CPX**, the latter responds with a message with the data requested.

In order to perform the required conversation, a configuration file indicating how this conversion shall be done is needed. The name of the file depends on the protocol to be emulated; however, in general, its name will relate to the name of the protocol. This file will contain the data necessary for the emulator, which is customized for each substation.

The files have a generic structure. Firstly, there is a block with general equipment-related parameters. Next, the parameters necessary to adapt the information to the format expected by the remote command are configured. This will generally consist of a table in which the name of the remote command signal appears on one side, with the name of the **CPX** signal on the other.

The type and number of signals supported depend on the type of protocol in question.

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6.7 Control Functions

The **CPX** can perform control functions at the substation level, encompassing operations on all of the substation equipment. If the control function is simple, it can be performed through the logic program. For more complex control functions, specific code modules are implemented, which are executed as an independent task.

6.7.1 Detection of Resistive Grounds

6.7.1.a Description

This control function is responsible for determining the origin of a resistive ground problem on medium voltage lines. An external device generates an alarm, indicating that resistive grounds have been detected, but it does not indicate on which line they have been detected. The control function determines which line has caused the alarm.

The control function requires some configuration data, such as the number of breakers, their priority, detection times, etc. The **CPX** allows up to four independent control functions, depending on the topology of the substation. This data is configured through the ***Zivergraph*** software, and the control function's task gets the data from the *tierr_x.cfg* file (where x indicates the control function module, i = 1, 2, 3, 4).

The detection method is by means of consecutively opening all of the breakers configured. After each one is opened, there is a configurable delay in order to determine whether the alarm disappears. If it disappears, the breaker remains open and an event is generated, indicating the line on which the problem occurred; if, on the other hand, the alarm does not disappear, that breaker is closed and the next one on the list is opened. If the origin of the alarm cannot be determined by the end of the entire process, the status returns to default and an event indicating "stopped without detection" is generated.

When there are several modules of the control function for grounds, they can be coordinated so that they behave as a single unit when the coupling circuit breaker for both buses is closed, and as two separate modules when it is open.

The information below refers to the control function applied to a single module; however, it can be extended to several control functions, duplicating the settings, signals, etc.

In the configuration of the substation, there is an **In Service** parameter (AJ_R_SERV). When it takes value **1**, the control function for resistive grounds is ready to operate, and an **In service** signal is activated (R_SERV). When it takes value **0**, the control function is **out of service**.

The control function may be activated / deactivated from three different locations:

1. From the central unit's console.
2. From remote control.
3. From the coupling IED (activate / deactivate function 64).

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Whatever the origin of the activation of the control function, it causes the ACT signal to take the value **1**. Deactivating the control function causes it to take the value **0**.

A priority of between 1 and 50 is defined for each of the IEDs, bearing in mind the fact that there cannot be two IEDs with the same priority. The priorities need not be consecutive; in other words, there may be unassigned priority indexes.

Henceforth, it will be assumed that the priority indexes are consecutive, i.e., that the actual index setting has been transformed to facilitate the operation of the control function.

6.7.1.b Contact Inputs

The input signals to the control function are the following:

Table 6-5

Signal	Description
ACT	ACTIVATION OF THE CONTROL FUNCTION
ALARMA	RESISTIVE GROUND ALARM
INT(n)_A	BREAKER (n) OPEN
F(n)_OA	FAILURE (n) OF OPEN COMMAND
F(n)_OC	FAILURE (n) OF CLOSE COMMAND

The index (n) indicates the priority number assigned to each breaker.

6.7.1.c Contact Outputs

The output signals of the control function are the following:

Table 6-6

Signal	Description
R_SERV	CONTROL FUNCTION IN SERVICE
ARR	CONTROL FUNCTION PICKED UP
BLQ	CONTROL FUNCTION BLOCKED
OA(n)	OPEN COMMAND ON BREAKER (n)
OC(n)	CLOSE COMMAND ON BREAKER (n)
ODACT64	DEACTIVATE 64 COMMAND

The index (n) indicates the priority number assigned to each breaker.

6.7.1.d Settings

The control function’s settings are the following:

Table 6-7

Setting	Description	Margin	Unit	Step	Default value
AJ_T_ALA	Pickup delay time	0 - 600	s	1	60
AJ_T_COM	Verification time	0 - 10	s	1	5
AJ_PRIxx	Set priority of IED (xx)	1 - 50		1	
SERxx	IED (xx) in service	YES - NO			YES

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6.7.1.e Status Flow Chart

The flow chart of the control function's status is shown below.

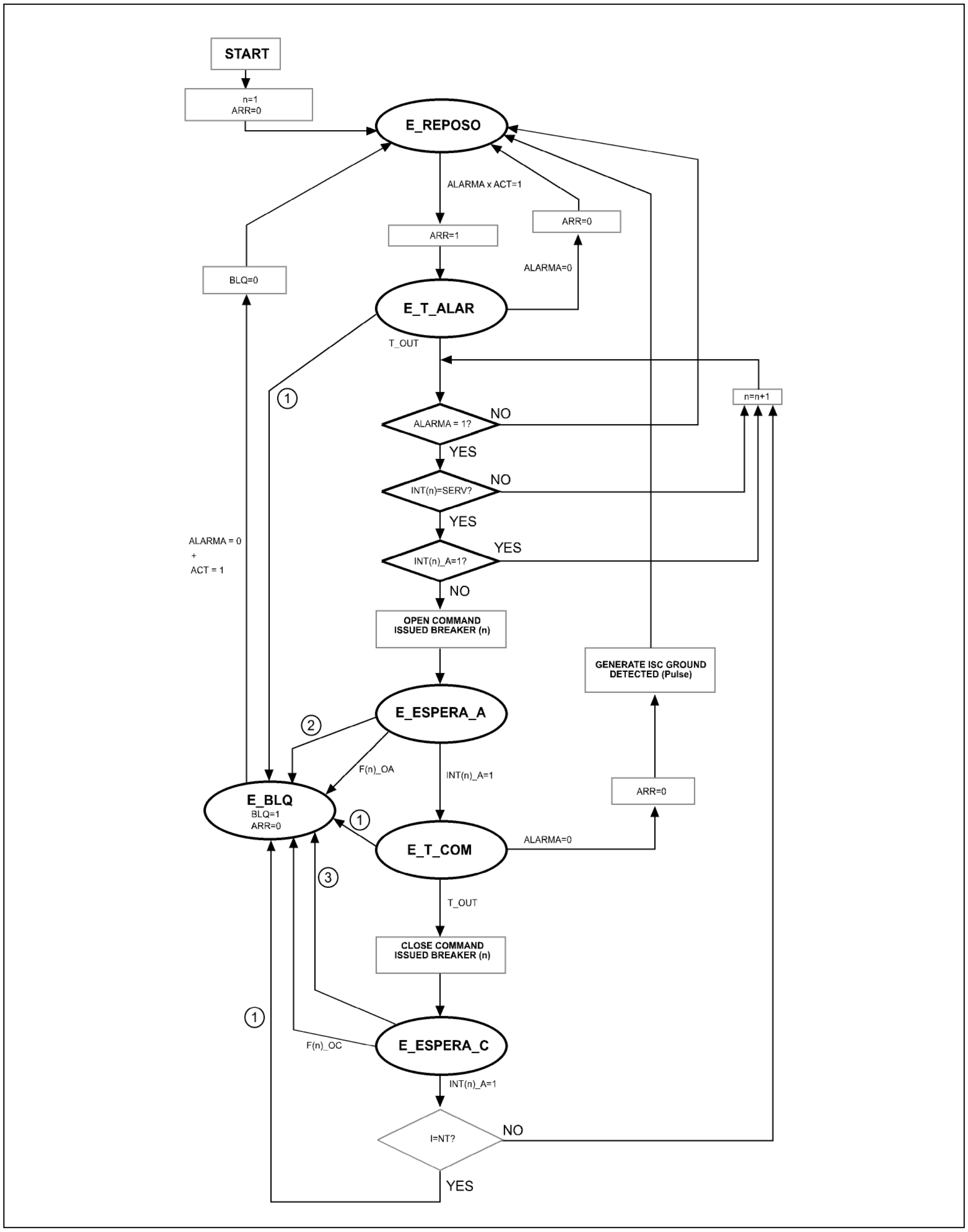

Figure 6.1: Control Function Status Flow Chart.

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In the diagram above, ① represents the open / closed condition of a breaker in the module corresponding to the control function. The open / closed status may be detected as a change in the open breaker signal [INT(n)_A].

In the diagram above, ② represents the open condition of a breaker in the module corresponding to the control function, excluding the one over which the control function is sending commands at that moment or the closing of any of the breakers, including that one. The open / closed status may be detected as a change in the open breaker signal [INT(n)_A].

In the diagram above, ③ represents the closed condition of a breaker in the module corresponding to the control function, excluding the one over which the control function is sending commands at that moment or the opening of any of the breakers, including that one. The open / closed status may be detected as a change in the open breaker signal [INT(n)_A].

6.7.1.f Operation

The automaton is initialized with the ARR variable with value **0** and n variable with value **1**, in the E_REPOSO (default condition) status.

It exits the default status when the activation of the following function takes place:

ALARMA x ACT = 1 [1]

When it exits the default status, the value **1** is given to the ARR signal and it goes to E_T_ALAR status. In this status, a timer with the setting AJ_T_ALAR starts up.

- If function [1] is reset while timing is taking place, the automaton goes into E_REPOSO status, after giving the ARR signal a value of **0**.
- If the opening or closing of any of the breakers associated with the control function is detected (condition ①), the automaton goes to E_BLQ status and gives a value of **1** to the BLQ signal.
- In either of the above two cases, the timer stops.
- If T_OUT is detected, indicating that the timer has stopped counting, the E_T_ALAR status is exited.
- If the SER setting associated with the breaker is NO, the index goes up, and this action is repeated until an index whose breaker has the SER setting at YES is reached. Once this point has been reached, signal INT(n)_A is verified to see whether it is inactive, indicating that the breaker is closed. If this is the case, an open command will be given, and the status will change to E_ESPERA_A. If this signal is inactive, indicating that the breaker is already open, the index will go up by one unit and the verifications of SER and INT(n)_A will be repeated.

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In the E_ESPERA_A status, nothing happens; this is a waiting period to see whether the open command that was issued is obeyed or fails.

- If the opening of any of the breakers associated with the control function is detected, other than the one on which the maneuver is taking place, or if the closing of any of them, including the one in question, is detected (condition ②), the automaton goes to E_BLQ status and gives a value of **1** to the BLQ signal.
- If the failure of open command signal [F(n)_OA] is detected for the breaker on which the maneuver is taking place, the automaton goes to E_BLQ status and gives a value of **1** to the BLQ signal.
- If the open breaker signal [INT(n)_A] is detected for the breaker on which the maneuver is taking place, the automaton goes to E_T_COM status.

In E_T_COM status, the automaton starts up a timer with the setting AJ_T_COM.

- If, while in this status, the drop of the ALARMA signal is detected, the ARR signal is deactivated, a signal that a ground has been detected on line(n) is generated, and E_REPOSO status is entered.
- If the opening or closing of any of the breakers associated with the control function is detected (condition ①), the automaton goes to E_BLQ status and gives a value of **1** to the BLQ signal.
- If T_OUT is detected, indicating that the timer has stopping counting, the E_T_COM status is exited, a close command is given for the breaker and E_ESPERA_C status is entered.

In the E_ESPERA_C status, nothing happens; this is a waiting period to see whether the close command that was issued is obeyed or fails.

- If the closing of any of the breakers associated with the control function is detected, other than the one on which the maneuver is taking place, or if the opening of any of them, including the one in question, is detected (condition ③), the automaton goes to E_BLQ status and gives a value of **1** to the BLQ signal.
- If the failure of close command signal [F(n)_OC] is detected for the breaker on which the maneuver is taking place, the automaton goes to E_BLQ status and gives a value of **1** to the BLQ signal.
- If the closed breaker signal [INT(n)_C] is detected, verification is made of whether the end has been reached, i.e., the last breaker in the sequence. If this is the case, the automaton goes to E_BLQ status and gives a value of **1** to the BLQ signal. Otherwise, the index goes up by one unit and the automaton goes on to the next breaker.

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6.7.1.g Reset

When the ALARMA1 signal takes the value **0**, the control function will exit blocked status and will go to E_REPOSO status.

6.7.1.h Own Signals

The control function for resistive grounds has 8 fixed, consecutive digital signals, with indexes ranging from ISC 0 to ISC 7. These signals are the following:

Table 6-8	
ISC Number	**Description**
0	Control function module 1 in service
1	Control function module 1 active
2	Pickup of control function model 1
3	Control function stopped with no detection / Blocked
4	Cycle has ended without detecting origin of the fault
5	Spare
6	Spare
7	Control function module 1 setting error

From signal 8 onwards, the “Ground detected on line(n)” signals are mapped; these are configurable and depend on the number of bays in the bus.

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6.7.2 H Control Function

6.7.2.a Description

The H control function involves automatically resetting the voltage in high voltage buses when it disappears for some unexpected reason. This control function works in substations where the high voltage part has an H-shaped topology. This control function is not included in all **CPX** software models.

This control function is made up of several subautomata that perform simpler tasks. These subautomata are:

- Voltage presence / absence control function. This is responsible for determining whether or not voltage is present in each of the elements involved: high voltage lines and medium voltage buses.
- Control function for the definition of high voltage statuses. This processes the information generated by the aforementioned control functions and determines the different statuses that the high voltage pair may have.
- Control function for high voltage maneuvers. If any of the operating conditions are met, it performs the appropriate maneuvers to reset the voltage in the bus where it was lost.
- Control function for medium voltage maneuvers. This control function acts on the high voltage lines when there is a loss of voltage in the medium voltage buses.
- Control function for switching due to protection tripping. If the loss of voltage is caused by a protection tripping, this control function safely resets the voltage.

There is an **In service** setting (AJ_H_SERV). When it takes the value **1**, the above control functions will operate, and an IN SERVICE signal (H_SERV) will be activated. When it takes the value **0**, the control functions will be out of service.

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The control function may be in manual or automatic mode. In manual mode, it does not operate, and behaves as if it were out of service. In automatic mode, there are up to three modes of operation, depending on the preference given to each line. We can supply power to the buses through one line (Preference A), through the other (Preference B) or each bus through its respective line (Preference AB).

Operating preferences for the control function are selected through the operating console, or from the remote control office via the appropriate protocol. However the selection of a preference is made, it causes the signal associated with that preference to take the value **1,** while all the rest take the value **0**, according to the table below:

Table 6-9

		Signal			
		P_A	**P_B**	**P_AB**	**MAN**
Selection	**PREF_A**	1	0	0	0
	PREF_B	0	1	0	0
	PREF_AB	0	0	1	0
	MAN	0	0	0	1

During normal operation, the control functions may become blocked. Said blocking causes **all switching modules** (high and medium voltage maneuvers and switching because of protection tripping) **to simultaneously become blocked**. A reset command takes them out of this condition. This command is the same for all control functions, so if they are blocked, **they will all be reset at the same time.**

6.7.2.b Voltage Presence / Absence Control Functions

There is a control function for each of the voltages involved in the operation of the H control function. They all have identical structures; only the measuring signals, the settings that determine their evolution and the outputs they provide vary.

Each of the automata has an output that indicates the presence or absence of the controlled voltage.

The measuring inputs and logic outputs are the following:

Table 6-10

Automaton	Measure	Output provided by the automaton
1a	MULA	ULA
1b	MULB	ULB
1c	MUA04	UA
	MUA08	
	MUA48	
1d	MUB04	UB
	MUB08	
	MUB48	

The origin of all of these measurements is configurable and are defined according to the installation.

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Each of the control functions has a voltage presence setting, and another voltage absence setting, as well as presence time and absence time settings. The margins for each of them are indicated below; they are the same for all voltages.

Table 6-11					
Setting	**Description**	**Margin**	**Unit**	**Step**	**Default value**
AJ_PRES	Presence level	50 - 100	% of Vnom	0.1	80%
AJ_AUSEN	Absence level	0 - 70	% of Vnom	0.1	50%
AJ_T_PRES	Presence time	0.5 - 5	s	0.1	1
AJ_T_AUSEN	Absence time	0.5 - 5	s	0.1	1

The outputs for the control function were defined in Table I.

- **Operation**

With regard to the figure describing the control function's operation, the following statuses have been defined:

E_AUS_V: Voltage absence status
E_PRES_V: Voltage presence status
E_T_AUS: Counting absence time status
E_T_PRES: Counting presence time status

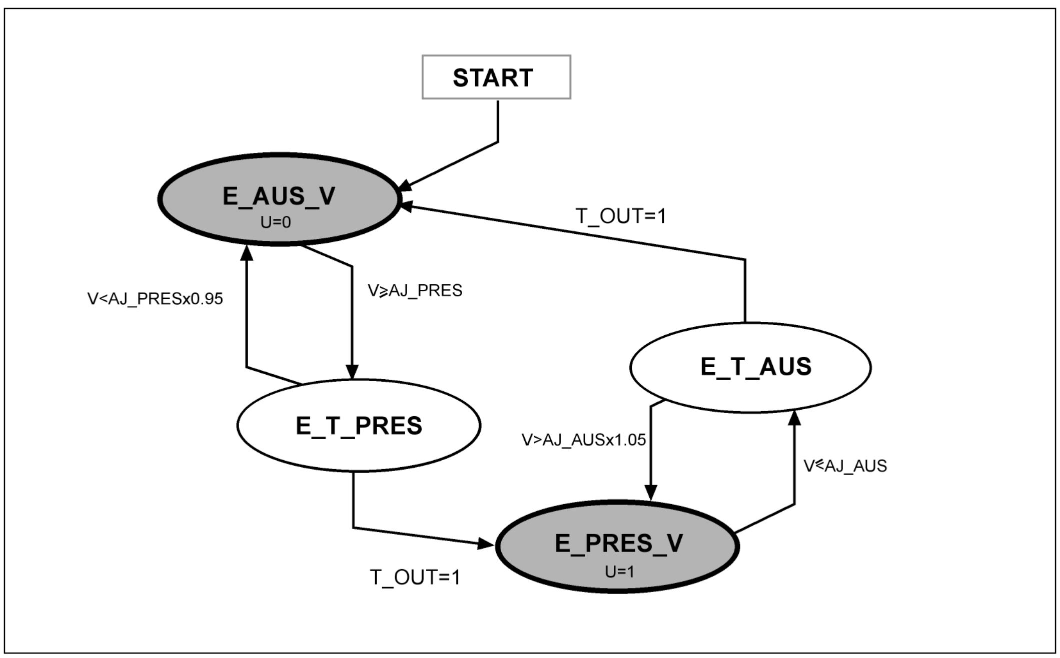

Figure 6.2: Voltage Presence / Absence Control Function.

At the start, the control function will be taken to E_AUS_V status, with the output signal value being U=0. When the variable measured exceeds the value of the AJ_PRES setting, its status changes to E_T_PRES, in which a counter with the AJ_T_PRES setting will start up.

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In the case of automata 1c and 1d, their status changes from E_AUS_V when the three voltages used in their operation exceed the threshold value set.

The E_T_PRES status will change either when the variable measured drops below 0.95xAJ_PRES (in the case of automata 1c and 1d, it will be when any voltage drops below 0.95xAJ_PRES), or when the timer times out; in the former case, the status will return to E_AUS_V and in the latter, it will go to E_PRES_V.

When the status goes to E_PRES_V, U will equal 1. When the variable measured drops below the value of the AJ_AUS setting, the status changes to E_T_AUS, in which a counter with the AJ_T_AUS setting will start up.

In the case of automata 1c and 1d, their status changes from E_PRES_V when any of the three voltages used in their operation is lower than the threshold value set.

The E_T_AUS status will change either when the variable measured exceeds the value of 1.05xAJ_AUS (in the case of automata 1c and 1d, it will be when all of the voltages exceed the value of 1.05xAJ_AUS), or when the timer times out; in the former case, the status will return to E_PRES_V and in the latter, it will go to E_AUS_V.

When the status goes to E_AUS_V, U will equal 0.

6.7.2.c Control Function for the Definition of High Voltage Status

This control function uses some of the output signals of the preceding one to define the status of the high voltage pair.

The inputs to this control function are the following:

Table 6-12	
Input	**Description**
ULA	Presence of voltage on Line A
ULB	Presence of voltage on Line B

The settings used by this control function are the following:

Table 6-13					
Setting	**Description**	**Margin**	**Unit**	**Step**	**Default value**
AJ_T_EST	Stability time	0 - 300	s	0.1	60
AJ_T_CONM	Switch time	0 - 10	s	0.1	5
P_T_ESP	Equality delay time	Fixed	s	Fixed	1

The last setting is not, strictly speaking, a setting, but a system parameter, with a fixed value of 1 second.

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The outputs provided by this control function are:

Table 6-14	
Input	**Description**
S_00	Absence of both voltages
S_01	Absence of voltage on line A and presence on line B
S_10	Presence of voltage on line A and absence on line B
S_11	Presence of voltage on both lines

- **Operation**

With regard to the figure describing the control function's operation, the following statuses have been defined:

E_00: no voltage on either line
E_01: ready to switch with voltage on line B and no voltage on line A
E_10: ready to switch with voltage on line A and no voltage on line B
E_11: ready to switch with voltage on both lines.
E_ESP(01): status with no voltage on line A, waiting for voltage drop on line B
E_ESP(10): status with no voltage on line B, waiting for voltage drop on line A
E_ESP_EST: counting stability time.
E_CONM(01): counting switch time with voltage on line B and no voltage on line A.
E_CONM(10): counting switch time with voltage on line A and no voltage on line B.
E_BLQ_X: blocked by the AUT_ACT signal.

At the start, the control function will be taken to E_00 status, with the output S_00 at **1** and all others at **0**.

The status flow chart can be seen in the figure below. The flow is prompted by the changes in the ULA, ULB and AUT_ACT signals. When it is indicated that a signal must take a value of **1** when a certain status is reached, it is understood that all the others must go to **0**.

In the E_ESP_(XX) statuses, a timer with a value of P_T_ESP starts up.

In the E_ESP_EST status, a timer with a value of AJ_T_ESP starts up.

In the E_CONM(XX) statuses, a timer with a value of AJ_T_CONM starts up.

In all transitions, the AUT_ACT signal should be at 1. If AUT_ACT=0 were to occur in any status, a transition to E_BLQ status would take place (not shown in the diagram); the latter is a *non-operating* status, which would change automatically once the AUC_ACT signal was activated.

The AUT_ACT signal is generated through a programmable logic function of some of the database signals.

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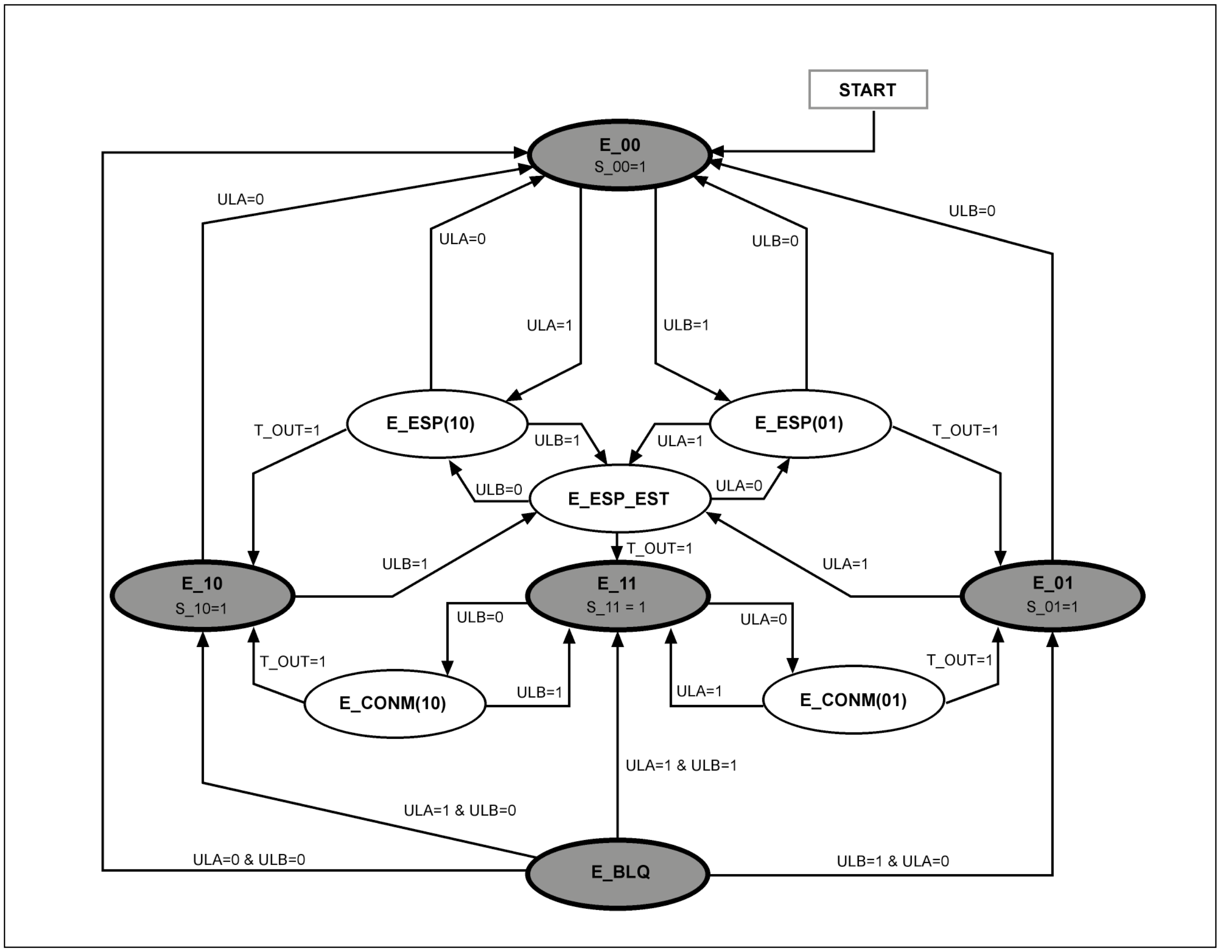

Figure 6.3: Control Function for the Definition of High Voltage Statuses.

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6.7.2.d Control Function for High Voltage Maneuvers

In response to the start event, this control function executes a sequence of maneuvers which end back in the E_REPOSO (default) status, or in a E_BLQ (blocked) status if any maneuver in the sequence fails.

The sequence of maneuvers is determined by the values of a set of signals, as defined further on.

The event that starts the sequence, taking the automaton from the *default* status, is any one of those listed below:

- The change in value of any of the CLOSED BREAKER signals of any of the **H** breakers (or what amounts to the same thing, if any of the OPEN BREAKER or CLOSED BREAKER signals change to **1**).
- The change in value of any of the automaton's output signals for high voltage statuses.
- The change in value of the CONTROL FUNCTION CONDITION ACTIVE signal (AUT_ACT).
- The modification of any preference.
- The resetting of either of the 86s (86A=0 or 86B=0).

The input signals to the control function are the following:

Table 6-15

Input	Description
52LA_C	Breaker 52LA closed
52LA_A	Breaker 52LA open
52LB_C	Breaker 52LB closed
52LB_A	Breaker 52LB open
52LAB_C	Breaker 52LAB closed
52LAB_A	Breaker 52LAB open
AUT_ACT	Control function condition active
S_00	Absence of voltage on both lines
S_01	Absence of voltage on line A and presence on line B
S_10	Presence of voltage on line A and absence on line B
S_11	Presence of voltage on both lines
P_A	Preference A
P_B	Preference B
P_AB	Preference AB
MAN	Manual
MED_ACT	Medium voltage control function activated
86TA_ACT	Trip 86A
86TB_ACT	Trip 86B

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Each signal's index is configurable and will be determined for each substation.

At the start, the control function executes the sequence selection logic; once this has been done, it can go to **default**, carry out a **sequence of maneuvers** or go to **blocked** if any command fails or finds no sequence to be executed.

After the pickup event, a 3 s. timer starts up for coordination with the control function for switching because of protection tripping; once the timer has finished, the sequence to be executed is selected.

Sequence selection, whether at the start or after a pickup event, is done according to the table below.

In this table, the MED_ACT signal comes from the medium voltage control function, and the way it is generated is described further on. It is used in calculating the sequence to be selected: if this signal has a value of **1**, the control function remains in the **default** status.

If either of the two 86s (signals 86TA and 86TB to 1) trips, this control function for high voltage maneuvers is prevented from operating, as if these signals are activated, the control function for switching because of protection tripping is the one that should operate.

The automaton changes to **non-operating** status if the AUT_ACT signal is inactive. It automatically changes from this status if either of the following conditions occurs:

- If the AUT_ACT signal is activated, with its status changing to *default* (E_REPOSO).
- If the control function is blocked, with its status changing to *blocked* (E_BLQ).

If the control function for medium voltage maneuvers or the one for switching because of protection tripping is blocked, this control function for high voltage maneuvers will also be blocked. To change the status from **blocked**, it will be necessary to reset the control function.

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Table 6-16															
52LA_C	**52LAB_C**	**52LB_C**	**S_00**	**S_01**	**S_10**	**S_11**	**P_A**	**P_B**	**P_AB**	**MAN**	**86TA**	**86TB**	**MED_ACT**	**AUT_ACT**	**SEQ**
X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	DEFAULT
X	X	X	X	X	X	X	0	0	0	1	X	X	X	1	DEFAULT
X	X	X	X	X	X	X	X	X	X	X	X	X	1	1	DEFAULT
0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	16
0	0	1	0	0	0	1	0	1	0	0	0	0	0	1	2
0	0	1	0	0	0	1	0	0	1	0	0	0	0	1	3
0	0	1	0	0	1	0	X	X	X	0	0	0	0	1	1
0	0	1	0	1	0	0	X	X	X	0	0	0	0	1	2
0	0	1	1	0	0	0	X	X	X	0	0	0	0	1	DEFAULT
1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	2
1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	17
1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	5
1	0	0	0	0	1	0	X	X	X	0	0	0	0	1	2
1	0	0	0	1	0	0	X	X	X	0	0	0	0	1	4
1	0	0	1	0	0	0	X	X	X	0	0	0	0	1	DEFAULT
1	0	1	0	0	0	1	1	0	0	0	0	0	0	1	6
1	0	1	0	0	0	1	0	1	0	0	0	0	0	1	7
1	0	1	0	0	0	1	0	0	1	0	0	0	0	1	DEFAULT
1	0	1	0	0	1	0	X	X	X	0	0	0	0	1	8
1	0	1	0	1	0	0	X	X	X	0	0	0	0	1	9
1	0	1	1	0	0	0	X	X	X	0	0	0	0	1	DEFAULT
1	1	0	0	0	0	1	1	0	0	0	0	0	0	1	DEFAULT
1	1	0	0	0	0	1	0	1	0	0	0	0	0	1	10
1	1	0	0	0	0	1	0	0	1	0	0	0	0	1	11
1	1	0	0	0	1	0	X	X	X	0	0	0	0	1	DEFAULT
1	1	0	0	1	0	0	X	X	X	0	0	0	0	1	12
1	1	0	1	0	0	0	X	X	X	0	0	0	0	1	DEFAULT
0	1	1	0	0	0	1	1	0	0	0	0	0	0	1	13
0	1	1	0	0	0	1	0	1	0	0	0	0	0	1	DEFAULT
0	1	1	0	0	0	1	0	0	1	0	0	0	0	1	14
0	1	1	0	0	1	0	X	X	X	0	0	0	0	1	15
0	1	1	0	1	0	0	X	X	X	0	0	0	0	1	DEFAULT
0	1	1	1	0	0	0	X	X	X	0	0	0	0	1	DEFAULT
0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	16
0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	17
0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	18
0	0	0	0	0	1	0	X	X	X	0	0	0	0	1	16
0	0	0	0	1	0	0	X	X	X	0	0	0	0	1	17
0	0	0	1	0	0	0	X	X	X	0	0	0	0	1	DEFAULT
1	1	1	0	0	0	1	1	0	0	0	0	0	0	1	1
1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	4
1	1	1	0	0	0	1	0	0	1	0	0	0	0	1	19
1	1	1	0	0	1	0	X	X	X	0	0	0	0	1	1
1	1	1	0	1	0	0	X	X	X	0	0	0	0	1	4
1	1	1	1	0	0	0	X	X	X	0	0	0	0	1	19
0	1	0	0	0	0	1	1	0	0	0	0	0	0	1	3
0	1	0	0	0	0	1	0	1	0	0	0	0	0	1	5
0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	20
0	1	0	0	0	1	0	X	X	X	0	0	0	0	1	3
0	1	0	0	1	0	0	X	X	X	0	0	0	0	1	5
0	1	0	1	0	0	0	X	X	X	0	0	0	0	1	DEFAULT
X	X	X	X	X	X	X	X	X	X	X	1	X	0	1	DEFAULT
X	X	X	X	X	X	X	X	X	X	X	X	1	0	1	DEFAULT

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In the preceding table, when DEFAULT appears in the SEQ column, it refers to sequence 0.

The operations to be performed in each of the sequences are the following:

Table 6-17	
SEQ no.	**Operations**
0	Default
1	Open 52LB
2	Close 52LAB
3	Close 52LA
4	Open 52LA
5	Close 52LB
6	Close 52LAB and open 52LB
7	Close 52LAB and open 52LA
8	Open 52LB and close 52LAB
9	Open 52LA and close 52LAB
10	Close 52LB and open 52LA
11	Close 52LB and open 52LAB
12	Open 52LA and close 52LB
13	Close 52LA and open 52LB
14	Close 52LA and open 52LAB
15	Open 52LB and close 52LA
16	Close 52LA and close 52LAB
17	Close 52LB and close 52LAB
18	Close 52LA and close 52LB
19	Open 52LAB
20	Close 52LA and close 52LB and open 52LAB
21	Put control function in Manual

Each of these commands is configurable, because although the sequences are fixed, the equipment and its configuration depend on each substation.

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- **Execution of sequences**

Each sequence of maneuvers is made up of a number of elementary maneuvers. The maneuvers are executed one after another: the next one is executed only after the previous one has been fully completed.

If the AUT_ACT signal is found to be inactive prior to the execution of a sequence, the sequence is interrupted and the status changes to **non-operating**. When this signal is once again activated, the status changes to **default** (E_REPOSO).

If a maneuver in the sequence fails, the sequence is interrupted and the control function goes to **blocked** (E_BLQ) status. The control function must be reset so that it can once again operate.

After the execution of the last maneuver in the sequence, the sequence automaton stays in **default** (E-REPOSO) status.

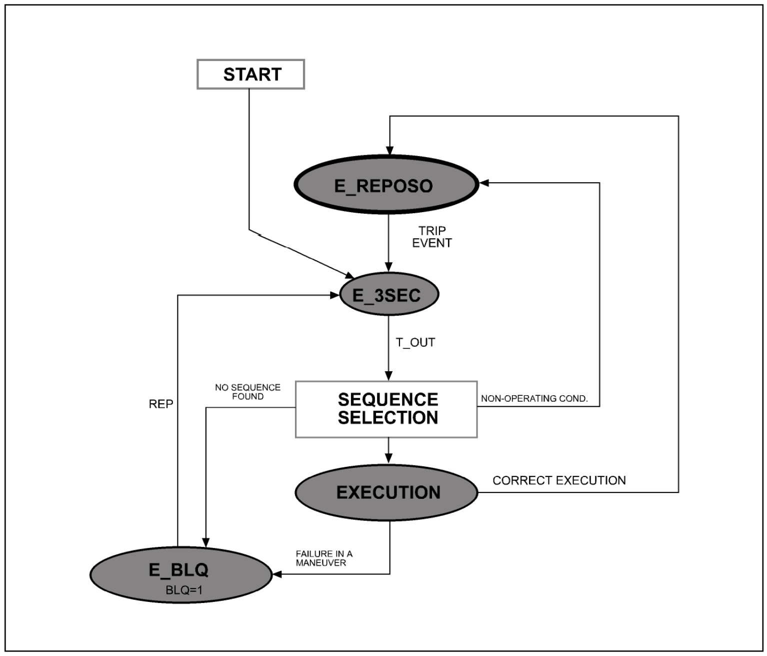

Figure 6.4: Execution of Sequences.

The procedure for the execution of sequences is shown in the accompanying diagram. There are two settings associated with this procedure that determine whether a delay should be included between two consecutive commands in the same sequence. These settings are:

Table 6-18

Setting	Description	Margin	Unit	Step	Default value
AJ_PERM_RET	Enable delay	0 - 1	BOOL	-	1
AJ_RETARDO	Command delay time	100-65535	ms	1	500

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When the automaton specific to the maneuver to be executed is entered, the command indicated in the table of maneuvers is sent, and the status then changes to **waiting** (E_ESPERA). This status is changed by the activation of the maneuver **failure** signal or by **completing** the maneuver. In the former case, the status changes to **blocked** (E_BLQ), and in the latter, it goes on to execute the next maneuver, if any, or returns to the **default** (E_REPOSO) status, if there are no other maneuvers.

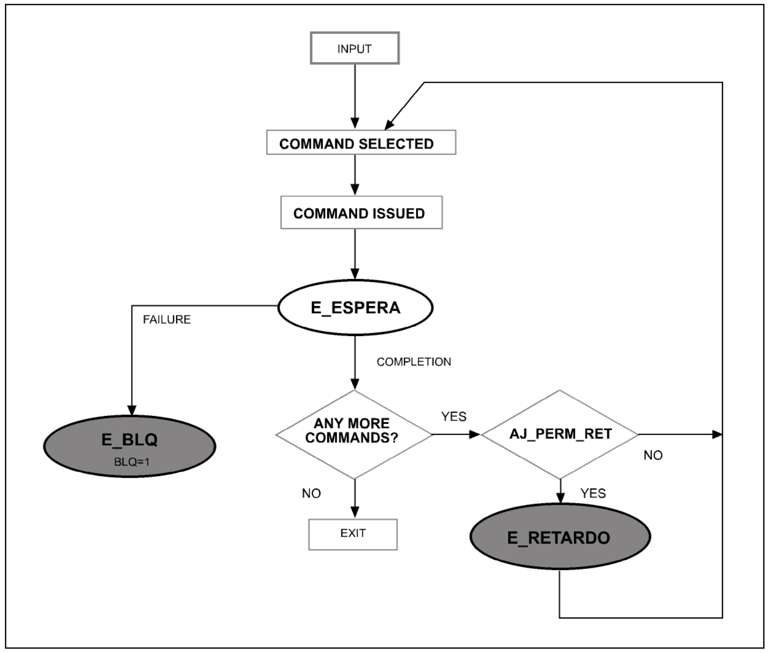

Figure 6.5: Maneuver Execution Procedure.

6.7.2.e Control Function for Medium Voltage Maneuvers

This control function is responsible for switching lines if it detects a loss of voltage in the medium voltage buses.

There is a MEDIUM VOLTAGE CONTROL FUNCTION IN SERVICE setting (AJ_M_SERV). When it takes the value **1**, the control function described in this heading operates and a MEDIUM VOLTAGE CONTROL FUNCTION IN SERVICE (M_SERV) signal is activated. When it takes the value **0**, the control function is out of service. This control function uses the following as input signals:

Table 6-19

Input	Description
UA	Presence / absence of voltage on A buses
UB	Presence / absence of voltage on B buses
ULA	Presence / absence of voltage on line A
ULB	Presence / absence of voltage on line B
52LA_C	Breaker 52LA closed
52LB_C	Breaker 52LB closed
52LAB_C	Breaker 52LAB closed
52TA_C	Line A transformer breaker closed
52TB_C	Line B transformer breaker closed
52B12_C	Breaker between bus 1 and 2 closed
MAN	Manual
AUT_ACT	Control function condition active

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It has the following settings:

Table 6-20					
Setting	**Description**	**Margin**	**Unit**	**Step**	**Default value**
AJ_T_M	Medium voltage switch time	0 - 10	s	0.1	5

At the start, the control function executes the sequence selection logic, causing the MED_ACT signal to take the value **0**. Once this has been done, it can go to **default** (E_REPOSO) or carry out a sequence of maneuvers.

From the **default** (E_REPOSO) status, the trip event (that causes the control function to exit its **default** (E_REPOSO) status) is the change in any UA or UB signal from **1** to **0**, or the activation of the AUT_ACT signal, in which case the control function will exit **non-operating** status.

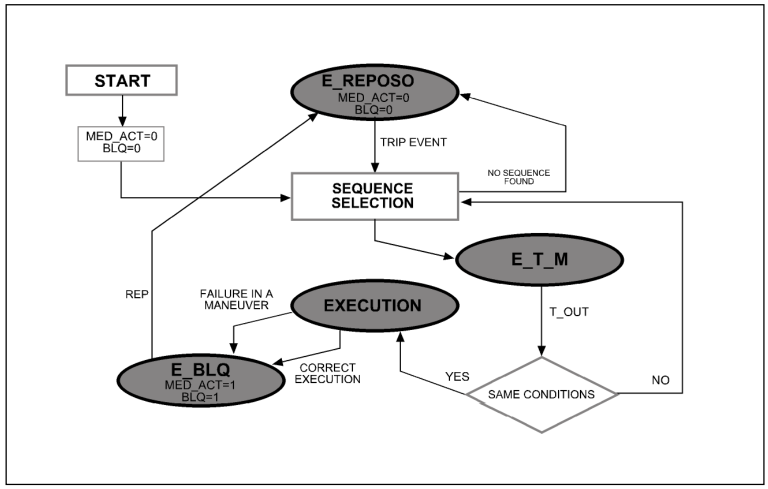

Figure 6.6: Sequence of Medium Voltage Maneuvers.

Once the control function is no longer in its **default** (E_REPOSO) status, the sequence of maneuvers is decided, the same as in the control function for high voltage maneuvers.

Once the sequence is selected, and before proceeding to execute it, a timer with the value AJ_T_M is started. While the timing is taking place, the automaton remains in E_T_M status. When the timeout takes place, this status changes; however, before it goes into the next one, the continuity of the switching conditions is checked (sequence chosen). If the response is negative, a new sequence is chosen and once again it goes to timing status (E_T_M); if it is affirmative, the sequence of maneuvers is executed.

Both in the case of a failure in any maneuver in the sequence or successful execution, the automaton's status changes to **blocked** (E_BLQ), causing the MED_ACT signal to take the value **1** to indicate that the medium voltage control function has operated.

The **blocked** (E_BLQ) status can only be exited if a **reset** (REP) command is received; this command makes the automaton go into its **default** (E_REPOSO) status.

The automaton will change to **non-operating** status if the AUT_ACT signal is inactive. It will automatically exit this status if any of the following conditions occurs:

- If the AUT_ACT signal is activated, with its status changing to *default* (E_REPOSO).
- If the automaton for medium voltage maneuvers is taken out of service from the console, with its status changing to *out of service*.
- If the control function is blocked, with its status changing to *blocked* (E_BLQ).

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If the control function for high voltage maneuvers or the one for switching because of protection tripping is blocked, this control function for medium voltage maneuvers will also be blocked. To exit this **blocked** status, it will be necessary to reset the control function.

- **Selection of sequences**

The selection of the sequence of maneuvers to be executed takes place according to the following table. The numbers indicating the sequence of operations refer to the table of sequences defined for the control function for high voltage maneuvers.

The destinations of the commands issued for maneuvers are the same as the ones in the table defined for the control function for high voltage. 6-21

Table 6-21

52LA_C	52LB_C	52LAB_C	52TA_C	52TB-C	52B12_C	UA	UB	ULA	ULB	MAN	AUT_ACT	SEQ
1	0	1	1	X	1	0	0	1	1	0	1	
1	0	1	1	0	0	0	X	1	1	0	1	10
1	0	1	1	1	0	0	0	1	1	0	1	
0	1	1	X	1	1	0	0	1	1	0	1	
0	1	1	0	1	0	X	0	1	1	0	1	13
0	1	1	1	1	0	0	0	1	1	0	1	
1	1	0	1	0	0	0	X	1	1	0	1	7
1	1	0	1	1	0	0	1	1	1	0	1	
1	1	0	0	1	0	X	0	1	1	0	1	6
1	1	0	1	1	0	1	0	1	1	0	1	
X	X	X	X	X	X	X	X	X	X	1	1	Default
X	X	X	X	X	X	X	X	X	X	X	0	Default

6.7.2.f Control Function for Switching due to Protection Tripping

This control function switches the lines when a loss of voltage situation arises when protection has tripped. The input signals it uses are the following:

Table 6-22

Input	Description
ULA	Presence / absence of voltage on line A
ULB	Presence / absence of voltage on line B
52LA_C	Breaker 52LA closed
52LB_C	Breaker 52LB closed
52LAB_C	Breaker 52LAB closed
86TA_ACT	Trip 86A
86TB_ACT	Trip 86B
MAN	Manual
DISP_DEF	Definitive trip
AUT_ACT	Control function condition active

The start event occurs whenever any of the 52LA_C, 52LB_C or 52LAB_C signals are deactivated, or any of the 86TA_ACT, 86TB_ACT, ULA, ULB, DISP_DEF or AUT_ACT signals are activated.

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The start event starts up a 3-second timer; after this timer runs, it checks to see whether the two 86s have tripped simultaneously, in which case it goes to MAN (manual) and the status changes to *default*. Otherwise, a maneuver is selected, according to the table below:

Table 6-23

52LA_C	52LB_C	52LAB_C	86TA	86TB	ULA	ULB	DISP_DEF	MAN	AUT_ACT	SEQ
X	X	X	X	X	X	X	X	1	1	Default
X	X	X	X	X	X	X	1	0	1	21
0	0	0	1	0	X	1	0	0	1	5
0	0	0	0	1	1	X	0	0	1	3
1	0	0	0	1	1	X	0	0	1	21
0	1	0	1	0	X	1	0	0	1	21
X	X	X	X	X	X	X	X	X	0	Default

If none of the combinations from the table above are met, no sequence is selected and the automaton's status changes to **default** (E_REPOSO).

Once the maneuver has been executed, the preferences take the value indicated in the accompanying diagram and the automaton remains in its **default** condition (E_REPOSO) in **manual** (MAN) status. If the execution of the maneuver fails, the system will be blocked, and this situation can only be exited by means of a **reset** (REP) command.

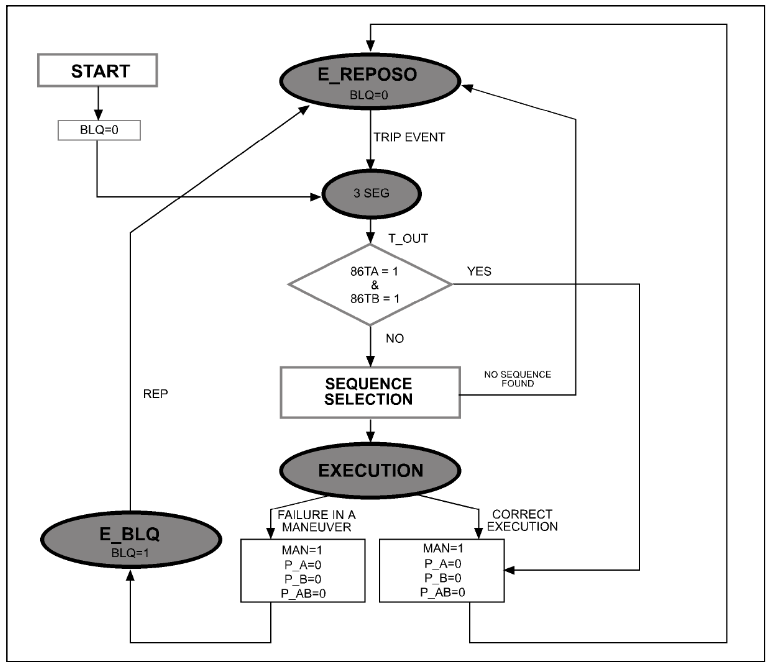

Figure 6.7: Sequence of Switching because of Protection Tripping.

The automaton changes to **non-operating** status if the AUT_ACT signal is inactive. It automatically exits this status if either of the following conditions occurs:

- If the AUT_ACT signal is activated, with its status changing to *default* (E_REPOSO).
- If the control function is blocked, with its status changing to *blocked* (E_BLQ).

If the control function for high or medium voltage maneuvers is blocked, this one for switching because of protection tripping will also be blocked. To exit this **blocked** (E_BLQ) status, it will be necessary to reset the control function.

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6.7.2.g Own Digital Signals

The H control function, as a logic equipment, has its own digital signals which may be used by the other tasks.

The digital signals provided by this control function are the following:

Table 6-24	
Number	**Signal**
0	HIGH VOLT. CONT. FUNC. FOR PRES./ABS. OF VOLTAGE A
1	HIGH VOLT. CONT. FUNC. FOR PRES./ABS. OF VOLTAGE B
2	ABSENCE OF BOTH VOLTAGES
3	ABSENCE OF VOLT. ON A AND PRES. ON B
4	PRESENCE OF VOLT. ON A AND VOLT. ON B
5	PRESENCE ON BOTH LINES
6	CONT. FUNC. FOR HIGH VOLTAGE MANEUVERS BLOCKED
7	CONTROL FUNCTION IN MANUAL MODE
8	PREFERENCE A
9	PREFERENCE B
10	PREFERENCE AB
11	MEDIUM VOLTAGE CONTROL FUNCTION ACTIVATED
12	MED. VOLT. CONT. FUNC. FOR PRES./ABS. OF VOLTAGE A
13	MED. VOLT. CONT. FUNC. FOR PRES./ABS. OF VOLTAGE B
14	MED. VOLT. CONTROL FUNCTION IN SERVICE
15	MEDIUM VOLTAGE CONTROL FUNCTION BLOCKED
16	CONT. FUNC. FOR TRIP CONDITIONS BLOCKED
17	LOSS OF UA VOLTAGE
18	LOSS OF UB VOLTAGE
19	LOSS OF ULA VOLTAGE
20	LOSS OF ULB VOLTAGE
21	SPARE 21 (ISC_86TA)
22	SPARE 22 (ISC_86TB)
23	ISC_A_UNO
24	ISC_A_CERO
25	CONTROL FUNCTION BLOCKED
26	COMMAND FAILURE
27	SPARE 27

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6.7.2.h Own Commands

The H control function has 14 commands, as follows:

Table 6-25	
Number	**Command**
0	Preference A from panel
1	Preference B from panel
2	Preference AB from panel
3	Manual from panel
4	Control function reset command (from panel)
5	Preference A from remote control
6	Preference B from remote control
7	Preference AB from remote control
8	Manual from remote control
9	Spare 9
10	Preference A from control function
11	Preference B from control function
12	Preference AB from control function
13	Manual from control function

6.7.2.i External Signals

In order to function properly, the H control function uses signals that report on the status of the substation. As some of these signals depend on the installation, they are not fixed, but configurable. However, the meaning related to each signal is fixed, and these meanings are shown in the table below.

Table 6-26	
Signal	**Meaning**
0. 52LA Cerrado	Line A breaker closed
1. 52LAB Cerrado	Breaker between lines A and B closed (not used)
2. 52LB Cerrado	Line B breaker closed
3. S_00	Absence of voltage on lines A and B
4. S_01	Absence of voltage on line A and presence on line B
5. S_10	Presence of voltage on line A and absence on line B
6. S_11	Presence of voltage on lines A and B
7. P_A	Preference A
8. P_B	Preference B
9. P_AB	Preference AB
10. MAN	Control function in manual mode
11. MED_ACT	Medium voltage control function activated
12. AUT_ACT	Authorization for operation
13. 52TA Cerrado	Line A transformer breaker closed
14. 52TB Cerrado	Line B transformer breaker closed

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Table 6-26	
Signal	**Meaning**
15. 52B12 Cerrado	Breaker between bus 1 and 2 closed
16. UA	Voltage on bus A
17. UB	Voltage on bus B
18. 86TA	Tripping in A transformer
19. 86TB	Tripping in B transformer (not used)
20. ULA	Voltage on line A
21. ULB	Voltage on line B
22. DISP_DEF	Final trip

6.7.3 Y control Function (specific case of H)

This section explains a specific case of the H control function: where there are two high voltage lines and a single medium voltage bus (see figure 6).

In this particular case of the H control function, everything that was previously said for this function is valid, with some nuances.

- It makes no sense to have preference AB, as one of the lines is used as a spare for the other, and power will never be supplied through both lines simultaneously.
- There will be a single control function for presence / absence of voltage on medium voltage buses, as we only have one bus (the control function for presence / absence of voltage on **bus A** will be used).

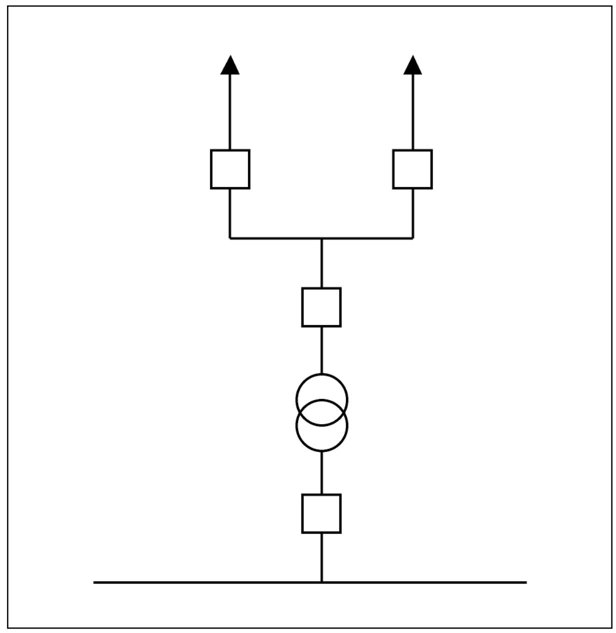

Figure 6.8: Y Control Function.

- All of the previous information for the control function for HIGH VOLTAGE STATUSES is valid.
- All of the previous information for the control function for HIGH VOLTAGE MANEUVERS is valid, except for the input signals to the control function, the sequences to be executed and the operations to be performed in each sequence, reflected in the tables below (note that preference AB is not taken into consideration when selecting the sequence to be executed).

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Table 6-27	
Signal	**Description**
89LA_C	DISCONNECT SWITCH 89LA CLOSED
89LA_A	DISCONNECT SWITCH 89LA OPEN
89LB_C	DISCONNECT SWITCH 89LB CLOSED
89LB_A	DISCONNECT SWITCH 89LB OPEN
52AB_C	BREAKER 52AB CLOSED
52AB_A	BREAKER 52AB OPEN
AUT_ACT	CONTROL FUNCTION CONDITION ACTIVE
S_00	ABSENCE OF VOLTAGE ON BOTH LINES
S_01	ABSENCE OF VOLTAGE ON LINE A AND PRESENCE ON LINE B
S_10	PRESENCE OF VOLTAGE ON LINE A AND ABSENCE ON LINE B
S_11	PRESENCE OF VOLTAGE ON BOTH LINES
P_A	PREFERENCE A
P_B	PREFERENCE B
P_AB	PREFERENCE AB (not used)
MAN	MANUAL
MED_ACT	MEDIUM VOLTAGE CONTROL FUNCTION ACTIVATED
86TA_ACT	TRIP 86A
86TB_ACT	TRIP 86B (not used)

Table 6-28

89LA_C	52LAB_C	89LB_C	S_00	S_01	S_10	S_11	P_A	P_B	MAN	86TA	MED_ACT	AUT_ACT	SEQ
X	X	X	X	X	X	X	X	X	X	X	X	0	Default
X	X	X	X	X	X	X	0	0	1	X	X	1	Default
X	X	X	X	X	X	X	X	X	X	X	1	1	Default
1	1	0	1	0	0	0	X	X	0	0	0	1	Default
1	1	0	0	1	0	0	X	X	0	0	0	1	1
1	1	0	0	0	1	0	X	X	0	0	0	1	Default
1	1	0	0	0	0	1	1	0	0	0	0	1	Default
1	1	0	0	0	0	1	0	1	0	0	0	1	2
0	1	1	1	0	0	0	X	X	0	0	0	1	Default
0	1	1	0	1	0	0	X	X	0	0	0	1	Default
0	1	1	0	0	1	0	X	X	0	0	0	1	3
0	1	1	0	0	0	1	1	0	0	0	0	1	4
0	1	1	0	0	0	1	0	1	0	0	0	1	Default
1	0	1	1	0	0	0	X	X	0	0	0	1	5
1	0	1	0	1	0	0	X	X	0	0	0	1	6
1	0	1	0	0	1	0	X	X	0	0	0	1	7
1	0	1	0	0	0	1	1	0	0	0	0	1	7
1	0	1	0	0	0	1	0	1	0	0	0	1	6
0	0	0	1	0	0	0	X	X	0	0	0	1	Default
0	0	0	0	1	0	0	X	X	0	0	0	1	8
0	0	0	0	0	1	0	X	X	0	0	0	1	9
0	0	0	0	0	0	1	1	0	0	0	0	1	9
0	0	0	0	0	0	1	0	1	0	0	0	1	8
1	0	0	1	0	0	0	X	X	0	0	0	1	Default
1	0	0	0	1	0	0	X	X	0	0	0	1	10
1	0	0	0	0	1	0	X	X	0	0	0	1	11
1	0	0	0	0	0	1	1	0	0	0	0	1	11
1	0	0	0	0	0	1	0	1	0	0	0	1	10
0	0	1	1	0	0	0	X	X	0	0	0	1	Default
0	0	1	0	1	0	0	X	X	0	0	0	1	11
0	0	1	0	0	1	0	X	X	0	0	0	1	12
0	0	1	0	0	0	1	1	0	0	0	0	1	12
0	0	1	0	0	0	1	0	1	0	0	0	1	11

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Table 6-28													
89LA_C	**52LAB_C**	**89LB_C**	**S_00**	**S_01**	**S_10**	**S_11**	**P_A**	**P_B**	**MAN**	**86TA**	**MED_ACT**	**AUT_ACT**	**SEQ**
1	1	1	1	0	0	0	X	X	0	0	0	1	5
1	1	1	0	1	0	0	X	X	0	0	0	1	13
1	1	1	0	0	1	0	X	X	0	0	0	1	5
1	1	1	0	0	0	1	1	0	0	0	0	1	5
1	1	1	0	0	0	1	0	1	0	0	0	1	13
0	1	0	1	0	0	0	X	X	0	0	0	1	Default
0	1	0	0	1	0	0	X	X	0	0	0	1	14
0	1	0	0	0	1	0	X	X	0	0	0	1	15
0	1	0	0	0	0	1	1	0	0	0	0	1	15
0	1	0	0	0	0	1	0	1	0	0	0	1	14
X	X	X	X	X	X	X	X	X	0	1	0	1	Default

Table 6-29	
SEQ no.	**Operations**
0	DEFAULT
1	OPEN 52AB, OPEN 89LA, CLOSE 89LB AND CLOSE 52AB
2	CLOSE 89LB AND OPEN 89LA
3	OPEN 52AB, OPEN 89LB, CLOSE 89LA AND CLOSE 52AB
4	CLOSE 89LA AND OPEN 89LB
5	OPEN 89LB
6	OPEN 89LA AND CLOSE 52AB
7	OPEN 89LB AND CLOSE 52AB
8	CLOSE 89LB AND CLOSE 52AB
9	CLOSE 89LA AND CLOSE 52AB
10	OPEN 89LA, CLOSE 89LB AND CLOSE 52AB
11	CLOSE 52AB
12	OPEN 89LB, CLOSE 89LA AND CLOSE 52AB
13	OPEN 89LA
14	OPEN 52AB, CLOSE 89LB AND CLOSE 52AB
15	OPEN 52AB, CLOSE 89LA AND CLOSE 52AB
16	--- (DEFAULT)
17	--- (DEFAULT)
18	--- (DEFAULT)
19	--- (DEFAULT)
20	--- (DEFAULT)
21	PUT CONTROL FUNCTION IN MANUAL MODE

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- All of the previous information for the control function for MEDIUM VOLTAGE MANEUVERS is valid, except the input signals to the control function and the sequences to be executed, which are reflected in the tables below:

Table 6-30	
Input	**Description**
UA	Voltage presence / absence control function
UB	(Not used)
S_11	Control function for high voltage statuses
89LA_C	Disconnect switch 89LA closed
89LB_C	Disconnect switch 89LB closed
52AB_C	Breaker 52AB closed
52TA_C	Line A transformer breaker closed
52TB_C	(Not used)
52B12_C	(Not used)
MAN	Manual
AUT_ACT	Control function condition active

Table 6-31								
89LA_C	**89LB_C**	**52AB_C**	**52TA_C**	**S_11**	**UA**	**MAN**	**AUT_ACT**	**SEQ**
1	0	1	1	1	0	0	1	2
0	1	1	1	1	0	0	1	4
X	X	X	X	X	X	1	1	DEFAULT
X	X	X	X	X	X	X	0	DEFAULT

- In this case, the control function for SWITCHING DUE TO PROTECTION TRIPPING operates when the DISP_DEF signal is activated or 86A trips. In both cases, the control function goes to **manual** (MAN) mode. The input signals to this control function and the sequences to be executed are reflected in the tables below:

Table 6-32	
Input	**Origin**
ULA	Presence / absence of voltage on line A
ULB	Presence / absence of voltage on line B
89LA_C	Disconnect switch 89LA closed
89LB_C	Disconnect switch 89LB closed
52AB_C	Breaker 52AB closed
86TA_ACT	Trip 86A
86TB_ACT	(Not used)
MAN	Manual
DISP_DEF	Definitive trip
AUT_ACT	Control function condition active

Table 6-33									
89LA_C	**89LB_C**	**52AB_C**	**86TA**	**ULA**	**ULB**	**DISP_DEF**	**MAN**	**AUT_ACT**	**SEQ**
X	X	X	X	X	X	X	1	1	DEFAULT
X	X	X	X	X	X	1	0	1	21
X	X	X	1	X	X	0	0	1	21
X	X	X	X	X	X	X	X	0	DEFAULT

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6.7.4 Automatic Service Reset Equipment (ERAS)

The ERAS control function is responsible for performing an ordered connection of the high and very high voltage breakers of an electrical substation after a loss of voltage situation has been detected on the buses.

When a loss of voltage is detected on the buses, the control function opens all of the breakers connected at that time; and after checking for voltage on the different power supply lines, it proceeds to consecutively close each of the breakers, according to preset programming.

This control function is structured in the form of independent units: one central unit and as many terminal units as there are high voltage breakers.

The central unit of the ERAS is made up of three independent automata: UCERAS1, UCERAS2 and UCERAS3. There is an **In service / Out of service** setting, which affects all of the central unit's automata.

The detection of an external close not generated by the ERAS at the terminals that are picked up takes place at the ERAS' terminals themselves. When any terminal detects this situation, it sends a signal to the ERAS to block it.

The S_TX signal is used as an input for the terminals, which are alerted to this situation through this signal and then proceed to reset. The ERAS (UCERAS2 control function) is reset because this signal has been detected and the terminals have been reset.

Each of the ERAS' terminals is made up of four automata: TERAS1, TERAS2, TERAS3 and TERAS4. There is an IN SERVICE / OUT OF SERVICE setting for each of the terminals, which affects all of the automata.

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6.7.4.a UCERAS1

This automaton is responsible for controlling the Blocked statuses. When the automaton is started, signal S_BLQ goes to 0 and signal S_CIEXT to 0, and the status changes to X_NBLQ, described below.

- **Statuses**

Table 6-34	
Status	**Description**
X_NBLQ	Non-blocked status. In this status, the system is checking the value of the function (F1+F2+S_BLOQUEO) and the arrival of a block command. If the previous function changes to a value of "1", the system changes from X_NBLQ status to X_BLQ_P, causing S_BLQ=1. If it receives a block command, the system will change to X_BLQ_I status, causing S_BLQ=1. It will also change status if the F5 function is activated, changing to X_BLQ_I, causing S_BLQ=1 and S_CX=1.
X_BLQ_P	Blocked status because an input has a constant incorrect level (not pulsed). In this status, the system is checking the value of the logic function that caused this status (F1+F2+S_BLOQUEO) or the occurrence of a block command. It changes status when the previous function takes the value "0" and switches to X_NBLQ, causing SBLQ=0. If it receives a block command, it will change to X_BLQ_I.
X_BLQ_I	Blocked status due to a block command. In this status, the system is checking the arrival of a unblock command. When this occurs, the status changes. If the function (F1+F2+S_BLOQUEO) has the value "1," it will change to X_BLQ_P; if the value of that function were "0," it would go to X_NBLQ, causing S_BLQ=0.

- **Contact inputs**

Table 6-35	
Signal	**Description**
98Tt/B-A	Tripping of the cutout for bus A voltage
98Tt/B-B	Tripping of the cutout for bus B voltage
S_TBLQ(N)	Terminal N blocked. There are as many inputs of this type as there are high voltage terminals at the substation.
S_BLOQUEO	Blocking input.
S_CIEXT(N)	External close signal detected by terminal N.

- **Contact outputs**

Table 6-36	
Signal	**Description**
S_BLQ	Control function blocked. This output is used as an input in the terminals to prevent them from performing, both opening and closing maneuvers.

- **Commands**

Table 6-37	
Signal	**Description**
OB	Block command
ODB	Unblock command

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- **Flow chart**

Functions used in the status changes of the automaton:

Table 6-38	
Function	**Description**
F1	OR for all 98Tt/B inputs.
F2	AND for all terminal blocked signals
F5	OR for external close indications (S_CIEXT(N)) detected by the ERAS terminals.

6.7.4.b UCERAS2

This automaton is responsible for issuing close commands to the terminals in reset conditions, according to the priorities set.

When the automaton is started, signal S_ARR goes to 1 and the status changes to X_REPOSO, described below.

- **Statuses**

Table 6-39	
Status	**Description**
X_REPOSO	Default status. This status changes when the F3 function is activated with the ERAS not unblocked ($F3 \cdot \overline{S\_BLQ} = 1$), switching to X_PKUP status, making the signal S_PKUP=1.
X_PKUP	ERAS picked up status. It is exited: 1. Because F3 is cancelled, with the ERAS unblocked, or F3 is cancelled with the excessive reset time signal having been activated $\left(\overline{F3} \cdot S\_TX + \overline{F3} \cdot \overline{S\_BLQ} = 1\right)$, changing to X_REPOSO status, and making S_ARR=0. 2. Because it has been detected that a terminal has reset conditions, with the ERAS unblocked, or the excessive reset time value has been exceeded $(F4 \cdot S\_BLQ = 1)$, changing to the function of selecting the terminal to be reset. After the selection, it changes to X_TREP(M) status if the end of the list of resets has not been reached, or to X_REPOSO if it has been reached, making S_ARR=0.
X_TREP(M)	Account status of the reset time for the priority terminal (M) . This status may be exited: 1. Because the count has finished (T_OUT). In this case, a close command is generated for the priority terminal (M) and the status changes to X_1S. 2. Because the S_BLQ signal is activated; in this case, the counter stops, memorizing the account, and it switches to the waiting status X_ESP(M). 3. Because priority terminal M loses its reset conditions (S_CREP(M)=0). In this case, the value of F4 is checked; if it is 0, the status changes to X_ARR, and if it is 1, it goes to the selection function.

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Table 6-39 (continued)	
Status	**Description**
X_ESP(M)	Waiting status. It is exited: 1. By deactivating the S_BLQ signal, in which case the status changes to X_TRES(M), where the count that was initiated ends. 2. Because priority terminal M loses its reset conditions (S_CREP(M)=0). In this case, the value of F4 is checked; if it is 0, the status changes to X_ARR, and if it is 1, it goes to the selection function.
X_TRES(M)	Continues with rest of count. It is exited: 1. Because the count has finished (T_OUT). In this case, a close command is generated for the priority terminal (M) and the status changes to X_1S. 2. Because the S_BLQ signal is activated; in this case, the counter once again stops, memorizing the count, and it switches to the waiting status X_ESP(M). 3. Because priority terminal M loses its reset conditions (S_CREP(M)=0). In this case, the value of F4 is checked; if it is 0, the status changes to X_ARR, and if it is 1, it goes to the selection function.
X_1S	1 s counting status. It is exited when the count finishes (T_OUT).

- **Contact inputs**

Table 6-40	
Signal	**Description**
S_PKUP(N)	Signal for terminal (N) picked up. There will be as many signals of this type as there are terminals in service.
S_BLQ	ERAS blocked signal.
S_CREP(N)	Signal for terminal (N) with reset conditions.

- **Contact outputs**

Table 6-41	
Signal	**Description**
S_ARR	ERAS signal picked up.

- **Commands**

Table 6-42	
Signal	**Description**
OC(M)	Close command for priority terminal (M).

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- **Settings**

Table 6-42		
Name	**Description**	**Margin**
AJ_TREP(N)	Setting for terminal (N) reset time.	3 - 30 s
AJ_TREPLRL(N)	Setting for terminal (N) reset time due to LRL (reserve to line).	3 -60 s
AJ_PRI	Setting for priorities. Indicates the order in which the terminals picked up will be reset.	1 - 20

As can be seen, there are two reset time settings for each terminal: AJ_TREP(N) and AJ_TREPLRL(N). You select one or the other depending on the type of pickup: AJ_TREPLRL(N) is used when the S_ARRLRL signal is active.

- **Flow chart**

Functions used in the status changes of the automaton:

Table 6-43	
Function	**Description**
F3	OR for all S_ARR(N) inputs.
F4	OR for all S_CREP(N) inputs.

There is a selection function that determines the next terminal to be reset, according to the priorities set. There is a table that determines the order (M) according to the priority settings and to the terminals in service and picked up. Only terminals that are in service and picked up are reset. The one with the highest priority is chosen from among all the ones that are picked up and have reset conditions.

Once the close command has been given to a terminal, a selection is made from among those with the highest priority from the remaining ones that are picked up, bearing in mind the fact that others with higher priority may have reached reset conditions, and these will have to be taken into account.

In other words, the list of terminals to be reset may vary because some terminals lose reset conditions, because others reach them (change in S_ARR(N) from 0 to 1) or because some have been reset. A terminal that has already been reset will only get back on the list if a change from 0 to 1 in its S_ARR(N) signal is detected.

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6.7.4.c UCERAS3

This automaton is responsible for controlling the **Excessive Reset Time**. When the automaton is started, signal S_TX goes to 1 and the status changes to X_EXREP, described below.

- **Statuses**

Table 6-44	
Status	**Description**
X_EXREP	Default status. It is exited when function F3 is activated, changing to X_TEX status.
X_TEX	Status with ERAS counting excess reset time (5 hours). It is exited: 1. Because F3 is cancelled, changing to X_EXREP status. 2. Because the count has finished (T_OUT). In this case, the status changes to X_TX, making S_TX=1
X_TX	Status with excessive reset time value exceeded. It is exited by receiving an unblock command (ODB), changing to X_EXREP status, making S_TX=0.

- **Contact inputs**

Table 6-45		
Signal	**Description**	**Origin**
S_ARR(N)	Signal for terminal (N) picked up. There will be as many signals of this type as there are terminals in service.	Terminals

- **Contact outputs**

Table 6-46	
Signal	**Description**
S_TX	Signal for excessive reset time value exceeded.

- **Commands**

Table 6-47	
Signal	**Description**
ODB	Reset command

- **Settings**

Table 6-48	
Signal	**Description**
AJ_TEX	Setting for excessive reset time (5 hours)

- **Flow chart**

Functions used in the status changes of the automaton:

Table 6-49	
Function	**Description**
F3	OR for all S_ARR(N) inputs.

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6.7.4.d TERAS1

This automaton is responsible for controlling the **Blocked** (BLQ) statuses. When the automaton is started, signal S_TBLQ goes to 0 and the status changes to H_NBLQ, described below.

- **Statuses**

Table 6-50	
Status	**Description**
H_NBLQ	Non-blocked status.
H_T_PT	Status counting time of voltage presence on line and absence on buses, while the breaker is closed. This time will be 2 s.
H_BLQ_I	Blocked status. This status may only be exited by an unblock command.
H_BLQ_P	Blocked status. This status lasts as long as the signals leading to it last.

- **Contact inputs**

Table 6-51	
Signal	**Description**
98Tt/L	Tripping of the cutout for line voltage
VL	Line voltage.
VB	Bus voltage.
IC	Breaker closed.
OCF	Open command failure.
CCF	Close command failure.
S_AVB	Tripping of the cutout for line voltage
S_CEX	External close signal.

- **Contact outputs**

Table 6-52	
Signal	**Description**
S_TBLQ	Terminal blocked

- **Commands**

Table 6-53	
Signal	**Description**
ODBT	Unblock command

- **Logic**

The VB signal to be used by the automaton will be determined by the position of the line disconnect switches in the case of a double bus. Of the two voltages available, the one corresponding to the closed disconnect switch will be used.

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6.7.4.e TERAS2

This automaton is responsible for undervoltage opening and for detecting pickup (ARR) and reset (REP) conditions, as well as for giving the close commands received from the ERAS central unit.

It controls the functions for faults on buses and lines, as well as the close orders for cutouts.

- **Statuses**

Table 6-54	
Status	**Description**
H_REP	Default status.
H_T_SUBT	Status of counting time for undervoltage opening. This time is a setting (AJ_T_SUBT).
H_ESPABR	Status of waiting for opening, after an open command has been issued. If opening does not take place, an OCF will be generated which will send the TERAS1 to blocked status. TERAS2 will remain in this status and will return to default condition when the unblock order is received, which will also take TERAS1 to non-blocked status.
H_ESPCR	Status of waiting for reset conditions.
H_ARRIMPLRL	Status of pickup impossible due to LRL. This occurs when there are pickup conditions, but the breaker had not been open long enough beforehand.
H_ARRIMPLRB	Status of pickup impossible due to LRB. This occurs when there are pickup conditions, but the breaker had not been open long enough beforehand.
H_ESPOC	Status of waiting for close order from UCERAS.
H_ESPCER	Status of waiting for close. Similar to H_ESPABR.
H_C_AVERÍA	Status of fault check after close. It will remain in this status for 3 s.
H_AVERÍA	Fault status.
H_CEX	Status of external close detected.

- **Contact inputs**

Table 6-55	
Signal	**Description**
98Tt/L	Tripping of the cutout for line voltage
98Tt/B	Tripping of the cutout for bus voltage.
VL	Line voltage.
VB	Bus voltage.
IC	Closed breaker.
IA	Open breaker
S_TBLQ	Terminal blocked signal.
S_ETBLQ	External block signal
S_BLQ	ERAS blocked signal
S_IC_TA	Signal for breaker closed long enough.
S_IA_TA	Signal for breaker open long enough.
S_FSINC	No sync signal
S_TX	Signal for excess reset time.

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- **Contact outputs**

Table 6-56	
Signal	**Description**
S_TARR	Terminal picked up.
S_CREP	There are reset conditions.
S_CEX	External close detected
S_OC_EB	Close command due to EB
S_OC_EL	Close command due to EL
S_OC_AT	Close command due to AT
S_OC_LRB	Close command due to LRB
S_OC_LRL	Close command due to LRL
S_AVBA	Fault on A buses
S_AVBB	Fault on B buses
S_AVL	Fault on line
S_C_AVERÍA	Signal for fault check, after close command executed.

The S_AVBA and S_AVBB signals will be generated from S_AVB, taking into consideration to which bus the terminal is connected.

- **Other signals used**

Table 6-57	
Signal	**Description**
S_ARRLRL	Signal for pickup due to LRL
S_ARRLRB	Signal for pickup due to LRB
S_ARRST	Signal for pickup due to undervoltage
S_CREPL	Signal for reset conditions due to EL or LRL
S_CREPB	Signal for reset conditions due to EB or LRB
S_CARR	Signal that pickup conditions exist (breaker closed for more than the time set) before open command is given.

- **Commands issued by the terminal**

Table 6-58	
Command	**Description**
OA	Open command to be sent to the associated IED.
OC	Close command to be sent to the associated IED.

- **Commands received by the terminal**

Table 6-59	
Command	**Description**
OC_ERAS	Close command from ERAS central unit.
ODBT	Terminal unblock command.

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- **Settings**

Table 6-60		
Name	**Description**	**Margin**
AJ_T_SUBT	Setting for disconnect time due to undervoltage.	0 -10 s
EB	Setting for terminal with energizing of buses	YES / NO
EL	Setting for terminal with energizing of line	YES / NO
AT	Setting for terminal with voltage coupling	YES / NO
LRL	Setting for terminal with reserve to line	YES / NO
LRB	Setting for terminal with reserve to buses	YES / NO

The EB, EL, AT, LRL and LRB settings may be simultaneous.

- **Logic**

The VB signal to be used by the automaton, as well as the 98Tt/B signal, will be determined by the position of the line disconnect switches in the case of a double bus. Of the two voltages and 98Tt/B available, the one corresponding to the closed disconnect switch will be used.

In the case of a double bus, there will be two S_AVB signals (signal for fault on a bus). A terminal will generate one signal or the other depending on what bar it is connected to. Likewise, one signal or the other will be used to control the blocking automaton (TERAS1).

- **Flow chart**

The following functions will be used in the description of the flow chart:

Table 6-61	
Function	**Description**
F6	$IC \cdot \overline{VL} \cdot \overline{VB} \cdot \overline{98Tt / L} \cdot \overline{98Tt / B} \cdot \overline{S\_TBLQ} \cdot \overline{S\_BLQ}$
F7	$IA \cdot \overline{VB} \cdot \overline{98Tt / B} \cdot \overline{S\_TBLQ} \cdot \overline{S\_BLQ} \cdot LRB$
F8	$IA \cdot \overline{VL} \cdot \overline{98Tt / L} \cdot \overline{S\_TBLQ} \cdot \overline{S\_BLQ} \cdot LRL$
F9	$VL \cdot \overline{VB} \cdot (EB + LRB) \cdot \overline{98Tt / B}$
F10	$VB \cdot \overline{VL} \cdot (EL + LRL) \cdot \overline{98Tt / L}$
F11	$VL \cdot VB \cdot \overline{S\_FSINC}$

- **Interaction with block signals**

In the H_REP status, the S_TBLQ signal will be checked. When this signal is active, the status can only be exited by activating F6. In the H_T_SUBT and H_ESPABR statuses, S_TBLQ need not be checked; in all other statuses, S_TBLQ must be at **0** in order to be able to exit them.

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6.7.4.f TERAS3

This automaton is responsible for detecting whether bus and line voltages drop while the fault check is being performed. This is necessary because the length of time that the voltage drop must last in order for there to be a fault is 2 s, while the verification time is 3 s; in other words, they are two different times that must run simultaneously.

- **Statuses**

Table 6-62	
Status	**Description**
W_REP	Default status.
W_NVLNVB2	Counting 2 s after detecting the drop in both voltages while the fault is being checked
W_ESPNAV	Waiting for TERAS2 to exit the fault check status (H_C_AVERÍA)

- **Contact inputs**

Table 6-63	
Input	**Description**
SIGNAL	DESCRIPTION
98Tt/L	Tripping of the cutout for line voltage
98Tt/B	Tripping of the cutout for bus voltage.
VL	Line voltage.
VB	Bus voltage.
S_C_AVERÍA	Fault check signal

- **Contact outputs**

Table 6-64	
Output	**Description**
S_NVLVB2	Signal that voltages have dropped for 2 s.

- **Logic**

The VB signal to be used by the automaton, as well as the 98TtB signal, will be determined by the position of the line disconnect switches in the case of a double bus. Of the two voltages and 98Tt/B available, the one corresponding to the closed disconnect switch will be used.

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6.7.4.g TERAS4

This automaton is responsible for determining whether the breaker has been closed long enough to pick up the terminal.

- **Statuses**

Table 6-65	
Status	**Description**
E_REP	DEFAULT STATUS
E_CTA_AB	STATUS OF COUNTING OPEN TIME FOR THE TIME SET
E_CTA_CE	STATUS OF COUNTING CLOSED TIME FOR THE TIME SET
E_TA_AB	STATUS OF OPEN FOR THE TIME SET
E_TA_CE	STATUS OF CLOSED FOR THE TIME SET

All of the times mentioned above are 10 s.

- **Contact inputs**

Table 6-66	
Input	**Description**
IA	OPEN BREAKER
IC	CLOSED BREAKER
IDES	UNKNOWN BREAKER

- **Contact outputs**

Table 6-67	
Output	**Description**
S_IA_TA	BREAKER OPEN FOR THE TIME SET
S_IC_TA	BREAKER CLOSED FOR THE TIME SET

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- **Operation**

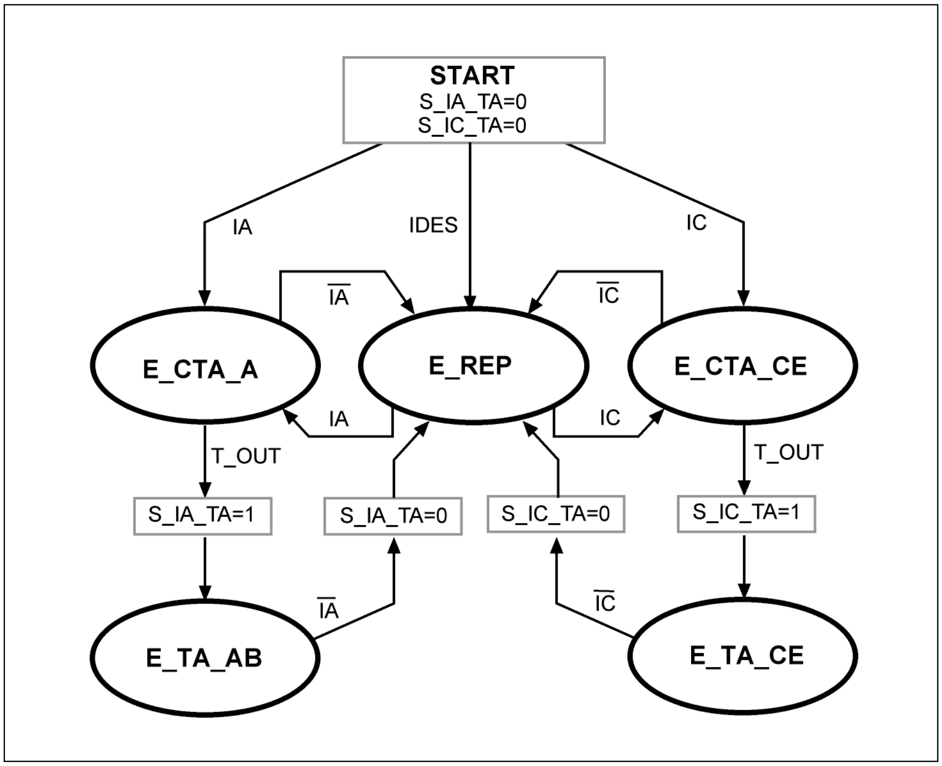

Figure 6.9: TERAS4 Control Function.

6.7.4.h Own Signals

As a virtual unit, the ERAS control function has a number of signals that provide information to the other tasks. This number of signals depends on the number of virtual terminals it has. There are 24 fixed signals for the control function, and then there will be 40 more for each terminal.

The following table shows what these signals are and how the terminals are mapped in the control function's signals as a whole. The fixed digital signals are:

Table 6-68	
Signal	**Meaning**
0. ERAS_SERVICIO	ERAS in service
1. S_BLQ	ERAS blocked
2. S_CX	ERAS connected
3. OB	Block command
4. ODB	Unblock command
5. ARR	ERAS picked up
6. TX	Excessive reset time value exceeded
7. AUTO	ERAS in automatic mode
8. MANUAL	ERAS in manual mode
9..23	Spare

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The signals for each terminal are:

Table 6-69	
Signal	**Meaning**
24. 98t-B terminal	Tripping of the cutout for bus voltage
25. VB	Bus voltage
26. S_TBLQ	Terminal blocked
27. S_TARR	Terminal picked up
28. S_CREP	There are reset conditions
29. S_CREPB	Signal for reset conditions due to EB[1]or LRB[2]
30. S_CREPL	Signal for reset conditions due to EL[3] or LRL[4]
31. S_CARR	Signal that pickup conditions exist (breaker closed for more than the time set) before open command is given.
32. S_ARRLRL	Signal for pickup due to LRL
33. S_ARRLRB	Signal for pickup due to LRB
34. S_ARRST	Signal for pickup due to undervoltage
35. S_CEX	External close signal
36. S_OC_EB	Close command due to EB
37. S_OC_EL	Close command due to EL
38. S_OC_AT	Close command due to AT[5]
39. S_OC_LRB	Close command due to LRB
40. S_OC_LRL	Close command due to LRL
41. S_AVBA	Fault on A Buses
42. S_AVBB	Fault on B Buses
43. S_AVB	Signal for fault on buses
44. S_AVL	Signal for fault on line
45. S_C_AVERIA	Fault check after close
46. S_NVLVBL	Signal indicating that voltages have dropped for more than 2s
47. S_IA_TA	Breaker open during the time set
48. S_IC_TA	Breaker closed during the time set
49. ODBT	Unblock command
50. OC_ERAS	Close command
51. OC_TEL	Close command from remote control
52. ORD_AUT	Automatic / manual command
53. VLi	Status of calculated VL or VL
54. 98Tt_Li	Tripping of the cutout for line voltage
55. S_CREPAT	Signal for terminal with voltage coupling with reset conditions
56. S_CREPLRL =	Signal for terminal with reserve to line with reset conditions
57. S_CREPLRB =	Signal for coupling terminal for reserve to buses with reset conditions
58. UT_SERVICIO =	Terminal in service
59..63.-	Spare

(1) EB = Energizing of buses
(2) LRB = Reserve to buses
(3) EL = Energizing of line
(4) LRL = Reserve to line
(5) AT = voltage coupling

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6.7.4.i Own Commands

The ERAS control function has 4 commands that modify its status. They are the following:

Table 6-70	
0	ERAS BLOCK
1	UNBLOCK
2	PUT IN AUTO MODE
3	PUT IN MANUAL MODE

6.7.4.j External Signals

Each IED terminal needs certain information about the status of the different elements associated with the IED it controls. For each terminal there are 15 signals, which are (in order):

Table 6-71	
Signal	**Meaning**
ISC_98Tt_L	Signal for tripping of the cutout for line voltage
ISC_89LA	Signal for line A disconnect switch status
ISC_89LB	Signal for line B disconnect switch status
ISC_VL	Line voltage signal
ISC_IA	Open breaker signal
ISC_IC	Closed breaker signal
ISC_IDES	Unknown breaker signal
ISC_FOA	Open command failure signal
ISC_FOC	Close command failure signal
ISC_S_ETBLQ	ERAS external block signal
ISC_ERAS_BLQ	Signal for ERAS blocked, generated by UCERAS1[1]
ISC_ERAS_TX	Excessive reset time signal generated by UCERAS3[2]
ISC_S_FSINC	No sync signal
ISC_S_AUTO	Signal for ERAS in automatic mode
ISC_S_S_MANUAL	Signal for ERAS in manual mode

(1) UCERAS1 = automaton belonging to the ERAS control function, responsible for controlling Blocked statuses.
(2) UCERAS3 = automaton belonging to the ERAS control function, responsible for controlling excess reset time.
UCERAS2 = automaton belonging to the ERAS control function, responsible for issuing close commands to the terminals in reset conditions, according to the priorities set.

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6.8 Programmable Logic

The **CPX** has a task that behaves like a logic equipment, whose function is to execute a logic program that performs certain programmable functions at the substation level. Among other things, this logic makes it possible to group signals, perform relatively simple control functions, etc.

It uses all of the signals in the **CPX**'s database as input variables. For outputs, it provides its own signals, which are configurable. In addition, it can perform commands on substation equipment.

This logic program is executed sequentially and continuously from beginning to end. To do this, it uses the status of the database immediately prior to execution. Changes in the logic signals are generated at the end, once the full program has been executed. The logic works by statuses, not by changes, so a short pulse is not processed.

The input and output variables that may be used in the different operations are shown in Table 6-72:

Table 6-72 input and output variables for logical operations

Variable	Description
ISC:	Digital Signals
ISE	Commands
ISS	Writing outputs
CON	Counters
Registros Internos	Internal logic records

Apart from these variables, settings can be used in the TEMPOR, DNIVEL and CMPCONT operations. The settings have the **AJn** format, where **n** varies between 0 and NumAjs-1, and NumAjs is the number of settings configured. They can be used in the above operations instead of the fixed parameters.

These settings may be modified during execution from the operating console. If fixed values are used in the parameters of the TEMPOR, DNIVEL and CMPCONT operations, they can only be modified from the logic editor included in ***Zivergraph***. However, if settings are used, they may be changed at any time from the respective Control Function Configuration screen in the operating console.

Setting changes take place immediately, as soon as they are sent from the operating console. The level detectors (DNIVEL) begin operating with the new values. Any timers that were running at that moment are reset and start counting from the beginning. In other words, if a timer is running and it has to count 8 seconds, if any logic setting is changed (it does not necessarily have to be the setting relating to that timer) when 6 seconds have elapsed, this timer would start over again and would finish at the end of 14 (6+8) seconds. This overcounting only happens the first time after a setting change, and only if the timer is running.

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The logic program has the following limitations:

- Maximum number of inputs per logical operation: 32.
- Maximum number of outputs per logical operation: 32. In addition, logical operation outputs may only be addressed to internal registers or to signals of the LOGICA virtual unit itself.
- Maximum number of internal logic registers: 1024 (0 … 1023). Several outputs may not be addressed to the same register in a single logical operation.
- Maximum number of timers available: 200.
- Maximum number of RS flip-flops: 225.
- Maximum number of JK flip-flops: 50.
- Maximum number of D flip-flops: 20.
- Maximum number of MANDO-type logical operators: 200.
- Maximum number of FMANDO-type logical operators: 40 (only model **1CPX-A**).
- Maximum number of ESC-type logical operators: 50.
- Maximum number of settings: 20.
- Maximum number of counters CONT: 50.
- Maximum number of counter comparators CMPCONT: 50.

This logic program is created using the logic editor included in the ***Zivergraph*** software.

The different operations that can be performed in this programming are listed below.

- **OR**

This is a logical OR operation with several inputs and several outputs.

Table 6-73: truth table		
In1	**In2**	**Out**
0	0	0
0	1	1
1	0	1
1	1	1

- **AND**

This is a logical AND operation with several inputs and several outputs.

Table 6-74: truth table		
In1	**In2**	**Out**
0	0	0
0	1	0
1	0	0
1	1	1

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- **XOR**

This is a logical exclusive-OR operation with several inputs and several outputs.

Table 6-75: truth table		
In1	**In2**	**Out**
0	0	0
0	1	1
1	0	1
1	1	0

- **NOT**

This is a logical NOT operation: it negates the input and assigns that value to the respective outputs.

Table 6-76: truth table	
In1	**Out**
0	1
1	0

- **CABLE**

This is an assignment, i.e., the value of the input is assigned to the different outputs.

Table 6-77: truth table	
In1	**Out**
0	0
1	1

- **FFRS**

This is an RS flip-flop.

Table 6-78: truth table		
R	**S**	**Qt+Δt**
0	0	Qt
0	1	1
1	0	0
1	1	X

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- **FFJK**

This is a JK flip-flop.

Table 6-79: truth table		
J	**K**	**Qt+Δt**
0	0	Qt
0	1	1
1	0	0
1	1	$\overline{Qt}$

- **MANDO**

It executes a command in the following way:

If the input signal is activated (goes from 0 to 1 or vice versa if it is negated), the command indicated with the desired operation code is executed, and whatever value the input signal has is assigned to the outputs.

Commands belonging to the LOGICA virtual unit itself may not be used as a command parameter in this logical operation, because it makes no sense for a unit to send commands to itself. Its operation is shown in figure 6.10:

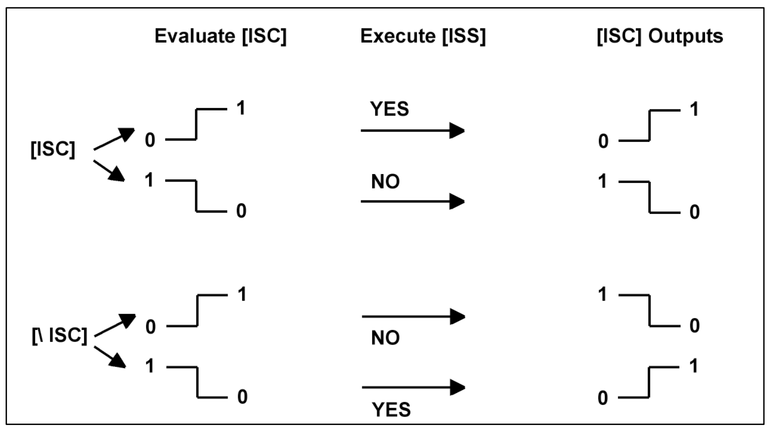

Figure 6.10: Operation of the MANDO Logical Operation.

- **FMANDO**

This is a variation of the preceding function: if the input signal is activated, the command associated with the operation code indicated is executed, and there is a delay of the time set for the execution of the command to see whether the test signal is activated. If it is activated during that time, the "command executed" output signal will be activated. If it is not activated during the time set, the "command not executed" output will be activated.

Commands belonging to the LOGICA virtual unit itself may not be used as a command parameter in this logical operation, because it makes no sense for a unit to send commands to itself.

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- **ESC**

This is a function that executes the output writing indicated with the activation operation code if the input signal is active, or with the deactivation operation code if the input signal is inactive. In addition, whatever value the input signal has is assigned to the outputs.

Its operation is shown in figure 6.11:

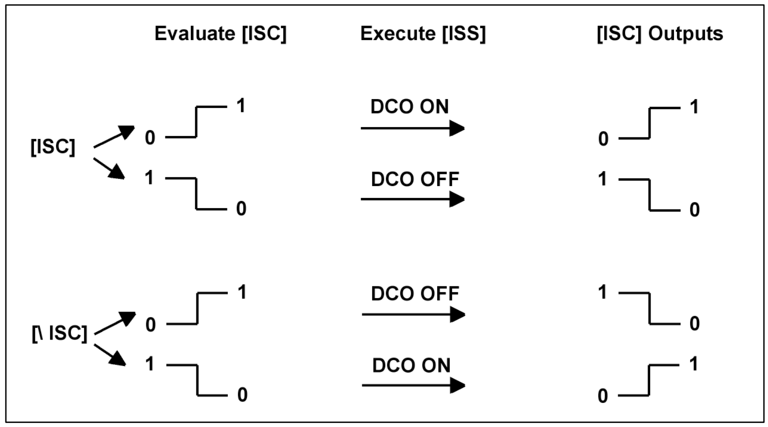

Figure 6.11: Operation of the ESC Logical Operation.

- **TEMPOR**

This is a timer whose operation is shown in figure 6-12:

TA and TB are expressed in full seconds.

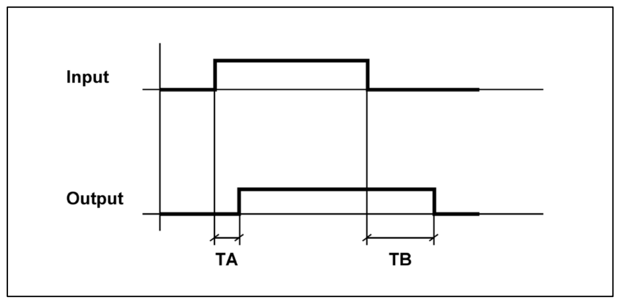

Figure 6.12: Operation of the Timer.

- **DNIVEL**

This is a range evaluator which works as follows:

The value of the field measurement (in volts or amperes) is taken and compared with {VC}, {VMIN} and {VMAX} as indicated in figure 6.13:

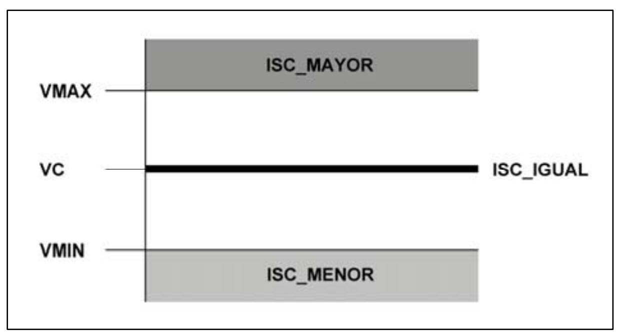

Figure 6.13: Operation of the Range Evaluator.

- If the measurement > {VMAX} → The (ISC_MAYOR) output signal is activated.
- If the measurement = {VC} → The (ISC_IGUAL) output signal is activated.
- If the measurement < {VMIN} → The (ISC_MENOR) output signal is activated.

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- **DEACT**

This is a detector for the only active input from among several inputs.

Table 6-80: truth table (particular case of 3 inputs)			
In1	**In2**	**In3**	**Out**
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

- **CONT**

It is a Pulse Counter, which increases when an ascending pulse is introduced into the Q input and resets if it receives an ascending signal from the other R input. In case both inputs activate, a counter reset will occur.

The number of defined counters must not surpass a maximum value stipulated as 10 counters.

- **CMPCONT**

It is a Counter Comparator, in such a manner that a value of a counter is compared with the set point value (Vc), fixed or declared in a logic adjustment. If the value is greater or equal to it, the definite output signal will activate. Otherwise, said signal will deactivate.

The number of defined counter comparators must not surpass a maximum value stipulated as 10 counters.

If CON >= Vc, the ISC activates
If CON < Vc, the ISC deactivates

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6.9 Remote Console

Some of the **CPX** models incorporate remote access functions to the control information of the substation, making the display and control of the different elements of the installation from a computer outside of it possible. This access is performed from a remote console. Access is also allowed to the protection information in transparent mode for equipment with PROCOME protocol.

Here, the word “remote” is not only a synonym of “far” but implies a different functionality. A local console is usually near the CPX, while the remote one is usually outside of the substation. However, it is possible to perform configurations in both consoles whether they are outside or inside of the substation. The operation of each one is independent to the physical place it is located.

There are various ways of connection to said remote access: RTC line, GSM, dedicated line and Ethernet network. The access through a direct line (cable or fibre) is not possible as it needs, mandatorily, a telephone MODEM. The connection to an Ethernet network is performed through the equipment internal HUB with RJ45 connections.

From the operational point of view, the connection to many remote consoles is permitted, but they cannot all be simultaneous. This restriction is determined in the CPX model

CPX-A

If the equipment is within the 1CPX-A family then only one remote access will be permitted through port 32009 (TCP port). Likewise, depending on the software model of the equipment, it may or may not be available. In chapter 1, the model selection table is shown.

CPX-B

If the equipment is within the 1CPX-B family then up to six simultaneous remote connections are allowed: a Remote Console in the 32009 port (as in the CPX-A family) and up to five Additional Remote Consoles in port 32010. This differentiation in the TCP ports, allows differentiating, in part, the operation allowed for each type of console as seen below.

A particularity exists. If the access is through a MODEM) RTC, GSM,...), only one remote access is permitted, independently from the access point. If there is an additional Ethernet access, more remote connections are permitted, up to the maximum number indicated previously. but only one of them is possible through the MODEM.

The **CPX** saves occurrences and alarm files common to all the remote consoles. These files are collected by the consoles each time that a connection is performed. The maximum number of alarms saved in the alarms file is 250. The maximum number of occurrences that are saved in the occurrences file is configurable, with 500 being the default value. These parameters are shared by all of the consoles.

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There is the possibility of allowing or not, by means of a configurable parameter, to perform orders from the remote console. There are two parameters: one controls the access by port 32009 and the other by port 32010. This allows the configuration of different operations for the different accesses. For example, the Remote Console (32009) can be used as a second console allowing the performance of orders, while the others (Additional Consoles, 32010) can be configured in display mode only. See attachment A for more information.

Another example. If permission of performing orders is desired by some consoles but not by others, within the same family, this parameter will be enabled in the **CPX**, but will be disabled in those consoles that must not do this. (PCD instruction manual)

The operation provided by this access remote is, basically, the same as that provided by the local console. The **CPX** cannot be reconfigured with a new configuration from the remote console. This operation can only be performed from the local console.

To be able to connect a Console to a CPX through the Additional port (32010) it is necessary to change a parameter in the console "TCP.CFG" file described in section A.9 of the corresponding instruction manual (LPCD0407A). In the parameter "*PortComRemota"*, the TCP port number must be configured adequately. 32009 for the Main Remote Console and 32010 for the Additional Remote Consoles.

The access by the remote console to the **CPX** through an Ethernet with TCP/IP protocol presents no difficulty and it is sufficient to configure said option in the **CPX**. However, in the CPX-A models, when a telephone line is used (whether it is RTC, GSM or dedicated), a *driver* must be loaded that implements the SLIP protocol. This *driver* is necessary to use TCP/IP on a RS232 line instead of an Ethernet network. This is not necessary in the CPX-B model as this is already included in the operation system.

The *driver* is found in the file **slip8250.com** which must be loaded before the application program ucs.exe is loaded. While this programming is loading it is necessary to provide certain parameters explained below. Not all the parameters are necessary because the default values are used.

- NumIntPacket: Number of the interruption vector that will be used to talk with the *driver packet*. This value will be 0x80.
- NumIrq: IRQ number that will be used to communicate with the serial port.
- DirIO: direction of the I/O of the Serial Port.
- Baudios (Bauds): communication speed, in bauds.
- TipoEq: Equipment type: 0 = CPX, 1 = CPP. Default, 0.
- Paridad (Parity): 0 = None; 1 = Par. Default, 0.
- TamBufTX: transmission buffer size. Default, 3000.
- TamBufRx: receiving transmission buffer size. Default, 3000.

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The parameters must be inserted in the order presented above. The values possible for the NumIrq and DirIO parameters are the following:

CPX			**CPP**		
Port	**DirIO**	**NumIrq**	**Port**	**DirIO**	**NumIrq**
COM1	0x3F8	4	P1	1100	4
COM2	0x2F8	3	P2	1108	3
COM3	0x3E8	10			
COM4	0x2E8	11			

For example, for the CPX the *driver* will be loaded with the following command:

slip8250 0x80 10 0x3e8 9600

For the CPP, the following command will be loaded:

slip8250 0x80 3 0x1108 9600 1

The loading of the *driver* will be configured in the file **tcp.bat**. This way, when the **CPX** is started up, the *driver* will load and then the execution of the application program will be performed.

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6.10 Commands

6.10.1 Description

There is a task in the **CPX** known as MANDO which is responsible for managing commands for different elements in the installation.

The desire to perform a command may come from outside the **CPX** (from the operating console or from the remote control office) or internally (the logic or a control function). The final destination of the command may be an IED or the **CPX** itself. This intention is collected by the MANDO task, which processes it and routes it towards the final destination after performing a series of checks.

The MANDO task first checks to see whether the element is already in position. If so, the command is not given. For this to take place, the status signal associated with the command must be configured in ***Zivergraph***. If this signal is not configured, no verification takes place.

After this filter, verification is made of whether there are any blocks at the **CPX** level. If there are block signals configured and any are active, the command will not be given. Otherwise, it will follow its route.

If the destination is an internal logic equipment of the **CPX**, it is sent to the respective task to be carried out. If it is an external unit, the command is sent to that unit.

If the command is external, the unit may, in turn, have its own blocking logic and command management. As a result, we will generally obtain positive or negative confirmation of the command being performed. In some cases, we will also obtain the reason why the command was not performed. This information is once again received by MANDO, which processes it and sends it back to the command requester.

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The accompanying figure shows a schematic diagram of the route that commands take through the **CPX**. It illustrates the particular case of a **ZIV** IDE using the PROCOME protocol. Depending on the configuration and on the model of the IDE, the checks and results may be different.

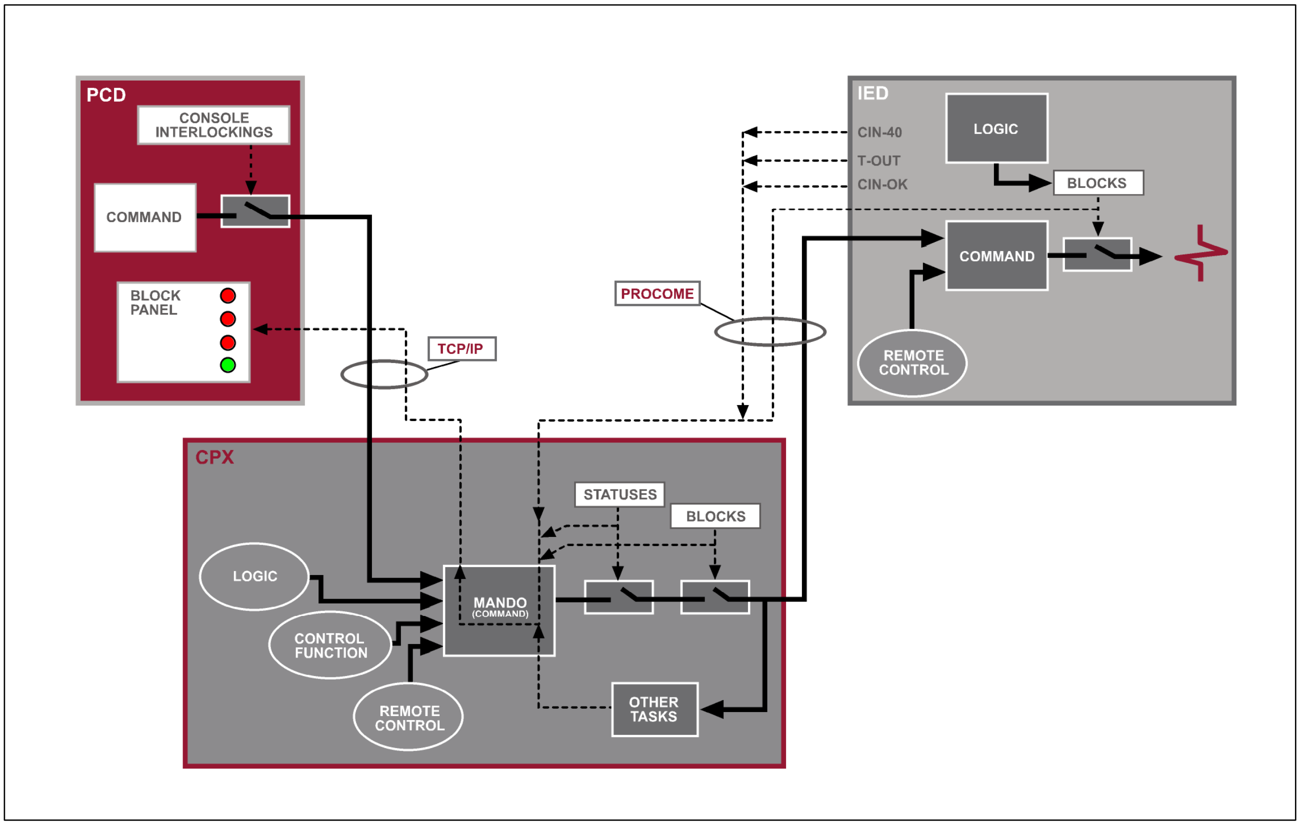

Figure 6.14: Command Logic (example).

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6.10.2 Group Commands

Another additional function of the MANDO task is to perform a particular control function relating to LOCAL / REMOTE CONTROL commands. In general, IEDs have a status indicating whether remote control is allowed, or whether only control local to the substation is allowed. This is a function relating to the worker safety.

If we put an IED in local mode, we may want the rest of the IEDs associated with it (same bus, transformer, etc.) to also be put in local mode, thus preventing operations from being performed on them from the remote control office.

This function is standard in the **CPX**. Using configuration information, the MANDO task monitors the status of the LOCAL / REMOTE CONTROL signals from all of the IEDs that have been configured within a command group. Whenever any of these changes its status, MANDO initiates commands to the rest of the IEDs, in order to put them in the same status as the one that changed.

6.10.3 Master Commands

The **CPX** has another function related to commands and writing outputs. Some command or writing groups are configured in which one acts as the master and the rest as slaves. When the signal associated with the master changes, a chain of command or writing is initiated for the slave elements, in order to switch them to the desired status.

This control function is used to transmit signals horizontally between different units through the **CPX**, thus avoiding the need for wiring between them.

For example, bus voltage is usually measured by the unit associated with the coupling IED. This unit’s inputs are wired to the outputs of the medium voltage transformers. This unit has the analog value of the voltage measurements. The rest of the units connected to this bus do not need the analog value of the voltage; they only need to know whether or not there is voltage on the bus. This information is calculated by the coupling IED and is sent to the **CPX** through the communications protocol. The **CPX** takes this signal and sends it to any units that need it. This operation is performed whenever a change is detected in the originating signal: **presence of voltage on buses.**

This functionality can be applied to a multitude of signals in the substation. The CPX makes it possible to transfer signals horizontally between different bay IEDs. The use of this function depends on the configuration and the installation.

These commands are affected by the blocking logic explained in point 6.10.1.

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6.11 LEDs

The **CPX** has 8 configurable LEDs at the right side of the front panel. Any digital signal from the database may be assigned to these LEDs. When the associated signal is active, the LED will light up, while if it is not, the LED will remain off.

For each LED, the associated signal, whether it is negated and whether it is flashing can be configured. If it is configured as flashing, it is possible to indicate the frequency of said flashing.

6.12 Digital Inputs

The number of digital inputs that the **CPX** has depends on the model. There are 8 digital inputs for each communications card.

These digital inputs are mapped as digital signals within the CENTRAL logic equipment, starting with signal 300. In other words, the first digital input corresponds to signal 300 in the CENTRAL unit, the second to 301, etc. The reading period is configurable in multiples of 6 ms.

The reading logic of the digital inputs has a debounce filter. The status must be maintained for at least 3 reading periods for a change to be considered valid.

6.13 Digital Outputs

The **CPX** has 4 configurable digital outputs for generic use. These outputs are externally accessible through writing outputs on the CENTRAL logic equipment.

Writing output 1 activates physical output 1, writing 2 activates output 2, etc.

6.14 Logs (optional)

Some **CPX** models incorporate a functionality know as logs, which makes it possible to periodically collect and store information about certain signals at the installation for later external processing.

There is a specific task responsible for performing the work related to this functionality.

As the **CPX**’s disk is limited in size, files are stored using a FIFO system. When a new file is created every night at midnight, the oldest file is deleted. The number of days that the **CPX** stores the information is, at first, configurable, but it depends on the size of the flash disk and on the amount of information one wishes to store.

These data files are extracted through the operating console, which exports them to swap files so that they can be easily processed using commercial software.

There are three types of logs: for **meters**, for **counters** and for **changes**.

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6.14.1 Metering Logs

The metering logs are responsible for periodically saving information to disk about measurements that are configured. The period is one minute.

Every minute at second 0, a record is saved to disk of the values of the configured measurements stored at that moment in the database. This data is stored in a file on the **CPX**'s disk, ordered in such a way that one file is created per day with all the data for that day.

6.14.2 Counter Logs

The counter logs are responsible for periodically saving information to disk about the counters that are configured. The period is configurable, with a default period of 15 minutes.

Every period at second 0, a record is saved to disk of the values of the configured counters stored at that moment in the database. This data is stored in a file on the **CPX**'s disk, ordered in such a way that one file is created per day with all the data for that day.

6.14.3 Change Logs

The change logs are responsible for storing a record on disk when a change occurs in one of the signals that are configured. It is possible to choose whether both activation and deactivation are recorded.

The data is also ordered in daily files with the same number of days stored as for the other types of logs.

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CHAPTER 7

Alphanumeric Keyboard and Display

VII

7.1 Alphanumeric Keyboard and Display

The liquid crystal alphanumeric display has a 4-row by 20-character matrix. It displays information about IED alarms, settings, metering, states, etc. There are 4 auxiliary function keys (**F1**, **F2**, **F3** and **F4**) under the display. The next section explains their functions. Figure 7.1 shows the default graphic display and the function keys.

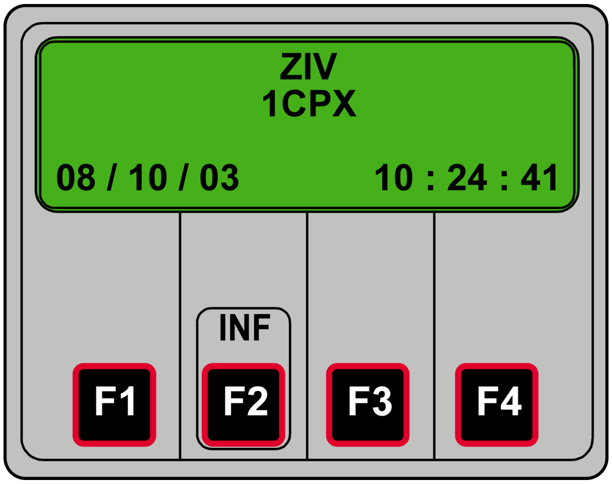

Figure 7.1: Alphanumeric Display.

- **Default display**

As you can see in figure 7.1, the default display shows the IED model, the date and the time.

- **Alphanumeric keyboard**

The keyboard consists of 16 keys arranged in a 4 x 4 matrix. Their properties are specified next. Figure 7.2 shows the layout of this keyboard.

In addition to the keys corresponding to the digits (keys from 0 to 9), there are the selection keys (↑ and ↓), the confirmation key (**ENT**), the escape key (**ESC**) and the contrast key (◑).

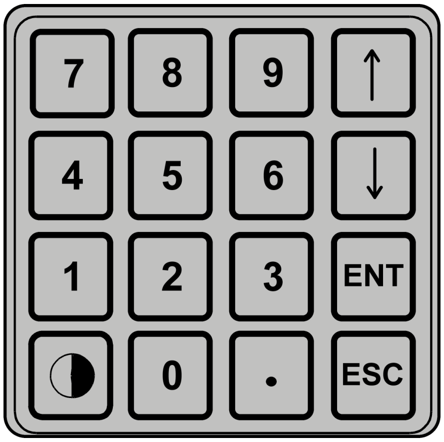

Figure 7.2: Keyboard Layout.

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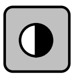
7.2 Keys, Functions and Operation Mode

This section explains the functions of the keys, both the ones associated with the alphanumeric display as well as those on the keyboard.

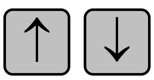
• Keyboard and associated functions



Contrast key

When this key is pressed, program trace and tracking information is displayed on the **CPX** screen. In other words, by pressing this key, tracking information for the **CPX** can be accessed without connecting the video monitor.

By pressing this key from any other screen where we may be, the system changes to display tracking information. Pressing it again brings back the initial display.



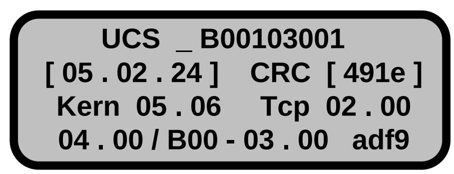
Display selection keys

If the selection keys are pressed after pressing the contrast key, the next higher or lower position in the video memory is accessed by means of vertical scrolling.

If the function keys are pressed after pressing the contrast key, the left or right position in the video memory is accessed by means of horizontal scrolling.

When this key is pressed, you access a looped display with information about the **CPX.**. The first display shows information about the executable file:

- Model of the executable file UCS.EXE
- Version of the executable file UCS.EXE
- Checksum of the executable file UCS.EXE
- Version of the multitask operating system
- Version of the TCP library
- Model and version of the software loaded on card TL-176
- Checksum of the software loaded on card TL-176



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The second display shows information about the status of certain of the **CPX**'s internal parameters.

- The configuration’s IP address.
- Size (in bytes) of the logic
- Size (in bytes) of free memory
- Status of the sockets: C = Central, P = Protection, M = Monitor.
- 00 = Waiting for connection; 03 = Connection established

Finally, we go back to the default display.

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CHAPTER 8

Commissioning

VIII

8.1 Commissioning

The **CPX** comes with factory-installed test software and a test configuration. The model of the software will generally not coincide with the one requested by the customer. In addition, the test configuration is not the one that the installation requires.

With this test configuration, when the **CPX** is powered up, the central unit's program will automatically run, showing the system's date and time on the front display. In addition, the continuous flashing of the LEDs associated with the communications ports where IEDs are configured can be seen on the back of the unit. The LEDs will be red when lit up, indicating transmission but no reception. This is normal, because the substation equipment does not correspond to the equipment configured.

If there is an operating console (PCD) at the installation, it should be connected to the **CPX** to check that the entire system is operating properly.

The system is equipped with a method to check the coherence of the information (models and configuration) of the local PCD and the **CPX**. This method checks to make sure that the console and central unit correspond to the same substation and that both are configured with the same equipment. Once this step has been carried out, communication is established between the two units, as long as the results of the coherence checking process were correct. To make sure that the system is operating properly, select the **SIPACS Status** option eral menu and make sure that there is no communication error. This ensures that communication has been satisfactorily established.

Once you have verified that the equipment is operating properly with the test configurations, you may proceed to load the definitive software and configurations appropriate to the installation's requirements. This is when the IEDs are connected to the **CPX**.

Once the CPX has been updated with the definitive configurations and software, you will need to make sure that the system is working properly. To do this, it is necessary that all signals that may occur in the substation be generated in the field, and verify one by one to make sure that they are updated correctly on all of the console's displays (if any) and/or on the displays in the control office (if any). If any errors occur, the system configuration should be checked. If the error persists, contact your supplier.

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CHAPTER 9

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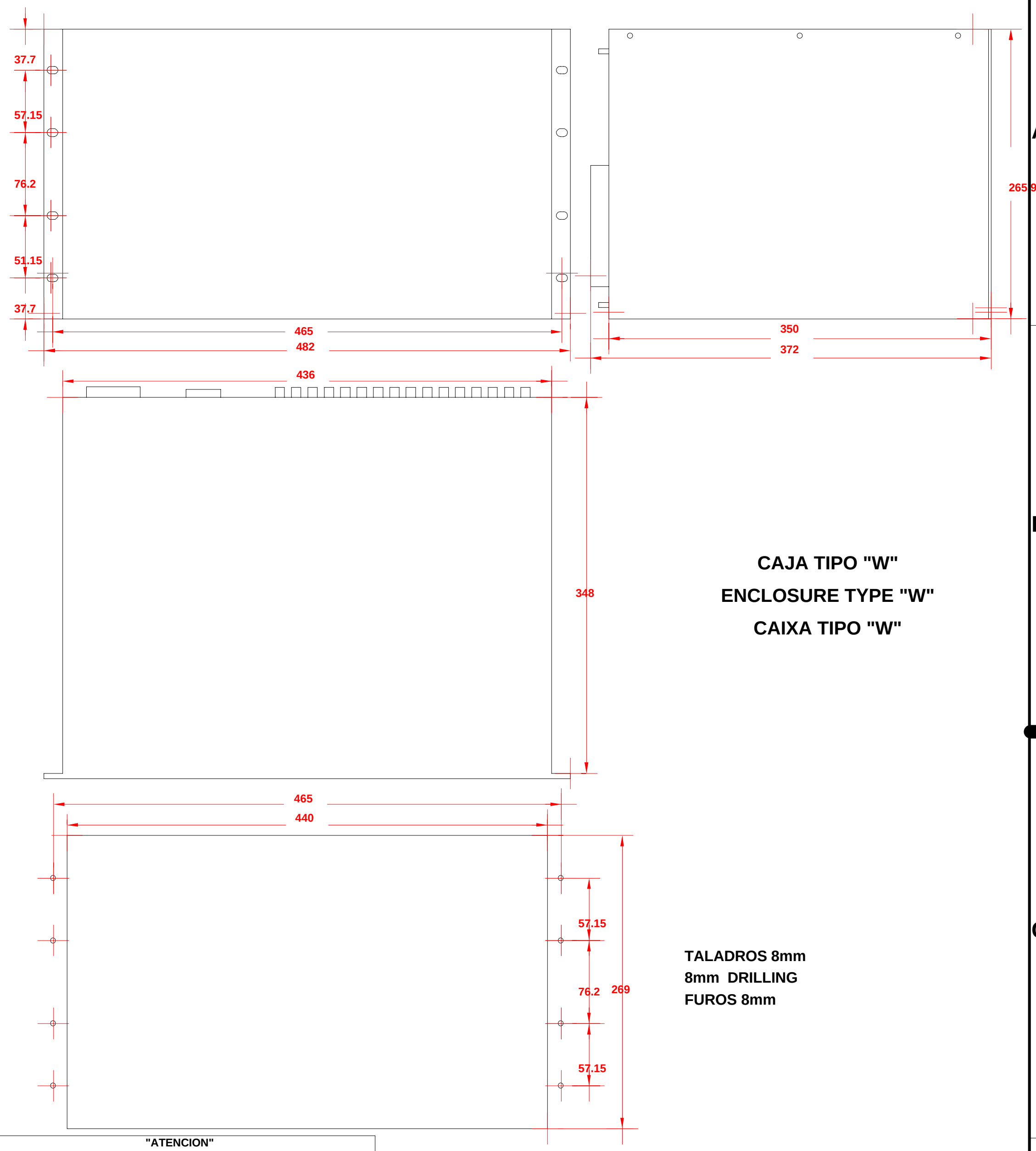
Schemes and Drawings

The following planes are attached:

Dimension and drill hole schemes	>>	4BF0100/0031
External connection schemes	>>	3RX0173/0007



CAJA TIPO "W"

ENCLOSURE TYPE "W"

CAIXA TIPO "W"

TALADROS 8mm
8mm DRILLING
FUROS 8mm

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TITULO: DIMENSIONES Y TALADRADO

PROYECTO: CAJA TIPO "W" 6U 1RACK

REVISIONES		0	CD0012165	1	CD0103163
2	CD0202125	3		4	
5		6		7	
8		9		10	
11		12		13	
14		15		16	

Rev. 0
Rev. 1 25/5/01
Rev. 2 14/2/02

NUMERO> **4BF0100/0031**

	Fecha	Nombre
Dibujado	26/2/01	J.C.S.
Aprobado	26/2/01	C.G.G.

Hoja: 1

Continua en Hoja:

LEDS

- FRONT:
  - Ready (green)
  - 8 programmable LEDS (red)
- PORTS:
  - COM1,2,3,4 -Red - TX
    -Green - Rx
- I/O MODULE:
  - 4 Programmable red LEDS (L1,L2,L3,L4) .
- ISOLATION MODULE:
  - TX/RX LEDS per port.
    -Red - TX
    -Green - Rx.

KBD

PIN	SEÑAL
1	CLOCK
2	DATA
3	N/C
4	GND
5	+5

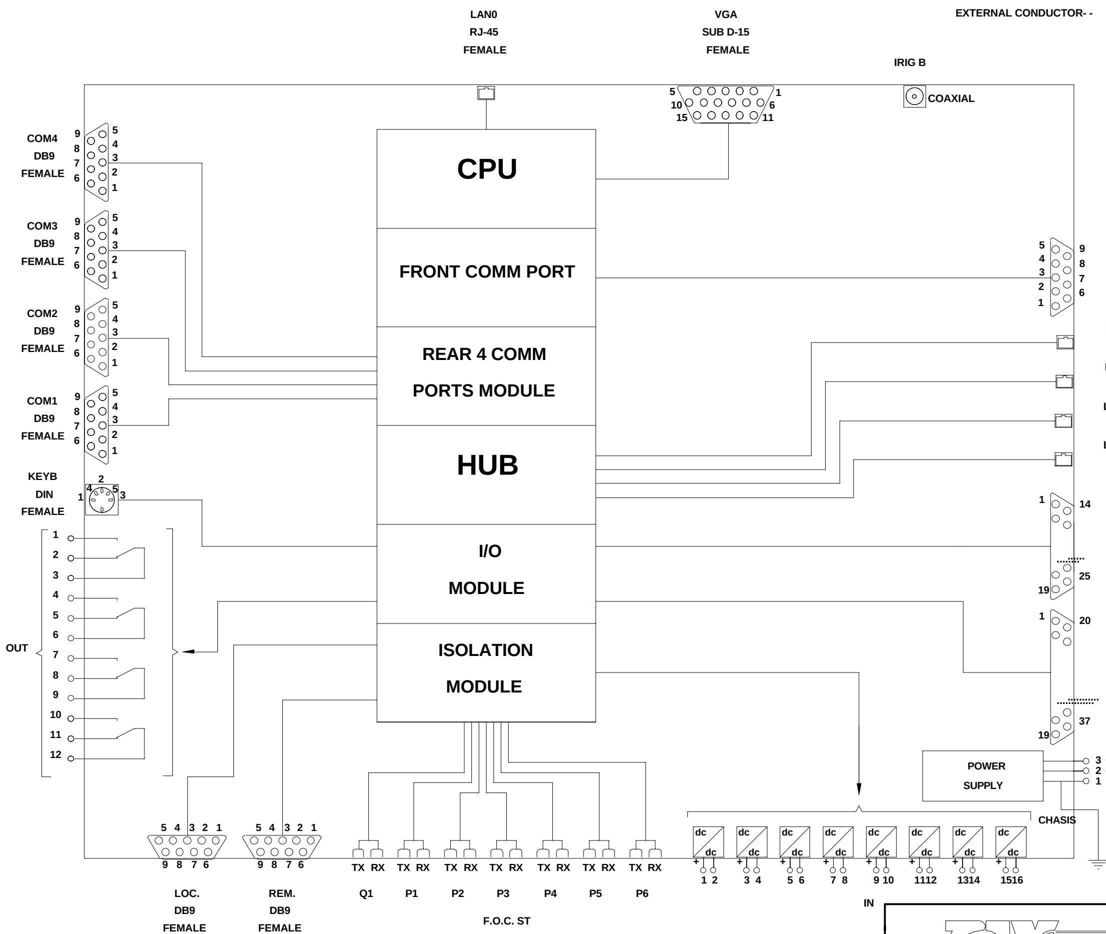
VGA

PIN	SEÑAL
1	RED VIDEO (75ohm,0.75Vpp)
2	GREEN VIDEO (75ohm,0.75Vpp)
3	BLUE VIDEO (75Ohm.0.75 Vpp)
4	ID2 (monitor ID, bit 2)
5	GND
6	RGND (red GND)
7	GGND (green GND)
8	BGND (blue GND)
9	N/C
10	SGND (Syncr. GND)
11	ID0 (monitor ID, BIT0)
12	ID1 (monitor ID, BIT1)
13	HSYNC o CSYNC (horiz. sync.)
14	VSYNC (vertical sync.)
15	ID3 (monitor ID, bit 3)

LOC REM

PIN	SEÑAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

PUSHBUTTON:
NORMAL - LAN4 (Standard LAN connector)
UPLINK- TX, RX are inverted in LAN4
- Default position is NORMAL



COM1,COM2,COM3,COM4,COM5

PIN	SIGNAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSK
7	RTS
8	CTS
9	RI

PP0

PIN	SIGNAL
1	IRQ
3	bit 15
4	bit 14
5	bit 13
6	bit 12
7	bit 11
8	bit 10
9	bit 9
10	bit 8
30	bit 7
31	bit 6
32	bit 5
33	bit 4
34	bit 3
35	bit 2
36	bit 1
37	bit 0
OTHER	—

Q0

PIN	SIGNAL
2	-
3	-
4	-
5	-
7	-
OTHER	-

LAN0,LAN1,LAN2,LAN3,LAN4

PIN	SIGNAL
1	TX+
2	TX-
3	RX+
4	N/C
5	N/C
6	RX-
7	N/C
8	N/C

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5		6		7		8		9		10
11		12		13		14		15		16

Z I V Aplicaciones y Tecnología S.A.

TITLE: EXTERNAL CONNEC. 1CPX-A03-#21000W#

PROJECT: CENTRAL UNIT

Rev.0

NUMBER: 3RX0173/0007

	Date	Name
Drawn	21/12/01	J.C.S.
Approved	21/12/01	J.M.Y.

Sheet: 1

Continued on Sheed: