1SDH001115R0001 L9951

Communication System Interface

Communication Interface for:
Protection relays Ekip LSI and Ekip LSIG + communication module Ekip Com, mounted on Tmax XT2 – XT4
Protection relay Ekip E-LSIG + communication module Ekip Com, mounted on Tmax XT4
Motor protection relay Ekip M-LRIU + communication module Ekip Com, mounted on Tmax XT2 – XT4
Motor protection relay Ekip M-LRIU, mounted on Tmax T4 – T5 – T6
Communication module Ekip Com mounted on Tmax XT2 – XT4
Protection relay Ekip E-LSIG mounted on Tmax T4 – T5

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1. INTRODUCTION

The document refers to the communication interfaces of trip units:

- Ekip LSI, Ekip LSIG, Ekip E-LSIG, Ekip M-LRIU on Tmax XT circuit breakers
- Ekip M-LRIU on Tmax circuit breakers
- Ekip Com communication module mounted on Tmax XT
- Ekip E-LSIG on Tmax circuit breakers

1.1 Scope

The aim of this document is to indicate the information necessary for communicating with the above-defined devices. Together with the devices annexes it explains the procedure to read information, to program the parameters and to use the functionalities of the above mentioned protection units.
Following are available

Communication System Interface:	1SDH001115R0001 (this document)
System Interface for Ekip LSIG Tmax XT	annex A
System Interface for Ekip LSI Tmax XT	annex A
System Interface for Ekip M-LRIU Tmax XT	annex B
System Interface for Ekip E-LSIG Tmax XT	annex C
System Interface for Ekip M-LRIU Tmax	annex D
System Interface for Ekip Com Tmax XT	annex E
System Interface for Ekip E-LSIG Tmax	annex F

1.2 Applicability

This document applies at the devices:

- Ekip LSI, Ekip LSIG, Ekip E-LSIG, Ekip M-LRIU on Tmax XT circuit breakers equipped with Ekip Com module
- Ekip M-LRIU on Tmax moulded case circuit breakers
- Ekip Com communication module in stand-alone mode
- Ekip E-LSIG on Tmax moulded case circuit breakers

Device	Circuit breaker series	Accessories	Relevant annex document
Ekip LSIG	XT2-XT4	Ekip Com (mandatory) MOE-E (for remote CB control)	1SDH001115R0001_annexA
Ekip LSI	XT2-XT4	Ekip Com (mandatory) MOE-E (for remote CB control)	1SDH001115R0001_annexA
Ekip M-LRIU	XT2-XT4	Ekip Com (mandatory) MOE-E (for remote CB control)	1SDH001115R0001_annexB
Ekip E-LSIG	XT4	Ekip Com (mandatory) MOE-E (for remote CB control)	1SDH001115R0001_annexC
Ekip M-LRIU	T4-T5-T6	---	1SDH001115R0001_annexD
Ekip LS/I	XT2-XT4	Ekip Com (mandatory) (*) MOE-E (for remote CB control)	1SDH001115R0001_annexE
Ekip N-LS/I	XT2-XT4	Ekip Com (mandatory) (*) MOE-E (for remote CB control)	1SDH001115R0001_annexE
Ekip G-LS/I	XT2-XT4	Ekip Com (mandatory) (*) MOE-E (for remote CB control)	1SDH001115R0001_annexE
Ekip Z-LS	XT2-XT4	Ekip Com (mandatory) (*) MOE-E (for remote CB control)	1SDH001115R0001_annexE

Device	Circuit breaker series	Accessories	Relevant annex document
Ekip M-I	XT2	Ekip Com (mandatory) (*) MOE-E (for remote CB control)	1SDH001115R0001_annexE
Thermomagnetic relays (TMD, TMA, TMG, MF, MA)	XT2-XT4	Ekip Com (mandatory) (*) MOE-E (for remote CB control)	1SDH001115R0001_annexE
Switch disconnectors	XT2-XT4	Ekip Com (mandatory) (*) MOE-E (for remote CB control)	1SDH001115R0001_annexE
Ekip E-LSIG	T4-T5	---	1SDH001115R0001_annexF

(*) Ekip Com allows only reading information about CB status and sending command to CB (with MOE-E installed)

1.3 Bibliography

Schneider Automation Inc., 'Modicon Modbus protocol reference guide'
Modbus IDA, "Modbus messaging on TCP/IP implementation guide"

1.4 Acronym and definition

1.4.1. Acronym

CB	Circuit Breaker
AI	Analog Input
AO	Analog Output
LSb	Least Significant Bit
LSB	Least Significant Byte
MSb	Most Significant Bit
MSB	Most Significant Byte
ADU	Application Data Unit
PDU	Protocol Data Unit

1.4.2. Definitions

ALARM: there are two types of alarm:

Alarm Type	Definition
Alarm	It is similar to a status. A Trip Reset is NOT necessary to reset it. Ex. L Pre-alarm, S Timing, ...
Trip	Only a command can reset it, i.e. a new alarm will not be signalled until the reset. Ex. L Tripped, S Tripped, ...

CB RESET: event (Any Trip) /alarm reset of any information related to the (last) trip together with CB open (if MOE-E is present)

DEVICE: Protection Unit

EVENT: information that signals normal (foreseen) device behaviour. Typically, the producer of an event is the device, while the consumer is the system.

PARAMETER: information that allows configuration of device functionality (e.g. a protection algorithm).

PROTECTION TRIPS: real protection trips. 'Real' means 'not caused by the Test Unit'.

PROTECTION UNIT: electronic devices that implement protection algorithms

REGISTER: the least analogue information container (one word = 2 bytes)

REMOTE SYSTEM: a device (SCADA) which behaves as Master on the external bus. It polls the information provided by the device and sends to it commands and parameters.

STATUS: information that represents the dynamics of functionality (e.g. the CB or a protection algorithm). It can be managed (i.e. set/reset) only by the device itself.

TRIP COMMAND FAIL: after a protection trip, with relevant opening command to the release, CB stays in CLOSED state. In this case, the device tries to open the CB by starting a back-up procedure.

TRIP RESET: command equal to CB Reset, without opening CB

2. COMMUNICATION MAP

2.1 Protection functions

The following table shows the available protections for each type of device:

	Ekip LSI	Ekip LSIG	Ekip E-LSIG	Ekip M-LRIU
L	√	√	√	√
S	√	√	√	
I	√	√	√	√
G		√	√ (1)	√ (1)
LC (2)	√	√	√	
R (stall)				√ (1)
R (jam)				√ (1)
U (phase loss)				√ (1)
U (unbalance)				√ (1)
UC				√ (1)
PTC				√
UV (3)			√ (1)	
OV (3)			√ (1)	

Table 1 Available protections

Legend:

√	**Available**
	Not available

(1) available only with electronic set enabled
(2) alarm only, no trip
(3) it is possible to select trip mode: enabled = trip | disabled = alarm

2.2 Measures

The following table shows the available measures for each type of device:

	Ekip LSI	Ekip LSIG	Ekip E-LSIG	Ekip M-LRIU
Line currents	Y	Y	Y	Y
Neutral current	Y	Y	Y	
Line to neutral voltages (1)			Y	
Line to line voltages (1)			Y	
Ground current	Y	Y	Y	Y
Total active power (1)			Y	
Line active powers (1)			Y	
Total reactive power (1)			Y	
Line reactive powers (1)			Y	
Total apparent power (1)			Y	
Line apparent powers (1)			Y	
Total power factor (1)			Y	
Line power factors (1)			Y	
Net frequency(1)			Y	
Min and max net frequency(1)			Y	
Trip history	Y	Y	Y	Y
Active energy(1)			Y	
Reactive energy(1)			Y	
Apparent energy(1)			Y	
Total harmonic distortion (2)			Y	
Current harmonics (2)			Y	
Contact wear (3)			Y	
Min/Max measures			Y	

Table 2 Available measures

Legend:

Y	**Available**
Y	**Available with four pole CB only**
	Not available

(1) available if Vaux present or sum of currents (L1+L2+L3+Ne) greater than 0.5 In
(2) available with a command sent by communication
(3) available with auxiliary supply and Ekip Com present

2.4 Communication system interface annex

Communication device annex is in MS Excel format and is made of 4 different sheets:

1) **Front page:** it contains title, version, date
2) **Map:** it contains information available on the device and how to interface to it

Definition	Description
Data type	Define the data type: **CHAR** ASCII character **U8** unsigned 8 bit **U16** unsigned 16 bit **U32** unsigned 32 bit **S8** signed 8 bit **S16** signed 16 bit **S32** signed 32 bit
Units of measure	Unit of measure of the parameter
Multiplier	Coefficient to convert data from protocol format to user format Example: data = 40 multiplier = 0.1 user format = 0 4
Range	Allowable range for the parameter
Access	**R** = Read only **RW** = Read-Write
Stored/Volatile	**Stored** = data saved permanently into the memory of device **Volatile** = data available up to next turn off
Description	A short description of the parameter
Modbus address (DEC)	Starting address or register address to put into PDU (decimal format)
Modbus address (HEX)	Starting address or register address to put into PDU (hexadecimal format)
Modbus number of registers	Number of registers to put into PDU
Bit field (X = YES)	Show if the register is handled as a bit field
Modbus function	Show with a '**X**' the functions available for the parameter to put into PDU

Table 3 Legend for communication device annex

3) **Tables:** it contains tables to define fields described into 'Map' sheet
4) **Revision history:** it contains the differences introduced into every version

3. MODBUS PROTOCOL

The Modbus protocol defines a simple 'Protocol Data Unit' **(PDU)** independent of the underlying communication layers. The mapping of Modbus protocol on specific buses or networks can introduce some additional fields on the 'Application Data Unit' **(ADU)**.

3.1 Data management

3.1.1. ADU on Modbus RTU

ADU		
Slave device address	**PDU**	**Error check (CRC)**

Table 4 General Modbus frame

3.2 Format management

Data format LINT (Acronym 1.4.1) (4 bytes = 2 words = 2 registers) is transferred with low significant part at lower Modbus address (LOW-HIGH)

Register i	LS word
Register i + 1	MS word

Within WORD data the most significant byte is transferred first (according to Modbus RTU standard)

MS byte	LS byte

3.3 Framing management

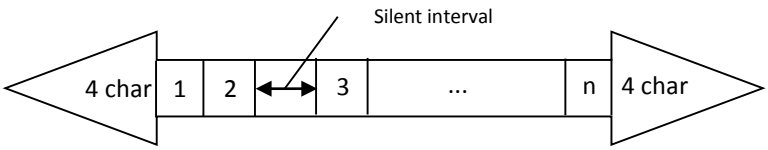
3.3.1. Device RTU Framing

The allowed inter-character silent interval has been relaxed from 'at least 2 characters' to 'at least 4 characters' (the same silent interval to recognize the end of a message). This means:

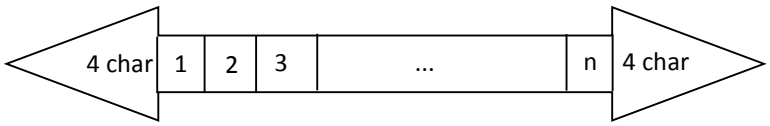
Silent interval < 4 char between two characters inside the message
In this case, the receiver filters the silent interval and the following characters will be appended to those already received. The difference from the protocol specification is:

1. Silent interval < 2 char between two characters inside the message

Transmitter



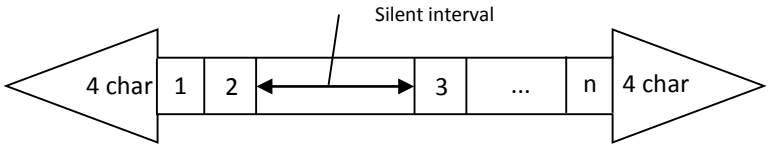
Receiver



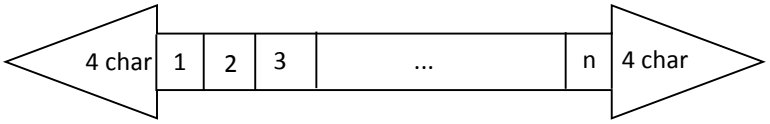
The behaviour is exactly as specified by the protocol.

2. Silent interval ≥ 2 char and < 4 char between two characters inside the message
   The received characters are NOT flushed and the following ones will be appended.

Transmitter



Receiver



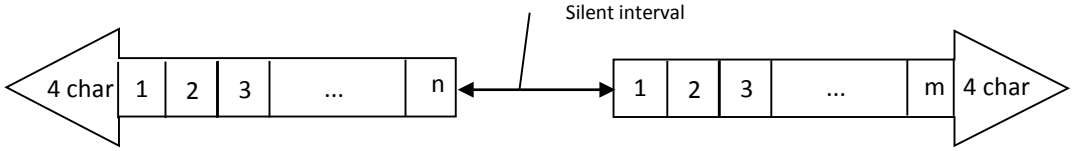
Note that after flushing, the standard protocol specification allows:
- reception of the remaining characters of a partially received message
- reception of a completely new message

The device behaviour **doesn't cover the second case** because it always appends new incoming characters to the previous ones, leading to a CRC error.
So the behaviour is exactly the same if and only if the incoming characters are NOT a new message. In this case the received packet will lead to a CRC error and the CRC error counter will be incremented.

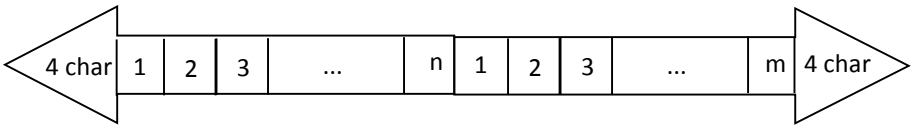
Silent interval ≥ 4 char between two characters inside the message
If the message transmission is NOT ended, all the previously received characters are managed as a message because this is exactly the protocol specification regarding the end of a message.

New frame before 4 character silent interval at the end of a frame
In this case, the receiver filters the silent interval and the following characters (of the new frame) will be appended to those already received.
This will lead to a CRC error.

Transmitter



Receiver



So the CRC error counter will count both the 'real' CRC errors and the inter-character errors.

3.4 Communication Parameters

Available communication parameters are:

Baud rate	Slave device address	Physical protocol
9600/19200	1 ÷ 247	E, 8, 1 / O, 8, 1 N, 8, 2 / N, 8, 1

Table 5 Communication parameters

The default parameters configuration is:

Baud rate	Slave device address	Physical protocol
19200	247	E, 8, 1

Table 6 Default communication parameters

3.5 Devices identification

Unit	Slave ID
Ekip LSIG for XT2 – XT4	0x09
Ekip LSI for XT2 – XT4	0x0A
Ekip M-LRIU for XT2 – XT4	0x0B
Ekip E-LSIG for XT4	0x12
Ekip M-LRIU for T4 – T5 – T6	0x15
Ekip Com for XT2-XT4	0x01
Ekip E-LSIG for T4-T5	0x1B

Table 7 Units identification

3.6 Available Modbus functions

Function code		Name	Applicable to
03 (03h)		Read Holding Registers	AO
04 (04h)		Read Input Registers	AI
06 (06h)		Write Single Register	AO
Function code	**Sub function code**	**Name**	**Applicable to**
08 (08h)	00 (00h)	Diagnostic Loop back	---
Function code		**Name**	**Applicable to**
16 (10h)		Write Multiple Registers	AO
17 (11h)		Report Slave ID	---

Note 1. All queries must respect the limitation of maximum Modbus message length of 256 byte

Table 8 Available Modbus function

3.7 PDU Structure

3.7.1. Function 03 (03h) - Read Holding Registers

Query

PDU				
Function	Starting address		Number of registers	
03h	High	Low	High	Low

Note 2. Number of registers ≤ 125

Response

PDU						
Function	Byte count	Register value		...	Register value	
03h	nn	High	Low	...	High	Low

3.7.2. Function 04 (04h) - Read Input Registers

Query

PDU				
Function	Starting address		Number of input registers	
04h	High	Low	High	Low

Note 3. Number of registers ≤ 125

Response

PDU						
Function	Byte count	Input register		...	Input register	
04h	nn	High	Low	...	High	Low

3.7.3. Function 06 (06h) - Write Single Register

Query

PDU				
Function	Register address		Register value	
06h	High	Low	High	Low

Response

PDU				
Function	Register address		Register value	
06h	High	Low	High	Low

3.7.4. Function 08 (08h) - Diagnostic

Query

PDU				
Function	**Sub function**		**Data**	**…**
08h	**00h**	**00h**	**yy**	**…**

Note 4. 0 ≤ Number of data bytes ≤ 250, any value

Response

PDU				
Function	**Sub function**		**Data**	**…**
08h	**00h**	**00h**	**yy**	**…**

3.7.5. Function 16 (10h) - Write Multiple Registers

Query

PDU										
Funct	**Starting address**		**Number of registers**		**Byte count**	**Register value**		**…**	**Register value**	
10h	**High**	**Low**	**High**	**Low**	**Nn**	**High**	**Low**	**…**	**High**	**Low**

Note 5. Number of registers ≤ 123

Response

PDU				
Function	**Starting address**		**Number of register**	
10h	**High**	**Low**	**High**	**Low**

Note 6. Number of registers ≤ 123

3.7.6. Function 17 (11h) - Report slave ID

Query

PDU
Function
11h

Response

PDU								
Function	**Byte count**	**Slave ID**	**Run indicator**	**Device SW version**		**Status address**		**Device serial number**
11h	**16h**	**ID**	**0FFh**	**High**	**Low**	**High**	**Low**	**16 byte (ASCII)**

3.8 Commands

Each command is formed by 2 fields:

Field name	
Command type	MS word
Command parameter	LS word

Table 9 Command structure

To execute the command, both fields shall be written in the same query.
Write into 'Command type' field the command code (mandatory) and into 'Command parameter' field the parameter value (optional, 0 if not required).
The only allowed Modbus function is 'Write multiple registers' (§ 3.7.5).

Example 1
To send 'Trip reset' command, write '01' as 'Command type' field and '00' as 'Command parameter' field (parameter not necessary for this command).

Query

PDU									
Function	**Starting address**		**Number of registers**		**Byte count**	**Command type**		**Command parameter**	
10	**00**	**00**	**00**	**02**	**04**	**00**	**01**	**00**	**00**

Response

PDU				
Function	**Starting address**		**Number of register**	
10	**00**	**00**	**00**	**02**

Example 2
To send 'Harmonics acquisition start' command on L2 phase, write '16' at 'Command type' field and '01' at 'Command parameter' field.

Query

PDU									
Function	**Starting address**		**Number of registers**		**Byte count**	**Command type**		**Command parameter**	
10	**00**	**00**	**00**	**02**	**04**	**00**	**10**	**00**	**01**

Response

PDU				
Function	**Starting address**		**Number of register**	
10	**00**	**00**	**00**	**02**

3.9 Exception responses

3.9.1. Illegal function

PDU	
Function	**Exception code**
Function + 80h	**01h**

3.9.2. Illegal data address

PDU	
Function	**Exception code**
Function + 80h	**02h**

3.9.3. Illegal data value

PDU	
Function	**Exception code**
Function + 80h	**03h**

3.9.4. Slave device failure

PDU	
Function	**Exception code**
Function + 80h	**04h**

3.9.5. Slave device busy

PDU	
Function	**Exception code**
Function + 80h	**06h**

3.9.6. Exception occurrences

		Exception				
		01 Illegal function	**02 Illegal data address**	**03 Illegal data value**	**04 Slave device failure**	**06 Slave device busy**
QUERY FUNCTION	**03**		- Starting address not valid	- Invalid query length - Number of requested registers not valid		
	04		- Starting address not valid	- Invalid query length - Number of requested registers not valid		- Reading attempt of busy non-volatile memory at present
	06		- Starting address not valid	- Invalid query length	- Parameter out of range (checked when written)	- Local state (1)
	08			- Sub function ≠ 00 00 - Invalid query length		
	16		- Starting address not valid	- Invalid query length - Number of registers not valid - Command not available - Command parameter field not valid - No rights to start a programming session (3)	- Parameters error (checked after a stop programming session command) - Alarm presence (checked after stop programming session command) - Parameter out of range (checked when written)	- Local state (1) - Programming session already open (3) - Programming session not open (4) - Session opened with alarms on - Command acceptance conditions not verified (2)
	17			- Invalid query length		
	Other	- Function unavailable				

Table 10 Exception occurrences

(1) not available for Ekip M-LRIU XT and Tmax
(2) see § 4.7
(3) checked on start programming session command
(4) checked on abort or stop programming session command

4. FUNCTIONAL DESCRIPTION

4.1 Parameters programming

WARNING: It is allowed to open a programming session only in REMOTE mode.
Ekip M-LRIU XT and Tmax are always in REMOTE mode.
There is a validity programming session timeout of 5 minutes: once expired, the session is aborted.
To extend it of 5 more minutes more, it is sufficient to send again an open programming session command.

Applicable at:

- Ekip LSI XT
- Ekip LSIG XT
- Ekip M-LRIU XT
- Ekip E-LSIG XT
- Ekip M-LRIU Tmax
- Ekip Com
- Ekip E-LSIG Tmax

The following flow chart describes the programming session.
White boxes refer to actions requested to the user.
Grey boxes refer to actions made by trip unit.
If during a session a new START PROGRAM SESSION command is sent, any change is flushed away and previous parameters are reloaded. A new session is opened.
If during a session a ABORT PROGRAM SESSION command is sent, any change is flushed away and previous parameters are reloaded. Session is closed.

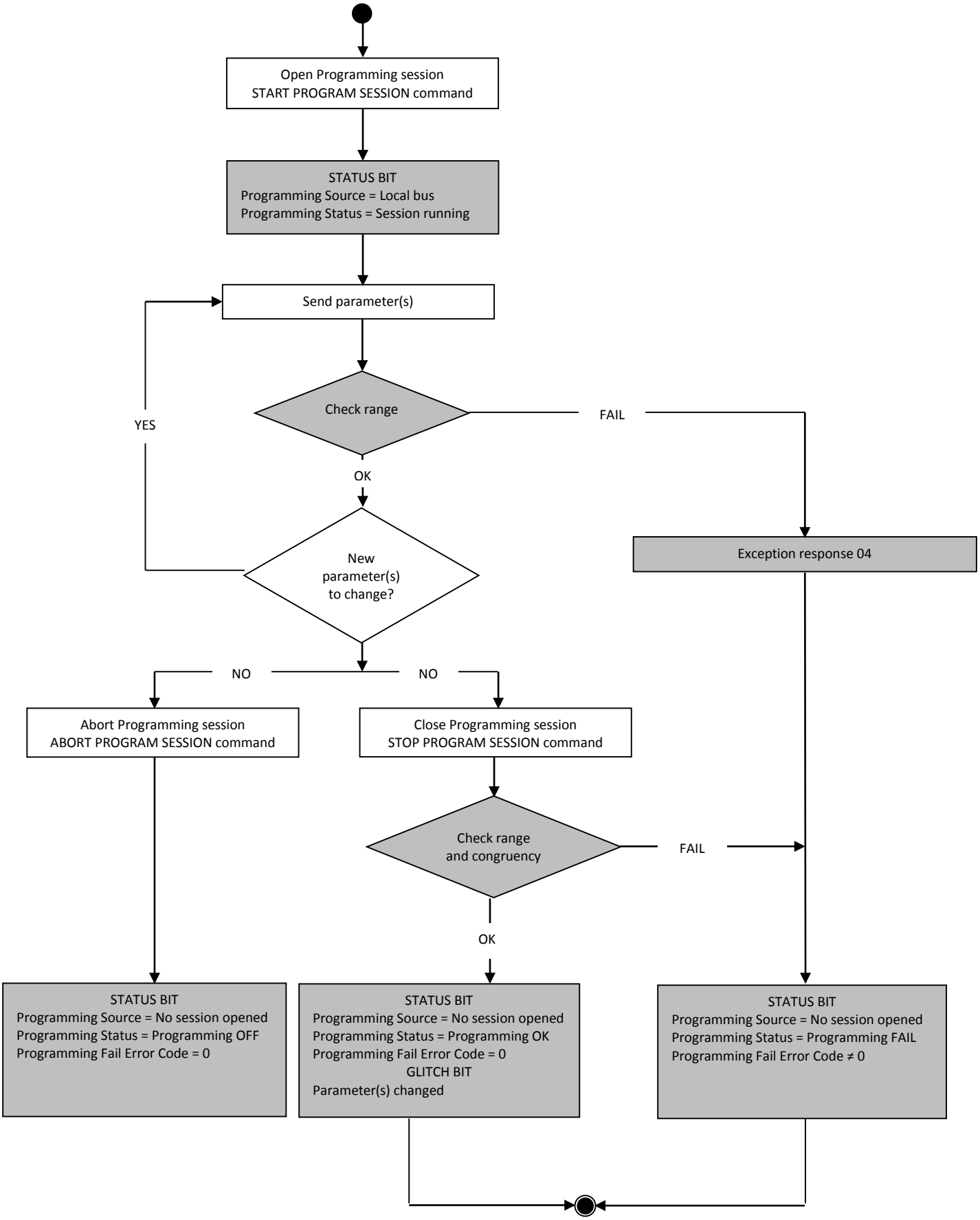


Figure 1. Programming session

4.2 Minimum and maximum measures

Applicable at:

- Ekip E-LSIG XT
- Ekip E-LSIG Tmax

The minimum and maximum values for every measure are stored.
When the device is turned off, data are erased.
It is possible to reset these measures with a command.
The format is the same described into § 4.10.

4.3 Harmonics and Total Harmonic Distortion

Applicable at:

- Ekip E-LSIG XT
- Ekip E-LSIG Tmax

It is possible to obtain the harmonic contents and the total harmonic distortion for one current phase, sending the relevant command.
The command requires a parameter to identify the phase and the net frequency.

Parameter value
L1 @ 50 Hz
L2 @ 50 Hz
L3 @ 50 Hz
Ne @ 50 Hz
L1 @ 60 Hz
L2 @ 60 Hz
L3 @ 60 Hz
Ne @ 60 Hz

When data are available a glitch is set.

4.4 CB status information

Applicable at:

- Ekip LSI XT + Ekip Com
- Ekip LSIG XT + Ekip Com
- Ekip M-LRIU XT + Ekip Com
- Ekip E-LSIG XT + Ekip Com
- Ekip Com
- Ekip E-LSIG Tmax + AUX-E

Ekip Com handles the information about CB status.

1) CB open/closed
2) CB tripped
3) CB undefined (Ekip Com detects an invalid CB status)

AUX-E handles the information about CB status.

1) CB open/closed
2) CB tripped
3) CB undefined

4.5 Communication statistical data

Applicable at:

- Ekip LSI XT
- Ekip LSIG XT
- Ekip M-LRIU XT
- Ekip E-LSIG XT
- Ekip M-LRIU Tmax
- Ekip E-LSIG Tmax

Device produces statistical data relevant to system bus communication.

1) number of received messages: counter of total number of messages received by device
2) number of received messages with CRC error: counter of total number of messages received with CRC error
3) number of transmitted messages: counter of total message sent by device
4) number of slave device busy responses: counter of total message sent by device with exception response “Slave Device Busy”
5) number of exception responses: counter of total message sent by device with any exception response

4.6 Circuit breaker statistical data

Applicable at:

- Ekip LSI XT
- Ekip LSIG XT
- Ekip M-LRIU XT
- Ekip E-LSIG XT
- Ekip E-LSIG Tmax + AUX-E

Device produces statistical data relevant to CB operations.

1) number of CB operations: counter of total CB operation
2) number of CB manual operations: counter of total CB operation due to manual opening
3) number of CB protection trips: counter of CB transition to TRIP due to protection trips
4) number of CB protection trips with trip command fail: counter of CB transition to TRIP due to protection trips with trip command fail
5) number of CB test trips: counter of CB transition to TRIP due to electronic trip test

The following table explains the relationship between CB operations and counters: 'X' shows the counters updated for every CB transitions.

Transition	Condition	Number of CB operations	Number of CB manual operations	Number of CB protection trips	Number of CB fail trips	Number of CB test trips
CLOSE TO OPEN	User operation: no trip	**X**	**X**			
CLOSE TO TRIP	Trip test					**X**
	Protection trip			**X**		
	Trip command fail				**X**	
TRIP TO OPEN	----	**X**				

Table 11. CB operations vs. counters

The relationship among counters is:

Number of CB manual operations	***+***
Number of CB protection trips	***+***
Number of CB protection trips with trip command fail	***+***
Number of CB test trips	***=***
Number of CB operations	

Table 12. Relationship among counters

4.7 Contact wear

Applicable to:

- Ekip E-LSIG XT

Contact wear estimates the status of CB contacts.
When value reaches 80% a pre-alarm warning is set.
When value reaches 100% an alarm is set.
This counter is updated only with Ekip Com present and device supplied with auxiliary supply.

Counter is updated:

- on CB status changes
- after protection trips

4.8 Test LED session

Applicable at:

- Ekip LSI XT
- Ekip LSIG XT
- Ekip M-LRIU XT
- Ekip E-LSIG XT
- Ekip M-LRIU Tmax
- Ekip E-LSIG Tmax

It is possible to test LED and to show the last trip.
User shall send START TEST LED command: LEDs are turned on in sequence from left to right.

At the end of the test, LED concerning last protection tripped is turned on. It remains on until one of these conditions is reached:

- WINK command is sent
- an alarm condition occurs
- a timing condition occurs
- protection L enters pre-alarm status
- there is a configuration error (manual parameters incongruence)
- STOP TEST LED command is sent

4.9 Commands execution conditions

For all commands, it is necessary that the device is in REMOTE operation mode, otherwise it is refused.

Command type	Action	Acceptance conditions
Dummy command	No action	-
Trip reset	Reset trip status bits	-
Reset communication statistics reset	Reset statistical data	-
Start programming session	Open programming session	No protection timings and TC connected
Abort programming session	Abort programming session Restore previous parameters values	Programming session opened
Stop programming session	End programming session	Programming session opened No consistency check errors No protection timings and TC connected
Open CB	Send open command to MOE-E	CB open command not in execution CB close command not in execution
Close CB	Send close command to MOE-E	CB in open position CB defined CB open command not in execution CB close command not in execution
Reset CB	Reset trip status bits Send open command to MOE-E	CB defined CB in trip position CB open command not in execution CB close command not in execution
Wink toggle command	Alive LED wink ON or OFF	-
Stop test LED	Exit from test LED session	-
Start test LED	Start test LED session	-
Trip test		Current less than 0.1 In
Reset minimum/maximum registers (1)	Reset minimum/maximum registers	-
Reset energy counters (1)	Reset energy counters	-
Request harmonics (1)	Calculate harmonics and THD of the selected phase	Command parameter out of range Frequency available 0.2 In ≤ I ≤ 1.2 In

Table 13 Commands acceptance conditions

(1) available only for Ekip E-LSIG XT and Tmax

4.10 Measure limits and representation

Measure	Special value	Description	Data
Currents	Too low	I < Imin	0
	Saturation	I > Imax	Imax
Internal ground current (2)	Not available	Protection G = OFF I_G > IGmax	0xFFFFFFFF
	Too low	I_G < IGmin	0
Line-to-line voltages (1)	Too low	V < Vmin	0
	Saturation	V > Vmax	Vmax
Line-to-neutral voltages (1)	Not available	Three-poles CB	0xFFFF
	Too low	V < Vmin	0
	Saturation	V > Vmax	Vmax
Active, reactive, apparent phase powers (1)	Not available	Three-poles CB	0x7FFFFFFF
	Too low	| P | < Pmin	0
	Positive saturation	P > Pmax	Pmax
	Negative saturation	P < - Pmax	- Pmax
Total power (P,Q, S) (1)	Positive saturation	P > Pmax	Pmax
	Negative saturation	P < - Pmax	- Pmax
Active, reactive, apparent energy (1)	Positive saturation	E > 2^{31}-1	0x7FFFFFFF
	Negative saturation	E < -2^{31}	0x80000000
Phase cosϕ (1)	Not available	Three-poles CB	0x7FFF
	Too low	|cosϕ| < cosϕmin	cosϕmin
	Positive saturation	cosϕ > cosϕmax	cosϕmax
	Negative saturation	cosϕ < - cosϕmax	- cosϕmax
Total cosϕ (1)	Too low	|cosϕ| < cosϕmin	cosϕmin
	Positive saturation	cosϕ > cosϕmax	cosϕmax
	Negative saturation	cosϕ < - cosϕmax	- cosϕmax
Frequency (1)	Too low	F < Fmin	Fmin
	Too high	F > Fmax	Fmax
Contact wear (1)	Saturation	CW > 100%	100.0%
Harmonic amplitude (1)	Saturation	Harm > Harm max	Harm max

(1) available only for Ekip E-LSIG XT and Tmax
(2) not available for Ekip LSI

Legend:

Imin	= 0.1 In	Pmin	= 0 W (VAR, VA)
Imax	= 14 In	Pmax	= 1000.0 kW (kVAR, kVA)
IGmin	= 0.2 In	Fmin	= 44.0 Hz
IGmax	= 2 In	Fmax	= 441.0 Hz
Vmin	= 10.0 V	cosϕmin	= 0
Vmax	= 828.0 V	cosϕmax	= 1.00
		Harm max	= 150 %

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1SDH001115R0001 L6938

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