SIEMENS

SICAM RTUs

SM-x551/GACMA0

GEC-Alstom Courier Master Protocol

System Element Manual

DC0-149-2.00

Hint

Please observe Notes and Warnings for your own safety in the Preface.

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Preface

This document is applicable to the following product(s):

- SICAM AK
- SICAM AK 3
- SICAM TM

Purpose of this manual

This manual describes the implementation of the GEC-Alstom Courier protocol Master in SICAM RTUs system.
The GEC-Alstom Courier protocol is a proprietary - serial based - communication protocol for interfacing GEC-Alstom relays (K-Series) to SICAM RTUs system.

This manual describes the functionality of the system element SM-x551/GACMA0 GEC-Alstom Courier Master protocol and essentially contains:

- Functional descriptions
- Technical Specifications
- Descriptions of interfaces to the process and other system elements
- Possible Configurations

Target Group

The document you are reading right now is addressed to users, who are in charge of the following engineering tasks:

- Conceptual activities, as for example design and configuration
- Creation of the assembly technical documentation using the designated engineering tools
- System parameterization and system diagnostic, using the designated engineering tools
- Technical system maintenance
- Above applies, as far as these tasks do not involve manipulations of the hardware.

Manipulating the hardware itself, as for example "unplugging" and "plugging" printed circuit boards and modules, or working on terminals and/or connectors – for instance when applying changes to the wiring – **are** – also if they are an issue in the context of configuration, parameterization and diagnostic – **not subject of this document**.

For activities, which comprise hardware manipulations, it is essential to pay attention to the appropriate safety instructions and to strictly adhere to the appropriate safety regulations.

Instructions and regulations are also stated in installation manuals or manuals which deal with hardware installation and other hardware manipulations.

Notes on Safety

This manual does not constitute a complete catalog of all safety measures required for operating the equipment (module, device) in question because special operating conditions might require additional measures. However, it does contain notes that must be adhered to for your own personal safety and to avoid damage to property. These notes are highlighted with a warning triangle and different keywords indicating different degrees of danger.

Danger

means that death, serious bodily injury or considerable property damage will occur, if the appropriate precautionary measures are not carried out.

Warning

means that death, serious bodily injury or considerable property damage can occur, if the appropriate precautionary measures are not carried out.

Caution

means that minor bodily injury or property damage could occur, if the appropriate precautionary measures are not carried out.

Hint

is important information about the product, the handling of the product or the respective part of the documentation, to which special attention is to be given.

Qualified Personnel

Commissioning and operation of the equipment (module, device) described in this manual must be performed by qualified personnel only. As used in the safety notes contained in this manual, qualified personnel are those persons who are authorised to commission, release, ground, and tag devices, systems, and electrical circuits in accordance with safety standards.

Use as Prescribed

The equipment (device, module) must not be used for any other purposes than those described in the Catalog and the Technical Description. If it is used together with third-party devices and components, these must be recommended or approved by Siemens.

Correct and safe operation of the product requires adequate transportation, storage, installation, and mounting as well as appropriate use and maintenance.

During operation of electrical equipment, it is unavoidable that certain parts of this equipment will carry dangerous voltages. Severe injury or damage to property can occur if the appropriate measures are not taken:

- Before making any connections at all, ground the equipment at the PE terminal.
- Hazardous voltages can be present on all switching components connected to the power supply.
- Even after the supply voltage has been disconnected, hazardous voltages can still be present in the equipment (capacitor storage).
- Equipment with current transformer circuits must not be operated while open.
- The limit values indicated in the manual or the operating instructions must not be exceeded; that also applies to testing and commissioning.

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1 Introduction

Contents

1.1 Application

The protocol element SM-x551/GACMA0 GEC-Alstom Master protocol is used in automation units of the systems SICAM AK and SICAM AK 3 for the interfacing of SICAM RTUs system with GEC-Alstom relays (K-Series) using GEC-Alstom Courier protocol. It is deployed in the field of telecontrol and automation.

Products	SICAM AK, SICAM AK 3, SICAM TM
System element type	Protocol Element
consists of	Module SM-2551 or SM-0551 with firmware GACMA0
can be used in	SICAM AK, SICAM AK 3, SICAM TM
Engineering	SICAM TOOLBOX II and OPM II

1.2 Overview

Protocol Element for GEC-Alstom Courier Master.

- GEC-Alstom Courier Master for max. 40 GEC-Alstom Relays (K-Series) using serial based GEC-Alstom Courier Protocol (external converter KITZ 102[1)] or KITZ102[1)] required)

  - Data conversion IEC 60870-5-101/104 ß à Courier Protocol (Master)
  - Supported Courier Protocol Features:
    - extraction of measurands
    - time synchronization
    - digital I/O signal status
    - control commands

[1)] KITZ 101, KITZ102:
The KITZ interface units provide protocol conversion between K-Bus, the communication medium or Courier compatible devices, and IEC870 frame format data.
It provides a serial connection (RS232/IEC870) which enables a master station running Courier software to communicate with slave devices.
KITZ101 and KITZ102 has identical functionality.
KITZ101 ... for desktop use
KITZ102 ... for rear panel mounting

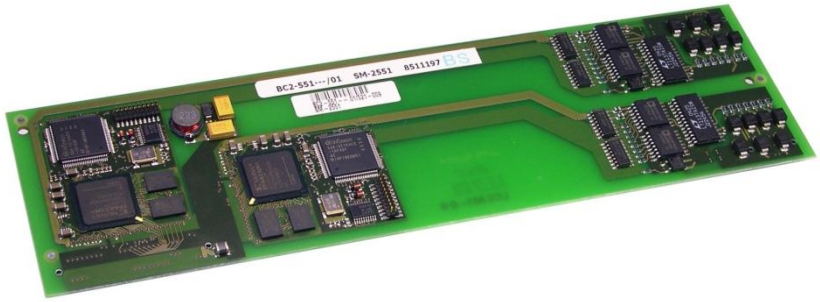
The protocol element can be attached to master control and communication elements of SICAM RTUs.

1.3 Mechanics

1.3.1 SM-2551

SIM SM-2551 can be attached to master control and communication elements of SICAM RTUs and Ax 1703 platforms.

View



1.3.2 SM-0551

SM-0551 can be attached to SIM SM-2558.

SIM SM-2558 can be attached to master control and communication elements of SICAM RTUs and Ax 1703 platforms.

View

Further Information see chapter 2.3.2; Hardware

2 Protocol Element SM-x551/GACMA0

Contents

2.1 Features and Functions

The following firmware's are available for the different systems:

Firmware	System	Standard and Function
GACMA0	SICAM AK SICAM TM SICAM AK 3	GEC-Alstom Courier Master [1)]

1) in addition the external converter GEC-Alstom KITZ 101 or KITZ 102 is required!

2.1.1 General Functions

Function	GACMA0
· **GEC-Alstom Courier Master**	
– max. number of GEC-Alstom Courier Slaves	40
– GEC-Alstom Courier Slaves address range	1-254
– max. number of process information in command direction (transmit direction)	1000
– max. number of process information in monitoring direction (receive direction)	4000
· **Supported GEC-Alstom Courier Protocol Functions**	
– Extractions of Measurands	ü
– Time Synchronization	ü
– Digital I/O Signal Status	ü
– Control Commands	ü
– Extractions of Disturbance Records	
– Extractions of Fault Records	
– Reset of Fault & Alarm Records	
– Clear Event & Fault Records	
– Display & Modification of Settings	
– Programmable Scheme Logic Settings	
– Single Level Addressing	ü
– Multi Level Addressing	
– K-BUS Frame Format	
– IEC60870 Frame Format	ü
· **Acquisition of events (transmission of data ready to be sent)**	ü
· **General interrogation, outstation interrogation** [1)]	ü
· **Command transmission**	ü
– Set control location	
– Check control location	

Function	GACMA0
· **Setpoint transmission**	
· **Transmission of integrated totals** [2)]	ü
· **Protocol element control and return information**	
Protocol element control	
– Send (general) interrogation command to all	
– Send (general) interrogation command to GI group	
– Set control location	
Protocol element return information	
– Station failure	
– Protocol specific return information 0 … 7	
· **Redundancy** (functions for the support of redundant communication interfaces)	ü
· **Engineering**	
– SICAM TOOLBOX II + OPM	ü
· **Accessories (mandatory)**	
– KITZ101: Converter K-BUS <> RS232/IEC60870-FT1 (for desktop use) (protocol converter between K-Bus, the communication medium or Courier compatible devices, and IEC870 frame format data)	ü
– KITZ102: Converter K-BUS <> RS232/IEC60870-FT1 (for desktop use) (protocol converter between K-Bus, the communication medium or Courier compatible devices, and IEC870 frame format data)	ü

[1)] Courier protocol does not define a general interrogation.
The actual state of data will be read cyclic from the slave.
After SICAM RTUs internal IEC60870-5-101/-104 general interrogation command from BSE à PRE the interrogated data will be sent to BSE with cause of transmission COT= 20 (interrogated by station interrogation) after next cyclic reading of data.

[2)] Courier protocol does not define a counter interrogation procedure.
The actual state of data will be read cyclic from the slave.
After SICAM RTUs internal IEC60870-5-101/-104 counter interrogation command from BSE à PRE the interrogated counters will be sent to BSE with cause of transmission COT= 37 (requested by general counter request) from PRE internal data base.

2.1.2 Message Formats

· **Supported message formats in command direction (=transmit direction) IEC60870-5-101/-104 à Courier Protocol (Master)**	
– <TI:=45> Single command	ü
– <TI:=46> Double command	ü
– <TI:=100> Interrogation command	ü
– <TI:=101> Counter interrogation command	ü
– <TI:=103> Time synchronization command	ü
· **Supported message formats in monitoring direction (receive direction) IEC60870-5-101/-104 ß Courier Protocol (Master)**	
– <TI:=30> Single-point information with time tag CP56Time2a	ü
– <TI:=31> Double-point information with time tag CP56Time2a	ü
– <TI:=34> Measured value, normalized value with time tag CP56Time2a	ü
– <TI:=35> Measured value, scaled value with time tag CP56Time2a	ü
– <TI:=36> Measured value, short floating point value with time tag CP56Time2a	ü
– <TI:=37> Integrated totals with time tag CP56Time2a	ü
· **Supported Courier Protocol data formats in command direction (=transmit direction)**	
– 1 bit of binary flags	ü
– 2 bit of binary flags (circuit breaker control)	ü
· **Supported Courier Protocol data formats in monitoring direction (=receive direction)**	
– 1 bit of binary flags	ü
– 2 bit of binary flags	ü
– Courier number (proprietary data format)	ü
– Signed/unsigned integer	ü
– Short floating point	ü

Hints

The above mentioned functions are described in detail in the chapter *Protocol Description*.

This protocol element supports only a restricted area of the protocol functionality for coupling to systems of other product groups or to systems of third party suppliers.
For using this protocol element in your project you have to verify if the supported functionality and supported data formats of the protocol element will be compatible to the required functionality and data formats for interfacing a specific 3rd party system.

2.1.3 Restrictions

- Extractions of Disturbance Records is not supported.
- Extractions of Fault Records (short and complex) is not supported.
  But the acknowledgement of fault records is supported
- Clear Event & Fault Records is not supported.
- Display & Modification of Settings is not supported.
- Programmable Scheme Logic Settings is not supported.
- Control location is not supported.
- The cycle time for data exchange between protocol element and slave cannot be guaranteed in all cases.
  (the PRE internal processing time depends on number of configured data points and the number of data changes)
- The output of short changes of indications on slave devices cannot be guaranteed caused by cyclic data exchange, exception: event data.
- Only single level addressing is supported. Multi level addressing means that the GACMA0 would not directly communicate to the Courier slave devices. There could be more than one level of master control units between. Each level adds its own address to the address data field.
- Requests resulting multiple transactions cannot be generated.

2.2 Modes of Operation

Operating mode	Patch Plug	Extras [1)]	Note
Unbalanced interchange circuit V.24/V.28 V.28 asynchronous	CM-2860 [a)]	KITZ 101 or KITZ 102	· 1200, 2400, 4800, 9600, 19200 bit/s · Signals and levels according to V.24, V.28, RS-232 · RJ45 connector RXD, TXD, CTS, RTS, DCD, DTR, DSR/+5 V, GND

1) Extras is optional equipment
KITZ 101, KITZ102:
- The KITZ interface units provide protocol conversion between K-Bus, the communication medium or Courier compatible devices, and IEC870 frame format data.
It provides a serial connection (RS232/IEC870) which enables a master station running Courier software to communicate with slave devices.
KITZ101 and KITZ102 has identical functionality.
KITZ101 ... for desktop use
KITZ102 ... for rear panel mounting

a) Patch Plug for SICAM AK
Note: no patch plug required for SICAM AK 3
("patch plug CM-2860 is integrated in hardware of CP-2016, CP-2019)

2.3 Communication

For the stations to communicate with each other, suitable transmission facilities and/or network components may be needed in addition.

Own Station (Courier Master)

System	System Element	Protocol Element	Note
SICAM AK	CP-2014/CPCX25 CP-2017/PCCX25	SM-2551/GACMA0 SM-0551/GACMA0	max. 40 Slaves [1)]
SICAM AK 3	CP-2016/CPCX26 CP-2019/PCCX26	SM-2551/GACMA0 SM-0551/GACMA0	max. 40 Slaves [1)]
SICAM TM	CP-6014/CPCX65	SM-2551/GACMA0 SM-0551/GACMA0	max. 40 Slaves [1)]

1) external Gateway KITZ101 or KITZ102 is required!

Remote Station (Courier Slaves)

System	System Element	Protocol Element	Note
Alstom Micom Relays			Courier Protocol according supported functionality as defined in Siemens GACMA0 system element manual
Alstom K-Series Relays			Courier Protocol according supported functionality as defined in Siemens GACMA0 system element manual
3rd party system			Courier Protocol according supported functionality as defined in Siemens GACMA0 system element manual

2.4 Configurations

SM-2551/GACMA0 in SICAM AK und SICAM TM

The following table lists supported configurations. In addition to one (SI0/SI1 or SI2/SI3) or two (SI0/SI1 and SI2/SI3) SM-2551, all parts (carrier module, connection board, patch plug, etc.) listed for the chosen configuration are needed:

Configuration			Interfaces			
Carrier Module (BSE)	**Connection Board** [1]	**Patch Plug** [1]	**SI0**	**SI1**	**SI2**	**SI3**
CP-2014	CM-2839	CM-2860	ü	ü		
CP-2017	CM-2838	CM-2860	ü	ü	ü	ü
CP-6014	---	CM-2860	ü	ü	ü	ü

[1] one connection board for each carrier module, one patch plug for each interface

SM-0551/GACMA0 in SICAM AK und SICAM TM

The following table lists supported configurations. In addition to SM-0551, all parts (SIM, carrier module, connection board, patch plug, etc.) listed for the chosen configuration are needed:

Configuration				Interfaces			
Carrier Module	**SIM**	**Connection Board** [1]	**Patch Plug** [1]	**SI0**	**SI1**	**SI2**	**SI3**
CP-2014	[4]	CM-2839	CM-2860	ü	[6]		
CP-2017	[4]	CM-2838	CM-2860	ü	[6]	ü	[6]
CP-6014	[4]	---	CM-2860	ü	[6]	ü	[6]

[1] one connection board for each carrier module, one patch plug for each interface

[4] SM-2558 required, on which SM-0551 can be installed

[6] interface is not operated by SM-0551 but directly by SM-2558

SM-2551/GACMA0 in SICAM AK 3

The SIM SM-2551 can be attached to the SICAM AK 3 basic system elements. The following table lists the required modules and the interface where the protocol is supported.

Basic System Element	SIM	BSE Interface			
		X0	**X1**	**X2**	**X3**
CP-2016	SM-2551	-	-	ü	ü
CP-2019	SM-2551	-	-	ü	ü

SM-0551/GACMA0 in SICAM AK 3

The SIM SM-0551 module can be attached to the SIM SM-2558. SM-2558 on the other hand can be attached to the SICAM AK 3 basic system elements.

The following table lists the required modules and the interface where the protocol is supported.

Basic System Element	SIM	BSE Interface			
		X0	X1	X2	X3
CP-2016	SM-2558 + SM-0551	-	-	ü	-
CP-2019	SM-2558 + SM-0551	-	-	ü	-

Hint

Details on assembly of SIMs and Patch Plugs can be found in the user manual of the respective SICAM RTU, chapter *Setup of external Communication Connections*.

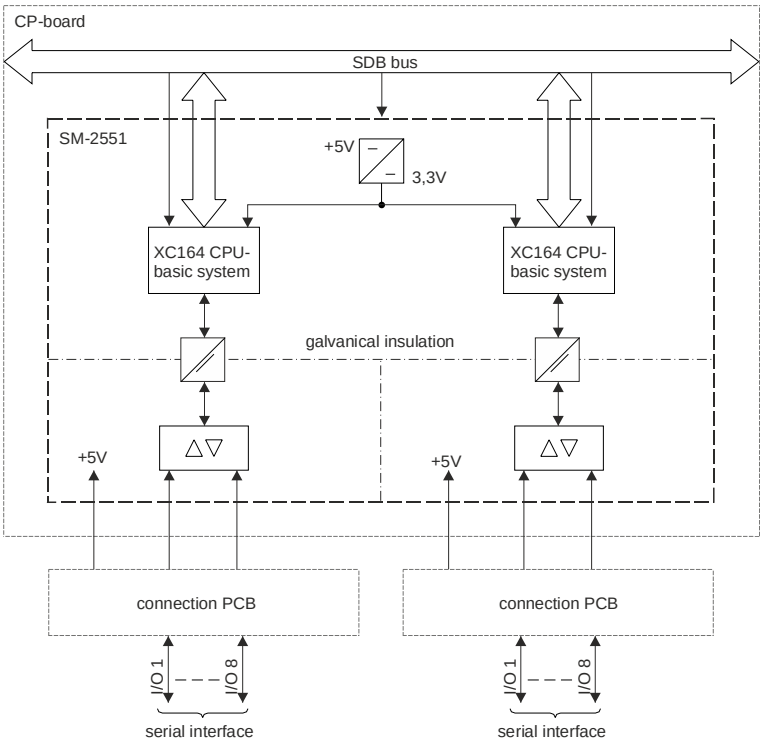
Details on assembly of the protocol elements for SICAM AK 3 can be found in *SICAM AK 3 user manual* , chapter *Setup of external Communication Connections*.

2.5 Engineering

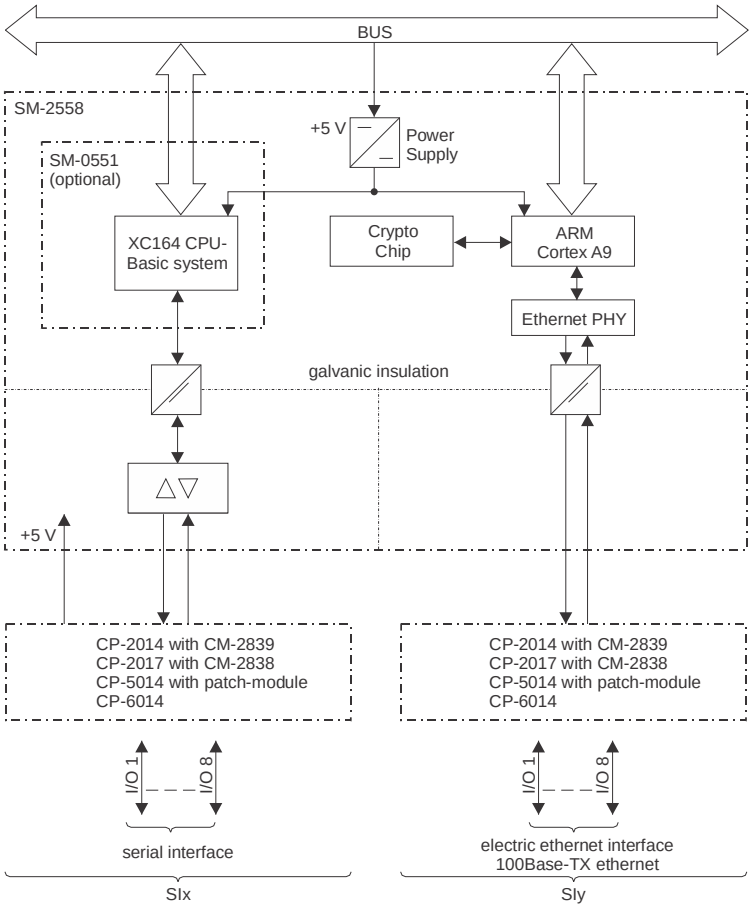
For diagnosis, testing, parameter setting or documentation, the system element is supported by the engineering tools of SIEMENS TOOLBOX II. OPM II is required.

2.6 Block Diagram

2.6.1 SM-2551



2.6.2 SM-0551



... on SM-2558

2.7 Technical Specifications

2.7.1 SM-2551

Communication Circuits	
2 serial interfaces	· Interface characteristics, interface signals, modes of operation, transmission rates – see description of the respective protocol, "Modes of operation" · Instead of the interface signal DSR the gate circuit voltage (+5 VDC) can be provided (settable) · Ability to be connected in parallel – outgoing interface signals in tristate technology – up to 2 interfaces can be connected in parallel – circuits for incoming interface signals always active · The signals are galvanically insulated from logic circuits · Line lengths V.28 – 50 bps up to 25 m – 115200 bps up to 5 m
Power supply	
Operating voltage	4.75…5.25 VDC, typ. 300 mA, max. 540 mA @5 V The voltage is supplied by the carrier module.
Gate circuit voltage +5VDC instead of DSR	· Voltage 4.7…5.6 VDC · Max. output current 150 mA at U > 4.75 V · Max. output power 750 mW · Max. idle voltage £ 5.6 VDC · Not short-circuit proof · Not overload proof · Galvanically insulated from logic voltage · The voltage (data circuit voltage) is supplied by the carrier module (galvanically insulated)
Mechanics	
Dimensions	227.3 x 63.5 mm
Weight	Approx. 200 g

2.7.2 SM-0551

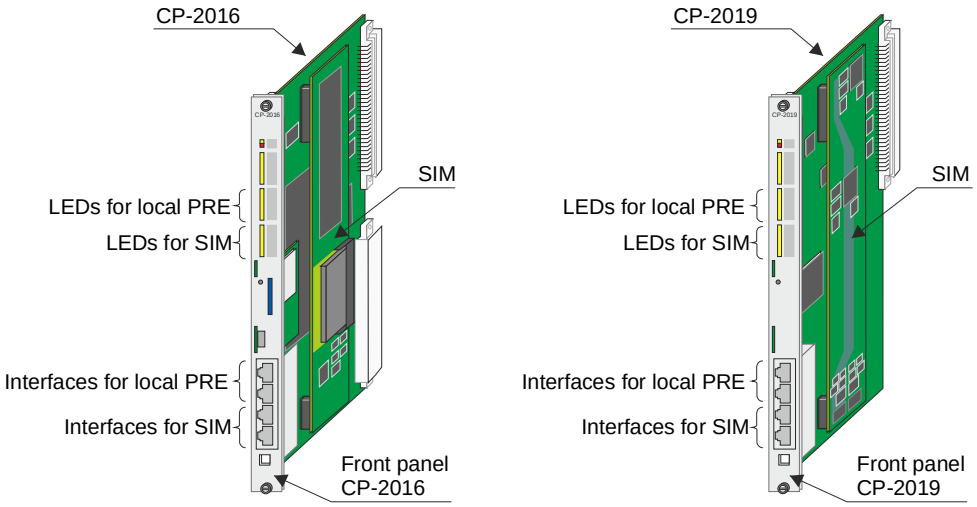
Communication Circuits	
1 serial interface	· Interface characteristics, interface signals, modes of operation, transmission rates – see description of the respective protocol, "Modes of operation" · Instead of the interface signal DSR the gate circuit voltage (+5 VDC) can be provided (settable) · Ability to be connected in parallel – outgoing interface signals in tristate technology – up to 2 interfaces can be connected in parallel – circuits for incoming interface signals always active · The signals are galvanically insulated from logic circuits · Line lengths V.28 – 50 bps up to 25 m – 115200 bps up to 5 m
Power supply	
Operating voltage	4.75…5.25 VDC, typ. 25 mA, max. 50 mA @5 V 3.14…3.47 VDC, typ. 150 mA, max. 330 mA @3.3 V The voltage is supplied by the carrier module.
Gate circuit voltage +5 VDC instead of DSR	· Voltage 4.7…5.6 VDC · Max. output current 150 mA at U > 4.75 V · Max. output power 750 mW · Max. idle voltage £ 5.6 VDC · Not short-circuit proof · Not overload proof · Galvanically insulated from logic voltage · The voltage (data circuit voltage) is supplied by the carrier module (galvanically insulated)
Mechanics	
Dimensions	56 x 43 x 5.5 mm
Weight	Approx. 15 g

2.8 Status and Function Display

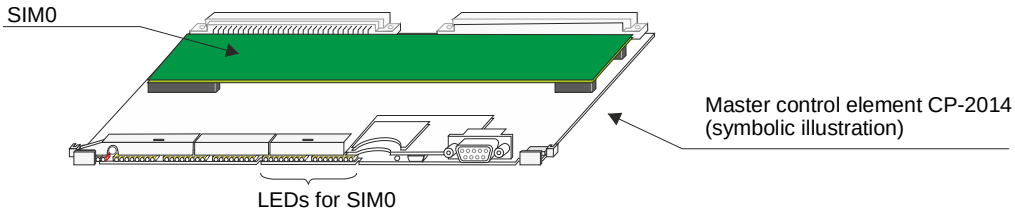
The protocol element SM-x551/GACMA0 has neither a front panel nor LEDs to display status and functions.

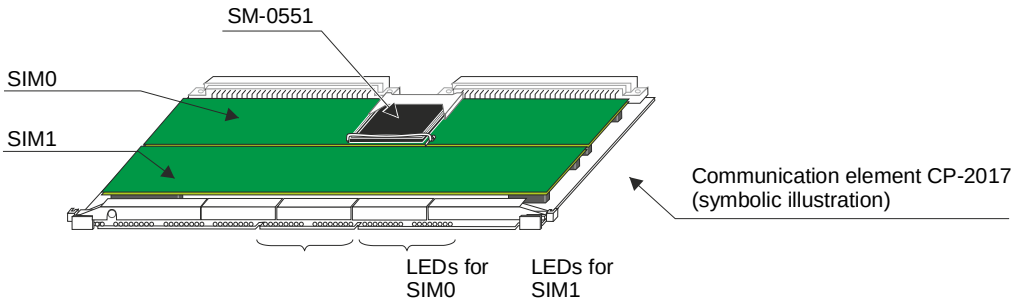
It use the LEDs of the master control unit or communication elements. The meaning of these LED displays is described in the manual of the concerning system element.

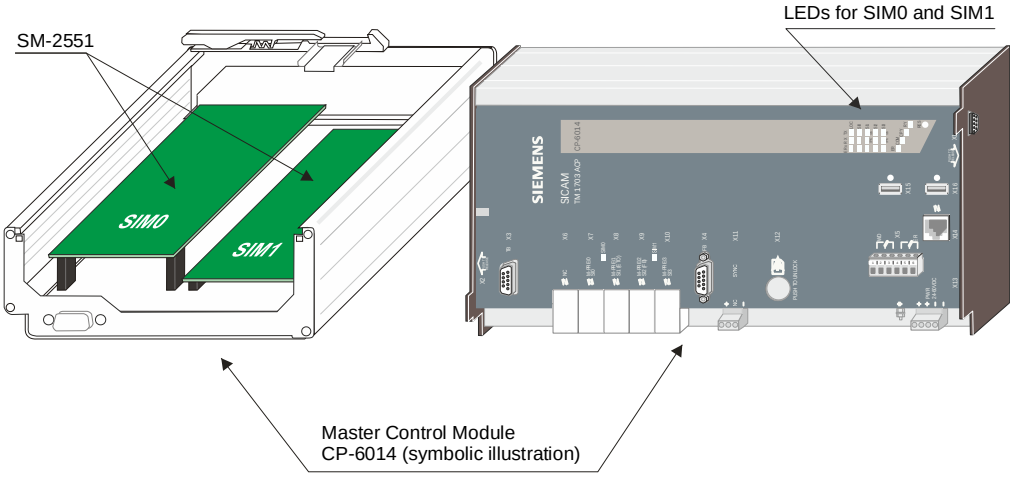
Protocol elements – Mounting place and LED display on SICAM AK 3



Protocol elements – Mounting place and LED display SICAM AK






LEDs for SIM0 and SIM1
SM-2551
SIM0
SIM1
SIEMENS
SICAM
Master Control Module
CP-6014 (symbolic illustration)

2.9 Pin Assignment

Operating Mode	Pin Assignment (RJ45)		
Unbalanced interchange circuit V.24/V.28 V.28 asynchronous	**pin**	**alias**	**signal**
	1	I/O 1	CTS
	2	I/O 2	RTS
	3	I/O 3	DSR/+5V
	4	I/O 4	TXD
	5	I/O 5	RXD
	6	I/O 6	GND
	7	I/O 7	DCD
	8	I/O 8	DTR

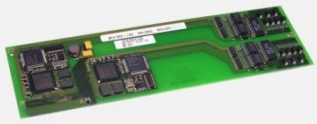
The abbreviations have the following meaning:

CTS .....serielle Schnittstelle (V.28) - Clear to Send
RTS .....serielle Schnittstelle (V.28) - Request to send
DSR.....serielle Schnittstelle (V.28) - Data Set Ready
DCD.....serielle Schnittstelle (V.28) - Data Carrier Detect
DTR .....serielle Schnittstelle (V.28) - Data Terminal Ready
TXD .....serielle Schnittstelle (V.28) - Transmit data
RXD.....serielle Schnittstelle (V.28) - Receive data
GND .....serielle Schnittstelle (V.28) - Signal Ground
+5V.....serielle Schnittstelle (V.28) - +5V Versorung

3 System Components

Contents

3.1 Hardware

	Designation	Item-Number/MLFB
	SM-2551 Serial Interface Processor 2 serial interfaces	BC2-551 6MF10130CF510AA0
	SM-0551 Serial Interface Processor 1 serial interface	BC0-551 6MF10130AF510AA0

3.2 Firmware

	Designation	Item-Number/MLFB
	GACMA0: GEC-Alstom Courier Master protocol	SC0-595-1
	TU GACMA0 TB II-Update	SC0-595-1.XX/53

3.3 Accessories

	Designation	Item-Number/MLFB
	CM-2860 Patch Plug Standard V.28, ET, TR Note: Not required for SICAM AK 3	CA2-860 6MF12110CJ600AA0
	GEC-Alstom KITZ101 ... for desktop use The KITZ 101 and KITZ 102 interface units provide protocol conversion for the Courier protocol from the K-Bus physical connection and format to EIA (RS) 232 physical connection and IEC870 FT1.2 format. This allows either a PC/RTU/Bay controller running Courier Master software to access the IED data. KITZ101 ... for desktop use KITZ102 ... for use at real of panel Note: - KITZ101, KITZ102 has identical functionality.	http://www.gegridsolutions.com/
 Symbol photo	GEC-Alstom KITZ102 ... for use at rear panel mount	http://www.gegridsolutions.com/

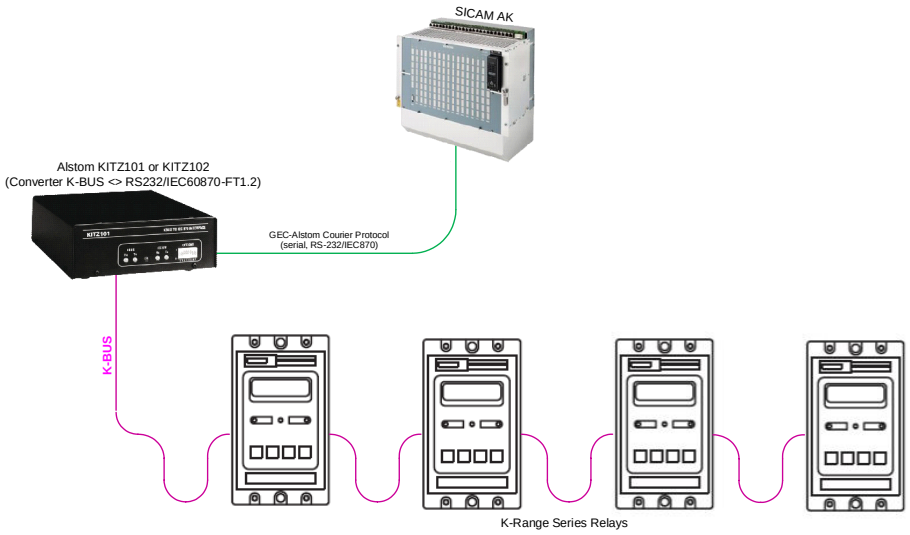
4 Protocol Description

Contents

4.1 Overview

The GEC Alstom Courier protocol is a vendor specific communication platform featuring a broad spectrum of possible usage in manufacturing and process automation.

The Courier communication language has been developed to provide generic control, monitoring , data extraction and setting changes on remote devices (primarily protection relays) within the substation environment.



4.1.1 K-Bus Communication Standard

At base there is the K-Bus communication standard which defines the physical layer and the data link layer. The physical layer is based on a RS485 interface at a typical transmission rate of 64kbit/s. The data link layer defines the logical information containing media access and logical link addressing.

K-Bus messages are transmitted as frames. A K-Bus frame is based upon the ISO High Level Data Link Control (HDLC) protocol.

Preamble	Start	Address	HDLC Information field	CRC	Stop
FFh FFh	flag	AA	xx xx ..... xx xx	xx xx	flag

HDLC Information field:

Network Address	Length	Data field
{AA..AA} 00	Lk	dd..dd

4.1.2 IEC870 Communication Standard

For an easier and wider range of third party products interfacing to these K-Bus devices an additional protocol based on the IEC870 communication standard has been founded.

IEC870 is an international standard communication system for telecontrol applications. The Courier protocol uses the unbalanced operation (master to slave). The frame format is based on the definition FT1.2 with variable length.

The physical layer is a RS232 interface with half duplex asynchronous transmission and transmission rates of 1200, 2400, 4800, 9600 or 19200 bit/s.

Start Byte	Length Byte	Length Byte	Start Byte	Information field	Checksum	End Byte
68h	LL	Repeated	68h	xx xx ..... xx xx	xx	16h

Information field:

Control Byte	Unit Address	Network Address	Data field
CC	UU	{AA..AA} 00	dd..dd

If the IEC870 communication standard is used then a gateway KITZ102 is required. This gateway is used to convert the messages of the IEC870 format into the K-Bus format.

The KITZ101/KITZ102 are required to convert the common used RS232 interface with the IEC870 telecommunication format into the K-Bus hardware interface and the media format.

KITZ101

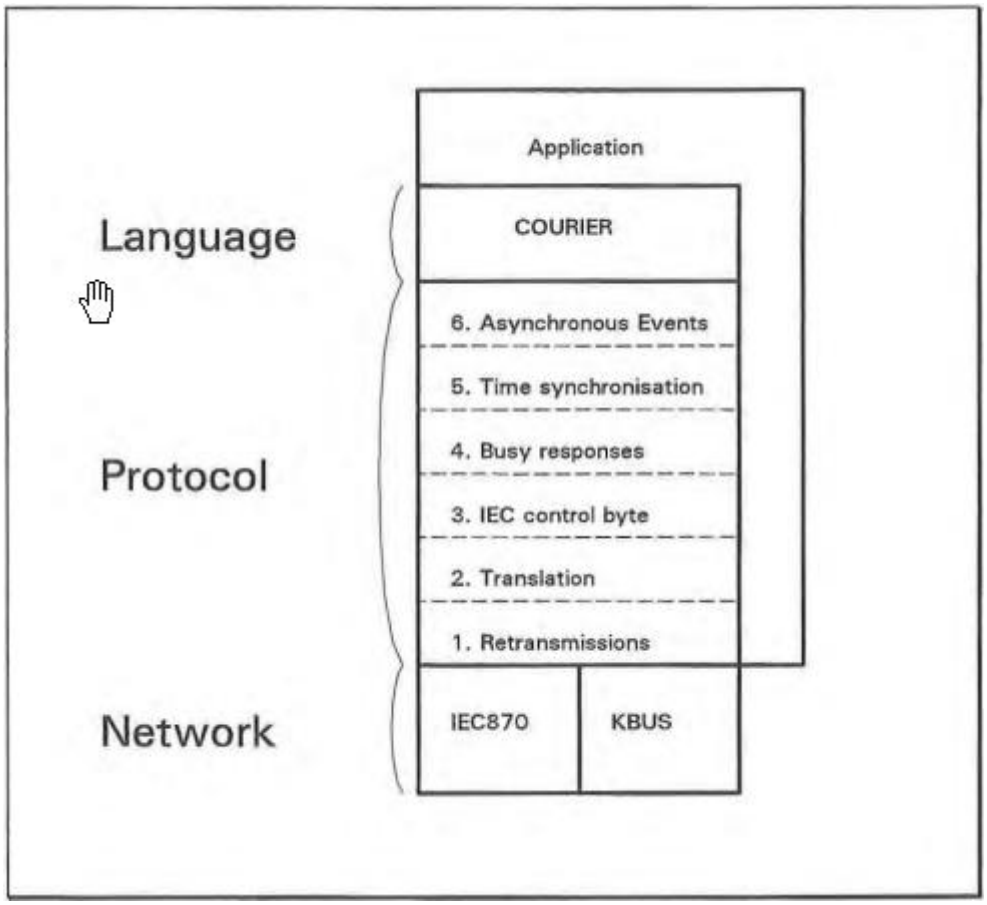
KITZ102
(symbol picture)

KITZ Version	Functions	Comment
KITZ101	The KITZ 101 and KITZ 102 interface units provide protocol conversion for the Courier protocol from the K-Bus physical connection and format to EIA (RS) 232 physical connection and IEC870 FT1.2 format. This allows either a PC/RTU/Bay controller running Courier Master software to access the IED data. KITZ101 … for desktop use KITZ102 … for rear panel mounting Note: - KITZ101, KITZ102 has identical functionality.	for desktop use
KITZ102	See KITZ101	for rear panel mounting
KITZ204	VDEW/IEC60870-5-103 KITZ protocol converter. The VDEW/IEC60870-5-103 KITZ (KITZ204) will provide an interface between K-Range and L-Range relays, and either an VDEW protocol or IEC60870-5-103 protocol-based master station.	End of life product! Not longer available!

4.2 Courier Protocol

This chapter gives a brief description of the Courier protocol, the message structure, communication procedures, data retrieval and data types. All information regarding to the IEC870 standard of the Courier protocol. The K-Bus definitions are not part of this document.

4.2.1 Courier Protocol Overview - Master



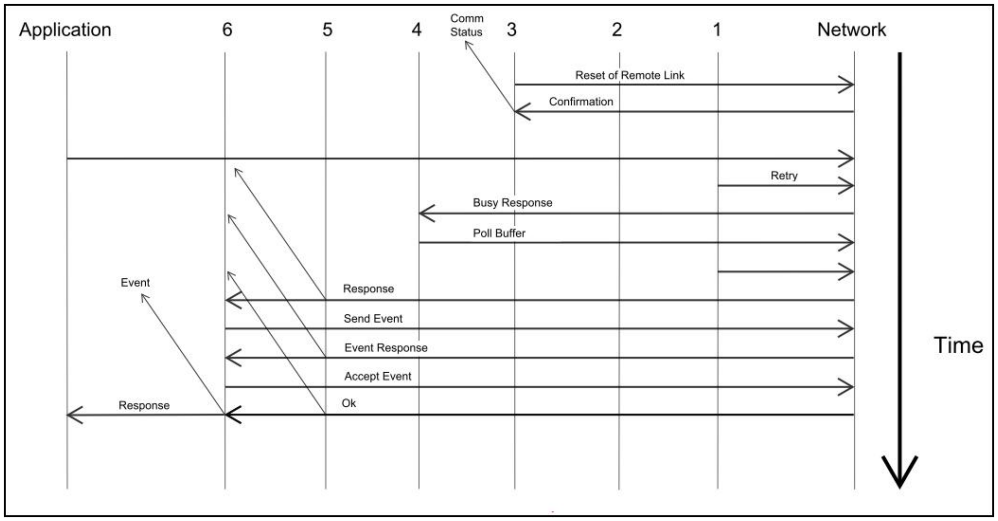
The Courier Protocol in the master control unit is divided into 6 distinct layers. An application request formatted into a Courier message is passed into layer 6 of the protocol. This will use the lower layers of the protocol to transmit the message and receive the response, which will be returned from this layer back to the application.

A logical connection is made to the slave device by layer 3 issuing a “Reset Remote Link” command. Layer 3 identifies that the slave device is present at that address and makes this communication status available to the application.

A Courier request is then made by the application. Layer 1 retries the request and obtains a response. Layer 4 detects that this is a busy response and issues a “Poll Buffer” request, which again layer 1 has to retry before it receives a response to the initial request.

Layer 5 performs any time synchronisation required.

Layer 6 detects that an event has taken place in the slave device. It therefore issues a “Send Event” command. The slave device returns the event straight away and again layer 5 performs any time synchronisation required. Layer 6 then issues the “Accept Event” command and the slave device returns “OK”. The event is stored for use by the application. Layer 6 finally returns the slave device’s response to the initial application request.



4.2.2 Courier Protocol Overview - Slave

The Courier Protocol in the slave device is divided into 5 distinct layers and works in the reverse manner to the protocol layers in the master control unit. A request message is received by layer 1 of the protocol and successively passed up through the layers to the application. This may then respond by returning a Courier response message to layer 5 which is then passed back through the layers to the communication network.

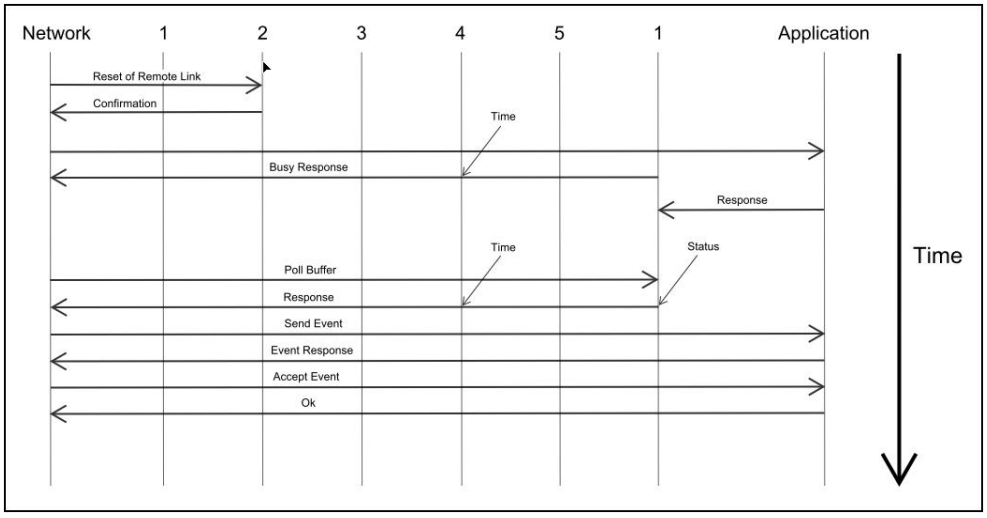
A “Reset Remote Link” command is received which layer 2 intercepts and returns a confirmation.

A Courier request is then received which is passed to the application layer. Layer 5 does not receive a response from the application within 5ms time out period and so it returns a “Busy Response” to the network.

The busy response prompts a “Poll Buffer” command which is handled by layer 5. By this time the application has returned a response, so this is returned as the reply to the “Poll Buffer” command with the current status byte (otherwise another “Busy Response” would have been returned).

Because the event bit is set in the previous response, the master control unit then issues a “Send Event” command. The application returns the event response. This is acknowledged with an “Accept Event” command which clears the event flag (as there are no more events) and the application returns an OK reply code.

In all responses the status byte is added at layer 5, the time is added at layer 4 and the IEC control byte is added at layer 2.

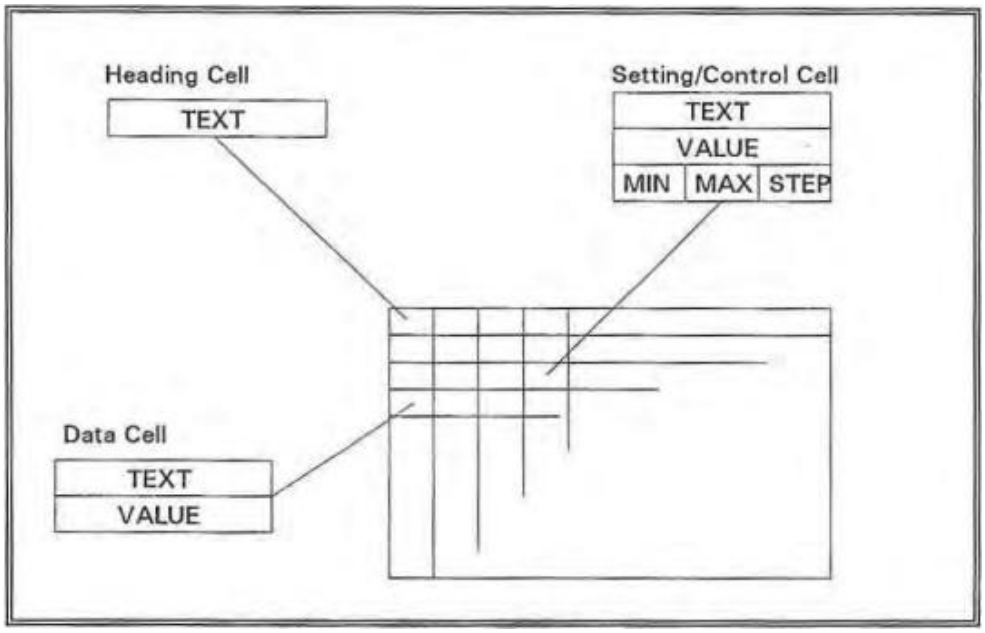


4.2.3 Courier Slave Device Database

The Courier communication language is designed around a standard database structure stored in each slave device. The slave device uses this database to store all data and settings which are accessible over the communication link. The structure of the database is very similar to that of a spreadsheet, consisting of individual cells organized into rows and columns. A single menu cell is the smallest unit of access within the database and can therefore contain only one item of data (although it may have other attributes as well). Menu cells are referenced by their row and column numbers, collectively referred to as a menu cell reference. Menu cell references are expressed in 4 digit hexadecimal notation with the column number appearing as the highest 2 digits and the row number as the lowest 2 digits. The reference for a menu cell in column 10 row 3 would therefore be known as 0x0A03. This limits the maximum size of the database to a table of 256 columns and 256 rows.

Two of the columns within the database (column 0x00 and 0xBF) are predefined to access data common to all devices.

4.2.3.1 Menu Cell Types



The database consists of 3 different types of cell, each one being a superset of the previous, as in the figure above. The three cell types are heading cells, data cells and setting/control cells.

4.2.3.1.1 Heading Cells

Heading cells simply contain a piece of descriptive text. These are used throughout the database as place markers to split the database into different areas. The most common heading cells are the database column heading cells which are used to describe the contents of a column.

4.2.3.1.2 Data Cells

Data cells contain a piece of text to describe their contents and a value which may be read. Intrinsic in this value is a data type which instructs the master control unit how the data is to be processed. The descriptive text for these cells will also contain some formatting control codes which locate and format how the data will be presented. It is the responsibility of the remote master control unit to extract the text and data value separately and combine them into a displayable form.

4.2.3.1.3 Setting And Control Cells

Setting cells are data cells which have text and a data value, but they also allow the data value to be changed. To do this generically, the menu cell contains the setting limits for the data value which specify the setting range and step size. These can be extracted from the slave device using a communication command. There is also a command to send the new value back to the slave device after is has been altered remotely.

Control cells are the same as setting cells except the action of setting particular values causes the slave device to perform functions (e.g. relay outputs).

4.2.3.2 Database Layout

Individual cells are grouped together into columns of related information such as particular settings, measurements, fault records etc. The cell in the first row if each column is a heading cell which describes the contents of the column. This organization is invariant across all slave devices. Thus, the contents of any slave device can be read in the same way. First the column headings are extracted and presented to the user as a menu. Individual cells may then be selected for further operation. Typically this could be change of setting, assignment to a measurement value on a mimic display, log to disc or real time graphing.

4.2.3.3 Predefined Menu Cell References

In practice it is found that all slave devices contain a certain amount of common information. This includes the device type, model number and serial number, its location, communications address, etc. This information is generally required by the master control unit when the slave device is first detected.

This common information is stored in two predefined columns of the database: column 0x00 – System Data Column and column 0xBF – Communication System Data Column. The format of these columns is fixed and allows common information to be extracted in the same way as all other data using the standard generic set of Courier commands, rather than providing special commands.

4.2.4 Transmission Procedures

The Courier protocol is based on a master slave communication. The slave is waiting for a request by the master and sends a response containing the requested information. The slave is not allowed to initiate a communication by sending data without a preceding request from the master.

A slave device must reply to a request within a response time of 5 milliseconds. If a slave device cannot generate the correct reply within the response time, it will send an empty BUSY message as a reply, thus allowing the master control unit to use the bus again.

A Courier transaction therefore consist of a request message from a master control unit and its associated response message from a slave device. There are several types of Courier transaction each determined by the type of response that is returned.

Simple transaction:
A simple transaction occurs when a single request message containing a single request command results in a response containing a single packet if information which fits into the response frame.

Grouped transaction:
A grouped transaction occurs when a single request message containing a single request command results in a response containing multiple packets of information which fit into the response frame. The multiple packets associated with the request are grouped together into a larger packet so that they can be identified as a single response entity.

Multiple transaction:
A multiple transaction occurs if a request message contains multiple request commands which would therefore result in multiple responses. This is not supported by the GACMA0 firmware.

Blocked transaction:
A blocked transaction occurs when a single request message containing a single request command results in a response containing multiple packets of information which cannot fit into a single message. The packets are grouped into blocks such that each block fits into a response frame. The nature of the response is indicated in the first response message from the slave device. The master control unit will then request each subsequent block in the transaction until all blocks have been transferred. Each block will contain multiple packets, most probably grouped into larger packets.

4.2.5 Courier Message Structure

The message structure for the IEC870 part looks like this.

Start Byte 68h	Length Byte LL	Length Byte Repeated	Start Byte 68h	Information field xx xx ..... xx xx	Checksum xx	End Byte 16h

The information field has the following structure.

Control Byte CC	Unit Address UU	Network Address {AA..AA} 00	Data field dd..dd

4.2.5.1 Control Byte

The control byte is 1 octet long and contains information about message direction, initiator of the message transmission, errors and data flow control and function.

Assignment of the control field:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
Res	PRM =1	FCB	FCV	Function Code				Primary Station to Secondary Station (MASTER ð SLAVE)

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
Res	PRM =0	=0	DFC	Function Code				Secondary Station to Primary Station (SLAVE ð MASTER)

Elements of the Control Field for IEC60870-5-101 (End-End)	
Res …	Reserved (not used)
PRM … Primary Bit (=Primary message)	PRM=1: Message from a master device (=requesting station) PRM=0: Message from a slave device (=responding station)
FCB … Frame Count Bit (message sequence bit)	Changing value for successive SEND/CONFIRM or REQUEST/RESPOND –services per station. (Retries are sent with the same FCB bit)
FCV … Frame Count Bit valid (message sequence bit valid)	FCV=0: Changing function of the FCB is invalid (not evaluated) FCV=1: Changing function of the FCB is valid
DFC … Data Flow Control (data flow control)	DFC=0: Further messages are accepted DFC=1: not supported by the Courier protocol
Function … Function code	

Data Link Function Codes used by the Courier protocol:

Function Codes of the Control Field in Messages of the master device (PRM=1)				
FC	Frame Type	Service Function	FCV Bit	Response Function Codes permitted from Secondary
0	SEND-CONFIRM expected	Reset Of Remote Link	0	0 (confirm)
4	SEND-NO REPLY expected	Deliver application data, no confirmation requested	0	no response
11	REQUEST-RESPOND expect.	Request class 2 data	-	8 (user data)

Function Codes of the Control Field in Messages of the slave device (PRM=0)		
FC	Frame Type	Service Function
0	CONFIRM	ACK … Positive Acknowledgement
8	RESPOND	User data

4.2.5.2 Address field

The address contains the unit address of the slave device and the network address followed by a 0 byte terminator. The network address is used to identify subservient units in a multi-tier hierarchical system. Since multi level addressing is not supported by this firmware this field only contains the unit address of the slave and the zero terminator.

4.2.5.3 User Data Field

Master device à Slave device:

The user data field contains at least one data packet, the command code and if necessary the command data.

Slave device à Master device

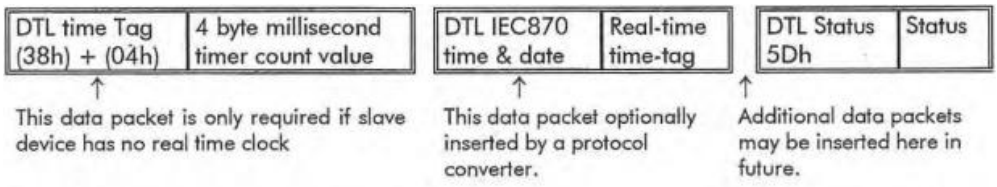
The user data field always contains the reply control field and is followed by one or more data packets which contain the requested information.

The data field is composed of a sequence of data packets. These exist in several formats to achieve a trade-off between packet length and flexibility. The data packets ensure that data can be identified, interpreted and analyzed easily.

4.2.5.3.1 Reply Control Field

The reply control field is only present in messages transmitted to the master control unit as it indicates various items of status information about the slave device. It consists of one or more Courier data packets terminated with a data packet of type 0x5D, indicating the Courier status byte.

The first packet is an optional time tag, which is used for the time-alignment of events within different relays. Optionally a data packet containing IEC870 time and data can be inserted by a protocol converter. The last packet is always present and contains the status information of the slave device



4.2.5.4 Courier Data Packet

Each data packet consists of 2 fields: a data type & length (DTL) field and a data field. A DTL field contains information about the type and length of the data field so that it may be interpreted correctly without any prior knowledge.

The DTL field is usually encoded into 1 byte, where the type is coded into the 6 highest bits and the length is coded into the 2 lowest bits.

Besides the data types which include the regarding information there are some data types that contain additional information. The following chapters give a brief description of these extended type codes.

4.2.5.4.1 Data Types

The following table shows all currently used data type codes and its variants depending on the length.

DTL code				Data Type	Valid length	GACMA0
Length						
next byte	1 byte	2 byte	3 byte			
00	01	02	03	Extended data type code	Arbitrary	-
04	05	06	07	Command	1,2 or 3	ü
08	09	0A	0B	Group identifier	2	ü
0C	0D	0E	0F	Block header	Arbitrary, typically 1	ü
10	11	12	13	Block footer	Arbitrary, typically 1	ü
14	15	16	17	Block identifier	1	ü
18	19	1A	1B	ASCII text	Arbitrary	-
1C	1D	1E	1F	ASCII password	Arbitrary	-
20	21	22	23	Binary flags	1 to 4	ü
24	25	26	27	Unsigned integer	1, 2 or 4	ü
28	29	2A	2B	Signed integer	1, 2 or 4	ü
2C	2D	2E	2F	Courier number	4 or 6	ü
30	31	32	33	reserved		-
34	35	36	37	IEEE floating point number	4	ü
38	39	3A	3B	Millisecond timer count	4	ü
3C	3D	3E	3F	IEC870 time and date	7	ü
40	41	42	43	Keycode	Arbitrary	-
44	45	46	47	Menu location	2	ü
48	49	4A	4B	Reply codes	1	ü
4C	4D	4E	4F	Cursor position and type	3	-
50	51	52	53	String index	1 to 2	-
54	55	56	57	Numeric index	2	-
58	59	5A	5B	Block transfer cell	1	-
5C	5D	5E	5F	Status byte	1	ü
60	61	62	63	IEC870 control byte	1	-
64	65	66	67	Foreign data	Arbitrary	-
68	69	6A	6B	Modem control strings	Arbitrary	-
6C	.....	.....	FF	Reserved		-

4.2.5.4.2 Group Identifier (0x0A)

A group identifier is a special data packet which precedes a group of several data packets which are the response to a single request in order to group them together. A group identifier packet has a data field of 2 bytes. The first byte represents the DTL code and the second byte of the data field is the total length of the following data packets in the group.

Since the length information is known the firmware GACMA0 can skip unsupported packets and continues with the next data packet.

The possible group identifiers are summarized in the following table.

Group type	description	GACMA0
0x00	Standard event record	ü
0x01	Short fault record	-
0x02	Long fault record	-
0x03	Complex fault record	-
0x10	Cursor and text	-
0x11	Column heading group	-
0x12	Column text group	-
0x13	Column value group	-
0x20	Indexed string group	-
0x21	Setting limits group	-
0x22	Setting limits with multiplier group	-
0x30	CCU unit list	-
0x40	Repeated data packet	-

4.2.5.4.3 Block Information

The block information contains 3 different data types. These are Block Header, Block Footer and Block Identifier.

A Block Header appears as the only data packet in a reply message user data field which initiates a blocked transaction. The data field is an unsigned integer which informs the master control unit how many blocks are going to be sent in the transaction. If the number of blocks is set to zero, the number of blocks that will be sent is unknown.

A Block Footer packet appears as the only data packet in a reply message at the end of a blocked transaction. The data field contains an unsigned integer indicating the total number of blocks transferred in the transaction which are compared with the actual number of blocks received.

A Block Identifier packet appears at the beginning of each blocked transaction message that appears between a block footer and a block header message. The data field is a single byte unsigned integer which indicates the sequence number of the block. It start at 0 and wrap around to zero after the value 255. The blocks must be sent in sequence.

4.2.5.4.4 Courier Numeric Type (Courier Number)

The Courier numeric type was created to allow a large dynamic range of numbers to be displayed with four significant digits, a variable decimal point location and an inherent unit type prefixed with a scalar multiplier.

Simple Courier numeric type:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
M^7	M^6	M^5	M^4	M^3	M^2	M^1	M^0	Mantissa 0 – 9999
S	M^{14}	M^{14}	M^{12}	M^{11}	M^{10}	M^9	M^8	S = sign bit, 1 = negative
M^7	M^6	M^5	M^4	M^3	M^2	M^1	M^0	Exponent
U^7	U^6	U^5	U^4	U^3	U^2	U^1	U^0	Units

Mantissa:

The mantissa is stored as a 15 bit binary unsigned integer in the range 0 to +9999 and a separate sign bit in the highest bit. The mantissa is normally in the range 1000 to 9999, thus providing 4 significant digits. Less digits are displayed for mantissas less than 1000. For example, the following values are equivalent, but are displayed differently:

- Value $1000 * 10^{-3}$ A = 1.000 A
- Value $10 * 10^{-1}$ A = 1.0 A

Units:

The following base units have been defined.

Byte Value	Physical Quantity	Base Unit	Display
0x00	Current	Amps	A
0x01	Voltage	Volts	V
0x02	Angle	Degrees	Deg
0x03	Impedance	Ohms	Ohms
0x04	Power	Watts	W
0x05	Active Power	Voltamps active	VA
0x06	Reactive Power	Voltamps reactive	VAr
0x07	Length	Meters	m
0x08	Time (interval)	Seconds	s
0x09	Ratio	xxxx:1	xxxx:1
0x0A	Temperature	Degrees Celsius	°C
0x0B	Frequency (speed)	Hertz	Hz
0x0C	Percentage	Percent	%
0x0D	Per Unit Value	Per Units	PU
0x0E	Square Amps	Square Amps	A^2
0x0F	Reserved	Decimal, no units	
0x10	Energy	Watt Hours	Wh
0x11	Energy (active power)	Vah	VAh
0x12	Energy (reactive power)	VArh	VArh
0x13	Time (interval)	Minutes	mins
0x14	Inverse Ohms	mho	mho

Exponent:

The exponent is stored in the third byte and indicates the power of 10 that the mantissa should be raised to. This is an unsigned byte with an inherent offset of 126 and can therefore express decimal exponents from 10^{-126} to 10^{+129}. However this is restricted by the Courier protocol definition to the range 10^{-18} to 10^{+18}. Possible values are in the range of $1 * 10^{-18}$ to $9999 * 10^{+21}$.

Note that the scalar is shifted by 10^3 since the mantissa is normalized in the range 1000 – 9999 to provide 4 significant digits and therefore $1000 * 10^0$ A = $1.000 * 10^3$ A = 1.000 kA.

Hint

Please note that the Courier Protocol is using a SI-prefix to keep the original 4 digits, but change the scalar if needed. For example: $2345 * 10^3$ W = 2.345 MW. This cannot be applied to the firmware GACMA0 because it converts without any SI-prefix (scalar). That's why the firmware GACMA0 cannot completely convert the whole possible range $1 * 10^{-18}$ to $9999 * 10^{+21}$. The possible range for TI=36 (short floating point) goes from $1 * 10^{-10}$ to $9999 * 10^{+10}$ including a possible loss of precision at both ends of the scale. That's why the usage of proper adaption parameters (x0, x100 à y0, y100) is necessary this case.

More Precise Courier Numeric Type:

The Courier Numeric Type may also be used to provide for 9 significant digits. This is achieved by extending the mantissa field to 4 bytes whilst maintaining the sign bit in the highest bit position of this field. The maximum value of the mantissa will therefore be 999'999'999.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
M^7	M^6	M^5	M^4	M^3	M^2	M^1	M^0	
M^{15}	M^{14}	M^{14}	M^{12}	M^{11}	M^{10}	M^9	M^8	Mantissa 0 – 999'999'999
M^{23}	M^{22}	M^{21}	M^{20}	M^{19}	M^{18}	M^{17}	M^{16}	
S	M^{30}	M^{29}	M^{28}	M^{27}	M^{26}	M^{25}	M^{24}	S = sign bit, 1 = negative
M^7	M^6	M^5	M^4	M^3	M^2	M^1	M^0	Exponent
U^7	U^6	U^5	U^4	U^3	U^2	U^1	U^0	Units

4.2.5.4.5 Menu Location Reference

The menu is of the same format for all relays. This takes the form of a table with each cell being addressed by its column and row number. Each menu cell is identified by a two byte word, with the highest byte identifying the column and the lowest byte the row. This means a range of 0x00, 0x00 (column, row) to 0xFF, 0xFF (column, row) of total 65535 cells.

Only cells in selected columns between 0x00 to 0x7F are accessible to the user via the user interface (keypad and display on the front of the relay). Cells located in columns 0x80 to 0xBF are reserved for remote control functions and as such are only accessible by a master control unit over the communication link. Columns 0xC0 to 0xFF are reserved for slave device configuration and calibration data and can only be accessed via the communication port after an appropriate command has been executed.

4.2.5.4.6 Reply Codes

Reply codes are returned as acknowledgement or to indicate an error in a request. These errors do not include communication errors which result in a complete message being ignored.

The following table indicates the symbolic name by which the reply codes are referred to. The column IDR represents logged information that can be read out with ST-Emulation (command IDR) including the request that caused the reply code.

Reply code	Value	Description	IDR
ERR_OK	0x00	Positive acknowledgement	-
ERR_NOCODE	0x01	Given menu location does not exist	ü
ERR_NODATA	0x02	Menu cell has no data	-
ERR_NOACCESS	0x03	Cell cannot be accessed at the moment	ü
ERR_NOVERIFY	0x04	Verify error on setting change	ü
ERR_NOSETTINGS	0x05	This is not a settable cell	ü
ERR_NOPASSWORD	0x06	Password is required to change setting	ü
ERR_LOCAL	0x07	Local operator is changing a setting	ü
ERR_OKCHANGE	0x08	Same as ERR_OK, but cell(s) should be subsequently re-read	-
ERR_INVALIDCOMMAND	0x09	Other non-specific error	ü
ERR_GENERAL	0xFF		ü

4.2.5.4.7 Status Byte

The status byte is a single binary flag type value. This data type is used to signify the end of communication header and the start of the user data field. It is present in all slave device responses except the reply to “Reset Remote Link” command which simply returns the IEC870 control byte.

The status byte consists of 8 flags to indicate various items of status information in the slave device.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
TRIP [1)]	ALARM [1)]	EVENT	OOS [1)]	BUSY	CONTROL	PLANT	DIST [1)]

TRIP flag:
The trip flag is used to indicate the state of the trip LED on the front of the slave device. It is used for annunciation purposes on mimic diagrams to indicate trip states and for mimicking a slave device’s display when using the Local Display Unit (LDU). The clearance of this flag is application dependent, although the Reset Trip Indication command would normally reset this flag provided the trip condition does not still exist. It can be automatically reset by the slave device or by the master control unit via communication line. This command is not supported by the firmware GACMA0.

ALARM flag:
The alarm flag is used to indicate that state of the alarm LED on the front of the slave device. It is used for annunciation purposes on mimic diagrams to indicate alarm states and for mimicking a slave device’s display when using the LDU. The clearance of this bit is application dependent.

Event flag:
The event flag is set whenever a slave device contains at least one event record. The master control unit should extract all events from a relay as a high priority whenever it sees this flag set.

OOS flag:
The Out Of Service flag is set whenever the slave device is out of service due to a detected error, an appropriate control command, test condition or if the slave device has been put into calibration or configuration mode. This flag indicates that the protection is not running.

Busy flag:
The busy flag is set when the relay has not had sufficient time to form the reply to the previous request within the time-out period. The master control unit will poll the relay with the "POLL_STATUS" or "POLL_BUFFER" command when this flag is set, until the flag is reset, which indicates that the reply is now available. The reply can be extracted using the "POLL_BUFFER" command. When this flag is set, all other status flags and timer count values in the message should be ignored since the busy response message may have been returned from an intermediate device in a hierarchical system.

CONTROL flag:
The control flag indicates that a binary word in the slave device called the "Control Status Word" has changed its value. The master control unit should then read the value of this word as a normal "Get Value" request from the appropriate cell in the "System Data Column" of the slave device's menu, the action of which will reset this flag.

PLANT flag:
The plant flag indicates that a binary word in the slave device called the "Plant Status Word" has changed its value. The master control unit should then read the value of this word as a normal "Get Value" request from the appropriate cell in the "System Data Column" of the slave device's menu, the action of which will reset this flag.

DIST flag:
Slave devices which contain a disturbance or wave form recorder will set this flag to indicate that they have a disturbance record ready to be extracted. Once extracted, the clearing of this flag is implementation dependent. It is usually performed by starting the recorder capturing data again.

1)

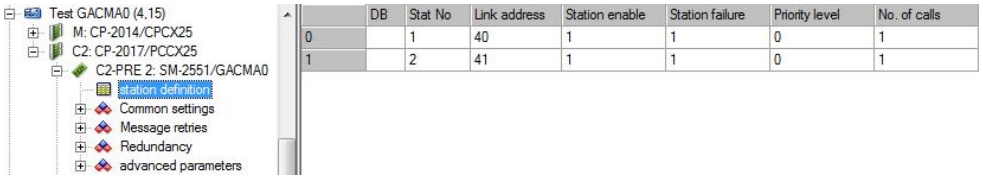
These flags can be converted into single binary indication by using these addresses:
- Station number of the slave device
- column = 0
- row = 0
- bit number = corresponding bit number of the status byte (for example 7 = TRIP status)

4.3 Protocol Element for Courier Master

The protocol element in SICAM RTUs for Courier Master is protocol element the is based on a serial communication link. The protocol element is sending out a request which the slave device has to respond, except messages that don't need a response, e.g. broadcast messages.

4.3.1 Definition of the Connections (Station Definition)

Station specific parameters of the connected PROFIBUS-DP Slaves must be set in the parameters for `station definition` in the protocol element of Courier Protocol Master.



The following parameters can be set per station (for each Slave):

- Parameter "Stat No" (internal station number)
  The internal station number is used internal for the routing of the data, diagnostic treatment and failure management. The station number (Stat. No.) is to be entered on the protocol element in the parameters of the `station definition` in the field `Stat No` for each slave.

- Parameter "Link address"
  The link address is used as station address for the Courier slave device. This is needed to know which slave device can be accessed in order to the internal station number. The parameter `Link address` represents the address of the regarding Courier slave device.

- Parameter "Station Enable"
  A parameterised station can be enabled/not enabled on the protocol element selectively per station in the system technical parameters of the `station definition` in the field `Station Enable`.
  e.g. this way stations can be prepared, that are first activated at a later time by means of parameter setting.
  Data to "prepared stations" are fetched from the protocol element and discarded without error.

- Parameter "Station failure"
  For certain operating modes the failure of a connection can be suppressed on the protocol element for SICAM RTUS internal diagnostic selectively per station in the system technical parameters of the `station definition` in the field `Station failure`.
  If the station failure will be suppressed, station will never be reported as failed in the diagnostics, no data emulation with NT bit =1 and no general interrogation after station failure will be done.

· Parameter "Priority level“

This defines if needed a priority level for a certain Courier slave device. The higher the level is, the more often this device will be called for requests. The parameter `Priority level` goes from 0 (highest priority) to 3 (lowest priority). Devices in the same priority level are called subsequently. If different priority levels are used, the slave devices are called in this order à priority level 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 3
Time based requests or commands/set point values do not follow this rule and got executed immediately.

· Parameter "No. Of calls“

This can be used to call the slave device more than once until the change of next device in a request cycle. This parameter `No. Of calls` should only be used on special purposes and therefore be left at value 1.

4.3.2 Data Exchange Start Up Procedure

Every time a connection to a Courier slave device got established or re established after communication failure the protocol element does some requests to update the internal database for the regarding Courier slave device. It takes several time to finish this update process.

During start up these data are requested:

- System data column 0x00 of the slave device database
- Each column heading cell of the slave device database
- All data cells of every known column of the slave device database
- All parameterized process technical data (detailed routing records) in the OPM linked to the regarding slave device

With this copy of the slave device database within the protocol element it is now possible for the GACMA0 firmware to manage the data exchange between the master and the slave device. It is also needed for the knowledge of all possible data that can be extracted from the slave device if no specified information about the slave database is available. Therefore it can be used for parameterization of the data exchange in the OPM.

Using the command “IDD” on the service terminal (ST-Emulation) shows all these information. The following picture give a short example of this information.

```
:2/Z130:idd
 --------   connected device   --------
 station address (internal stat.no)  :  1
 network address                     :  40
 station state                       :  communication OK
 serial number                       :  652132F
 device type                         :  KMPC13001F15MEA
 device desription                   :  Grid Trans 5
 plant reference                     :  132/33 TX
 device trip indication              :  no
 device alarm state                  :  no

+=============================================================================================+
|                              Table: data base of a slave device                             |
+=============================================================================================+
|   this shows a brief desription of the name of all available column and row numbers of this |
|   device and every line consits of 2 data sets of the regarding row number                  |
+---------------------------------------------------------------------------------------------+
| T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec.
|       number, t=7 byte time, c=single character, s=ASCII string                             |
+---------------------------+-----------------------------------------------------------------+
|  column number:   000     |  description:  SYSTEM DATA                                      |
+-------+-------------------+-+-------+-----------+-------+-------------------+-+-------+-----------+
|  row  |    description    |T| unit  |   value   |  row  |    description    |T| unit  |   value   |
|  nr.  |                   | |       |           |  nr.  |                   | |       |           |
+-------+-------------------+-+-------+-----------+-------+-------------------+-+-------+-----------+
|   2   |SYS Password       |s|       |           |   3   |SYS Fn. Links      |b|       | 0x00000041|
|   4   |SYS Description    |s|       |           |   5   |SYS Plant Ref.     |s|       |           |
|   6   |SYS Model No.      |s|       |           |   8   |SYS Serial No.     |s|       |           |
|   9   |SYS Frequency      |u|Hz     |           |  10   |SYS Comms Level    |u|       |           |
|  11   |SYS Rly Address    |u|       |           |  12   |SYS Plant Status   |b|       | 0x00000000|
|  13   |SYS Ctrl Status    |b|       | 0x00000000|  14   |SYS Setting Grp    |u|       |           |
|  15   |SYS LS Stage       |s|       |           |  16   |SYS CB Control     |s|       |           |
|  17   |SYS Software Ref   |s|       |           |  32   |SYS Logic Stat     |b|       | 0x00000000|
|  33   |SYS Relay Stat     |b|       |           |  34   |SYS Alarms         |b|       |           |
+-------+-------------------+-+-------+-----------+-------+-------------------+-+-------+-----------+
| T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec.
|       number, t=7 byte time, c=single character, s=ASCII string                             |
+---------------------------+-----------------------------------------------------------------+
|  column number:   001     |  description:  FAULT RECORDS                                    |
+-------+-------------------+-+-------+-----------+-------+-------------------+-+-------+-----------+
|  row  |    description    |T| unit  |   value   |  row  |    description    |T| unit  |   value   |
|  nr.  |                   | |       |           |  nr.  |                   | |       |           |
+-------+-------------------+-+-------+-----------+-------+-------------------+-+-------+-----------+
|   1   |FLT Ia             |k|       |           |   2   |FLT Ib             |k|       |           |
|   3   |FLT Ic             |k|       |           |   4   |FLT Io             |k|       |           |
|   5   |FLT Vab            |k|       |           |   6   |FLT Vbc            |k|       |           |
|   7   |FLT Vca            |k|       |           |   9   |FLT CB Trip Time   |k|       |           |
|  10   |FnowG%s            |s|       |           |  11   |Fn  G%s            |s|       |           |
|  12   |Fn-1G%s            |s|       |           |  13   |Fn-2G%s            |s|       |           |
|  14   |Fn-3G%s            |s|       |           |  15   |Fn-4G%s            |s|       |           |
|  16   |FLT Records        | |       |           |       |                   | |       |           |
+-------+-------------------+-+-------+-----------+-------+-------------------+-+-------+-----------+
| T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec.
|       number, t=7 byte time, c=single character, s=ASCII string                             |
+---------------------------+-----------------------------------------------------------------+
|  column number:   002     |  description:  MEASUREMENTS(1)                                  |
+-------+-------------------+-+-------+-----------+-------+-------------------+-+-------+-----------+
|  row  |    description    |T| unit  |   value   |  row  |    description    |T| unit  |   value   |
|  nr.  |                   | |       |           |  nr.  |                   | |       |           |
+-------+-------------------+-+-------+-----------+-------+-------------------+-+-------+-----------+
|   1   |MS1 Ia             |k|A      | 0.00000000|   2   |MS1 Ib             |k|A      | 0.00000000|
|   3   |MS1 Ic             |k|A      | 0.00000000|   4   |MS1 Io             |k|       |           |
|   5   |MS1 Vab            |k|V      | 0.00000000|   6   |MS1 Vbc            |k|       |           |
|   7   |MS1 Vca            |k|       |           |   8   |MS1 Va             |k|       |           |
|   9   |MS1 Vb             |k|V      | 0.00000000|  10   |MS1 Vc             |k|       |           |
|  12   |MS1 F              |k|Hz     | 50.0000   |       |                   | |       |           |
+-------+-------------------+-+-------+-----------+-------+-------------------+-+-------+-----------+
```

4.3.3 Data Exchange Procedure

The data exchange between master control unit and slave device is controlled by the protocol element. Request-/response services are used for the initialization and data exchange from/to the slave device.

4.3.3.1 Read Static Data

The input data from the slave devices are read cyclic by the protocol element. Every request from the master contains only one data cell according to the process technical parameters (detailed routing record) in the OPM. The data containing in the response from the slave device are converted into the internal data format and if there was a change they will be forwarded into the system to transport them further e.g. to a HMI.

4.3.3.2 Read Event Data

Other as static data the request for event data can be done cyclic by using the parameter `GACMA0 à advanced parameters à common Courier settings à cycle time for event inquiry (0 to 250 seconds)` or the slave device informs the master that events are pending by setting the “event flag” to 1 in the slave device status byte.

4.3.4 General Interrogation, Outstation Interrogation

The general interrogation function (RTU interrogation) is used for updating the master station after startup, redundancy switchover or after communication error.

The Courier protocol does not define a general interrogation procedure!

Please refer to chapter 4.3.2 Data Exchange Start Up Procedure where it is already described.

Hint

Please note that this procedure takes up to 1 minute for every slave. The cyclic or event data exchange even if a different slave device is addressed can only start if this procedure is finished.

4.3.5 Failure Monitoring

Failure Monitoring for Communication to the Slave Device

The data exchange between the protocol element and slave device will be done cyclic. The data communication from/to slave device is monitored by the protocol element. Each request must be answered by a response sent from the slave device during response timeout.

In case of communication failure (response timeout), the slave device will be reported as failed.

The response timeout can be set on the protocol element with the system technical parameter `GACMA0 | advanced parameters | monitoring times | expected_ack_time_corr_factor` within the range of 0,01 to 655,35 seconds.

4.3.6 Clock Synchronization

One of the important functions of existing SCADA Systems is sequence of event recording. This gives the System engineer valuable insight into the order In which events on the system occur. The typical accuracy of existing Systems ranges from +10ms to ± 1ms. This function is currently carried out by the RTU's of the SCADA system which monitor System events using digital inputs. These events are generally time tagged using a system synchronizing pulse distributed around the communication network. Often of more importance than the absolute time of an event is its time relative to other events across the system.

Two possible methods of time tagging are provided in the Courier Protocol. The first allows each slave device to have its own real time clock synchronized to the rest of the system. Time tagged events are logged by recording this time in IEC time & date format and transmitting this Information with the event. However, using multiple real time clocks can be expensive and requires them all to be synchronized externally.

An alternative method of time Synchronisation has been devised which removes the need for separate clock Synchronisation wiring. Rather than trying to synchronize the clocks within each individual slave device, the clocks are allowed to free run. Events within each slave device are time tagged relative to the internal free running clock. This is derived from the microprocessors clock and resolutions of ±1 ms are easily obtained.

Clearly when these event records are transmitted to the master control unit, events from different slave devices will be out of step. This problem is solved by also transmitting the current value of the slave device's clock. This is compared with the master control units clock and the difference used to calculate the actual time of the event.

The time Synchronisation process generally produces a real time value adjusted by an offset for each slave device, which when added to a time tag in the Courier response message, converts the relative time to a time synchronized real time value. This offset real time value is calculated in layers 1 and 5 of the master control unit and passed to the application by a separate path so that it can be used when required.

4.3.7 Command Transmission

Commands to Courier protocol slave devices will be transmitted in a sequence of telegrams.

- Master to slave command “Enter setting mode” for the designated menu cell
- Slave to master response “Setting limits group” with current value, minimum and maximum range and step value
- Master to slave command “Preload value” at the designated menu cell with the new value
- Slave to master echoes the new setting request
- Master to slave command “Execute setting”
- Slave to master response with reply code Ok

If there is a reply code from the slave different to Ok during the complete command procedure then the master will abort it immediately by sending the command “abort setting”.

4.4 Redundancy Functions

The protocol element does only support generic redundancy functions.

The operating mode of the interface with redundancy state "PASSIVE" can be set according to the redundancy configuration with the parameter `GACMA0 | Redundancy | operation if passive` as follows:

- Transmitter "tristate", listening mode
- Transmitter "active", listening mode
- Transmitter "active", normal mode

From the redundant, not active master / remote terminal unit, listened messages are passed on to the basic system element (BSE) and forwarded by this in the system with the identifier "passive" in the state.

In redundant master / remote terminal units that are not active, a failure of the interface is monitored globally.

The failure of the interface is detected by the STANDBY station by monitoring for cyclic message reception. The monitoring time is set with the parameter `GACMA0 | Redundancy | listening_mode (failure monitoring time)`. The monitoring time is retriggered with a message received free of errors (except REQUEST STATUS OF LINK, RESET OF REMOTE LINK and positive acknowledgment message using single character E5H).
On receive timeout (active master / remote terminal unit or transmission facility has failed) the interface is signaled as failed.

The failure of the interface is reset in redundant STANDBY stations, if an error-free message from the respective remote station is "listened" or if no failure monitoring is parameterized.

Activation / Deactivation of the Interface in Redundancy Mode "passive"

For the implementation of project specific redundancy modes the interface and the operation of the protocol can be activated/deactivated with protocol element control message when redundancy mode is in "passive" and with parameter "operation if passive" is set to "transmitter tristate".
The activation/deactivation of the interface can be used for supervision of redundant communication links to the remote station.

Behavior when interface is "activated":

- the interface mode will be switched over
  from transmitter "tristate", listening mode
  to transmitter "active", normal operation
- all date received from remote station (listening mode) will be forwarded to basis system element. By redundancy mode "passive" enabled the received data will be marked on basis system element with "R=1" (data received from "passive" interface).
- all data ready for transmit sent from basis system element to protocol element will be sent to the remote station.

Behavior when interface is "deactivated":

- the interface mode will be switched over
  from transmitter "active", normal operation
  to transmitter "tristate", listening mode
- all date received from remote station (listening mode) will be forwarded to basis system element. By redundancy mode "passive" enabled the received data will be marked on basis system element with "R=1" (data received from "passive" interface).
- all data sent from basis system element to protocol element will be discarded by the protocol element.

PRE control message for controlling the protocol mode will be accepted only in redundancy mode "passive".

The actual state of the interface and the protocol mode (activated/deactivated) will be sent from protocol element to basis system element spontaneous after change of event and during general interrogation.

No general interrogation command will be initiated by the protocol element firmware after activation of the interface.

Note:
- the operating mode of the interface will be updated always by the AU internal protocol element control message (redundancy control message has higher priority than PRE control message).

4.5 Protocol Element Control and Return Information

This function is used for the user-specific influencing of the functions of the protocol elements.

This function contains two separate independent parts:

- Protocol element control
- Protocol element return information

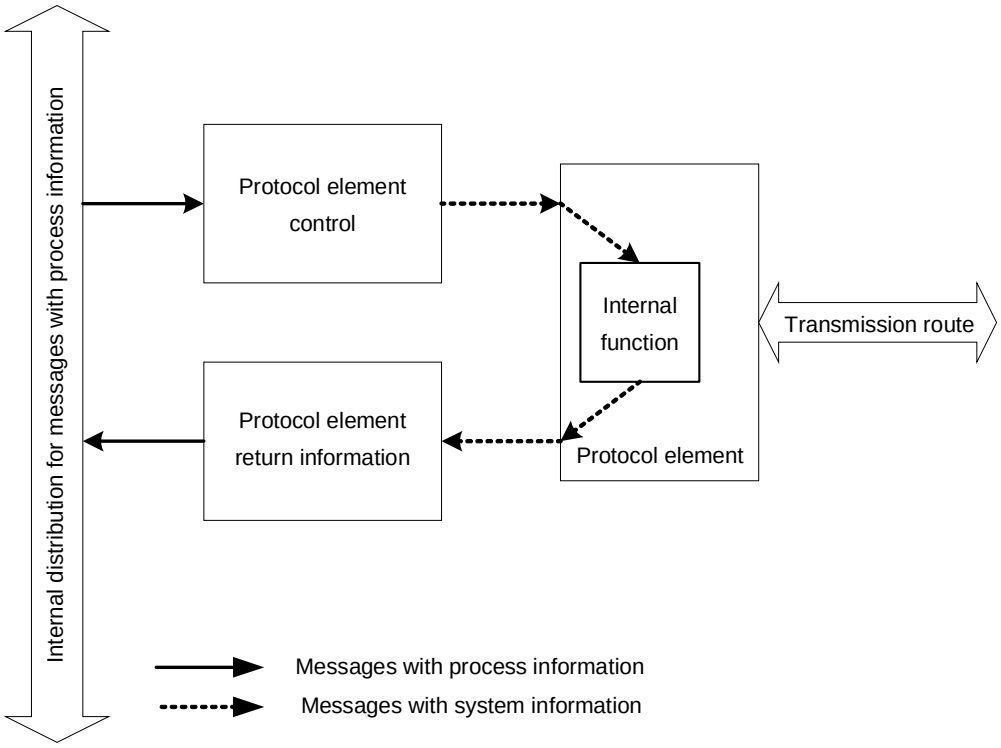
The **Protocol Element Control** enables:

- Protocol element internal functions
- Protocol element system functions

The **Protocol Element Return Information** enables:

- States of certain status lines to be used as process information
- Information to be obtained about the station status/failure

Block Diagram



4.5.1 Protocol Element Control

With the help of *messages with process information*, the protocol element control on the basic system element enables specific functions of the protocol elements to be controlled.

The specific functions are determined by the protocol element implemented.

The assignment of the *messages with process information* to the functions is carried out with the help of process-technical parameters of the SICAM RTUs system data *protocol element control message*.

The messages for protocol control are transmitted immediately from the basic system element to the protocol element, regardless of the user data to be sent and the priority control.

For *messages with process information* which are used in SICAM RTUs as *protocol element control message*, an unused CASDU is to be used! All CASDU´s for process information are distributed automatically to the corresponding remote terminal unit.

Possible functions:

	Parameter				
Function **)	**SF**	**Station**	**Z-Par**	**FI**	**Note**
Send (general) interrogation command	244	-	CASDU		This function is processed on the BSE and sent to the protocol element as system message and not using PRE-control message! CASDU = selective

Legend:

SF..... Control function_(PRE)
Station..... Station number
0 - 99 station 0 - 99 of the selected protocol element
125 all stations of the selected protocol element (=BROADCAST)
Z-Par ..... Additional parameter_(PRE)
FI ..... Edge

4.5.2 Protocol Element Return Information

The protocol element return information generates on the basic system element *messages with process information in monitor direction* and thereby enables states of the protocol elements to be displayed and processed.

Supported categories of return information:

- Station failure

The assignment of the *messages with process information* to the return information is carried out on the basic system element with the help of process-technical parameters of the SICAM RTUs system data *protocol element return information*.

From which source the parameterized return information are to be generated, is set with the parameters "Supplementary system element" and "Station number".

Messages for protocol element return information are transmitted to the basic system element by the protocol element spontaneously with change or as response to a general interrogation command.

Possible master station return information:

	Parameter	
Return information function_(PRE)	**Station**	**Note**
Station failure	0 – 99	1 = Station failed

Legend:

Station …….. Station number
0 - 99 Station 0-99 of the selected protocol element

5 Message Conversion

Contents

5.1 Overview

Data in transmit direction are transferred from the basic system element to the protocol element in the SICAM RTUs internal IEC 60870-5-101-/104 format. The conversion of the data format from IEC60870-5-101/-104 à Courier protocol slave device is done by the protocol element. The transmission of the data to the slave device is done spontaneously.

Data in receive direction will be read cyclic or getting received spontaneously by the protocol element from the slave device and then converted by the protocol element from the Courier format to the SICAM RTUs internal IEC 60870-5-101/104 format and transferred to the basic system element.

The conversion of the message formats SICAM RTUs « Courier protocol formats and the conversion of the address information is called message conversion.

The parameterization for the conversion of the address information from IEC 60870-5-101/104 ó Courier protocol is to be done with TOOLBOX II (OPM) using "SIP Message Address Conversion". The parameterization for the conversion of the address information includes also mapping Courier data type ó IEC 60870-5-101/104 type identification.

Categories for SIP Message Address Conversion:

Data	Direction	Category	GACMA0
Indications	Receive Direction	*firmware* /Rec_binary_information	ü
Measured values	Receive Direction	*firmware* /Rec_measured_value	ü
Counters	Receive Direction	*firmware* /Rec_counter_value	ü
Commands	Transmit Direction	*firmware* / Trans_command	ü
Setpoint Values	Transmit Direction	*firmware* / Trans_setpoint_command	ü

Following parameters valid for all parameter categories:

Parameter	
Lk_Reg	**Link Region Number** … data point assigned to automation unit (AU) with selected region number.
Lk_Comp	**Link Component Number** … data point assigned to automation unit (AU) with selected component number.
Lk_BSE	**Link BSE** … data point assigned to BSE (basic system element) in selected automation unit (AU).
Lk_SSE	**Link SSE** … data point assigned to selected SSE of selected BSE in selected automation unit (AU).
Lk_Cat	**Link Category**
Lk_Prep	Link Prepared: Data point: - prepared … Signal will not be converted/loaded into destination system - activated … Signal is activated and will be converted/loaded into destination system.

5.2 Message Conversion in Transmit Direction (Master à Slave)

Message Conversion in Transmit Direction IEC60870-5-101/104 à Courier

IEC 60870-5-101/104 ð		Courier Data Format
Type ID	**Designation**	**Designation**
<TI=45>	Single command	Relay outputs, settings
<TI=46>	Double command	Relay outputs
<TI=48>	Set point command, normalized value	Settings
<TI=49>	Set point command, scaled value	Settings
<TI=50>	Set point command, short floating point	Settings
<TI=100>	Interrogation command	-
<TI=101>	Counter interrogation command	-

5.2.1 Commands

The parameterization of the address and message conversion for commands in transmit direction is to be done with TOOLBOX II / OPM with the parameter category *firmware* / Trans_command.

Parameter Category:
firmware /Trans_command

Parameter	Value
Lk_Reg	4
Lk_Comp	15
Lk_BSE	002 CP-2017/PCCX25
Lk_SSE	130 SM-2551/GACMA0
Lk_DS	Protocols
Lk_Cat	GACMA0/Trans_command
Lk_Prep	Activated
CASDU1	4
CASDU2	40
IOA1	2
IOA2	130
IOA3	57
TI	Double command (TI 46)
TERM-CASDU1	255
TERM-CASDU2	255
TERM-IOA1	255
TERM-IOA2	255
TERM-IOA3	255
link_address(GACMA0)	40
column_number	0
row_number	16
bit_index	0

Parameter	
TI .. type identification	Supported Type Identifications: · <TI:=45> .. single command · <TI:=46> .. double command
CASDU, IOA	SICAM RTUs internal IEC608705-101/-104 message address
TERM-CASDU, TERM-IOA	Address of the binary indication (single/double) which feedback can be used for the Termination of the command
Link_address(GACMA0)	Courier address of the slave device: · 1-254
Column_number	Column number of the menu cell in the database: · 0-255
Row_number	Row number of the menu cell in the database: · 0-255
Bit_index	Bit index that has to be changed in the array of up to 32 bits of this menu cell: · 0 – 31 [single command] · 0 – 30 [double command] · 255 à the menu cell only contains one data point to change

Supported Data Formats:

TI	SICAM RTUs 101/-104 Data Format			
45	single command			Ê
46	double command		Ê	
		Ê		
Format	**Command**			
Binary array	Settings via command procedure		ü	ü
Command code	Settings via direct command code		ü	
Indexed String	Circuit Breaker Control		ü	ü

Message Conversion

The table describes the evaluated elements of the IEC 60870-5-101/104 message during message conversion.

Elements of the message		
TI	.. Type identification	TI 45 .. single command TI 46 .. Double command
CASDU, IOA .. Message address		can be set by parameter
Cause of transmission		
06	.. activation	evaluated (only “activation” accepted)
xx	.. other COTs	not accepted (only “activation” accepted)
T	.. test	not supported
Information		
SCO/DCO/RCO		
SCS	single command state	[<TI:=45> only]
	0 .. OFF	not evaluated
	1 .. ON	evaluated
DCS	double command state	[<TI:=46> only]
	0 .. not permitted	not supported
	1 .. OFF	evaluated
	2 .. ON	evaluated
	3 .. not permitted	not supported
RCS	regulating step command state	[<TI:=47> only]
	0 .. not permitted	not supported
	1 .. next step LOWER	not supported
	2 .. next step HIGHER	not supported
	3 .. not permitted	not supported
QOC	S/E	
	0 = execute	evaluated
	1 = select	not evaluated
QU	qualifier of command	
	0 .. no additional determinations	evaluated
	1 .. short output time	evaluated
	2 .. long output time	evaluated
	3 .. Persistent command	not supported

... elements of IEC60870-5-101/-104 message not included in table are not evaluated/not supported!

5.2.2 Setpoint Commands

The parameterization of the address and message conversion for measured values/setpoint values in transmit direction is to be done with TOOLBOX II / OPM with the parameter category *firmware* / Trans_setpoint_command.

Parameter Category:
firmware /Trans_setpoint_command

Parameter	Value
Lk_Reg	4
Lk_Comp	15
Lk_BSE	002 CP-2017/PCCX25
Lk_SSE	130 SM-2551/GACMA0
Lk_DS	Protocols
Lk_Cat	GACMA0/Trans_setpoint_command
Lk_Prep	Prepared
CASDU1	4
CASDU2	40
IOA1	2
IOA2	130
IOA3	62
TI	Setpoint val. positioning comm. scaled (TI 49)
X_0%	-32768
X_100%	-100
Y_0%	32767
Y_100%	100
link_address(GACMA0)	40
column_number	255
row_number	255

Hint

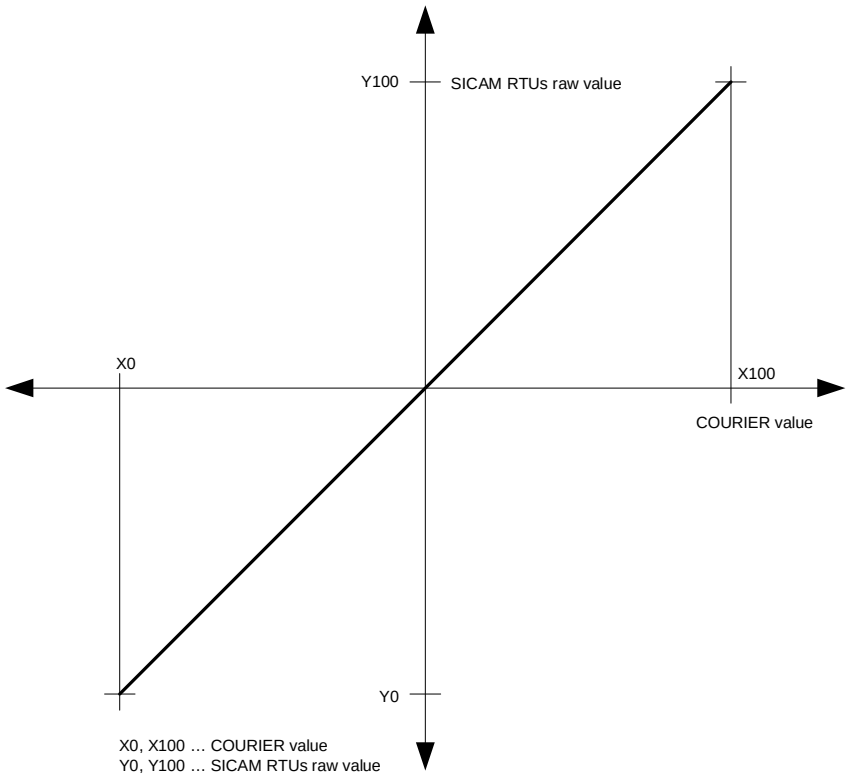
Please note that setpoint commands currently are not implemented. The documentation and the process technical parameters right now serve only documentation purposes and are reserved for future use.

Parameter	
TI .. type identification	Supported Type Identifications: · <TI:=48> .. set-point command normalized value · <TI:=49> .. set-point command, scaled value · <TI:=50> .. set-point command, short floating point number
CASDU, IOA	SICAM RTUs internal IEC608705-101/-104 message address
Link_address(GACMA0)	Courier address of the slave device: · 1-254
Column_number	Column number of the menu cell in the database: · 0-255
Row_number	Row number of the menu cell in the database: · 0-255
X_0%, X_100% Y_0%, Y_100%	Parameters for value adaption: (scaling) Note: - <TI:=34, 48> .. X_0% and X_100% must not be greater or smaller than ± 1. - <TI:=35, 49> .. X_0% and X_100% must not be smaller than - 32768 and not greater than +32767. - value adaption inactive when X_0% and X_100 = 0

Supported Data Formats:

TI	SICAM RTUs 101/-104 Data Format						
48	set-point command normalized value						Ê
49	set-point command, scaled value					Ê	
50	set-point command, short floating point number				Ê		
				Ê			
			Ê				
		Ê					
Format	**Command**						

Value Adaption:
The adaption is defined by the parameters X_0%, X_100%, Y_0%, Y_100%.



The value adaption is only enabled if X_0% or X_100% is parameterized <> “0“.

Notes:
- If value adaption is enabled and if SICAM RTUs raw value is less than X_0% or greater then X_100% no conversion is performed and the error “format conversion in transmit direction” is set.

- If value adaption is disabled (=direct forwarding) and if SICAM RTUs raw value is outside of the selected Courier data range of value no conversion is performed and the error “format conversion in transmit direction” is set.

Message Conversion

The table describes the evaluated elements of the IEC 60870-5-101/104 message during message conversion.

Elements of the message		
TI	.. Type identification	TI 48 .. set-point command normalized value TI 49 .. set-point command, scaled value TI 50 .. set-point command, short floating point number
CASDU, IOA .. Message address		can be set by parameter
QDS	.. Quality descriptor	
BL	.. blocked	not evaluated
SB	.. substituted	not evaluated
NT	.. not topical	NT=1: As selected with parameter “error behavior” the actual state or the parameterized substitute value will be written in output byte.
IV	.. invalid	IV=1: As selected with parameter “error behavior” the actual state or the parameterized substitute value will be written in output byte.
Cause of transmission		not evaluated
QDS	.. Quality descriptor	
06	.. activation	evaluated (only “activation” accepted) [<TI:=48, 49, 50, 51> only]
xx	.. other COTs	not evaluated
T	.. Test	not evaluated
Information		
Value	..	normalized value scaled value IEEE STD 754 = short floating point number
S	.. sign	
QOS	S/E	[<TI:=48, 49, 50> only]
	0 = execute	evaluated, only “execute” accepted)
	1 = select	not supported
time tag		
CP56Time2a	.. date + time	not evaluated

… elements of IEC60870-5-101/-104 message not included in table are not evaluated/not supported!

5.3 Message Conversion in Receive Direction (Master ß Slave)

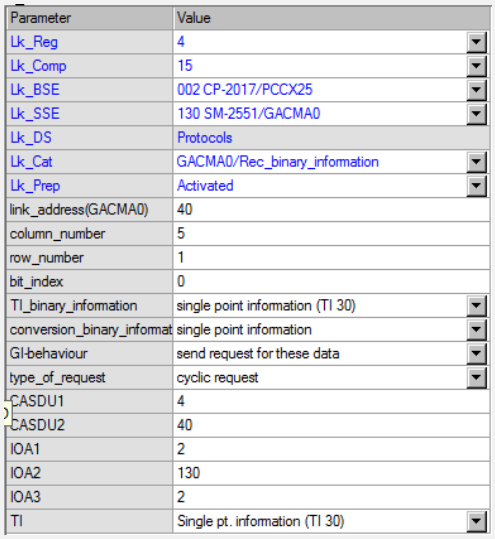
Message Conversion in Receive Direction IEC60870-5-101/104 ß Courier Protocol:

IEC 60870-5-101/104		ï Courier Data Format
Type ID	**Designation**	**Designation**
<TI=30>	Single-point information with time tag CP56Time2a	Array of binary flags
<TI=31>	Double-point information with time tag CP56Time2a	Array of binary flags
<TI=34>	Measured value, normalized value with time tag CP56Time2a	Signed Integer, Unsigned Integer, Courier Number, Short Floating Point
<TI=35>	Measured value, scaled value with time tag CP56Time2a	Signed Integer, Unsigned Integer, Courier Number, Short Floating Point
<TI=36>	Measured value, short floating point value with time tag CP56Time2a	Signed Integer, Unsigned Integer, Courier Number, Short Floating Point
<TI=37>	Integrated totals with time tag CP56Time2a	Signed Integer, Unsigned Integer, Courier Number, Short Floating Point

5.3.1 Indications

The parameterization of the address and message conversion for indications in receive direction is to be done with TOOLBOX II / OPM with the parameter category *firmware* / Rec_binary_information.

Parameter Category:
firmware /Rec_binary_information



Parameter	Value
Lk_Reg	4
Lk_Comp	15
Lk_BSE	002 CP-2017/PCCX25
Lk_SSE	130 SM-2551/GACMA0
Lk_DS	Protocols
Lk_Cat	GACMA0/Rec_binary_information
Lk_Prep	Activated
link_address(GACMA0)	40
column_number	5
row_number	1
bit_index	0
TI_binary_information	single point information (TI 30)
conversion_binary_informat	single point information
GI-behaviour	send request for these data
type_of_request	cyclic request
CASDU1	4
CASDU2	40
IOA1	2
IOA2	130
IOA3	2
TI	Single pt. information (TI 30)

Parameter	
TI .. type identification	Supported Type Identifications: · <TI:=30> .. single point information with time tag CP56Time2a · <TI:=31> .. single point information with time tag CP56Time2a
CASDU, IOA	SICAM RTUs internal IEC608705-101/-104 message address
Link_address(GACMA0)	Courier address of the slave device: · 1-254
Column_number	Column number of the menu cell in the database: · 0-255
Row_number	Row number of the menu cell in the database: · 0-255
Bit_index	Bit index that has to be converted in an array of up to 32 binary flags of this menu cell: · 0 – 31 [single point information] · 0 – 30 [double point information] · 255 à the menu cell only contains one data point
TI_binary_information	Conversion related to the Type Identification: · Single point information [single point information] · Single point information inverted [single point information] · Double point information OFF before ON [double point information] · Double point information ON before OFF [double point information]
Conversion_binary_information	Type of conversion: · single point information · transient information (only ON passing) · Double point information with DIFF/FAULT suppression · Double point information without DIFF/FAULT suppression
GI_Behaviour	· Send request for these data · Use the data from the internal process image (no request)
Type_of_request	· Cyclic request/update · Request only on GI

Supported Data Formats:

TI	SICAM RTUs 101/-104 Data Format		
30	single point information with time tag CP56Time2a		Ê
31	double point information with time tag CP56Time2a	Ê	
Format	**Data type**		
Array of binary flags	Byte/Flag	ü	ü

Message Conversion

The table describes the evaluated elements of the IEC 60870-5-101/104 message during message conversion.

Elements of the message		
TI	.. Type identification	TI 30 .. single point information with time tag CP56Time2a TI 31 .. double point information with time tag CP56Time2a
CASDU, IOA .. Message address		can be set by parameter
QDS	.. Quality descriptor	
BL	.. blocked	not supported (BL="0")
SB	.. substituted	not supported (SB="0")
NT	.. not topical	not supported (NT="0")
IV	.. invalid	not supported (IV="0")
Cause of transmission		
03	.. spontaneous	upon change of information state or quality descriptor
20	.. interrogated by station interrogation	On reception of a GI request
xx	.. other COTs	not supported
T	.. Test	not supported
Information		
Single point information		
SPI	0 .. OFF	supported
	1 .. ON	supported
Double point information		
DPI	0 .. indeterminate or intermediate state	supported
	1 .. OFF	supported
	2 .. ON	supported
	3 .. indeterminate	supported
time tag		
CP56Time2a	.. date + time	PRE internal time (receive time)

... elements of IEC60870-5-101/-104 message not included in table are not evaluated/not supported!

5.3.2 Measured Values

The parameterization of the address and message conversion for measured values in receive direction is to be done with TOOLBOX II / OPM with the parameter category *firmware /* Rec_measured_value.

Parameter Category:
*firmware /*REC_measured_value

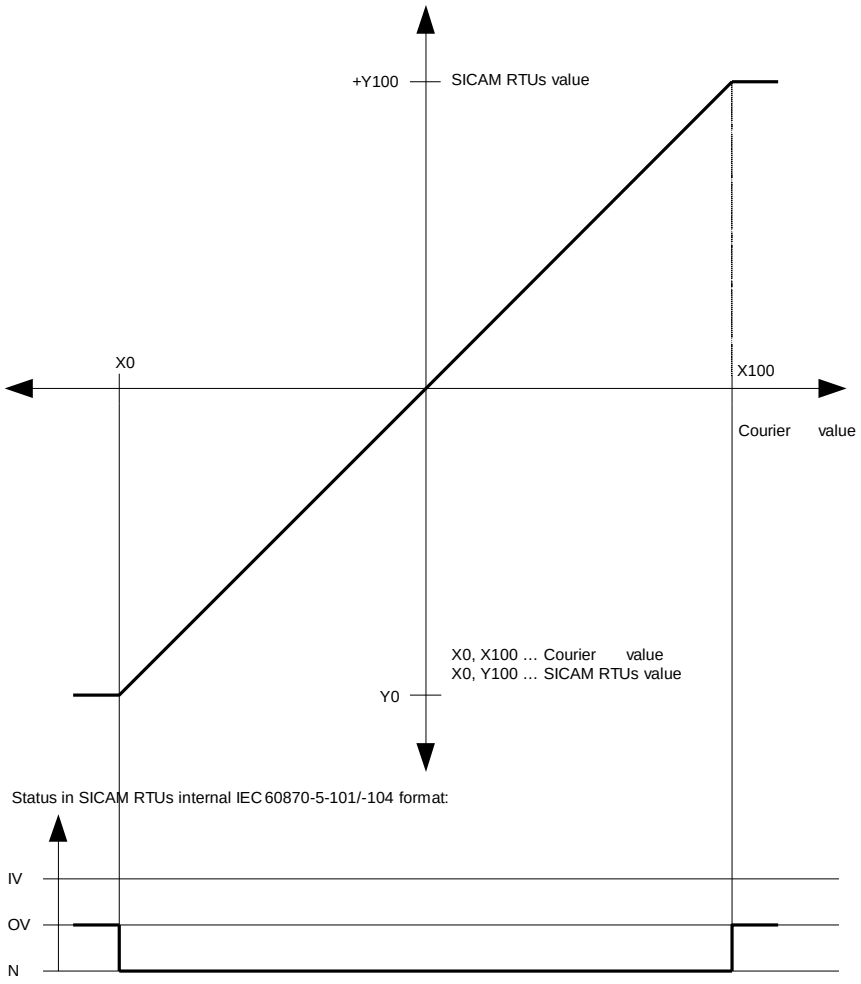
Parameter	Value
Lk_Reg	4
Lk_Comp	15
Lk_BSE	002 CP-2017/PCCX25
Lk_SSE	130 SM-2551/GACMA0
Lk_DS	Protocols
Lk_Cat	GACMA0/Rec_measured_value
Lk_Prep	Activated
link_address(GACMA0)	40
column_number	2
row_number	5
type_of_request	cyclic request
X_0%	-100000
X_100%	100000
Y_0%	-32768
Y_100%	32767
Measured_value_threshold_larg	10
Measured_value_threshold_add	3
CASDU1	4
CASDU2	40
IOA1	2
IOA2	130
IOA3	41
TI	Measured val. 15 bit + sign scaled (TI 35)

Parameter	
TI .. type identification	Supported Type Identifications: · <TI:=33> .. bitstring of 32 bit with time tag CP56Time2a · <TI:=34> .. measured value, normalized value with time tag CP56Time2a · <TI:=35> .. measured value, normalized value with time tag CP56Time2a · <TI:=36> .. measured value, normalized value with time tag CP56Time2a
CASDU, IOA	SICAM RTUs internal IEC608705-101/-104 message address
Link_address(GACMA0)	Courier address of the slave device: · 1-254
Column_number	Column number of the menu cell in the database: · 0-255
Row_number	Row number of the menu cell in the database: · 0-255
Type_of_request	· Cyclic request/update · Request only on GI
X_0%, X_100% Y_0%, Y_100%	Parameters for value adaption (scaling) Note: - <TI:=34> .. Y_0% and Y_100% must not be greater or smaller than ± 1. - <TI:=35> .. Y_0% and Y_100% must not be smaller than - 32768 and not greater than +32767. - value adaption inactive when X_0% and X_100 = 0
thresh_uncond	Value will be sent to BSE immediately when change of value > thresh_uncond.
thresh_additive	Value will not be sent immediately to BSE when change of value <= thresh_uncond. Additive change monitoring will be activated. Additive Change Monitoring: If summarized changes (=adding the changes with sign since last forwarding) > thresh_additive value will be forwarded to BSE.

Supported Data Formats:

TI	SICAM RTUs 101/-104 Data Format				
34	measured value, normalized value with time tag CP56Time2a				Ê
35	measured value, scaled value with time tag CP56Time2a			Ê	
36	measured value, short floating point with time tag CP56Time2a		Ê		
		Ê			
Format	**Data type**				
Signed integer	Integer value 8, 16 or 32 bit with sign bit (most significant bit)	ü	ü	ü	ü
Unsigned integer	Integer value 8, 16 or 32 bit without sign bit	ü	ü	ü	ü
Courier specific number	See chapter 4.2.5.4.4 Courier Numeric Type (Courier Number)	ü	ü	ü	ü
Short floating point	Short floating point value (32 Bit)	ü	ü	ü	ü

Value Adaption:
The adaption is defined by the parameters X_0%, X_100%, Y_0%, Y_100%.



The value adaption is only enabled if X_0% or X_100% is parameterized <> “0“.

Note:
- OV=”1” if value adaption is disabled (direct forwarding) and if Courier raw value is outside of the value range specified for the selected IEC60870-5-101/-104 type identification.

Message Conversion

The table describes the evaluated elements of the IEC 60870-5-101/104 message during message conversion.

Elements of the message	
TI .. Type identification	TI 34 .. Measured value, normalized value with time tag CP56Time2a TI 35 .. Measured value, scaled value with time tag CP56Time2a TI 36 .. Measured value, short floating point number with time tag CP56Time2a
CASDU, IOA .. Message address	can be set by parameter
QDS .. Quality descriptor	
BL .. blocked	not supported (BL="0")
SB .. substituted	not supported (SB="0")
NT .. not topical	NT="1" if DP/DP coupler status "data valid = 0" (otherwise NT="0")
IV .. invalid	IV=1: - FLOAT32 format if value = "NAN" ("Not A Number") … otherwise IV="0".
OV .. overflow	OV=1: <u>Value adaption enabled:</u> - Courier value is outside of the range of the selected TI <u>Value adaption disabled:</u> - Courier value is smaller than X_0% or greater than X_100%
Cause of transmission	
03 .. spontaneous	Alteration of the measured value depending on the thresholds or alteration of the quality descriptor
20 .. interrogated by station interrogation	On reception of a GI request
xx .. other COTs	not supported
T .. Test	not supported
Information	
value .. S .. sign	normalized value scaled value IEEE STD 754 = short floating point number
time tag	
CP56Time2a .. date + time	PRE internal time (receive time)

… elements of IEC60870-5-101/-104 message not included in table are not evaluated/not supported

5.3.3 Integrated Totals

The parameterization of the address and message conversion for integrated totals in receive direction is to be done with TOOLBOX II / OPM with the parameter category *firmware /* Rec_Counter_value.

Parameter Category:
*firmware /*REC_Counter_value

Parameter	Value
Lk_Reg	4
Lk_Comp	15
Lk_BSE	002 CP-2017/PCCX25
Lk_SSE	130 SM-2551/GACMA0
Lk_DS	Protocols
Lk_Cat	GACMA0/Rec_counter_value
Lk_Prep	Activated
link_address(GACMA0)	40
column_number	3
row_number	26
type_of_request	cyclic request
IEC-group	Group 1
Transmit	Counter interr.
Overflow_(102MA0)	transparent data transfer
raw value type	relative value -> absolute value
CASDU1	4
CASDU2	40
IOA1	2
IOA2	130
IOA3	70
TI	Count 31 bit + sign (TI 37)

Parameter	
TI .. type identification	Supported Type Identifications: · <TI:=37> .. integrated totals with time tag CP56Time2a
CASDU, IOA	SICAM RTUs internal IEC608705-101/-104 message address
Link_address(GACMA0)	Courier address of the slave device: · 1-254
Column_number	Column number of the menu cell in the database: · 0-255
Row_number	Row number of the menu cell in the database: · 0-255
Type_of_request	· Cyclic request/update · Request only on GI
Transmit	Definition for transmit integrated totals to BSE (counter freeze and read): · counter interrogation · periodic forwarding: 1, 2, 3, 5, 10, 15, 30, 60 minute(s)
IEC-group	Request Counter Group: · Request counter group 1, 2, 3, 4
Overflow	Overflow for integrated totals at: · 24, 31 bit integer · 2, 3, 4, 5, 6, 7, 8, 9 decades BCD · transparent, no adaption
raw value type	not evaluated

Supported Data Formats:

TI	SICAM RTUs 101/-104 Data Format	
37	integrated totals with time tag CP56Time2a	Ê
Format	**Data type**	
Signed integer	Integer value 8, 16 or 32 bit with sign bit (most significant bit)	ü
Unsigned integer	Integer value 8, 16 or 32 bit without sign bit	ü
Courier specific number	See chapter 4.2.5.4.4 Courier Numeric Type (Courier Number)	ü
Short floating point	Short floating point value (32 Bit)	ü

Message Conversion

The table describes the evaluated elements of the IEC 60870-5-101/104 message during message conversion.

Elements of the message	
TI .. Type identification	TI 37 .. integrated totals with time tag CP56Time2a
CASDU, IOA .. Message address	can be set by parameter
data point quality descriptor	
sequence number	With each trigger for latching for a group the sequence number is incremented in the range from 1 .. 31.
CY .. Carry	On overflow of the count in the associated count period
CA .. presets	not supported
IV .. invalid	IV="0"
Cause of transmission	
03 .. spontaneous	for transmit = periodic forwarding
37 .. requested by general counter interrogation	for general request counter (all counter groups)
38-41 .. interrogated by group 1-4 interrogation	For request counter group (1..4)
T .. Test	not supported
Information	
value .. S .. sign	Binary counter reading
time tag	
CP56Time2a .. date + time	PRE internal time

… elements of IEC60870-5-101/-104 message not included in table are not evaluated/not supported!

Message Conversion “Counter Interrogation Command” (SICAM RTUs internal only)

This table describes the data point quality descriptor and the cause of transmission according to IEC 60870-5-101/104.

Elements of the message		
TI .. Type identification		TI 101 .. Counter Interrogation Command
CASDU, IOA .. Message address		Defined
QCC .. Identifier counter interrogation		
FRZ	RQT	FRZ … Freeze RQT … Request
0	1..4	read (no freeze or reset) request counter group (1..4)
	5	read (no freeze or reset) general request counter (all counter groups)
1	1..4	counter freeze without reset request counter group (1..4)
	5	counter freeze without reset all counter groups
2	1..4	counter freeze with reset request counter group (1..4)
	5	counter freeze with reset all counter groups
3	1..4	counter reset request counter group (1..4)
	5	counter reset all counter groups
x	0; 6 .. 63	not supported
Cause of transmission		
06 .. activation		must be set
xx .. other COTs		not supported
T .. Test		not supported

5.4 Application Notes

5.4.1 Get Database

Sometimes when no information are available about the database of the slave device for the parameterization of the data conversion, it has to be read out directly from the slave device. Therefore the firmware GACMA0 is able to show the database of the slave device.

To do so follow these steps:

- connect to the SICAM RTU
- open the ST-Emulation (Toolbox II à service tools à special tools à ST Emulation)
- type the command “L” to logon
- connect to the related basic system element where GACMA0 is equipped à command “gcX” (where X means the BSE number) or “gm” if GACMA0 is equipped on the MCU
- connect to the GACMA0 firmware à command “gzY” (where Y means the PRE number 128, 129, 130 or 131)
- type the command “IDD” to display the local database of all connected slave devices

The result should look like this:

```
C2/Z130:idd
 --------   connected device   --------
 station address (internal stat.no)  :  1
 network address                     :  40
 station state                       :  communication OK
 serial number                       :  652132F
 device type                         :  KMPC13001F15MEA
 device desription                   :  Grid Trans 5
 plant reference                     :  132/33 TX
 device trip indication              :  no
 device alarm state                  :  no
```

Table: data base of a slave device

this shows a brief desription of the name of all available column and row numbers of this device and every line consits of 2 data sets of the regarding row number

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 000 — description: SYSTEM DATA

row nr.	description	T	unit	value	row nr.	description	T	unit	value
2	SYS Password	s			3	SYS Fn. Links	b		0x00000041
4	SYS Description	s			5	SYS Plant Ref.	s		
6	SYS Model No.	s			8	SYS Serial No.	s		
9	SYS Frequency	u	Hz		10	SYS Comms Level	u		
11	SYS Rly Address	u			12	SYS Plant Status	b		0x00000000
13	SYS Ctrl Status	b		0x00000000	14	SYS Setting Grp	u		
15	SYS LS Stage	s			16	SYS CB Control	s		
17	SYS Software Ref	s			32	SYS Logic Stat	b		0x00000000
33	SYS Relay Stat	b			34	SYS Alarms	b		

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 001 — description: FAULT RECORDS

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	FLT Ia	k			2	FLT Ib	k		
3	FLT Ic	k			4	FLT Io	k		
5	FLT Vab	k			6	FLT Vbc	k		
7	FLT Vca	k			9	FLT CB Trip Time	k		
10	FnowG%s	s			11	Fn G%s	s		
12	Fn-1G%s	s			13	Fn-2G%s	s		
14	Fn-3G%s	s			15	Fn-4G%s	s		
16	FLT Records								

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 002 — description: MEASUREMENTS(1)

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	MS1 Ia	k	A	0.00000000	2	MS1 Ib	k	A	0.00000000
3	MS1 Ic	k	A	0.00000000	4	MS1 Io	k		
5	MS1 Vab	k	V	0.00000000	6	MS1 Vbc	k		
7	MS1 Vca	k			8	MS1 Va	k		
9	MS1 Vb	k	V	0.00000000	10	MS1 Vc	k		
12	MS1 F	k	Hz	50.0000					

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 003 description: MEASUREMENTS(2)

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	MS2 W	k	W	0.00000000	2	MS2 VA	k		
3	MS2 VAr	k			4	MS2 Iave	k		
5	MS2 Vave	k			6	MS2 Inps (%%)	k		
7	MS2 Vnps (%%)	k			9	MS2 Wa	k		
10	MS2 Wb	k			11	MS2 Wc	k		
12	MS2 PowerFactor	k		-0.01000000	13	MS2 VAra	k		
14	MS2 VArb	k			15	MS2 VArc	k		
16	MS2 Sum (Ops)	u			26	MS2 MWh	k		
27	MS2 MVARh	k			30	MS2 Power Mode	u		

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 004 description: MEASUREMENTS(3)

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	MS3 tD>	s			2	MS3 tD	k		
4	MS3 D Ia	k			5	MS3 D Ib	k		
6	MS3 D Ic	k			10	MS3 PD Ia	k		
11	MS3 PD Ib	k			12	MS3 PD Ic	k		
17	MS3 D +3ph W	k			18	MS3 D -3ph W	k		
19	MS3 D +3ph VAr	k			20	MS3 D -3ph VAr	k		
22	MS3 PD +3ph W	k			23	MS3 PD -3ph W	k		
24	MS3 PD +3ph VAr	k			25	MS3 PD -3ph VAr	k		

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 005 description: EARTH FAULT(1)

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	EF1 Fn. Links	b		0x00000000	5	EF1 Io>	k		
6	EF1 to>	k							

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 006 description: PHASE FAULT(1)

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	PF1 Fn. Links	b		0x00000000	2	PF1 CT Ratio	k		
3	PF1 VT Ratio	k			5	PF1 I>	k		
6	PF1 t>	k			13	PF1 I<	k		

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 009 description: LOGIC FUNCTIONS

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	LOG Fn. Links	b			3	LOG tAUX1	k		
4	LOG tAUX2	k			5	LOG tAUX3	k		
6	LOG tBF	k			7	LOG tTRIP	k		
8	LOG tCLOSE	k			9	LOG LS GROUP	u		
10	LOG tRESTORE	k			15	LOG DefaultDsply	s		

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 010 description: INPUT MASKS

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	INP Blk to>	b			5	INP Blk t>	b		
8	INP Aux 1	b			9	INP Aux 2	b		
10	INP Aux 3	b			12	INP CB Opened	b		
13	INP CB Closed	b			14	INP Bus Posn 2	b		
15	INP LTrip CB	b			16	INP LClose CB	b		
21	INP Reset tD>	b							

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 011 description: RELAY MASKS

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	RLY Io>	b			4	RLY to>	b		
6	RLY I>	b			9	RLY t>	b		
12	RLY Aux1	b			13	RLY Aux2	b		
14	RLY Aux3	b			15	RLY V Reduct1	b		
16	RLY V Reduct2	b			17	RLY V Reduct3	b		
18	RLY CB Trip	b			19	RLY CB Close	b		

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 012 description: RECORDER

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	REC Control	s			2	REC Capture	s		
3	REC Post Trigger	u	samples		5	REC Relay trig	b		

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 144 description: DISTURBANCE REC.

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	DIS Record No.				2	DIS Trigger Time	u		
3	DIS Ch Available	b			4	DIS Ch Types	b		
5	DIS Upload				6	DIS Upload			
16	DIS Rec Length	u			17	DIS Trigger Posn	u		
18	DIS Time Base	k			20	DIS Upload			
32	DIS Upload				33	DIS Upload			
34	DIS Upload				35	DIS Upload			
36	DIS Upload				37	DIS Upload			
38	DIS Upload				39	DIS Upload			
40	DIS Upload				41	DIS Upload			

T(ype): b=binary, x=hexadecimal, d=integer, u=singed integer, f=floating point, k=COURIER spec. number, t=7 byte time, c=single character, s=ASCII string

column number: 191 description: COMM SYSTEM DATA

row nr.	description	T	unit	value	row nr.	description	T	unit	value
1	COM Rec Ctrl	x			2	COM Rec Load	x		
4	COM Reset MDI				255	COM o/r	u		

This shows the complete database of a KMPC130 device. It contains the column number with its description and the row numbers with the description of the data point. Additional the most data points have a data type and if a physical unit is applicable it will be shown as well. The actual value is only displayed if this data point is already parameterized in the detailed routing table and got successfully requested by the master control unit.

For example, if the current of Phase A should be requested, than it can be found in “MEASUREMENTS(1)” column number = 2 and row number = 1 “MS1 Ia”. The value has the physical unit “A” (ampere). If not displayed there is no scalar or prefix like kilo or Mega.

Literature

SICAM RTUs • Ax 1703 Common Functions Protocol Elements	DC0-023-2
SICAM RTUs Common Functions System and Basic System Elements	DC0-015-2
SICAM RTUs Platforms Configuration Automation Units and Automation Networks	DC0-021-2

Documents on Interoperability

Ax 1703 Interoperability IEC 60870-5-101 or -104	DA0-046-2
SICAM RTUs Interoperability IEC 60870-5-101/104	DC0-013-2

International Standards

IEC 60870-5-101	

Other

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