INTERNATIONAL STANDARD

IEC 61850-9-1

First edition
2003-05

Communication networks and systems in substations –

Part 9-1: Specific Communication Service Mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMUNICATION NETWORKS AND SYSTEMS IN SUBSTATIONS –

Part 9-1: Specific Communication Service Mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link

FOREWORD

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International Standard IEC 61850-9-1 has been prepared by IEC technical committee 57: Power system control and associated communications.

The text of this standard is based on the following documents:

FDIS	Report on voting
57/619/FDIS	57/636/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IEC 61850 consists of the following parts, under the general title *Communication networks and systems in substations.*

Part 1: Introduction and overview

Part 2: Glossary [1]

Part 3: General requirements

Part 4: System and project management

Part 5: Communication requirements for functions and devices models [2]

Part 6: Configuration description language for communication in electrical substations related to IEDs [1]

Part 7-1: Basic communication structure for substation and feeder equipment – Principles and models

Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)

Part 7-3: Basic communication structure for substation and feeder equipment – Common data classes

Part 7-4: Basic communication structure for substation and feeder equipment – Compatible logical node classes and data classes

Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO/IEC 9506-1 and ISO/IEC 9506-2) and to ISO/IEC 8802-3 [1]

Part 9-1: Specific communication service mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link

Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3 [1]

Part 10: Conformance testing [1]

The relationship between IEC 60044-8 and this standard is as follows:

IEC 60044-8 defines a merging unit as interface to electronic current and voltage transformers. Data objects provided by that merging unit are specified in IEC 60044-8. This standard specifies a serial communication interface between the merging unit and equipment using the digital output of the merging unit like protection or metering equipment. For the specification of that serial interface, a subset of the abstract communication services defined in IEC 61850-7-2 are mapped on an ISO/IEC 8802-3 based communication link.

The committee has decided that the contents of this publication will remain unchanged until 2005. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this standard may be issued at a later date.

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1 Under consideration.

2 To be published.

INTRODUCTION

This part of IEC 61850 applies to electronic current and voltage transformers (ECT and EVT) with a digital output via a merging unit, for use with electronic measuring instruments and electronic protective devices.

The transformer technology can be based on optical arrangements equipped with electronic components, on air core coils (with or without a built-in integrator) or, on iron core coils with integrated burden and used as a current to voltage converter, alone or equipped with electronic components.

For digital output, this standard takes into account a point to point connection from the merging unit to electronic measuring instruments and electronic devices.

This mapping allows interoperability between devices from different manufacturers.

This standard does not specify individual implementations or products, nor does it constrain the implementation of entities and interfaces within a computer system. This standard specifies the externally visible functionality of implementations.

Reading Guide

- The point to point transformer interface as defined here is based on the concepts described in IEC 60044-8. This standard extends this concept and proposes an alternative link layer to provide a solution for transmitting sampled measured values via Ethernet based interfaces. For the definition and measurement of the accuracy, synchronisation methods, data rates etc. of the transformers, refer to IEC 60044-8.

- This document can best be understood if the reader is thoroughly familiar with Parts 7-1, 7-2, 7-3 and 7-4 of this Standard.

- No explanations to the ACSI services are given in this part of the standard. For detailed information about the use of the ACSI services, refer to IEC 61850-7-2.

COMMUNICATION NETWORKS AND SYSTEMS IN SUBSTATIONS –

Part 9-1: Specific Communication Service Mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link

1 Scope

This part of IEC 61850 specifies the specific communication service mappings for the communication between bay and process level and it specifies a mapping on a serial unidirectional multidrop point to point link in accordance with IEC 60044-8. This part of IEC 61850 specifies a mapping of the abstract service for the transmission of sampled values (as defined in IEC 61850-7-2) on a serial unidirectional multidrop point to point link in accordance with IEC 60044-8. It applies to the communication between merging units of electronic current (ECT) or voltage-transformers (EVT) and bay devices such as protection relays. If higher requirements on sampling rate, further sampled measured value data sets in addition to the universal data set, inter-bay communication and synchronisation apply, these will be covered by IEC 61850-9-2[3]. Figure 1 shows the schematics of this interface.

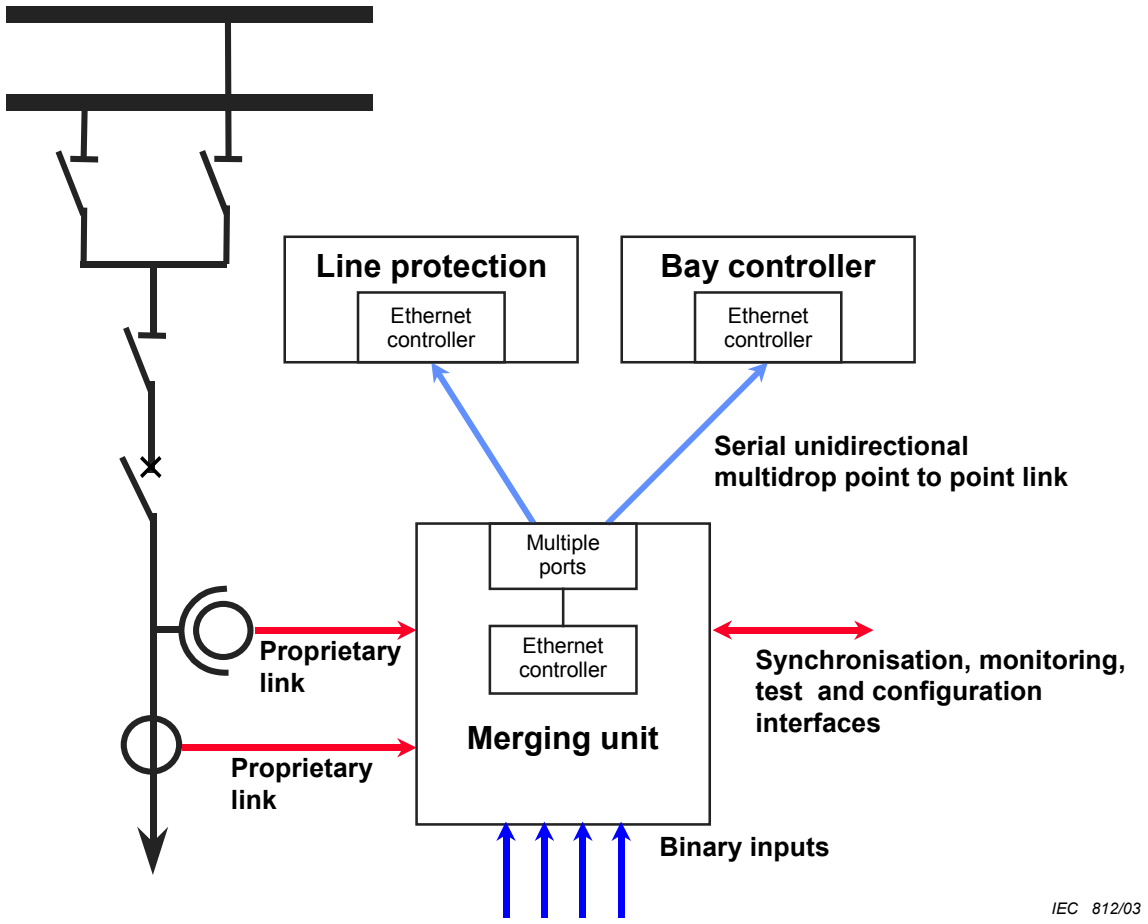

Figure 1 – Example for the use of the serial unidirectional multidrop point to point link

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3 Under consideration.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60044-7: *Instrument Transformers – Part 7: Electronic voltage transformers*

IEC 60044-8: *Instrument Transformers – Part 8: Electronic current transformers*

IEC 60874-10-1:1997, *Connectors for optical fibres and cables – Part 10-1: Detail specification for fibre optic connector type BFOC/2,5 terminated to multimode fibre type A1*

IEC 61850-7-2: *Communication networks and systems in substations – Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)*

IEC 61850-7-3: *Communication networks and systems in substations – Part 7-3: Basic communication structure for substation and feeder equipment – Common data classes*

ISO/IEC 8802-3: *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

ISO/IEC 8825-1: *Information technology – ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER)*

IEEE 802.1Q-1998: *IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks*

IEEE 802.3: *Information Technology – Telecommunication and Information Exchange Between Systems – LAN/MAN – Specific Requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*

3 Terms and definitions

For the purpose of this part of IEC 61850, the definitions of IEC 61850-2[4], IEC 60044-7 and IEC 60044-8 apply.

4 Abbreviations

ACSI	Abstract Communication Service Interface
ASDU	Application Service Data Unit
ASN.1	Abstract Syntax Notation number One
APCI	Application Protocol Control Information
APDU	Application Protocol Data Unit
AUI	Attachment Unit Interface
BER	ASN.1 Basic Encoding Rules
CFI	Canonical format identifier

4 Under consideration.

CSMA/CD	Carrier Sense Multiple Access/Collision Detection
DF	Data Frame
DO	Data Object
DSG	Data Set Group
ECT	Electronic Current Transformers
EVT	Electronic Voltage Transformers
LSDU	Link Layer Service Data Unit
MAC	Media Access Control
MSVCB	Multicast Sampled Value Control Block
MU	Merging Unit
PDU	Protocol Data Unit
SBO	Select Before Operate
SC	Secondary Converter
SCSM	Specific Communication Services Mapping
SIG	Status Indication Group
SAV	Sampled Analogue Value
TCI	Tag Control Information
TPID	Tag Protocol Identifier
VID	VLAN Identifier
VLAN	Virtual Local Area Network

5 Principle of mapping to the serial unidirectional multidrop point to point link

This Clause gives an overview of the mapping to the serial unidirectional multidrop point to point link. It defines the communication stack and data unit structures for the application layer. Restrictions to the application that are a consequence of this mapping are defined as well.

5.1 Communication stack

Figure 2 gives an overview of the communication stack. The link layer is in conformity with ISO/IEC 8802-3. This standard is usually referred to as Ethernet. In the following, the term Ethernet will be used instead of ISO/IEC 8802-3 (CSMA/CD).

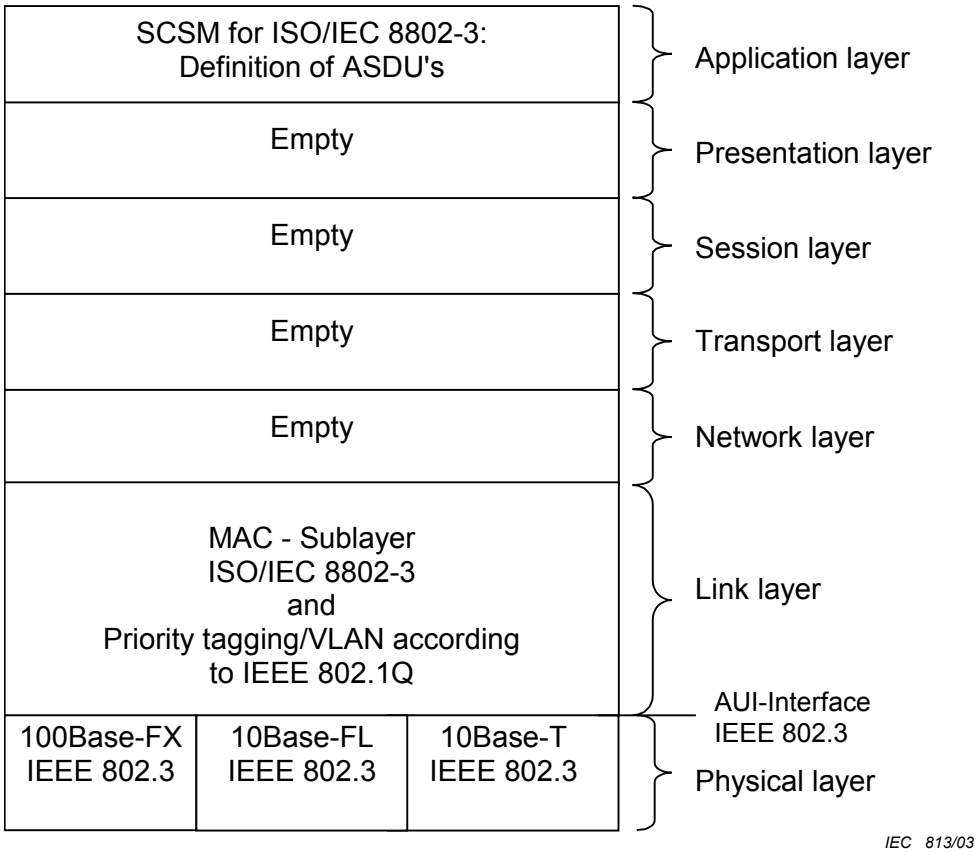


Figure 2 – Communication stack

The relevant device standards will specify whether 100Base-FX, 10Base-FL or 10Base-T is used, depending on the application.

5.1.1 Physical layer

5.1.1.1 Specifications for the Medium Attachment Unit (MAU)

The connection of the merging unit to the secondary equipment can be an optical fibre transmission system. By taking into account and solving the EMC requirements, a copper based transmission system is an option.

5.1.1.2 Fibre optic transmission system

The preferred version of the fibre optic transmission system is IEEE 802.3 100Base-FX. The 10Base-FL system could be used also for sampling rates below 48 × f_r (a selection guide is given in Annex B). This interface shall be used for applications where this media interface is already used for other communication links. It is recommended to use the BFOC connectors (IEC 60874-10-1). Two fibres are always necessary for the optical fibre transmission system in order to support the link supervision.

5.1.1.3 Twisted-pair transmission system

The twisted-pair medium according to IEEE 802.3 10Base-T could be used as an option, if appropriate electromagnetic shield measures are considered.

5.1.2 Link layer

5.1.2.1 Ethernet addresses

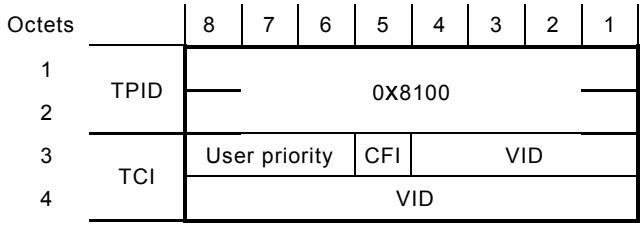
The Ethernet broadcast address shall be used as a default value for a destination address, which consists of ones in the destination address field (the Ethernet frame format is shown in Annex B). For this reason, no address configuration is necessary on the publisher side. However, the destination address could be configurable as an optional feature for example, adjust a multicast address to connect a merging unit via switch to bay level devices. A unique Ethernet address shall be used as a source address.

NOTE The recommended address range assignments will be specified in IEC 61850-9-2 and IEC 61850-8-1.

5.1.2.2 Priority tagging/Virtual LAN

Priority tagging according to IEEE 802.1Q is used to separate time critical and high priority bus traffic for protection relevant applications from low priority busload.

Structure of the tag header:



Key

TPID value: 0x8100

User priority: BS3; user priority value shall be set by configuration to separate sampled analogue values and time critical protection relevant GOOSE messages from low priority busload.

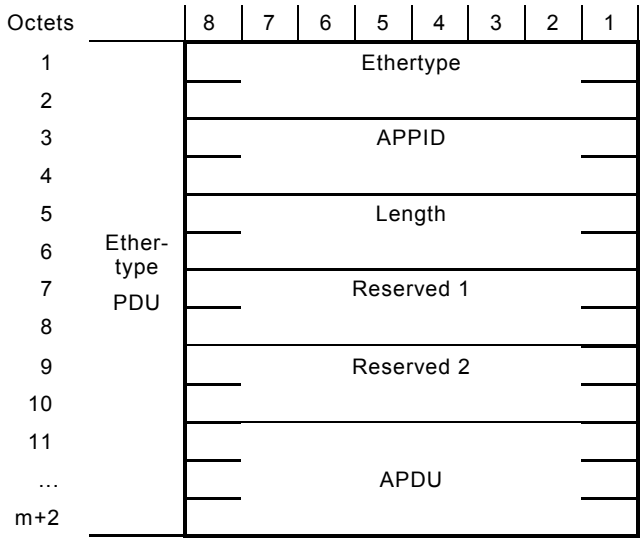
CFI: BS1 [0]; No Embedded RIF field follows the length/type field in the Ethernet tagged frame.

VID: Virtual LAN support is optional. If this mechanism is used, the VLAN identifier (VID) shall be set by configuration. Otherwise, the VLAN identifier is set by default to 0.

5.1.2.3 Ethertype

An Ethertype based on ISO/IEC 8802-3 MAC – Sublayer is registered by the IEEE Authority Registration. The registered Ethertype value is 88-BA (hexadecimal). The sampled analogue value buffer update is directly mapped to the reserved Ethertype and the Ethertype PDU.

Structure of the Ethertype PDU:



Key

APPID: application identifier. The APPID is used to select sampled analogue value messages and to distinguish the application association.

Reserved value range for SAV are 0x4000 to 0x7FFF.

Length: number of octets including the Ethertype PDU starting at APPID (8 + m) (m < 1480).

Reserved 1/Reserved 2: reserved for future standardised applications.

5.1.3 Network layer

This layer is intentionally left empty.

5.1.4 Transport layer

This layer is intentionally left empty.

5.1.5 Session layer

This layer is intentionally left empty.

5.1.6 Presentation layer

Empty. See additional definitions in 7.3.

5.1.7 Application layer

Empty. See additional definitions in 7.3.

5.2 Restrictions

This specification is restricted to define the communication between the ECT/EVT related merging unit and devices on bay level which need raw data of ECT and/or EVT for their algorithms. Referring to the ACSI, only the mapping of sampled values using multicast/ broadcast is supported. The multicast sampled value control (MSVC) class is implicit.

The transmission of sampled values as specified in this standard only uses a unidirectional link from merging unit to bay level devices with broadcast/multicast addressing. However, the devices supporting this transmission will use an interface which is fully Ethernet compatible that includes all the facilities for easy plug in. This may imply that bi-directional exchanges exist to establish and maintain good quality transmission. These exchanges are part of the lower communication layers and are specified in the relevant standards.

The use of the Ethernet link in a bi-directional way to support other exchanges should be possible according to device capability, but it should not impact transmission of the universal data set. Typical cases may be synchronisation of local clocks, configuration loading and mode switching. These features are outside the scope of this standard.

6 Mapping of common types

6.1 Object name

For the transmission of the sampled value buffer, the object reference is encoded as integer values. The single elements of the object reference are assigned to integer values. Integer values related to logical node name and data name are defined with this SCSM. The integer value related to the logical device name will be defined by configuration tools or will be agreed by vendors of the client and server.

6.2 Object reference

As defined in IEC 61850-7-2, the name structure for the whole path to an instance is as follows:

<LDName> / <LNName>.<DataName>[.<DataName>]. <DataAttributeName>

The object reference in this SCSM concludes the whole path of the class and instance reference. Other hierarchy levels are not separately accessible.

In detail the SCSM Data Sets are mapped to the object reference as follows:

Table 1 – Mapping of the object reference

ACSI Object name	SCSM value
<LDName>	INTEGER UI16
<LNName>	INTEGER UI8
<DataName>	INTEGER UI8
<DataAttributeName>	not visible
NOTE It is assumed, that the data sets used for the transmission of sampled values in many cases include data objects from more than one logical node and are therefore allocated in LLN0.	

7 Mapping of the model for transmission of sampled values using multicast

There are two data sets specified in this document. The universal data set is compatible with IEC 60044-8 and the status indications is specified in Annex A.

Each data set refers to one multicast sampled value control class instantiation. The mapping of the sampled value buffer update is defined.

The transmission buffer refresh rate and the communication update rate are always equal and not independent from each other. The consequences on the publisher level are:

- After the sampling procedure is finished, the APDU will be stored into the transmission buffer (refresh rate = sampled rate), or more than one ASDU (*n* = number of ASDUs) could be stored into one APDU frame before the transmission buffer is refreshed (refresh rate = sampled rate/*n*). For a description of the blocking mechanism, see 7.3.
- Only one APDU can be stored into the transmission buffer, previous entries will be overwritten. The consistency of stored data will be guaranteed in case of overwriting.
- To avoid data overwriting, the data transmission must be initiated from the communication system immediately after the buffer update process is finished.

7.1 Mapping of the multicast sampled values services

Table 2 – Mapping of the multicast sampled value services

ACSI services	Ethernet services
Send MSVMessage	not supported
GetMSVCValue	not supported
SetMSVCValue	not supported

7.2 Mapping of the update of the sampled value buffer

According to the standard of IEC 61850-7-2, the communication system is responsible for updating the buffer of the subscriber.

The update is directly mapped to an Ethertype reserved for IEC 61850 applications based on ISO/IEC 8802-3 MAC – Sublayer.

However, the communication stack used does not provide the following functionalities:

- Initiating the update of the sampled value buffer over the communication link. This is an application layer functionality.
- Encode the abstract data types. This is a presentation layer functionality.
- Concatenation and segmentation of ASDU's is not supported.

NOTE Segmentation is not further considered, since the maximum frame length of the link layer protocol is sufficient.

Therefore, the additional definitions of 7.3 apply.

7.3 Additional definitions for the transmission of sampled analogue values

7.3.1 Application layer functionality

The mapping provides the capacity, to concatenate more than one ASDU into one APDU before the APDU is posted into the transmission buffer. The number of ASDUs which will be concatenated into one ASDU is defined with a configuration parameter and related to the sample rate.

Details are shown in Figure 3.

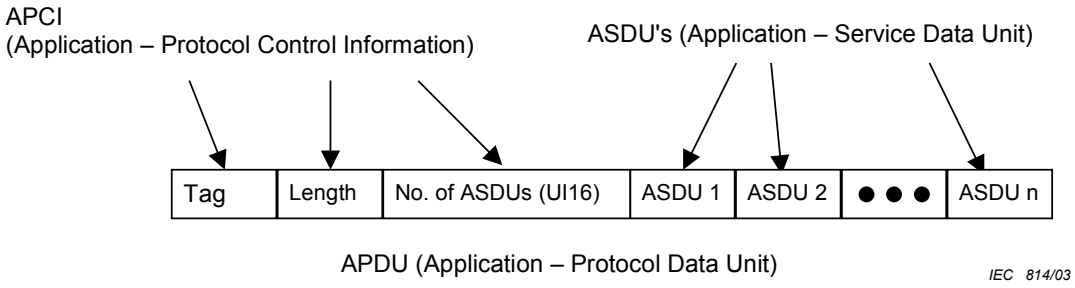


Figure 3 – Concatenation of several ASDU's into one APDU

An ASN.1 tag and length according to ISO/IEC 8825-1 is added up front as a part of the APCI. This tag specifies an octet string and is defined as context-specific and primitive (0x80) according to the ASN.1 basic encoding rules. The ASN.1 grammar for the sampled analogue value messages are defined as follows to ensure data consistency in combination with further sampled analogue value messages as described in this SCSM.

```
IEC61850 DEFINITIONS

IecSavPdu ::= CHOICE {
    9-1-Pdu             [0] IMPLICIT OCTET STRING,  -- Used for 9-1 APDU
    savPdu              [1] IMPLICIT SavPdu,    -- Reserved for 9-2 APDUs


        -- others TBD
}
```

7.3.2 Presentation layer functionality

For the transmission, the sampled value buffer is encoded as specified in Table 3.

Table 3 – Encoding for the transmission of sampled value buffer

Abstract Buffer Format according to IEC 61850-7-2		Coding in IEC 61850-9-1	Comment
Attribute Name	**Attribute Type**		
		OCTET: Tag	Tag is encoded according to ASN.1 Basic encoding rules
		OCTET STRING: Length	Length is encoded according to ASN.1 Basic encoding rules
		UI16: No. of ASDUs	Number of ASDU which will concatenated into one APDU and stored into the sampled value buffer
MsvID	VISIBLE STRING65	OCTET STRING	Broadcast MAC address is part of the Ethernet header
		UI16: Length	Length of the ASDU added as header (UI = Unsigned Integer)
OptFlds	PACKED LIST		Not mapped
DatSet	ObjectReference		
LNName DataSetInstanceName DataSetName LDName		UI8: UI8: UI16:	
Sample [1 .. n]	Value of the member of the instance of the DATA-SET	*Encoding of common data classes*	See Note
SmpCnt	INT16U	UI16	Counter specification see IEC 60044-8
RefrTm	TimeStamp		Not mapped
ConfRev	INT32U	UI8	Configuration revision number will be incremented each time that the configuration of the logical device changes. Default value is NULL
SmpSynch	BOOLEAN		See IEC 60044-8 status word attribute "NotSynch"
SmpRate	INT16U	UI8	0 = not defined; 1 – 255 = number of samples per cycle related to f_r

NOTE For the encoding of the samples, the rules for the encoding of the common data classes apply for the SIG. The mapping of the sampled values and status attributes in the universal data set is optimised according to the specifications in IEC 60044-8. It is not necessary that all possible transformers be connected to the merging unit. In this case, in the universal data set for the current or respectively voltage values not used, zeros are transmitted and the relevant data invalid bits are set.

7.3.3 Transport layer functionality

The communication system of the publisher has to send the sampled value buffer over the communication link after every buffer refresh. The buffer refresh rate depends on the sampling rate and the number of concatenated ASDUs as specified in Clause 7.

8 Mapping of the common data classes

8.1 Overview

For the use of the common data classes defined in IEC 61850-7-3 with the model for the transmission of sampled analogue values, the definitions of 8.2 apply.

8.2 Additional definitions for the mapping of the common data classes

To support the mapping to a bitstring based status indication group, an extended common data class SPS will be defined as follows by using the name space mechanism specified in IEC 61850-7-2.

Table 4 – Extended common data class single point status information

SPS class					
Attribute Name	**Attribute Type**	**FC**	**TrgOp**	**Value / Value Range**	**M/O**
DataName	Inherited from Data Class (see IEC 61850-7-2)				
DataAttribute					
status					
stVal	BOOLEAN	ST	dchg	TRUE | FALSE	AC_UDS_M
grpVal	BIT STRING	ST	dchg, dupd		AC_SIG_M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
configuration, description and extension					
cdcNs	VISIBLE STRING255	EX		"IEC 61850-9-1:2003"	

Abbreviation	**Condition**
AC_UDS_M	Attribute is mandatory, if universal data set is supported
AC_SIG_M	Attribute is mandatory, if status indication group is supported

Data attribute name	**Semantics**
grpVal	Bitstring where each bit represents a status

The common data classes of IEC 61850-7-3 and of this standard used in the context of the transmission of sampled analogue values shall be encoded as specified in Tables 5, 6 and 7 (only status attributes are shown).

Table 5 – Encoding of the common data class SPS used for the universal data set

Common data class SPS (IEC 61850-9-1)		**Coding in IEC 61850-9-1**	**Comment**
Attribute name	**Attribute type**		
stVal	BOOLEAN	BOOLEAN <0> = FALSE, OFF <1> = TRUE, ON	Status attribute of the universal data set according to IEC 60044-8.
grpVal	BIT STRING	-	Not mapped
q	Quality	-	Not mapped
t	TimeStamp	-	Not mapped
NOTE The transmission of information with the common data class SPS is only supported in the context of the universal data set that is defined in IEC 60044-8.			

Table 6 – Encoding of the common data class MV

Common data class MV (IEC 61850-7-3)		Coding in IEC 61850-9-1	Comment
Attribute name	**Attribute type**		
instMag	AnalogueValue		Not mapped
mag	AnalogueValue		
i f	INT32 FLOATING POINT32	UI16 -	Sampled analogue values of the universal data set according to IEC 60044-8.
range	ENUMERATED	-	Not mapped, see Note 1
q	Quality		
validity	CODED ENUM	BOOLEAN <0> = valid <1> = questionable, invalid	
detail-qual	PACKED LIST	-	Not mapped
source	CODED ENUM	-	Not mapped
test	BOOLEAN	-	Not mapped
operatorBlocked	BOOLEAN	-	Not mapped
t	TimeStamp	-	Not mapped, see Note 2

NOTE 1 According to IEC 61850-7-3, range is an optional attribute and is not required in the sampled value buffer format defined in IEC 61850-7-2.

NOTE 2 According to IEC 61850-7-3, t is a mandatory attribute. However, in the specification of the sampled value buffer format as defined in IEC 61850-7-2, t is not included with the data object values; there is only one sample counter attached that indicates the refresh of the universal data set sampled values as specified in IEC 60044-8.

However, for the universal data set, the encoding of the list of data object values does not follow some general rules but is instead optimised. The encoding of the list of data object values is defined in IEC 60044-8.

Table 7 – Encoding of common data class SPS used for the status indication group

Common data class SPS (IEC 61850-7-3)		Coding in IEC 61850-9-1	Comment
Attribute name	**Attribute type**		
stVal	BOOLEAN	-	Not mapped
grpVal	BIT STRING	BS16 <0> = FALSE, OFF <1> = TRUE, ON	16 individual status values. See Annex A
		BS16 <0> = VALID <1> = INVALID	16 individual quality indications related to the status values. See Annex A
q	Quality		
validity (IV)	CODED ENUM	BS1 [0] <0> = VALID <1> = INVALID	
detailQual	PACKED LIST	BS7 [1] = oscillatory (OS) [2] = failure, external error (EE) [3] = oldData (OD) [4] = inconsistent (IC) [5..7] = reserved (RE)	Further elements of detail-qual not mapped
source	CODED ENUM	-	Not mapped
test	BOOLEAN	-	Not mapped
operatorBlocked	BOOLEAN	-	Not mapped
t	TimeStamp		
SecondsSinceEpoch	INT32	UI32	
FractionOfSecond	INT24	UI24	
TimeQuality	TimeQuality		
LeapSecondsKnown (LK)	BOOLEAN	BS1 [0] <0> = FALSE <1> = TRUE	SecondsSinceEpoch includes leap seconds
ClockFailure (CF)	BOOLEAN	BS1 [0] <0> = FALSE, <1> = TRUE,	Time function is unreliable
ClockNotSynchronized (NS)	BOOLEAN	BS1 [1] <0> = FALSE, <1> = TRUE,	Clock is not synchronized to the reference source
TimeAccuracy	CODED ENUM	UI5	Reserved

Annex A
(normative)

Definition of data set instances and related multicast sampled value control instances

A.1 ASDU for universal data set

This data set is defined in IEC 60044-8, an overview is shown in Annex C.

Table A.1 – Predefined multicast sampled value control block instances relating to the transmission of the Universal Data Set according to IEC 60044-8

MSVCB attribute	Value
MsvCBNam	Implicit (IEC 60044-8)
MsvCBRef	Not visible
SvEna	Enabled during the start up phase
MsvID	Broadcast MAC address (optional multicast if configurable)
DatSet	<LDName> = UI16 = <FFFF H> or configurable
	<LNName>.<DataSetName> = <UI8>.<UI8> = <2>.< 1>
ConfRev	Preconfigured
SmpRate	Preconfigured
OptFlds	refresh-time=FALSE sample-synchronised=TRUE sample-rate=TRUE

A.2 ASDU for status indication data set

The status indication data set contains binary input status and quality information which will be transmitted periodically in the same way as the sampled analogue values. The intention is to give for example merging units or simpler devices the possibility to transmit binary input status indications, as a kind of distributed I/O mechanism based on the sampled value class model, to avoid the implementation of the reporting models specified in IEC 61850-7-2. Only one data set instance is permitted. This data set is related to the data name “Ind” of the logical node GGIO.

Octets		8	7	6	5	4	3	2	1
1	Length	msb			Length = 21				
2									lsb
3	Data set reference	msb			LNName = 2				lsb
4		msb			DataSetName = 2				lsb
5		msb			LDName				
6									lsb
7	SIG	S16	S15	S14	S13	S12	S11	S10	S9
8		S8	S7	S6	S5	S4	S3	S2	S1
9		Q16	Q15	Q14	Q13	Q12	Q11	Q10	Q9
10		Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1
11		**RE**	**RE**	**RE**	**IC**	**OD**	**EE**	**OS**	**IV**
12		2^{31}							2^{24}
13		2^{23}			SecondsSinceReference				2^{16}
14		2^{15}							2^{8}
15		2^{7}							2^{0}
16		Reserved					NS	CF	LK
17		2^{23}							2^{16}
18		2^{15}			FractionOfSecond				2^{8}
19		2^{7}							2^{0}
20	SC	msb			Counter				
21									lsb
22	SR	msb			Sample Rate				lsb
23	CR	msb			Configuration Revision				lsb

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Figure A.1 – Data set for status indication

Table A.2 – Predefined multicast sampled value control block instances relating to the transmission of status indications

MSVCB attribute	Value
MsvCBNam	Implicit (Status indications)
MsvCBRef	Not visible
SvEna	Enabled during the start up phase.
MsvID	Broadcast MAC address (optional multicast if configurable)
DatSet	<LDName> = UI16 = <FFFF H> or configurable
	<LNName>.<DataSetName> = <UI8>.<UI8> = <2>.< 2>
ConfRev	Preconfigured
SmpRate	Preconfigured
OptFlds	refresh-time=FALSE sample-synchronised=FALSE sample-rate=TRUE

Annex B
(informative)

Calculation of required bandwidth

The following tables can be used as a guideline for the selection of the appropriate physical layer related to the transmission of sampled analogue values.

Table B.1 – Selection guide for Ethernet physical layer (receiving node)

Sampling rate	Number of connected MUs				
	1	2	3	4-5	
10 × f_r	10 Mbps	10 Mbps	10 Mbps	10 Mbps	
12 × f_r	10 Mbps	10 Mbps	10 Mbps	10 Mbps	
16 × f_r	10 Mbps	10 Mbps	10 Mbps	10 Mbps	
20 × f_r	10 Mbps	10 Mbps	10 Mbps	10 Mbps	Rated value according to IEC 60044-8
40 × f_r	10 Mbps	10 Mbps	10 Mbps	100 Mbps	
48 × f_r	10 Mbps	10 Mbps	10 Mbps	100 Mbps	Rated value according to IEC 60044-8
80 × f_r	10 Mbps	100 Mbps	100 Mbps	100 Mbps	Rated value according to IEC 60044-8
200 × f_r	100 Mbps	100 Mbps	100 Mbps	100 Mbps	
f_r: Rated frequency (Hz).					
NOTE Concerning 400 × f_r: the available bandwidth of 100 Mbps Ethernet is not sufficient to allow three or more MUs transmit their samples to one receiving device.					

Table B.2 – Selection guide for Ethernet physical layer (sending node)

Sampling rate	1	
10 × f_r	10 Mbps	
12 × f_r	10 Mbps	
16 × f_r	10 Mbps	
20 × f_r	10 Mbps	Rated value according to IEC 60044-8
40 × f_r	10 Mbps	
48 × f_r	10 Mbps	Rated value according to IEC 60044-8
80 × f_r	10 Mbps	Rated value according to IEC 60044-8
200 × f_r	100 Mbps	
f_r: Rated frequency (Hz).		

Available Data rate: $S_R \times T_L \times n_{MU} \leq D_R$

D_R: Data rate (10 Mbps or 100 Mbps).

S_R: Sampling rate (Hz).

T_L: Max. telegram length; (26 Byte Ethernet frame + 4 Byte Priority tagging + 8 Byte Ethertype PDU + 2 Byte ASN.1 tag/length + 2 Byte No. of blocks + 46 Byte universal data set + 23 Byte status indications = 111 Byte × 8 Bit = 888 Bit + 96 Bit interFrameGap = 984 Bit)

n_{MU}: Number of connected MUs

EXAMPLE $S_R \times T_L \times n_{MU}$ = (400 × 60 Hz) × 984 Bit × 1 = 23,616 Mbps ≤ 100 Mbps

NOTE The above equation to determine the available data rate is theoretical only. In practice, it should be calculated with a reserve of approximately 10 %. In real applications, the available data rate depends normally on the CPU-power within the sender or receiver.

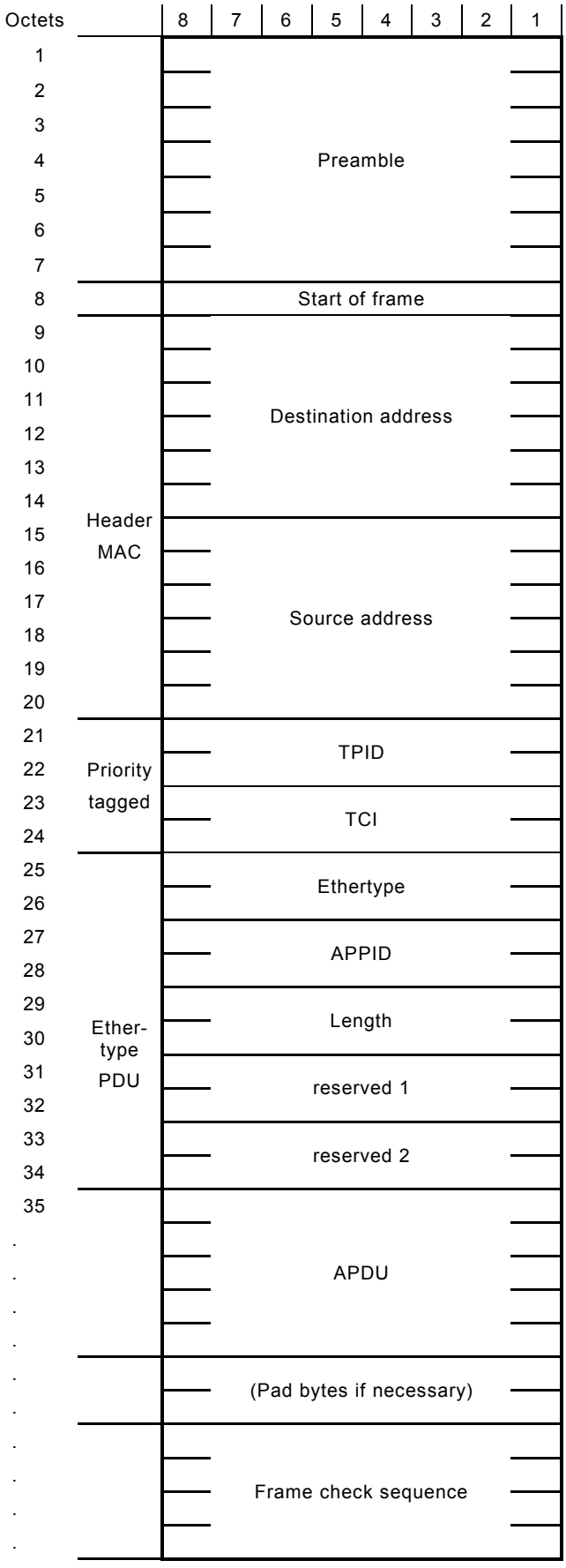

Figure B.1 – Ethernet Frame Format

Annex C
(informative)

Definitions of logical node instance names and data names related to the data sets

The following tables show the relationship between the universal data set and status indications data set object names related to the logical node and data classes defined in IEC 61850-7-4.

Table C.1 – Definitions of logical instance name and data names related to the universal data set

Attribute	Type	Definition
DataSetName	INTEGER	For the universal data set according to IEC 60044-8 the integer value is set to 1
Data-Reference	See next table	

Logical node instance name	Data name	Common data class	Definition according to IEC 60044-8
phsaTCTR	ARtg	ASG	Rated phase current Defines the rated current in Ampere r.m.s.
neutTCTR	ARtg	ASG	Rated neutral current Defines the rated neutral current in Ampere r.m.s.
phsaTVTR	VRtg	ASG	Rated phase voltage Defines the rated voltage in 1/10 kV r.m.s.
	Tdr	SAV	Rated delay time Defines the rated delay time in μs. The rated delay time indicates the time between the instant a certain current/voltage is present at the primary terminals and the instant the transmission of the belonging digital data set starts. According to this standard, synchronisation pulses are used to synchronise several merging units. Therefore the rated delay time is not relevant for the ECT/EVT accuracy. The rated delay time value shall be high enough to allow reasonable antialiasing filters in the merging unit, but it shall not be so high that it significantly affects protection device performance. Therefore the rated delay time for this standard should be 3 000 μs (tolerance band –100 % to +10 %) for all sampled rates. Tdr is not defined in IEC 61850-7-4.
phsaTCTR	Amp	SAV	Current phase A, used for protection
phsbTCTR	Amp	SAV	Current phase B, used for protection
phscTCTR	Amp	SAV	Current phase C, used for protection
neutTCTR	Amp	SAV	Current neutral
phsaTCTR1	Amp	SAV	Current phase A; different scaling; used for measurement
phsbTCTR1	Amp	SAV	Current phase B; different scaling; used for measurement
phscTCTR1	Amp	SAV	Current phase C; different scaling; used for measurement
phsaTVTR	Vol	SAV	Voltage phase A
phsbTVTR	Vol	SAV	Voltage phase B
phscTVTR	Vol	SAV	Voltage phase C
neutTVTR	Vol	SAV	Voltage neutral
bbTVTR	Vol	SAV	Busbar Voltage

Logical node instance name	Data name	Common data class	Definition according to IEC 60044-8
LPHD	PhyHealth	ISI	Merging unit maintenance required: This attribute is part of the first status word defined in IEC 60044-8. If the merging unit has failed, the maintenance required status shall be set. <0> = Maintenance not required <1> = Maintenance required The stVal attribute will be mapped to BIT STRING.
LLN0	Mod	ISC	Merging unit test status: This attribute is part of the first status word defined in IEC 60044-8. This status shall be set if the merging unit operates in test mode and calculates sampled values internally. <0> = Normal operation <1> = Test mode activated The stVal attribute will be mapped to BIT STRING.
	WkUpTim	SPS	Wake up time indication: This attribute is part of the first status word defined in IEC 60044-8. Wake up time indication shall be set during a wake up time period respectively start up time period corresponding with the sampled value invalid indication. <0> = Normal operation <1> = Data not valid WkUpTim is not defined in IEC 61850-7-4.
	SynchMeth	SPS	Synchronisation method: This attribute is part of the first status word defined in IEC 60044-8. The synchronisation method indicates whether the sampled values of the data set are suitable for interpolation or whether the data set values cannot be used with interpolation schemes. <0> = Data set values not to be used with interpolation schemes <1> = Data set values are suitable for interpolation; Not recommended for IEC 61850-9-1 applications SynchMeth is not defined in IEC 61850-7-4.
	NotSynch	SPS	Merging Unit not synchronised: This attribute is part of the first status word defined in IEC 60044-8. If interpolation schemes are defined via the synchronisation method, the unsynchronised bit must be set. <0> = Time synchronisation activated and ready. <1> = Time synchronisation missing or invalid. NotSynch is not defined in IEC 61850-7-4.
	CTType	SPS	Type of CT output: This attribute is part of the first status word defined in IEC 60044-8. Type of CT output shall be set to indicate the use of air core coils. <0> = $i(t)$ <1> = $\mathrm{d}(i(t))/\mathrm{d}t$; air core coils. CTType is not defined in IEC 61850-7-4.
	Range Flag	SPS	Range flag defines the scaling factor for the phase current data for protection applications. <0> = 01CF H (dynamic range 50 × I_r) <1> = 00E7 H (dynamic range 100 × I_r) RangeFlag is not defined in IEC 61850-7-4.

Table C.2 – Definitions of logical instance name and data names related to the status indication data set

Attribute	Type	Definition
DataSetName	INTEGER	For the status indication data set, the integer value is set to 2
Data-Reference	See next table	

Logical node name	Data name	Common data class	Definition
GGIO	Ind	SPS	Binary Status Indication: Individual binary status inputs and related quality status indications. Quality bit for each status point gives the sending unit (i.e. the merging unit) the ability to tag the specific bits as invalid to indicate unused or disabled status points to the receiving IED. Binary status input: <0> FALSE, OFF <1> TRUE, ON Quality Indication: <0> VALID <1> INVALID

		2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Byte 1	ASDU Header	msb	Length of ASDU (= 44)						
Byte 2									lsb
Byte 3		msb	LNName (=02)						lsb
Byte 4		msb	DataSetName (=01)						lsb
Byte 5		msb	LDName						
Byte 6									lsb
Byte 7		msb	Rated Phase Current						
Byte 8									lsb
Byte 9		msb	Rated Neutral Current						
Byte 10									lsb
Byte 11		msb	Rated Phase Voltage						
Byte 12									lsb
Byte 13		msb	Rated Delay Time						
Byte 14									lsb
Byte 15	ASDU (universal data set)	msb	Current Phase A, prot.						
Byte 16									lsb
Byte 17		msb	Current Phase B, prot.						
Byte 18									lsb
Byte 19		msb	Current Phase C, prot.						
Byte 20									lsb
Byte 21		msb	Current Neutral						
Byte 22									lsb
Byte 23		msb	Current Phase A, mes.						
Byte 24									lsb
Byte 25		msb	Current Phase B, mes.						
Byte 26									lsb
Byte 27		msb	Current Phase C, mes.						
Byte 28									lsb
Byte 29		msb	Voltage Phase A						
Byte 30									lsb
Byte 31		msb	Voltage Phase B						
Byte 32									lsb
Byte 33		msb	Voltage Phase C						
Byte 34									lsb
Byte 35		msb	Voltage Neutral						
Byte 36									lsb
Byte 37		msb	Busbar Voltage						
Byte 38									lsb
Byte 39		msb	StatusWord#1						
Byte 40									lsb
Byte 41		msb	StatusWord#2						
Byte 42									lsb
Byte 43		msb	Sample Counter						
Byte 44									lsb
Byte 45		msb	Sampling rate						lsb
Byte 46		msb	Configuration revision no.						lsb

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Figure C.1 – Contents of the universal data set based on the specification in IEC 60044-8

Annex D
(informative)

Electronic transformers block diagram and configuration example

D.1 General block diagram of electronic transformers

Figure D.1 is a general block diagram of an electronic transformer. Depending on the application, not all of the illustrated blocks may be included in the transformers (see IEC 60044-8).

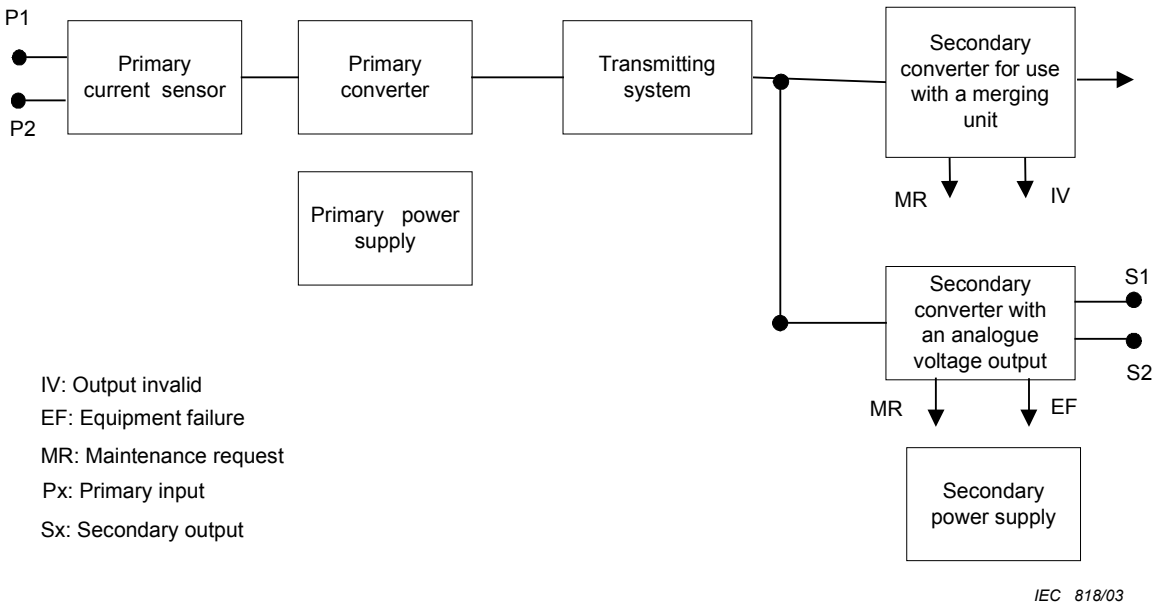

Figure D.1 – Example for general block diagram of a single-phase electronic transformer

D.2 General block diagram of electronic transformers with a digital output and the merging unit

Up to seven current transformers and up to five voltage transformers are grouped together using a merging unit (MU). This merging unit supplies the secondary equipment with a time-coherent set of current and voltage data.

Figure D.2 gives the maximum configuration.

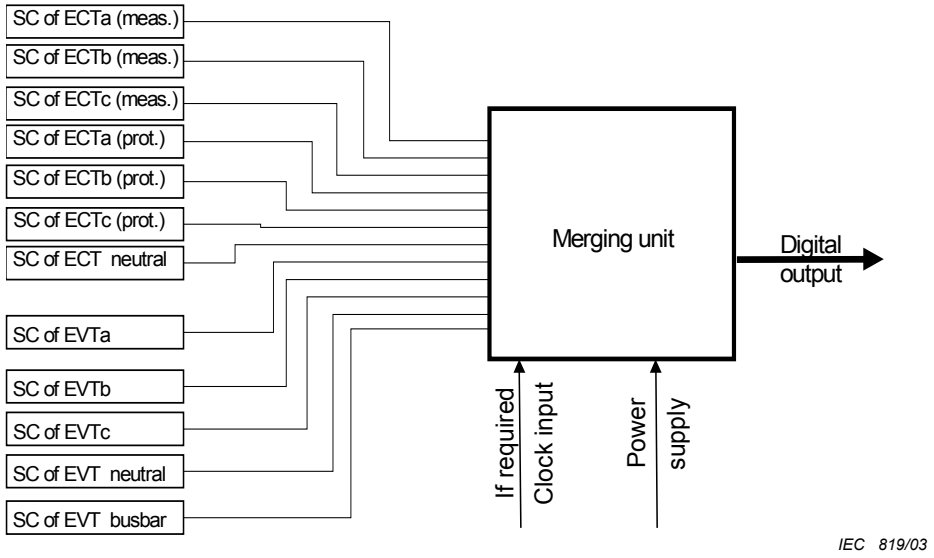

Figure D.2 – Example for electronic transformers configuration

NOTE SC of EVTa is the secondary converter of the electronic voltage transformers of phase a (see IEC 60044-7). SC of ECTa is the secondary converter of the electronic current transformers of phase a (see IEC 60044-8).

The implementation of the merging unit as a standalone device is not a mandatory requirement. It may be part of the ECT or EVT electronics.

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