INTERNATIONAL STANDARD

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2000-11

Programmable controllers –

Part 5: Communications

Automates programmables –

Partie 5:
Communications

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PROGRAMMABLE CONTROLLERS –

Part 5: Communications

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
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6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61131-5 has been prepared by subcommittee 65B: Devices, of IEC technical committee 65: Industrial-process measurement and control.

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

FDIS	Report on voting
65B/411/FDIS	65B/420/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 3.

This part should be read in conjunction with the other parts of IEC 61131. IEC 61131 consists of the following parts under the general title: *Programmable controllers.*

Part 1:1992, General information.

Part 2:1992, Equipment requirements and tests.

Part 3:1993, Programming languages.

Part 4:1994, User guidelines (published as technical report IEC TR 61131-4)

Part 5:2000, Communications

Part 8:2000, Guidelines for the application and implementation of programming languages (published as technical report IEC TR 61131-8)

Annexes A and B form an integral part of this standard.

Annex C is for information only.

Where a conflict exists between this and other IEC standards (except basic safety standards), the provisions of this standard should be considered to govern in the area of programmable controllers and their associated peripherals.

The committee has decided that the contents of this publication will remain unchanged until 2006. 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.

PROGRAMMABLE CONTROLLERS –

Part 5: Communications

1 Scope

This part of IEC 61131 specifies communication aspects of a programmable controller. It specifies from the viewpoint of a PC how any device can communicate with a PC as a server and how a PC can communicate with any device. In particular, it specifies the behavior of the PC as it provides services on behalf of other devices and the services the PC application program can request from other devices. It is not intended to specify how any device can communicate with any device using a PC as a router or gateway. The behavior of the PC as a communication client and server is specified independent of the particular communication subsystem, but the communication functionality may be dependent on the capabilities of the communication subsystem used.

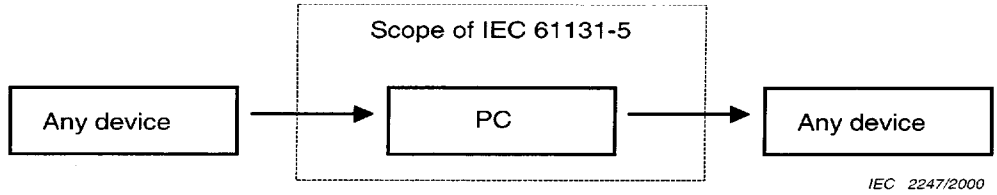


Figure 1 – Scope of this part of IEC 61131

The scope of this part is a subset of the "communication model" shown in figure 2 of IEC 61131-3; namely figures 2c and 2d are included in the scope of this part. Additionally, the means defined in this part of IEC 61131 may be used for communications within a program or between programs.

The mapping of the PC behavior to some particular communications subsystems is provided in the annexes.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61131. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 61131 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60050-351:1998, *International Electrotechnical Vocabulary – Part 351: Automatic control*

IEC 61131-1:1992, *Programmable controllers – Part 1: General Information*

IEC 61131-2:1992, *Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61131-3:1993, *Programmable controllers – Part 3: Programming languages*

ISO/IEC 2382-1:1993, *Information technology – Vocabulary – Part 1: Fundamental terms*

ISO/IEC 9506-1:1990, *Industrial automation systems – Manufacturing Message Specification – Part 1: Service definition*

ISO/IEC 9506-2:1990, *Industrial automation systems – Manufacturing Message Specification – Part 2: Protocol specification*

3 Definitions

For the purpose of this part of IEC 61131, the following definitions apply.

This part of IEC 61131 is based on the concepts of parts 1 to 3 of IEC 61131 and makes use of the following terms defined in other international standards.

Definitions from other publications

IEC 60050-351

control

monitoring

IEC 61131-1

application program (2.1)

application program archiving (4.6.4)

cold restart (2.56)

input (2.25)

main processing unit (2.32)

modifying the application program (4.6.2.6)

output (2.40)

programmable controller (2.50)

programmable controller system (2.51)

testing the application program (4.6.2.5)

warm restart (2.56)

IEC 61131-3

access path (1.3.2)

direct representation (1.3.23)

invocation (1.3.43)

program (verb, 1.3.60)

sub-element (2.3.3.1)

ISO/IEC 2382-1

data

ISO/IEC 9506-1

client

download

event (clause 15)

server

uninterruptible variable access (12.1.1.1)

upload

variable

Definitions of this part

3.1
alarm
event which signals a specific condition

3.2
data acquisition
collection of data for the purpose of process monitoring and report generation

3.3
direct operator interface
when the client can communicate to the operator interface via the communication system with no application program interaction

3.4
device verification
allows other devices to determine if the PC is able to perform its intended function in the control system

3.5
health
the health of a PC or its subsystems is specified by returning one, and only one, of the three possible values. They are, in order of decreasing health: GOOD, WARNING and BAD

3.6
interlocked control
control through the synchronization of data exchanges between two parties. At various points in time, one party is waiting for the other party to deliver some expected data

3.7
local
internal to the PC; opposite of remote

3.8
parametric control
control by the client writing to control variables residing in the PC

3.9
processing unit
part of the main processing unit. It is the portion of a PC system which is responsible for the storage of the application program and data and the execution of the application program. A PC system has one or more processing units

3.10
program verification
testing of a PC application program to verify that it performs the function(s) it was designed to do in the process environment

3.11
recipe
description of procedures, or data for those procedures, or both, for making a product which uses the process or machinery that the controller is attached to, which is different from a previous product

3.12
remote
external to the PC; opposite of local

3.13
state
the state of the PC system is indicated by a list of attributes, each of which may be TRUE or FALSE. Zero, one, or more of these attributes may be TRUE at the same time

3.14
unsolicited
performed without an explicit request

4 Symbols and abbreviations

These are some abbreviations frequently used in this part of IEC 61131. These terms are defined or referenced in clause 3 of this part of IEC 61131.

CFB	Communication function block
FB	Function block
I/O	Input and output
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
MMS	Manufacturing Message Specification, ISO/IEC 9506-1 and ISO/IEC 9506-2
OSI	Open Systems Interconnection
PADT	Programming and debugging tool
PC	Programmable controller
PU	Processing unit

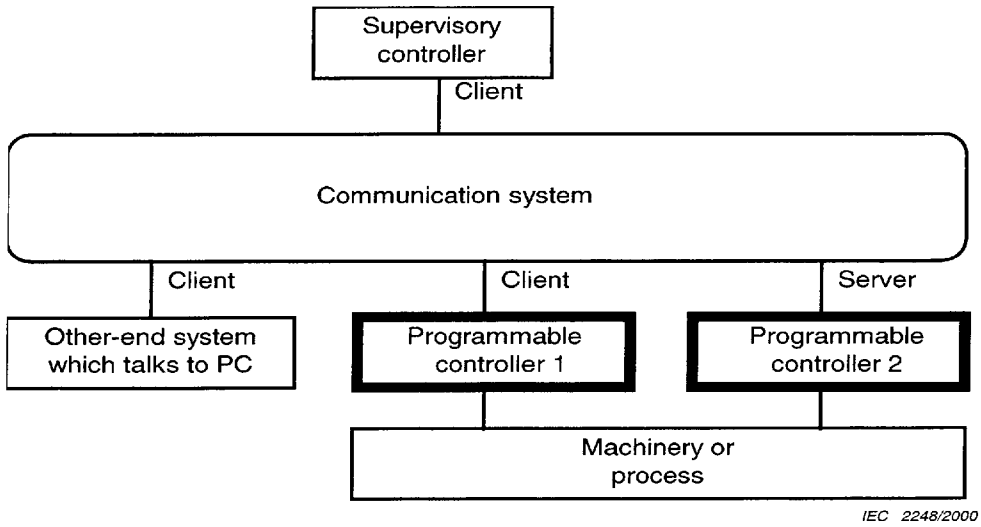
5 Models

This clause specifies the models which are used in the remainder of this part of IEC 61131.

5.1 PC network communication model

A programmable controller supplies some specific application functions to the rest of the control system. It may also request functions from other programmable controllers. The communication functions defined in this part of IEC 61131 are based on a communication subsystem that can report communication errors to the signal processing function of the PC (see 5.2).

The following diagram illustrates the devices in a communication network, showing three possible devices that request PC functions (clients) from PC 2. The two highlighted PCs are in the scope of this part of IEC 61131.



NOTE From the communication viewpoint the 'supervisory controller' and the 'other-end system which talks to PC' mentioned in this figure exhibit the same behavior to a PC communication server, i.e., they submit requests to the PC2.

Figure 2 – PC communication model

A PC may use its client function to communicate with any device if it behaves like a PC.

5.2 PC functional model

A PC consists of several functions (see figure 3). For a PC within the scope of this part of IEC 61131, at least one communication function is present.

The following diagram is taken from IEC 61131-1, figure 1. It is designed to illustrate some of the subsystems of a typical PC.

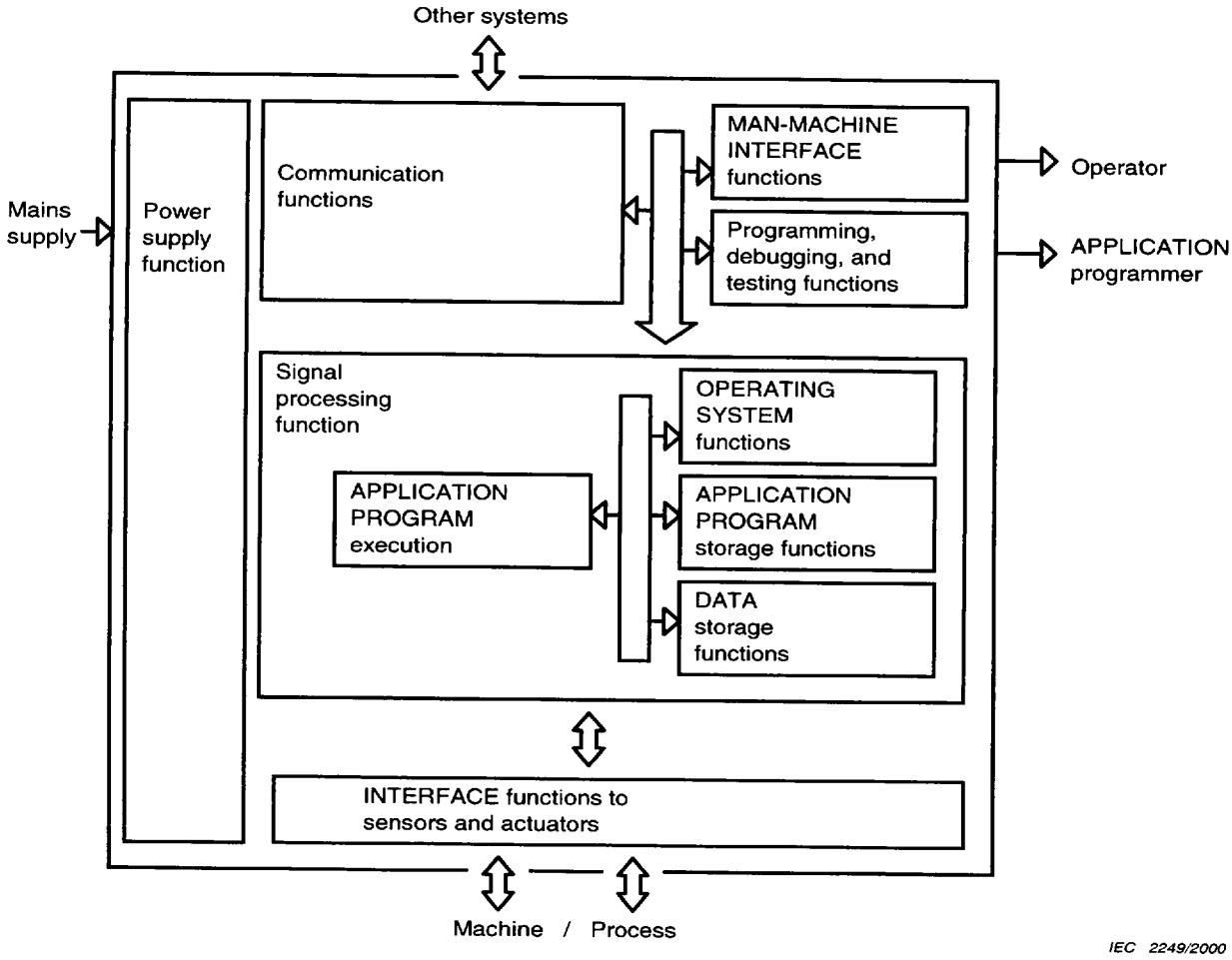


Figure 3 – Programmable controller functional model

There is a function that is part of the PC system, but usually external to the PC itself, known as the programming and debugging tool (PADT). The PADT is modelled as interacting with the PC via the communications function.

The Interface Function to Sensors and Actuators can have I/O which are local or remote to the Main Processing Unit (see 5.3 for the hardware model). The Interface Function to Sensors and Actuators has two attributes for each Application Program which defines how the PC is monitoring and controlling the machine/process. The input attribute has the following states:

- inputs provided to the Application Program are being supplied by the sensors,
- inputs provided to the Application Program are being held in the current state.

The output attribute has the following states:

- the actuators are being controlled by the Application Program,
- the actuators are being held in the current state.

5.3 PC hardware model

The following figure shows the PC hardware model. It shows the modules that make up a PC. A PC subsystem consists of one or more modules. The following figure corresponds to figure B.1 of IEC 61131-1 and figure 1 of IEC 61131-2.

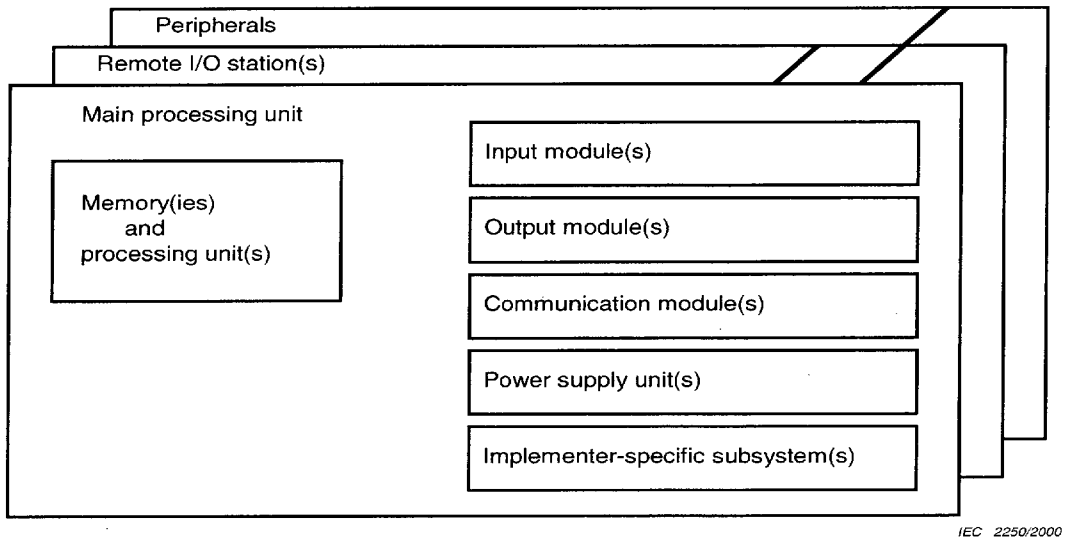


Figure 4 – Programmable controller hardware model

5.4 Software model

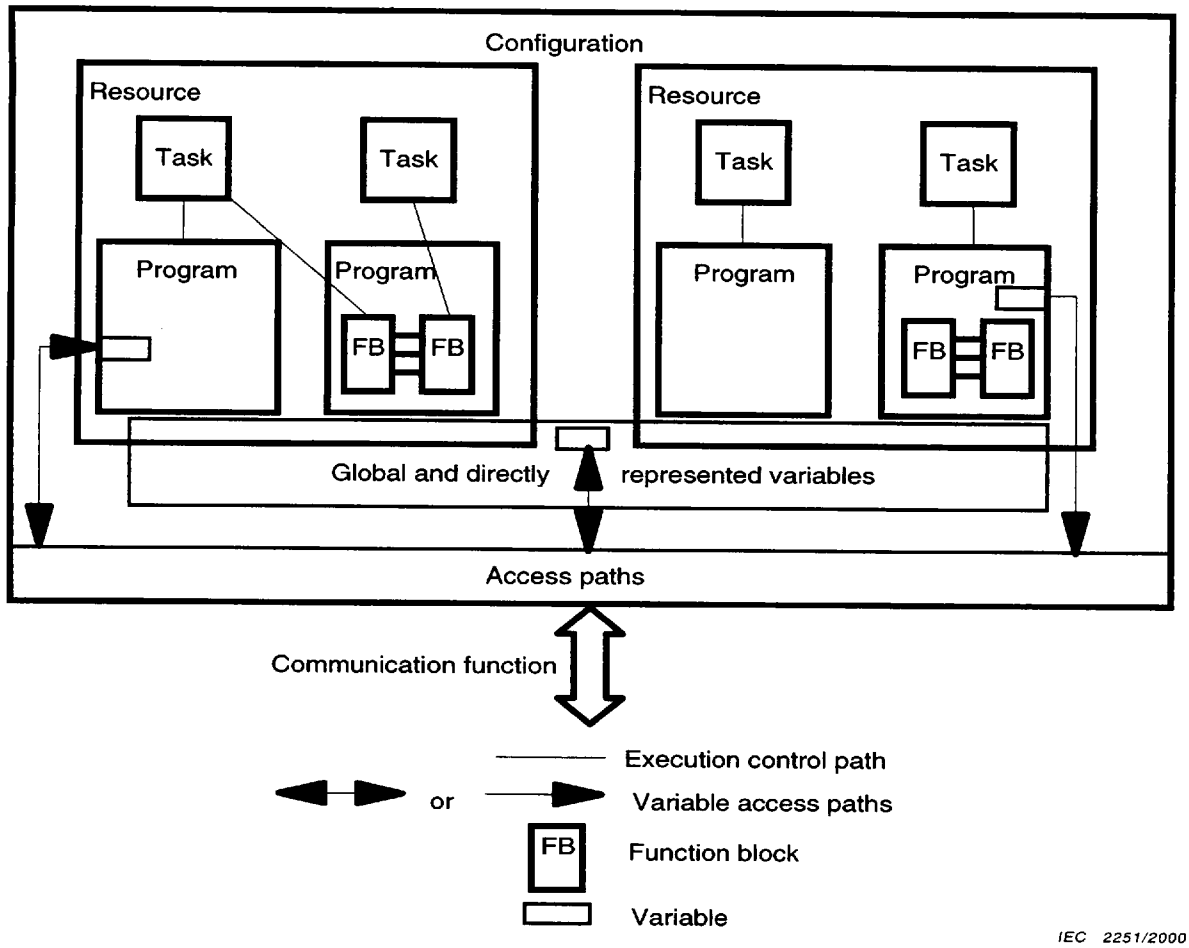
Figure 5 shows the PC software model defined in IEC 61131-3, figure 1. It illustrates the basic high-level language elements of the PC programming languages and their interrelationships. These consist of elements which are programmed using the languages defined in IEC 61131-3, i.e. programs and function blocks; and configuration elements, namely, configurations, resources, tasks, global variables, and access paths, which support the installation of programmable controller programs into programmable controller systems.

A configuration is the language element which corresponds to a programmable controller system as defined in IEC 61131-1. A resource corresponds to a "signal processing function" and its "man-machine interface" and "sensor and actuator interface" functions (if any) as defined in IEC 61131-1. A configuration contains one or more resources, each of which contains one or more programs executed under the control of zero or more tasks. A program may contain zero or more function blocks or other language elements as defined in IEC 61131-3.

Configurations and resources can be started and stopped via the "operator interface", "programming, testing, and monitoring", or "operating system" functions defined in IEC 61131-1. The mechanisms for the starting and stopping of configurations and resources via communication services are defined in this part of IEC 61131.

Programs, resources, global variables, access paths (and their corresponding access privileges), and configurations can be loaded or deleted by the "communication function" defined in IEC 61131-1. The loading or deletion of a configuration or resource shall be equivalent to the loading or deletion of all the elements it contains.

Access paths and their corresponding access privileges allow to access variables of a PC via communication services.



NOTE 1 This figure is illustrative only. The graphical representation is not normative.

NOTE 2 In a configuration with a single resource, the resource need not be explicitly represented.

Figure 5 – PC software model

6 PC communication services

This clause describes the concept of status information of a PC and provides a specification of the services the PC provides to the control system via the communication subsystem. (The next clause specifies how the PC application program can use the communication subsystem to interact with other devices.)

6.1 PC subsystems and their status

A PC can provide status, which includes state information and fault indications.

Status can be reported on some of the subsystems identified in the following figure. In addition, there is a summary status that provides general information about the PC.

Table 1 – Status presenting entities

No.	Status presenting entities
1	PC (as a whole)
2	I/O subsystem (includes Input and Output modules and other intelligent I/O devices)
3	Processing unit
4	Power supply subsystem
5	Memory subsystem
6	Communication subsystem
7	Implementer specific subsystems
NOTE The status is intended to provide information about the controller including its hardware and firmware subsystems, not considering configuration information. It is not intended to provide information about the controlled process nor the PC application program. The status data contains information concerning the state and the health of the PC and its subsystems.	

There are two concepts used in this part of IEC 61131 related to status: health and state. The "health" of a PC or its subsystems is specified by returning one and only one of the three possible values. The semantics associated with each value is specified below. They are, in order of decreasing health:

a) GOOD – If TRUE, the PC (or the specified subsystem) has not detected any problems which would prohibit it from performing the intended function;

b) WARNING – If TRUE, the PC (or the specified subsystem) has not detected any problems which would prohibit it from performing the intended function, but it has detected at least one problem which could place some limits on its abilities. The limit may be time, performance, etc. (see the following statements for further definition of these limits);

c) BAD – If TRUE, the PC (or the specified subsystem) has detected at least one problem which could prohibit it from performing the intended function.

The "state" of the PC system is indicated by a list of attributes, each of which may be TRUE or FALSE. Zero, one, or more of these attributes may be TRUE at the same time. The semantics associated with each attribute is specified in the remainder of this clause.

Each of the status information can also have implementer specified attributes. Some examples of implementer specified attributes are:

a) additional error diagnostics (e.g. EEPROM write cycles exceeded);

b) additional operational states (e.g. auto-calibrate enabled);

c) local key status (e.g. auto-restart required).

Implementations are not required to provide subsystem status. All instances of similar types of subsystems present in a system are reported separately. The name of the subsystem can be provided to allow differentiating subsystems of the same type.

6.1.1 PC summary status

The PC provides the following summary status information.

Table 2 – PC summary status

No.	Item	Description	
1	Health	GOOD	All subsystems in the PC indicate a GOOD health condition
2		WARNING	At least one subsystem indicates a WARNING health condition and no subsystem indicates a BAD health condition
3		BAD	At least one subsystem indicates a BAD health condition
4	Running	If TRUE, this attribute indicates if at least one part of the user application has been loaded and is under control of the PC	
5	Local control	If TRUE, this attribute indicates if local override control is active. If active, the ability to control a PC and its subsystems from the network may be limited. For example, this could be closely tied to the use of a local key switch	
6	No outputs disabled	If TRUE, this attribute indicates that the PC can change the physical state of all outputs as a result of application program execution or other means. If not TRUE, the physical state of some of the outputs are not affected (logical state may be affected). This is typically used in the testing and modifying of application programs in the PC	
7	No inputs disabled	If TRUE, this attribute indicates that the PC can access the physical state of all inputs as a result of application program execution or other means. If not TRUE, the physical state of some inputs cannot be accessed. This is typically used in the testing and modifying of application programs where the inputs can be simulated	
8	Forced	If TRUE, this attribute indicates that at least one I/O point associated with the PC has been forced. When an Input is forced, the application program will receive the value specified by the PADT instead of the actual value from the machine or process. When an output is forced, the machine or process will receive the value specified by the PADT instead of the value generated by execution of the application program. When a variable is forced, the application program will use the value specified by the PADT instead of that generated by the normal program execution	
9	User application present	If TRUE, this attribute indicates that the Processing Unit has at least one user application present	
10	I/O subsystem	If TRUE, this attribute indicates "WARNING" or "BAD" which is caused by an I/O subsystem	
11	Processing unit subsystem	If TRUE, this attribute indicates "WARNING" or "BAD" which is caused by a processing unit subsystem	
12	Power supply subsystem	If TRUE, this attribute indicates "WARNING" or "BAD" which is caused by a power supply subsystem	
13	Memory subsystem	If TRUE, this attribute indicates "WARNING" or "BAD" which is caused by a memory subsystem	
14	Communication subsystem	If TRUE, this attribute indicates "WARNING" or "BAD" which is caused by a communication subsystem	
15	Implementer specified subsystem	If TRUE, this attribute indicates "WARNING" or "BAD" which is caused by an implementer specified subsystem	

6.1.2 I/O subsystem

The PC provides the following status information of its I/O subsystem.

Table 3 – Status of I/O subsystem

No.	Item	Description	
1	Health	GOOD	indicates that there have been no errors detected in this I/O subsystem
2		WARNING	indicates that a minor fault has been detected in the I/O subsystem. An example of a minor fault is the occurrence of recoverable errors in the communication with a remote I/O station
3		BAD	indicates that a major fault has been detected in the I/O subsystem. An example of a major fault is losing communication with a remote I/O station
4	No outputs disabled	If TRUE, this attribute indicates that the PC can change the physical state of all outputs associated with the specified I/O subsystem as a result of application program execution or other means. If not TRUE, the physical state of some of the outputs is not affected (logical state may be affected). This is typically used in the testing and modifying of application programs in the PC	
5	No inputs disabled	If TRUE, this attribute indicates that the PC can access the physical state of all inputs associated with the specified I/O subsystem as a result of application program execution or other means. If not TRUE, the physical state some inputs cannot be accessed. This is typically used in the testing and modifying of application programs where the inputs can be simulated	
6	I/O forced	If TRUE, this attribute indicates that at least one I/O point associated with this subsystem has been forced. When an Input is forced, the application program will receive the value specified by the PADT instead of the actual value from the machine or process. When an output is forced, the machine or process will receive the value specified by the PADT instead of the value generated by execution of the application program	
NOTE The definition of "major fault" and "minor fault" shall be provided by the implementer.			

6.1.3 Processing unit

The PC provides the following status information of its processing unit.

Table 4 – Status of processing unit

No.	Item	Description
1 2 3	Health	This attribute identifies the health of the processing unit. The implementer shall specify the conditions when GOOD, WARNING or BAD are valid
4	Running	If TRUE, this attribute indicates if at least one part of the user application has been loaded and is under control of the processing unit
5	Local control	If TRUE, this attribute indicates if local override control is active. If active, the ability to control the processing unit from the network may be limited. For example, this could be closely tied to the use of a local key switch
6	No outputs disabled	If TRUE, this attribute indicates that the processing unit can change the physical state of all outputs controlled by this processing unit as a result of application program execution or other means. If not TRUE, the physical state of some of the outputs are not affected (logical state may be affected). This is typically used in the testing and modifying of application programs in the PU
7	No inputs disabled	If TRUE, this attribute indicates that the processing unit can access the physical state of all inputs accessible from this processing unit as a result of application program execution or other means. If not TRUE, the physical state of some inputs cannot be accessed. This is typically used in the testing and modifying of application programs where the inputs can be simulated
8	User application present	If TRUE, this attribute indicates that the Processing Unit has at least one User Application present
9	Forced	If TRUE, this attribute indicates that at least one variable associated with this Processing Unit has been forced. When a variable is forced, the application program will use the value specified by the PADT instead of that generated by the normal program execution.

6.1.4 Power supply subsystem

The PC can provide status information about any of the power supply subsystems; see figure 6 for the assumed configuration of a PC power supply. The requirements on power supplies of PC systems and their behavior is described in IEC 61131-1 and IEC 61131-2.

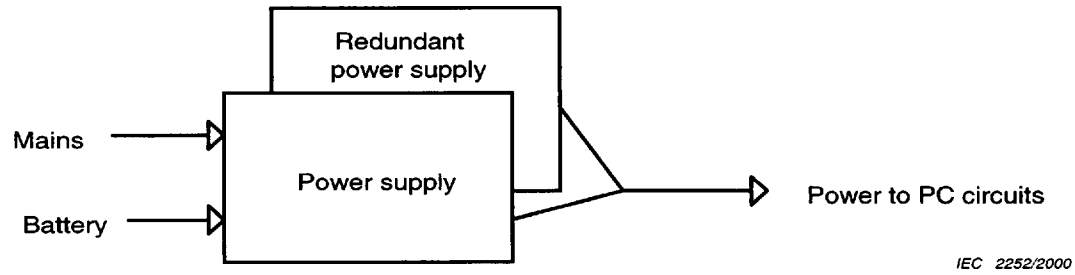


Figure 6 – Programmable controller power supply

Table 5 – Status of power supply

No.	Item	Description	
1	Health	GOOD	indicates that there have been no problems detected in the power supply to prevent it from remaining operable for an indefinite time
2		WARNING	indicates that a problem has been detected in the power supply which may cause to become inoperable in a limited time
3		BAD	indicates that the power supply is not operable
4	In use	If TRUE, this attribute indicates that the power supply subsystem is in use, i.e. it supplies power to the PC	
5	Mains operating	If TRUE, this attribute indicates that the mains are supplying power within the range specified for the power supply	
6	Mains low	If TRUE, this attribute indicates that the mains are not supplying power within the range specified for the power supply	
7	Battery operating	If TRUE, this attribute indicates that the battery is supplying power within the range specified for the power supply	
8	Battery low	If TRUE, this attribute indicates that the battery is not able to supply power within the range specified for the power supply	
9	Protection tripped	If TRUE, this attribute indicates that a protection device within the power supply has removed a portion of the power to the PC	

6.1.5 Memory subsystem

The PC provides the following status information of its memory subsystem.

Table 6 – Status of memory

No.	Item	Description	
1	Health	GOOD	No errors have been found in the memory associated with this subsystem
2		WARNING	At least one correctable error has been detected and no uncorrectable errors have been detected
3		BAD	At least one uncorrectable error has been detected
4	Protected[1)]	If TRUE, this attribute indicates that the memory in this memory subsystem has been protected in that it cannot be modified. This generally indicates that the application program located in this memory subsystem cannot be altered. [1)] This attribute models a logical state not physical characteristics of the subsystem. If some portions of the memory are protected and some are not, these shall be reported as multiple subsystems.	

6.1.6 Communication subsystem

The PC provides the following status information of its communication subsystem.

Table 7 – Status of communication subsystem

No.	Item	Description	
1	Health	GOOD	indicates that either no errors or an acceptable number of recoverable errors has occurred
2		WARNING	indicates that more than an acceptable number of recoverable errors has occurred
3		BAD	indicates that the communication subsystem is not able to communicate with all devices as intended
4	In use	If TRUE, this attribute indicates that the communication subsystem is currently operating. For example in the case of an MMS communication interface this means that at least one application association is established. Otherwise, the implementer shall define the semantic of this attribute	
5	Local error	If TRUE, this attribute indicates that there are some errors, internal to the communication subsystem, that inhibit operation	
6	Remote error	If TRUE, this attribute indicates that there are some errors, at devices being communicated with, that inhibit operation	
NOTE 1 The communication subsystem reporting its state may not be able to report its own bad state in the way defined in this clause. But, within a PC system, several independent communication subsystems may operate, and all of them may provide status information. NOTE 2 It is intended that the implementer specific information will provide additional information about each particular interface. ISO network interfaces also provide additional information via network management functions.			

6.1.7 Implementer specific subsystems

Other subsystems of a PC system shall be modelled as implementer specific subsystems. Some examples of these subsystems are:

a) PID controller;

b) motion controller;

c) other auxiliary processors.

Table 8 – Status of implementer specific subsystem

No.	Item	Description	
1	Health	GOOD	indicates that there have been no errors detected in this subsystem
2		WARNING	indicates that a minor fault has been detected in this subsystem
3		BAD	indicates that a major fault has been detected in this subsystem
NOTE The definition of "major fault" and "minor fault" shall be provided by the implementer.			

6.1.8 Presentation of status information

The status information shall be presented using variables with a pre-defined access path in the configuration declaration of the PC application program or shall be presented as a variable with direct representation to a remote communication partner.

Table 9 – Presentation of status information

No.	Presentation of status information
1	PC summary status as variable with pre-defined access path P_PCSTATE
2	PC summary status as variable with direct representation %S
3	PC summary status and status of all subsystems as variable with pre-defined access path P_PCSTATUS
4	Status information of each subsystem as a set of variables with direct representation %SC<n>
5	Type of each subsystem as a set of variables with direct representation %SU<n>
6	Name of each subsystem as a set of variables with direct representation %SN<n>
7	State of each subsystem as a set of variables with direct representation %SS<n>
8	Implementer specific status of each subsystem as a set of variables with direct representation %SI<n>

If the PC summary status shall be presented in a variable, it shall have the access path P_PCSTATE which shall be pre-defined in the configuration declaration. The variable shall be of type WORD and shall contain the PC summary status beginning with item number 1 at the least significant bit upwards.

If the PC summary status shall be presented as a variable with direct representation, the direct representation shall be %S and shall be of type WORD. It shall contain the PC summary status beginning with item number 1 at the least significant bit upwards.

If the complete status information shall be presented as a variable, it shall have the access path P_PCSTATUS pre-defined in the configuration section. This variable shall have a structured type as follows:

```
ARRAY [0..p_NOS] OF
    STRUCT
        SUBSYSTEM  : (SUMMARY, IO, PU, POWER, MEMORY, COMMUNICATION,
                IMPLEMENTER);
        NAME    : STRING[<Max_Name_Len>];
        STATE   : ARRAY[0..15] OF BOOL;
        SPECIFIC    : ARRAY[0..p_BIT] OF BOOL;
    END_STRUCT;
```

IEC 2253/2000

Figure 7 – Type description of status information

The array element with the number 0 shall contain the PC summary status, each element with a higher number shall contain the status of one subsystem. The sub-element SUBSYSTEM shall contain the type of the PC or of a subsystem. The sub-element NAME shall contain the name of the PC or of a subsystem. The implementer shall specify the supported maximum length for name strings, i.e. the value of Max_Name_Len. The sub-element STATE shall contain the state information of the PC or of a subsystem as an array of BOOL in the same order as specified in tables 2 to 8. The implementer shall specify the number of elements of the array P_PCSTATUS i.e. the value of p_NOS, the supported types of subsystems, the semantic of the values in the sub-element STATE for the implementer specific subsystem, the size of the sub-element SPECIFIC, i.e. the value of p_BIT, and the semantic of the sub-element SPECIFIC.

The status information of each subsystem may be presented as a variable with direct representation %SC<n>, where <n> stands for a number between 0 (representing the PC summary status) and the number of subsystems p_NOS. The variable shall have the same internal representation as a variable with the type of the structure part of the type described in the figure above.

Additionally there may be a set of variables with direct representation %SU<n>, %SN<n>, %SS<n>, and %SI<n>. The <n> stands for a number between 0 (representing the PC summary status) and the number of subsystems p_NOS. The variables shall have the same internal representation as a variable with the type of one of the structure sub-elements of the type described in the figure above. In detail, the %SU<n> shall correspond to the sub-element SUBSYSTEM, %SN<n> to the sub-element NAME, %SS<n> to the sub-element STATE, and %SI<n> to the sub-element SPECIFIC.

6.2 Application specific functions

The remainder of this clause describes the functions which a PC provides to a control system, using the communication subsystem, as illustrated in figure 2.

PC communication function	PC as requester	PC as responder	Function block available
Device verification	yes	yes	yes
Data acquisition	yes	yes	yes
Control	yes	yes	yes
Synchronization between user applications	yes	yes	yes
Alarm reporting	yes	no	yes
Program execution and I/O control	no	yes	no
Application program transfer	no	yes	no
Connection management	yes	yes	yes

Each of these is treated separately in the remainder of this clause. Not all functions are available in all PCs. See clause 7 for the function block definitions.

There are some applications which combine the application categories defined below, for example, supervisory control and data acquisition.

The following elements, while usually provided by PCs, are outside the scope of this part of IEC 61131:

a) operator interface;

b) programming, testing, and modifying the application program, and program verification.

PCs have the ability to use operator interface devices. These devices are used by an operator to monitor or modify the controlled process or both. They may also be used by a client system to communicate with the operator.

Direct operator interface is when the client can communicate to the operator interface via the communication system with no application program interaction.

Programming is the process of creating a PC application program on an instruction by instruction or a function block by function block basis. Testing and modifying is the process of finding and removing errors ("bugs") in an existing application program by making changes to it. Program verification is the testing of a PC application program to verify that it performs the function(s) it was designed to do in the process environment.

6.2.1 Device verification

This function is provided to allow other devices to determine if the PC is able to perform its intended function in the automated system. A PC can provide status of itself and its subsystems. Status includes health and state information. A device may explicitly request status from the PC or the PC may initiate an unsolicited status report using services provided by the communication interface. See 6.1 for the definition of health and state information of a PC system and of its subsystems.

Table 10 – Device verification features

No.	Device verification
1	Provide status information
2	Initiate unsolicited status reports

6.2.2 Data acquisition

Data contained in a PC is presented as variables. This data may come from a variety of sources and may have a wide range of meanings. It can be obtained by the client through one of several methods.

a) Polled – The client reads the value of one or more variables at a time or condition determined by the client. The access to the variables may be controlled by the PC. Only selected variables are accessible over the network.

b) Programmed – The data is provided by the PC to the client at a time or condition determined by the PC application program.

c) Configured – The communications interface to the PC can be configured by a client to initiate a data transfer to the client.

The kinds of variables in the PC which are visible to the communication system are:

a) variables with direct representation;

b) other variables which have access paths (see IEC 61131-3 for the definition of access paths).

If the directly represented variables are accessible for communication these variables shall use the direct representation as an identifier. The PC server (i.e. the PC which owns the variables) can interpret the identifier using an implementer defined algorithm.

NOTE Variables with direct representation can be used like "normal" variables while programming an application program. An additional symbolic name may be assigned to a directly represented variable using the AT construct in the variable declaration (see IEC 61131-3).

Typically there are thousands of these variables with direct representation even in a smaller PC. It is not reasonable to hold the name and the address of all these variables in an object dictionary of a PC.

The PC system may restrict access to variables with direct representation. The conditions (size, location, etc.) under which each data type supported by the PC can be uninterruptedly accessed shall be specified by the implementer.

Table 11 – Data acquisition features

No.	Data acquisition
1	Variables with direct representation are accessible
2	Access paths on configuration level
3	Access paths on program level
4	Means to restrict access to variables with direct representation
5	Conditions for uninterruptible access to variables

6.2.3 Control

A PC may support two methods of control: parametric and interlocked.

Parametric control is when the operation of the PC is directed by writing values to variables residing in the PC. This change in operation is determined by either the application program or other local mechanisms.

The access to the variables is controlled by the PC which holds the variables. Only those variables which have the READ_WRITE qualifier selected in the access path declaration are accessible over the network for parametric control.

Interlocked control is when the client requests the server to execute an application operation and to inform the client of the result of the operation. There are two aspects of this service, the synchronization of the client and server, and the exchange of data between them.

In interlocked control, this data exchange occurs at synchronization points in the application program. This service can be used to have the effect of a remote procedure call from one application program to another. The timeline shown in figure 8 illustrates this.

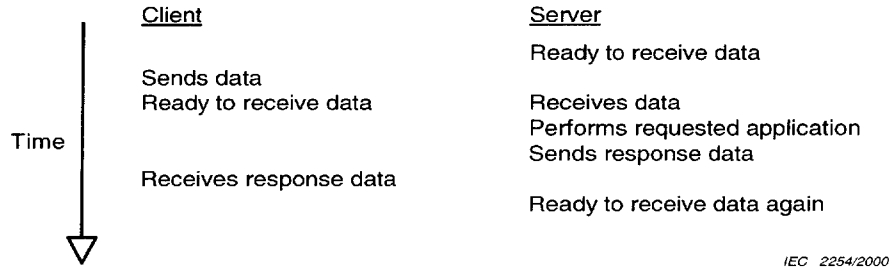


Figure 8 – Interlocked control timeline

The PC implements interlocked control using the SEND (client) and RCV (server) function blocks. Other devices may use other means to emulate the behavior of these function blocks to access this PC communication function.

Table 12 – Control features

No.	Control
1	Variables with direct representation are accessible
2	Access paths on configuration level
3	Access paths on program level
4	Means to restrict access to variables with direct representation
5	Conditions for uninterruptible access to variables
6	Interlocked control

6.2.4 Synchronization between user applications

User applications may need a synchronization service. For example, a user application may start the execution of another application after completion of an algorithm. The synchronization service is provided by the interlocked control mechanism (see 6.2.3).

6.2.5 Alarm reporting

The PC can have the ability to signal alarm messages to a client when a predetermined condition occurs. The client may indicate an acknowledgement of these alarms to the PC. This differs from normal data acquisition in that the state of an alarm point is remembered by the PC until it is acknowledged by the client. A summary of the unacknowledged alarms can be generated by the PC at the request of the client.

Table 13 – Alarm reporting features

No.	Alarm reporting
1	Signal messages
2	Receive acknowledgements
3	Generate summary of unacknowledged alarms

6.2.6 Application program execution and I/O control

Execution of a PC Application Program is managed by the Application Program Execution function (see 5.2). PC Application Programs can be started and stopped. PC Application Programs can be started either from an initial state or from the state they were in at the time they were stopped.

The PC application program in a PC system consists of one configuration and zero, one or more resources (see IEC 61131-3). Configurations and resources may be started and stopped. The resources are started and stopped when the configuration is started and stopped and they can be started or stopped independently of the configuration.

The Interface Function to Actuators (outputs) associated with a running Application Program can be directed to either use the values supplied by the Application Program or held in a known state. This Interface state is specified at the time the Application Program state is changed. The outputs can be directed to either be set to implementer specified states, hold the outputs in the current state, set all outputs to zero, or change some outputs to user specified states (on or off, with those not specified holding the last state) through an implementer specified mechanism (for example, tables, PC procedure, etc.).

The Interface Function to Sensors (inputs) associated with a running Application Program can be directed to either provide the actual data from the sensors or to continue to use previously supplied values. The input state is specified at the time the Application Program state is changed.

Table 14 – Startable and stoppable units

No.	Startable and stoppable unit
1	Configuration
2	Resource

The I/O (inputs and outputs) associated with a running resource shall either be controlled by the program or held in a known state, which is determined when the resource is started. Resources shall be able to be started either from an initial state (cold restart using START) or from the state they were in at the time they were stopped (warm restart using RESUME). The desired state of the outputs shall be able to be specified as part of the stopping process.

The state of the I/O can be set to the following values when a configuration or resource is started or stopped:

Table 15 – Meaning of I/O State

Value of I/O State	Meaning	Set by
Controlled	Actuators are being controlled by the application program or the part of the application program being started. Inputs are being supplied to the application program or the part of the application program being started by the interface function to sensors and actuators.	Starting
Hold outputs	Actuators are not being controlled by the application program or the part of the application program being started, they are held in the current state. Sensors are being supplied to the application program or the part of the application program being started by the interface function to sensors and actuators.	Starting
Hold current state	Actuators are not being controlled by the application program or the part of the application program being started or stopped, they are held in the current state. Sensors are not being supplied to the application program or the part of the application program being started, they are held in the current state.	Starting, stopping
Implementer state	Actuators are not being controlled by the application program or the part of the application program being stopped, they are held in a state, which was specified by the implementer. The application program is not running, therefore the state of the Sensor Interface is not specified.	Stopping
Zero outputs	Actuators are not being controlled by the application program or the part of the application program being stopped, they are held in the zero state. The application program is not running, therefore the state of the Sensor Interface is not specified.	Stopping
User specified	Actuators are not being controlled by the application program or the part of the application program being stopped, they are held in a state which was specified by the user. The application program is not running, therefore the state of the Sensor Interface is not specified.	Stopping

Table 16 – I/O state

No.	I/O state
1	Controlled
2	Hold outputs
3	Hold current state
4	Implementer specified
5	Zero outputs
6	User specified
NOTE The communication subsystem should not be depended upon as a replacement for hardwired emergency stop switches. Normal safety practices should be followed.	

Table 17 – Execution and I/O control features

No.	Execution and I/O control
1	Receive requests to start a startable and stoppable unit
2	Receive requests to stop a startable and stoppable unit
3	Receive requests to resume a startable and stoppable unit

6.2.7 Application program transfer

The application program is transferred using the application program storage and data storage function of a PC (see 5.2). Application program transfer allows the client to upload the complete contents of the programmable memory or portions thereof for archiving or verification or to download it for restoring the PC to a known state. This function also provides the ability to place the PC in a safe state before modifying the contents of its programmable memory, and restarting it in a safe manner when the application program transfer is completed.

The initiation of the program transfer is typically done by a device that is not a PC. The services include:

a) upload for archive;

b) upload for verification;

c) download for restore to previously known good system; and

d) download an off-line developed system.

The portions of the programmable memory which can be uploaded or downloaded are given in table 18.

NOTE A load unit contains the variable P_DDATE, their value is the date of the last modification of the load unit.

Table 18 – Loadable units

No.	Loadable units
1	Configuration
2	Resource
3	Programs
4	Global variables
5	Access paths on configuration level
6	Access paths on program level
7	Load units contain the variable P_DDATE

The implementer shall specify if other language elements, for example, function types or function block types are loadable and the conditions and restrictions for downloading and uploading these.

This part of IEC 61131 defines a means to perform uploads and downloads on the whole PC, a subsystem of the PC and a portion of a subsystem. The whole or the portion of the PC to be downloaded shall be explicitly stopped before the download. The whole or the portion of the system being downloaded shall not be available for other uses until the download is completed. The implementer shall specify what other clients can do with a PC when one client is downloading it.

Table 19 – Application program transfer features

No.	Application program transfer
1	Receive requests to download a loadable unit
2	Receive requests to upload a loadable unit

6.2.8 Connection management

The Connection Management provides the means to install, to maintain and close communications connections to a remote communication partner. If multiple requests are initiated to operate with a device, they may all work over the same connection. Not all communications subsystems require connections, for example, point-to-point communication.

Connections are controlled explicitly by the application program using the CONNECT function block or are provided by the communication subsystem if and when needed.

Table 20 – Connection management features

No.	Connection management
1	Install connections
2	Close connections
3	Using one connection for multiple requests

7 PC communication function blocks

7.1 Overview of the communication function blocks

The following PC communication functions and their corresponding function blocks are described below.

Table 21 – Overview of the communication function blocks

No.	Subclause	Name of communication function block or function
1	7.2 Semantic of communication FB parameters (addressing of remote variables)	REMOTE_VAR
2 3	7.3 Device verification	STATUS, USTATUS
4	7.4 Polled data acquisition	READ,
5 6 7 8	7.5 Programmed data acquisition	USEND, URCV, BSEND, BRCV
9	7.6 Parametric control	WRITE,
10 11	7.7 Interlocked control	SEND, RCV
12 13	7.8 Programmed alarm report	NOTIFY, ALARM
14	7.9 Connection management	CONNECT

The numbers given in the above table shall be used to state compliance to these communication function blocks (CFB).

7.1.1 Device verification

The STATUS and USTATUS function blocks are provided so that the PC can collect status from other devices. These are provided to allow the PC to determine if the other devices are able to perform their intended function in the automated system.

7.1.2 Data acquisition

Data contained in other devices may be presented as variables. This data may come from a variety of sources and may have a wide range of meanings. It can be obtained by the PC through one of two methods using communication function blocks.

a) Polled – The PC uses the READ function block to obtain the value of one or more variables at a time or condition determined by the PC application program. The access to the variables may be controlled by the device being read.

b) Programmed – The data is provided to the PC at a time or condition determined by the other device. The PC uses the URCV function block to provide the data to the PC application program. The PC uses the USEND to provide unsolicited data to other devices.

The conditions (size, location, etc.) under which each data type supported by the other device can be uninterruptedly accessed is determined by the other device.

7.1.3 Control

Two methods of control shall be supported by PCs: parametric and interlocked.

Parametric control is when the operation of the other device is directed by writing values to variables residing in it. The access to the variables may be controlled by the PC which holds the variables. The PC uses the WRITE function block to perform this action from the PC application program.

Interlocked control is when the client requests the server to execute an application operation and to inform the client of the result of the operation. The PC uses the SEND and RCV function blocks to implement the client and server roles, respectively.

7.1.4 Alarm reporting

The PC can have the ability to signal alarm messages to a client when a predetermined condition occurs. The client may indicate an acknowledgement of these alarms to the PC. The ALARM and NOTIFY function blocks are used by the PC application program to generate acknowledged and unacknowledged alarms, respectively.

7.1.5 Connection management

The PC application program uses the CONNECT function block to manage connections.

7.2 Semantic of communication FB parameters

The communication function blocks use a common semantic of their function block inputs and outputs. The meaning of these inputs and outputs is described below. Some communication function blocks have special input or output parameters, they are described where the communication function blocks themselves are described.

Table 22 – Semantic of communication FB parameters

Parameter name	Data type of the parameter	Interpretation
EN_R	BOOL	Enabled to receive data
REQ/RESP	BOOL	Perform function on raising edge
ID	COMM_CHANNEL	Identification of the communication channel
R_ID	STRING	Identification of the remote FB inside the channel
SD_i	ANY	User data to send
VAR_i	STRING or data type of the output of the function REMOTE_VAR	Identification of a variable of the remote communication partner
DONE	BOOL	Requested function performed (good and valid)
NDR	BOOL	New user data received (good and valid)
ERROR	BOOL	New non-zero status received
STATUS	INT	Last detected status (error or good)
RD_i	ANY	Last received user data

The ID input references the communication channel used by the instance of the communication function block, i.e. it determines the remote communication partner. The ID input is of COMM_CHANNEL type which shall be implementer defined.

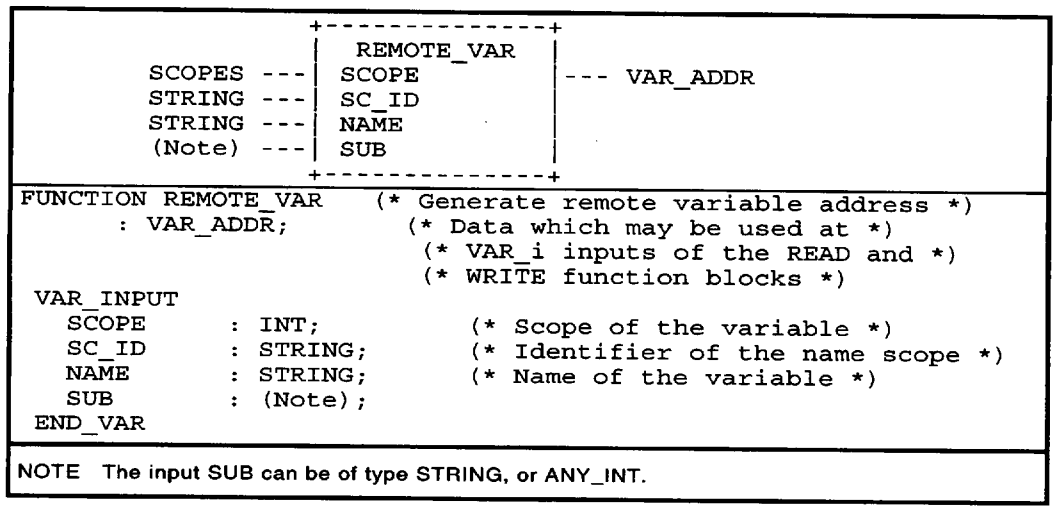
NOTE The value given at the ID input of a communication function block instance is intended to hold or reference the information which is necessary to manage the communication to the remote communication partner. This information may be dependent on the implementation and the communication subsystem used.

The R_ID input is used to identify the corresponding instance of the communication function block at the remote partner, if the PC communication function is provided by a corresponding pair of function block instances.

One instance of a communication function block shall use the same communication channel and communicate to the same corresponding remote function block instance throughout its whole lifetime.

The variables to be read or written are identified using the VAR_i inputs of the READ and WRITE function blocks. The actual parameter is typically a string which contains the name of the remote variable.

Additionally the VAR_i parameter may also have an implementer defined data type named VAR_ADDR. A function REMOTE_VAR is defined to generate the access information for nested variables.




```
FUNCTION REMOTE_VAR    (* Generate remote variable address *)
      : VAR_ADDR;        (* Data which may be used at *)
                          (* VAR_i inputs of the READ and *)
                          (* WRITE function blocks *)
 VAR_INPUT
   SCOPE      : INT;          (* Scope of the variable *)
   SC_ID      : STRING;       (* Identifier of the name scope *)
   NAME       : STRING;       (* Name of the variable *)
   SUB        : (Note);
 END_VAR
```

NOTE The input SUB can be of type STRING, or ANY_INT.

Figure 9 – Function REMOTE_VAR

IEC 2255/2000

SCOPE is an integer which identifies the name scopes of the programming languages of IEC 61131-3, the communication system, or the implementer supports as scope of a remote variable.

Table 23 – Values of the SCOPE parameter

Name scope of IEC 61131-3	Value
Configuration	0
Resource	1
Program	2
Function block instance	3
Reserved for future standardization	4 .. 9
Reserved for name scopes specific to communication subsystems	10 .. 99
Implementer specific	<0, > 99

If the SCOPE of the variable requires an identifier, the SC_ID is used to supply that identifier. NAME contains the name of the remote variable. If SUB is of string type, the value of the string is interpreted as a sub-element name. If SUB is an ANY_INT, the value is interpreted as an index. If SUB is an empty string, the complete variable is addressed.

The data type of the function output is implementer defined. The result of the function may be passed to the VAR_i inputs of the READ and WRITE function block or may be stored in a variable of the same data type. The use of the REMOTE_VAR function may be restricted only to produce valid values for the VAR_i parameters of the READ and WRITE function blocks.

There may be additional functions to support the communication subsystem specific or implementer specific addressing schemes which produce an output of VAR_ADDR type. The communication subsystem specific functions are specified in the mapping annexes of this part of IEC 61131.

All parameters of the communication function blocks are mandatory except the extensible parameters SD_i, RD_i, and VAR_i depending on the function block type. It is not requested

that the SD_i or RD_i parameters have the same data type if more than one SD_i parameter is used at one function block instance or if an SD_i parameter is used with different function block instances. The implementer shall specify the number of SD_i, RD_i, and VAR_i parameters which are supported with one invocation of a communication function block. Additionally, he shall describe if there are restrictions with the use of these parameters, for example data type or size of the actual parameters.

If a communication function block requests that data types are compatible, the compatibility check shall always be true if the same IEC 61131-3 data types are used at a client PC and a server PC. Additional communication subsystem specific compatibility rules may be defined.

The outputs are initialized with system zero. NDR, DONE, and ERROR pulse true until the next invocation of this instance. That is, each of the communication function blocks implies the following structure, which is not shown in the state diagrams of those function blocks.

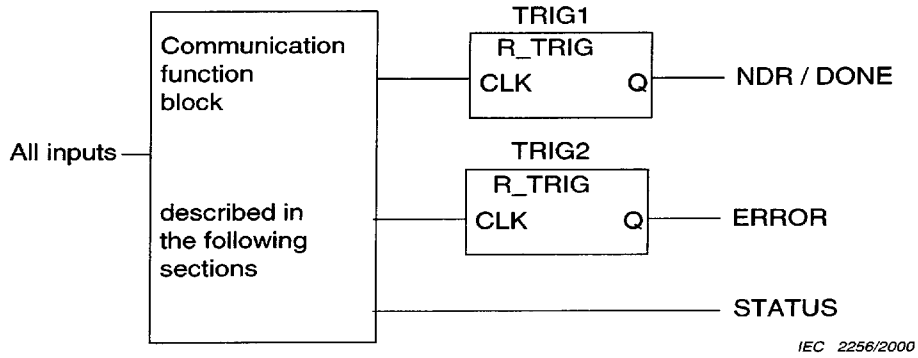


Figure 10 – Principle of status signalling

If a communication error of an instance of a communication function block is detected by the PC system or by the algorithm of the communication function block, the ERROR and the STATUS output of the function block instance are set. The ERROR output remains true during the time between two invocations of this instance (see figure 11).

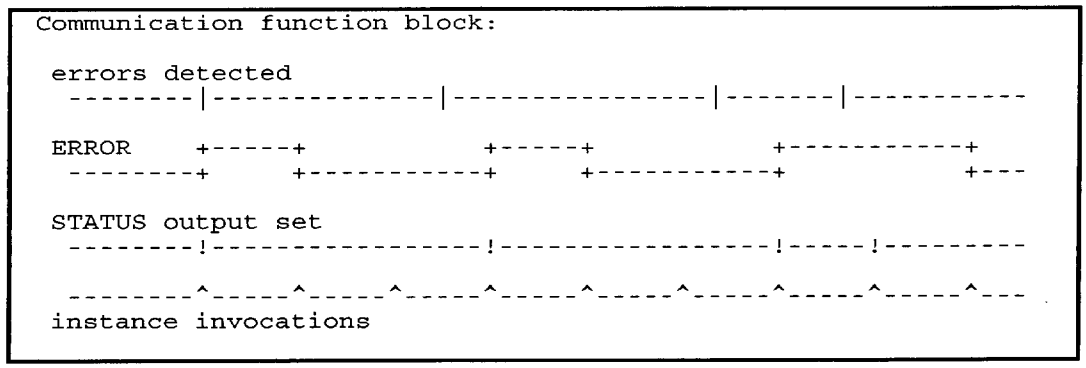


Figure 11 – Timing diagram of the ERROR and STATUS outputs

The NDR, DONE, ERROR and the STATUS output shall be set to new values only synchronously to the instance invocations of the communication function blocks, even if an error is detected in between.

The following values for the STATUS output of the various function blocks have been defined. Not all values are used by all function blocks.

Table 24 – Value and interpretation of the STATUS output

STATUS value	Interpretation
0	No error
1	Error of lower layers, no communication possible
2	Other negative response from remote communication partner
3	R_ID does not exist in the communication channel
4	Data type mismatch
5	Reset received
6	Receiver not enabled
7	Remote communication partner in wrong state
8	Access denied to remote object
9	Receiver overrun (user data are new)
10	Access to local object rejected
11	Requested service exceeds local resources
12 .. 20	Reserved for future standardization
–1	Instance of this function is busy and cannot provide additional services at this time
< –1 or > 20	Codes less than –1 or greater than 20 are to be specified by the implementer

If errors are received from one or more communication partners in the case of one-to-many or one-to-all communication, the STATUS parameter is set according to the first error received.

The RD_i parameters shall contain the received data. These parameters shall be input/output parameters.

The following subclauses contain a description of the communication function blocks. The representation of the function blocks is given in a graphical and a textual way, and the types and the meanings of the associated inputs and outputs are shown. The STATUS output shall take on the appropriate value as defined.

The normal operation is illustrated by a timing diagram.

The operation of the function blocks is described based on state diagrams. The transitions depending on the application program are mapped onto conditions of the function block inputs. The transitions depending on the communication system are described independent of the communication system used. The explicit mappings to certain communication systems is described in the annexes. The value of the function block outputs are given for each state of the state diagram.

Errors caused by the communication system or by local problems may occur asynchronously in all states of a communication function block. Only those errors are explicitly described in the state diagrams which cause state transitions or require actions. Otherwise, the errors shall only be signalled to the application program using the ERROR and STATUS outputs as shown in figures 10 and 11.

The communication function blocks need to be initialized. The initialization state INIT contained in all state diagrams shall be left at least before the return of the first invocation of the function block instance. In this state, all actions shall be done to enable communication. The communication channel to the remote communication partner shall be established, if the connection management of the channel is not explicitly programmed.

7.3 Device verification

The PC communication function device verification uses the STATUS and the USTATUS function blocks.

One instance of a STATUS or USTATUS function block provides one instance of the PC function device verification.

A PC can request a remote communication partner to send back to it its status information using the STATUS function block.

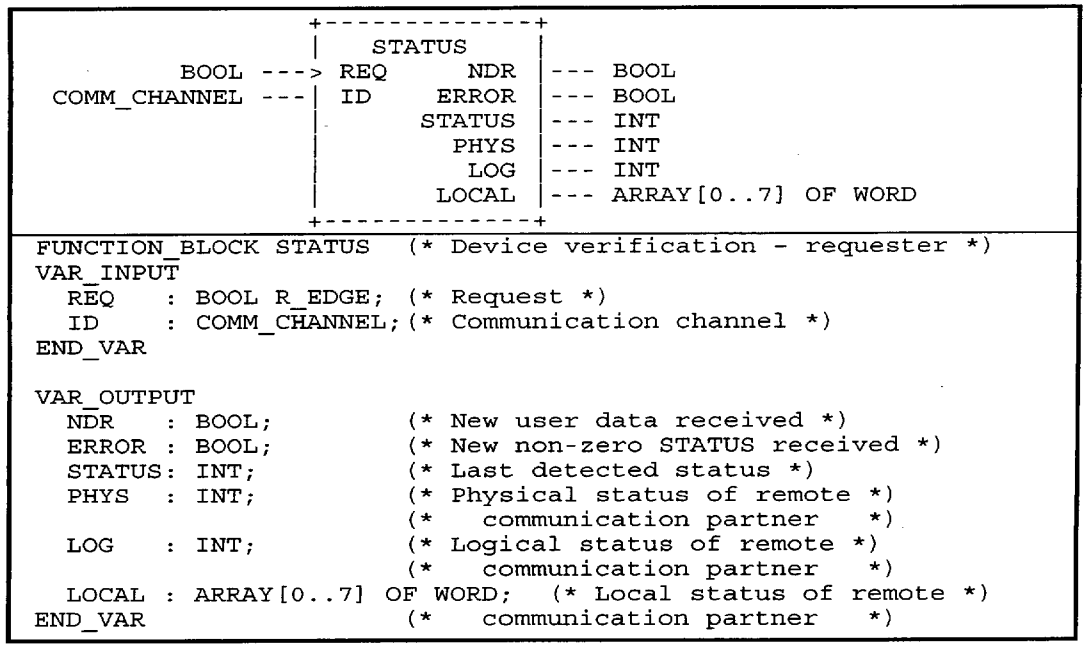
A PC can itself enable to receive status information of a remote communication partner using the USTATUS function block. The remote communication partner shall at least inform the USTATUS instance whenever its status information presented in the PHYS and LOG output changes.

The FB output PHYS contains the physical status of the remote device, the FB output LOG contains its logical communication status. The FB output LOCAL may contain additional status information up to 128 bits. The implementer shall specify the used length of this additional status information and shall define the semantics of it.

NOTE The READ function block can be used to obtain additional status information.

The ID parameter identifies the communication channel to the remote communication partner.

If an error occurred, the ERROR output pulses one cycle to indicate an error and the STATUS output contains the error code.




```
FUNCTION_BLOCK STATUS   (* Device verification - requester *)
VAR_INPUT
  REQ    : BOOL R_EDGE; (* Request *)
  ID     : COMM_CHANNEL;(* Communication channel *)
END_VAR

VAR_OUTPUT
  NDR    : BOOL;         (* New user data received *)
  ERROR  : BOOL;         (* New non-zero STATUS received *)
  STATUS: INT;           (* Last detected status *)
  PHYS   : INT;          (* Physical status of remote *)
                         (*   communication partner   *)
  LOG    : INT;          (* Logical status of remote *)
                         (*   communication partner   *)
  LOCAL : ARRAY[0..7] OF WORD;  (* Local status of remote *)
END_VAR                  (*   communication partner   *)
```

IEC 2258/2000

Figure 12 – STATUS function block

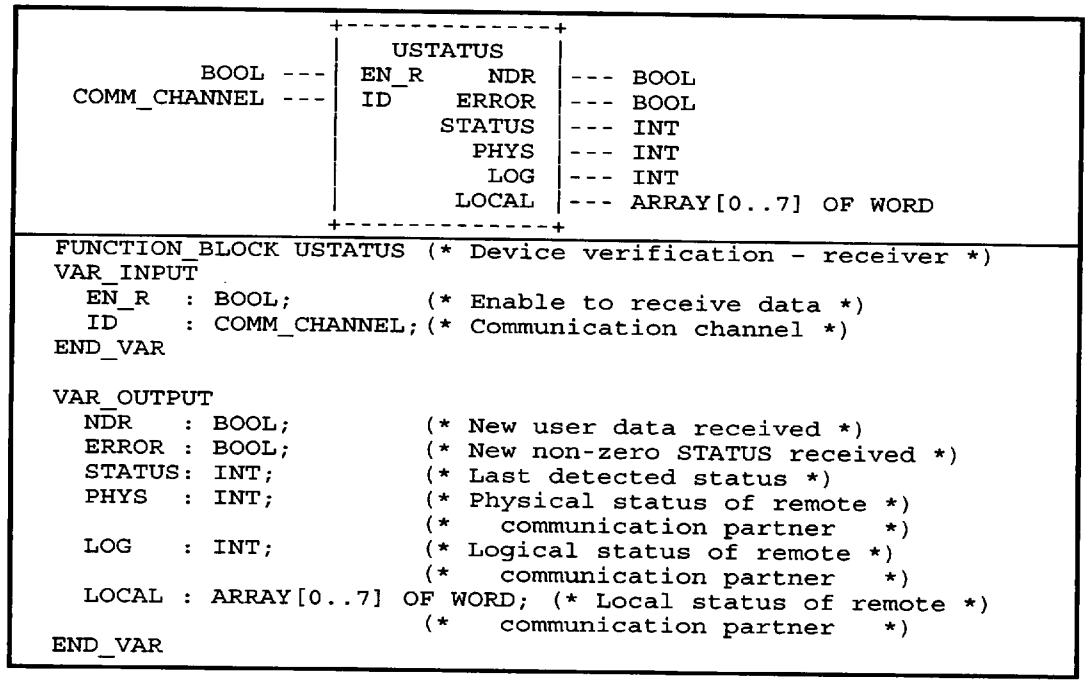


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Figure 13 – USTATUS function block

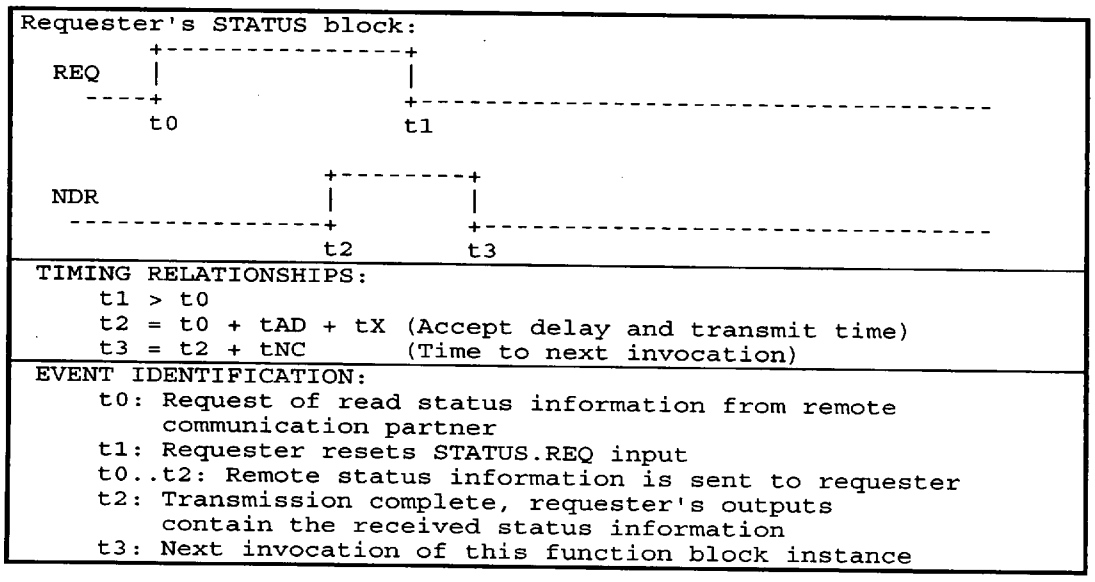

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Figure 14 – Timing diagram of the STATUS function block

The state diagram shown in figure 15 describes the algorithm of the STATUS function block. Tables 25 and 26 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the STATUS function block outputs.

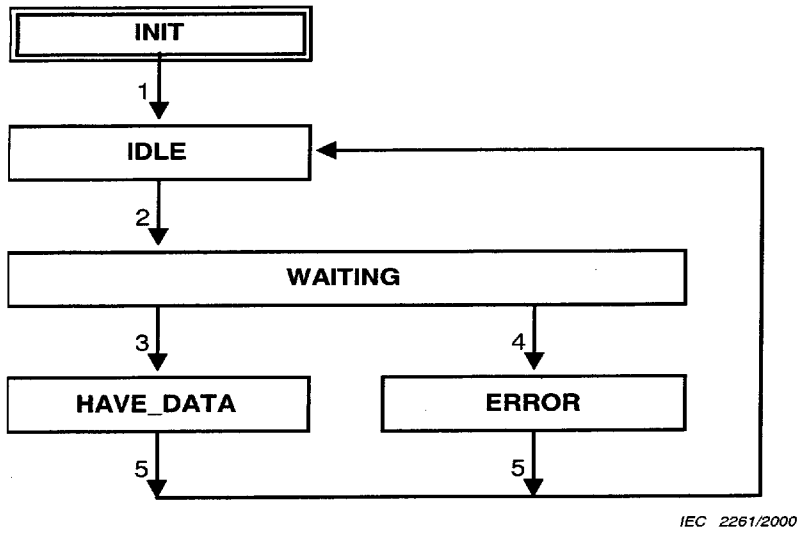


Figure 15 – State diagram of STATUS function block

Table 25 – Transitions of the STATUS state diagram

Transition	Condition
1	Initialization done
2	At raising edge of REQ input
3	Positive response from remote communication partner
4	Negative response from remote communication partner or communication problems detected
5	After next invocation of this instance

Table 26 – Action table for STATUS state diagram

		FB outputs			
State	**Actions**	**NDR [c]**	**ERROR [c]**	**STATUS**	**PHYS, LOG, LOCAL**
INIT [a]	Initialize outputs	0	0	0	0
IDLE	No actions	0	0	---	---
WAITING	Request status information from remote communication partner	---	---	–1	---
HAVE_DATA	Deposit status information in instance	1	0	0	New status information
ERROR	Indicate error	0	1	[b]	---

--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

The state diagram of figure 16 describes the algorithm of the USTATUS function block. Tables 27 and 28 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the USTATUS function block outputs.

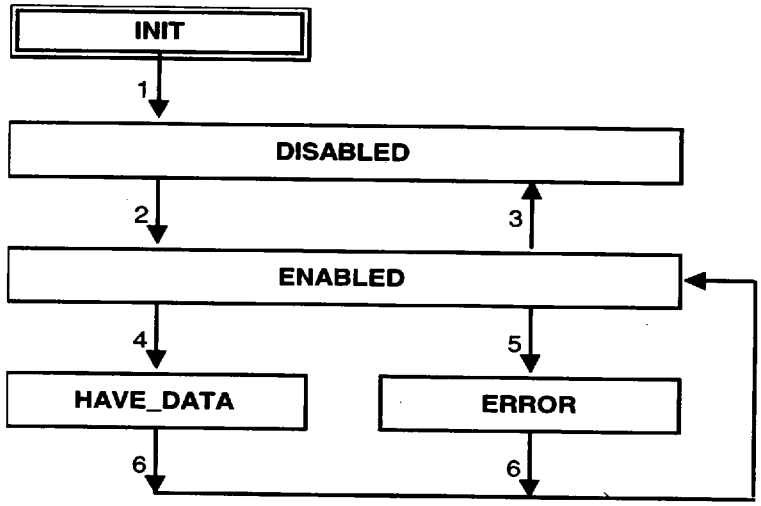


Figure 16 – State diagram of USTATUS function block

Table 27 – Transitions of USTATUS state diagrams

Transition	Condition
1	Initialization done
2	EN_R = 1
3	EN_R = 0
4	Status information received from remote communication partner
5	Communication problems detected
6	After next invocation of this instance

Table 28 – Action table of USTATUS state diagram

		FB outputs			
State	**Actions**	**NDR [c]**	**ERROR [c]**	**STATUS**	**PHYS, LOG, LOCAL**
INIT [a]	Initialize outputs	0	0	0	0
DISABLED	No actions	0	0	---	---
ENABLED	No actions	0	0	---	---
HAVE_DATA	Deposit status information	1	0	0	New status information
ERROR	Indicate error	0	1	[b]	---

--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

7.4 Polled data acquisition

The PC communication function polled data acquisition uses the READ function block.

One instance of a READ function block provides one instance of the PC function polled data acquisition.

The ID parameter identifies the communication channel to the remote communication partner.

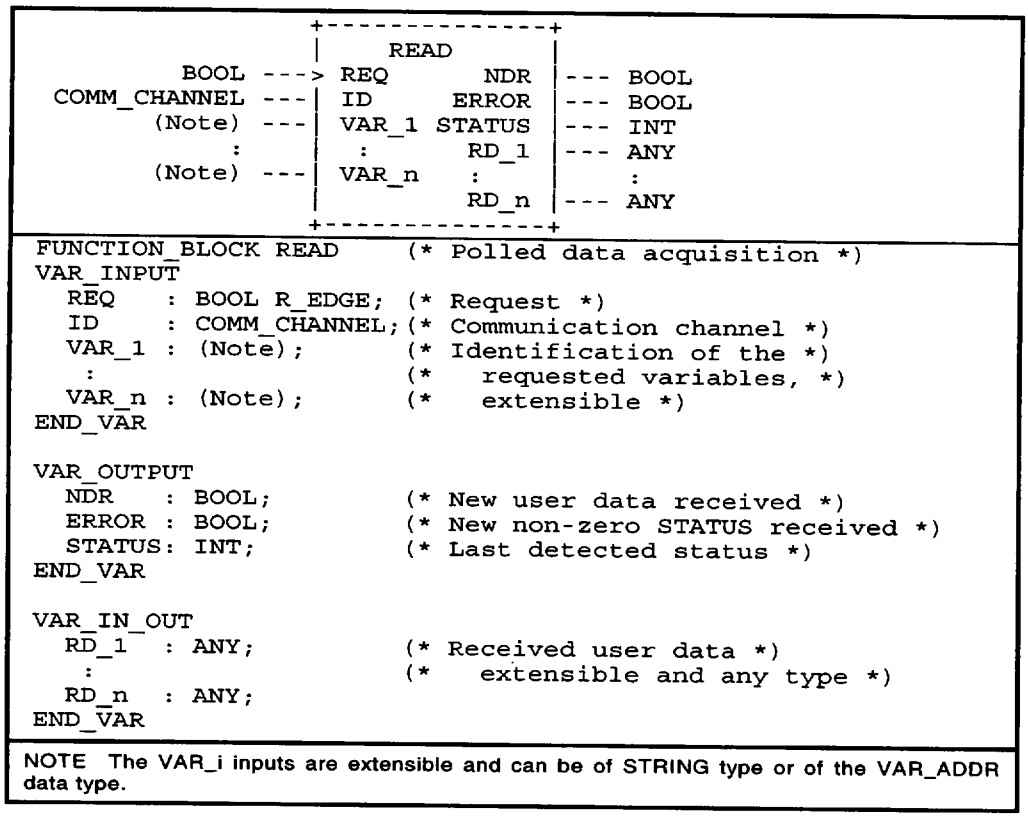
The VAR_i inputs of the READ function block contain a string which can be interpreted by the remote communication partner as variable identifier. The remote communication partner sends the values of these variables back to the requesting READ instance. The READ passes the received variable values to its application program via its RD_i outputs. Each requested variable of the remote communication partner shall have a compatible data type to the variable programmed at the RD_i outputs of the READ instance. The VAR_i and RD_i parameters are extensible. At least VAR_1 and RD_1 shall be present.

If the remote communication partner is a PC, variables with an access path and variables with direct representation may be accessed with a READ function block. The variables with an access path are referenced in the VAR_ACCESS construction of the PC programming languages (see 2.7.1 of IEC 61131-3). The access name specified in this construction shall be used as the identifier of the variable in the VAR_i input. If a variable with direct representation shall be accessed with a READ function block, the VAR_i input shall contain the direct representation, for example %IW17, as a string. It shall be possible to mix the access to variables with an access path and with direct representation in one invocation of a READ function block instance.

If a variable shall be read via an access path, which is declared inside a program (see 2.5.3 of IEC 61131-3) the REMOTE_VAR function shall be used. The name of the program instance shall be used at the SC_ID input, the name of the variable at the NAME input, for example to read the variable AB12 in the program DO7 the REMOTE_VAR function shall be invoked with REMOTE_VAR (2, "DO7", "AB12", "").

If a sub-element of a structured variable or an element of an array shall be read, the SUB input of the REMOTE_VAR function shall be used to identify this sub-element or element in the VAR_i inputs.

If an error occurred, the ERROR output pulses one cycle to indicate an error and the STATUS output contains the error code.

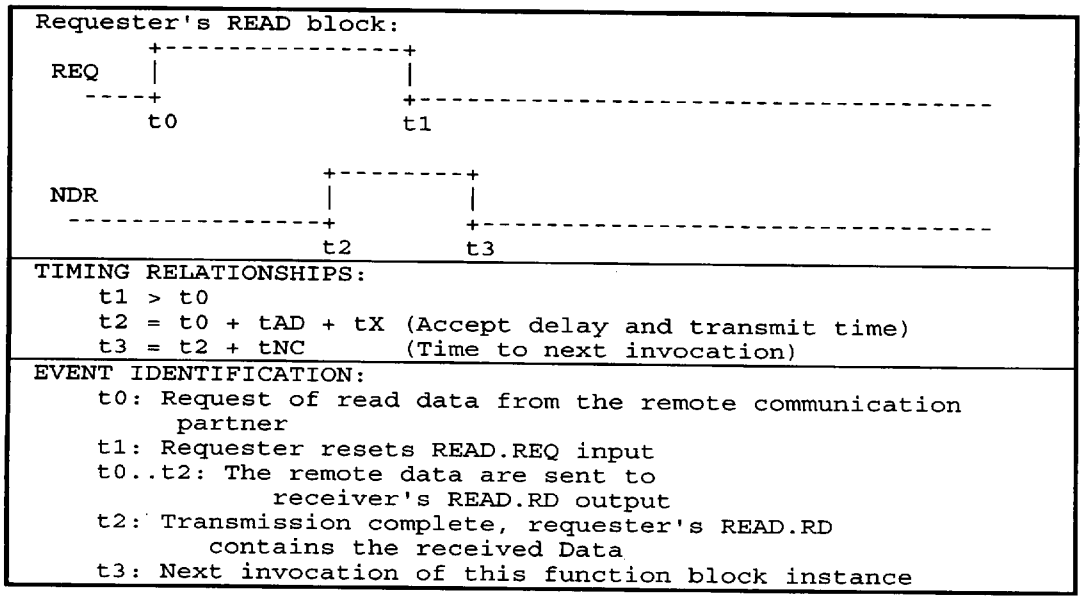



```
FUNCTION_BLOCK READ     (* Polled data acquisition *)
VAR_INPUT
  REQ    : BOOL R_EDGE; (* Request *)
  ID     : COMM_CHANNEL;(* Communication channel *)
  VAR_1  : (Note);      (* Identification of the *)
   :                    (*   requested variables, *)
  VAR_n  : (Note);      (*   extensible *)
END_VAR

VAR_OUTPUT
  NDR    : BOOL;        (* New user data received *)
  ERROR  : BOOL;        (* New non-zero STATUS received *)
  STATUS: INT;          (* Last detected status *)
END_VAR

VAR_IN_OUT
  RD_1   : ANY;         (* Received user data *)
   :                    (*   extensible and any type *)
  RD_n   : ANY;
END_VAR
```

NOTE The VAR_i inputs are extensible and can be of STRING type or of the VAR_ADDR data type.

IEC 2263/2000

Figure 17 – READ function block




```
TIMING RELATIONSHIPS:
    t1 > t0
    t2 = t0 + tAD + tX (Accept delay and transmit time)
    t3 = t2 + tNC      (Time to next invocation)
EVENT IDENTIFICATION:
    t0: Request of read data from the remote communication
        partner
    t1: Requester resets READ.REQ input
    t0..t2: The remote data are sent to
            receiver's READ.RD output
    t2: Transmission complete, requester's READ.RD
        contains the received Data
    t3: Next invocation of this function block instance
```

IEC 2264/2000

Figure 18 – Timing diagram of READ function block

The state diagram of figure 19 describes the algorithm of the READ function block. Tables 29 and 30 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the READ function block outputs.

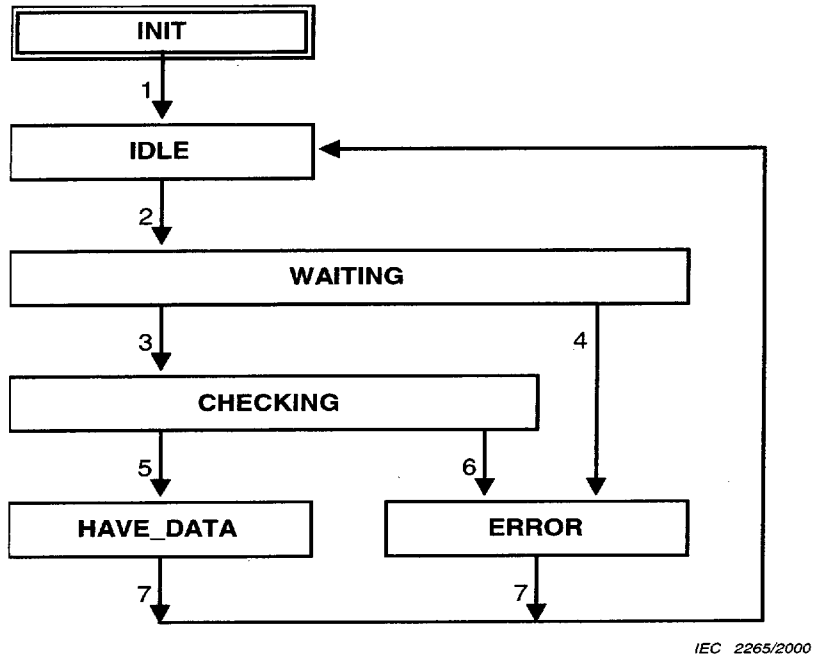


Figure 19 – State diagram of READ function block

Table 29 – Transitions of the READ state diagram

Transition	Condition
1	Initialization done
2	At raising edge of REQ input
3	Positive response from remote communication partner
4	Negative response from remote communication partner or other communication problems detected
5	Data types of RD_i and of received data match
6	Data types of RD_i and of received data do not match
7	After next invocation of this instance

Table 30 – Action table for READ state diagram

State	Actions	FB outputs			
		NDR [c]	ERROR [c]	STATUS	RD_1..RD..n
INIT [a]	Initialize outputs	0	0	0	System null
IDLE	No actions	0	0	---	---
WAITING	Request variables from remote communication partner	0	0	–1	---
CHECKING	Verify data type match	0	0	---	---
HAVE_DATA	Deposit data	1	0	0	New data
ERROR	Indicate error	0	1	[b]	---

--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

7.5 Programmed data acquisition

7.5.1 USEND/URCV function blocks

The PC communication function programmed data acquisition uses the USEND and the URCV function blocks.

Corresponding instances of one USEND and one URCV function block provide one instance of the PC function programmed data acquisition.

The USEND instance sends data to the URCV instance which may process this data with its application program. When requested the USEND instance takes the data from its SD_i inputs and transmits it to the corresponding URCV instance. Previously received data is overwritten. The URCV instance passes the received data to the application program via its RD_i outputs. This occurs whenever the application program requests its USEND instance to send data. The URCV instance passes newly received data whenever it gets one. It informs the application program when new data have arrived. The following data flow diagram illustrates this.

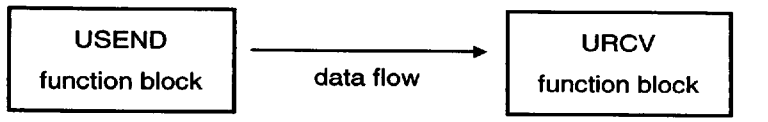


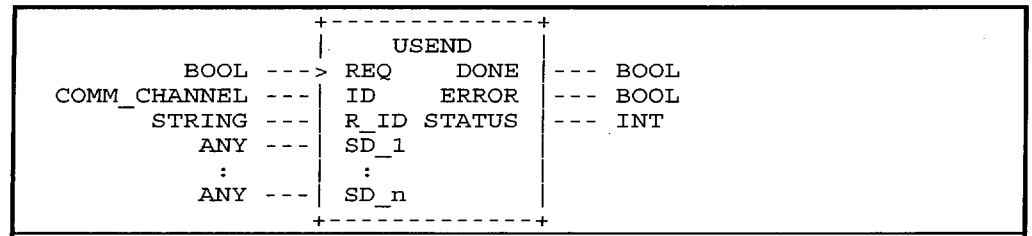
Figure 20 – Programmed data acquisition data flow

The SD_i and RD_i parameters are extensible. At least the SD_1 input at the FB USEND and the RD_1 output at the FB URCV shall be present. The number and each of the data types of the SD_i inputs of the USEND instance and the RD_i outputs of the corresponding URCV instance shall be compatible.

One USEND instance sends data to one URCV instance; that means, they are corresponding instances, if the value of the ID parameter references the same communication channel and if the value of the R_ID parameters are equal within the scope of this communication channel.

NOTE If the communication system provides communication channels which support one-to-many or one-to-all connections, these function blocks may be used to program a data acquisition function from one communication partner to many.

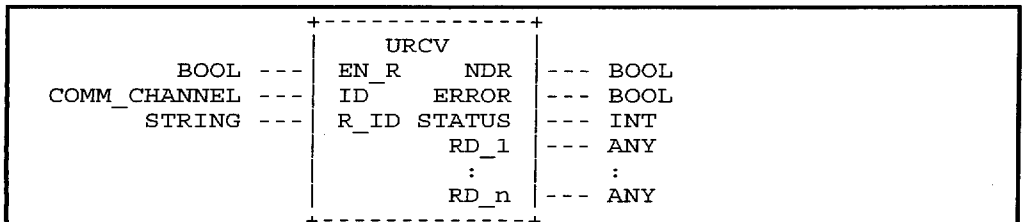
If an error occurred, the ERROR output pulses one cycle to indicate an error and the STATUS output contains the error code.




```
FUNCTION_BLOCK USEND     (* Programmed data acquisition *)
VAR_INPUT                (*    requester *)
  REQ    : BOOL R_EDGE; (* Request to send *)
  ID     : COMM_CHANNEL;(* Communication channel *)
  R_ID   : STRING;      (* Remote function block *)
  SD_1   : ANY;         (* User data to send *)
   :                    (*   extensible and any type *)
  SD_n   : ANY;
END_VAR

VAR_OUTPUT
  DONE   : BOOL;        (* Function performed *)
  ERROR  : BOOL;        (* New non-zero STATUS received *)
  STATUS: INT;          (* Last detected status *)
END_VAR
```

IEC 2267/2000

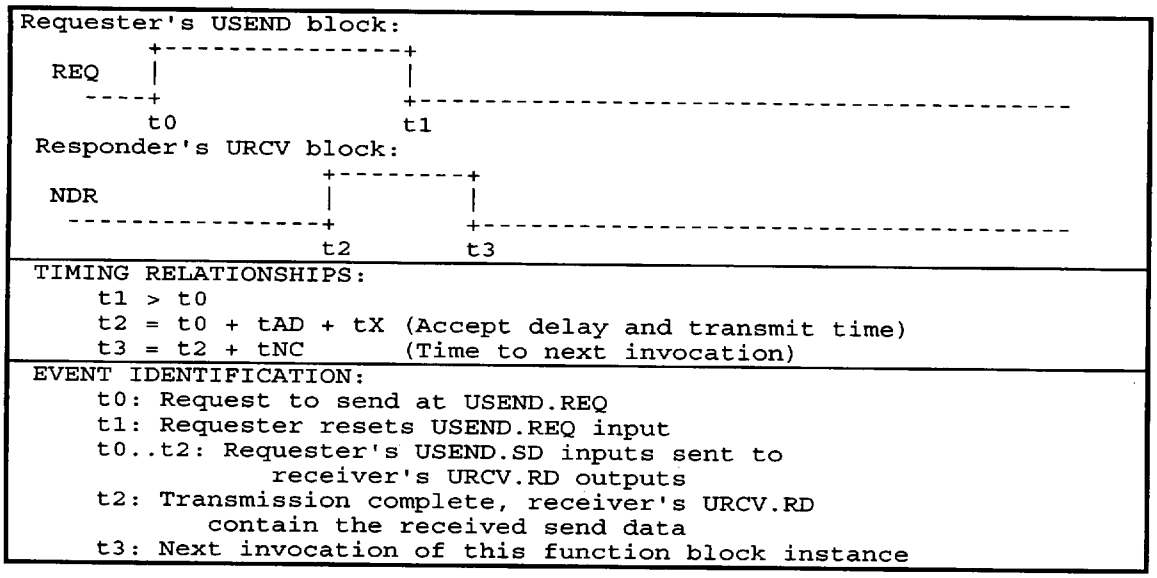
Figure 21 – USEND function block




```
FUNCTION_BLOCK URCV      (* Programmed data acquisition *)
VAR_INPUT                (*   receiver *)
  EN_R   : BOOL;        (* Enable to receive data *)
  ID     : COMM_CHANNEL;(* Communication channel *)
  R_ID   : STRING;      (* Remote function block *)
END_VAR

VAR_OUTPUT
  NDR    : BOOL;        (* New user data received *)
  ERROR  : BOOL;        (* New non-zero STATUS received *)
  STATUS: INT;          (* Last detected status *)
END_VAR

VAR_IN_OUT
  RD_1   : ANY;         (* Received user data *)
   :                    (*   extensible and any type *)
  RD_n   : ANY;
END_VAR
```

IEC 2268/2000

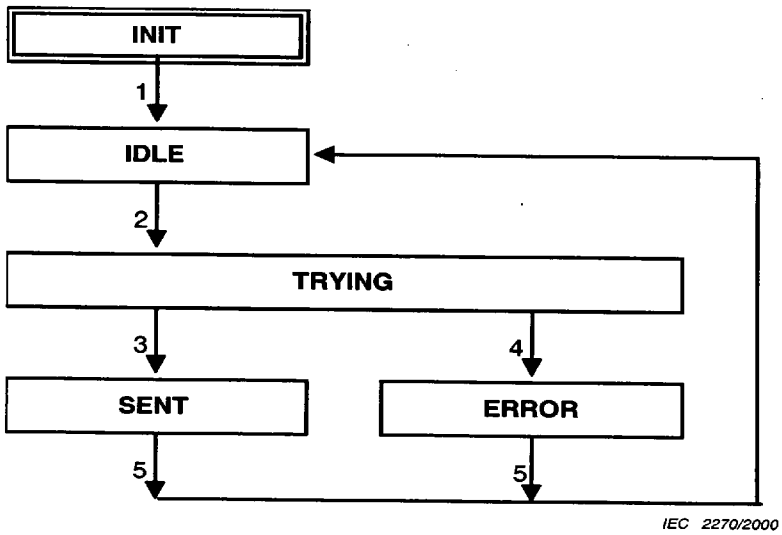
Figure 22 – URCV function block



IEC 2269/2000

Figure 23 – Timing diagram of USEND and URCV function blocks

The state diagram shown in figure 24 describes the algorithm of the USEND function block. Tables 31 and 32 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the USEND function block outputs.



IEC 2270/2000

Figure 24 – State diagram of USEND function block

Table 31 – Transitions of the USEND state diagram

Transition	Condition
1	Initialization done
2	At raising edge of REQ input
3	Communication system indicates "Sent to Remote Communication Partner"
4	Communication system indicates "Cannot Send to Remote Communication Partner" or other communication problems detected
5	After next invocation of this instance

Table 32 – Action table for USEND state diagram

		FB outputs		
State	Actions	DONE [c]	ERROR [c]	STATUS
INIT [a]	Initialize outputs	0	0	0
IDLE	No actions	0	0	---
TRYING	Send data given at the SD_i inputs to remote communication partner	---	---	---
SENT	Clear error indication	1	0	0
ERROR	Indicate error	0	1	[b]

--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

The state diagram of figure 25 describes the algorithm of the URCV function block. Tables 33 and 34 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the URCV function block outputs.

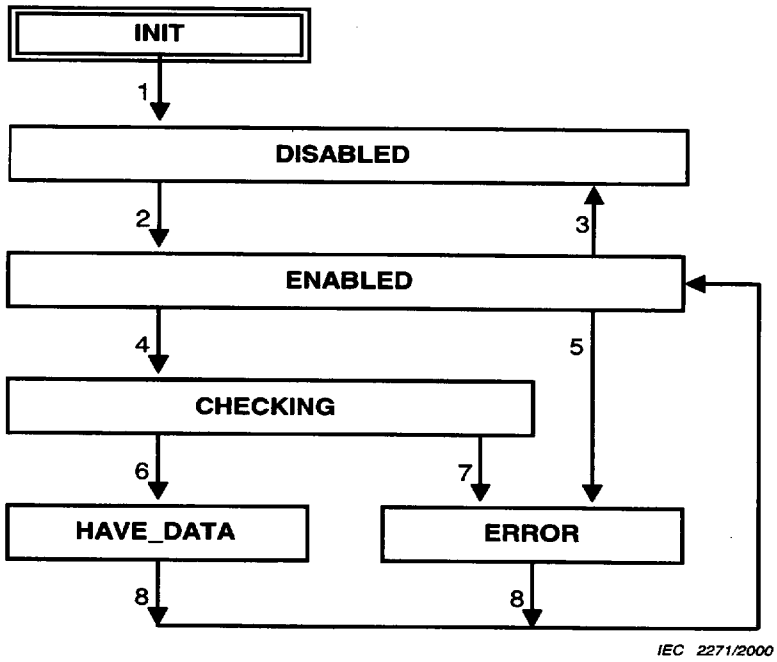


Figure 25 – State diagram of URCV function block

Table 33 – Transitions of URCV state diagrams

Transition	Condition
1	Initialization done
2	EN_R = 1
3	EN_R = 0
4	Data received from remote communication partner
5	Communication problems detected
6	Data types of SD_i of USEND and RD_i of URCV match
7	Data types of SD_i of USEND and RD_i of URCV do not match
8	After next invocation of this instance

Table 34 – Action table of URCV state diagram

		FB outputs			
State	**Actions**	**NDR** [c]	**ERROR** [c]	**STATUS**	**RD_1..RD..n**
INIT [a]	Initialize outputs	0	0	0	System null
DISABLED	No actions	0	0	---	---
ENABLED	No actions	---	---	---	---
CHECKING	Verify data type match	---	---	---	---
HAVE_DATA	Deposit data	1	0	0, 9	New data
ERROR	Indicate error	0	1	[b]	---

--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

7.5.2 BSEND / BRCV Function Blocks

Corresponding instances of one BSEND and one BRCV function block provide one instance of the PC function programmed data acquisition.

The BSEND instance sends data to the BRCV instance, which may process this data with its application program. When requested the BSEND instance takes the data from its SD_1 input and transmits it to the corresponding BRCV instance. Previously received data is overwritten. The BRCV instance passes the received data to the application program via its RD_1 output. This occurs when the application program requests its BSEND instance to send data. The BRCV instance passes newly received data when it has finished its previous request and gets new data. It informs the application program when new data have arrived.

The SD_1 input of the BSEND instance and the RD_1 output of the BRCV instance shall both be of data type ANY and are interpreted as a sequence of bytes.

NOTE The representation of the data in the controller is typically dependent on the implementation. The communication partners shall agree in the interpretation of any data if data of data type other than array of byte are transferred. This restricts the interoperability of programs using these communication function blocks.

The BSEND instance shall send as many bytes out of the data given at the SD_1 input as given at the LEN input of the BSEND instance. If the LEN input has the value 0 the complete variable given at the SD_1 input shall be transferred. The RD_1 output shall be able to store the data sent. The LEN output of the BRCV instance shall contain the count of bytes received in the RD_1 output. An error shall be signalled, if

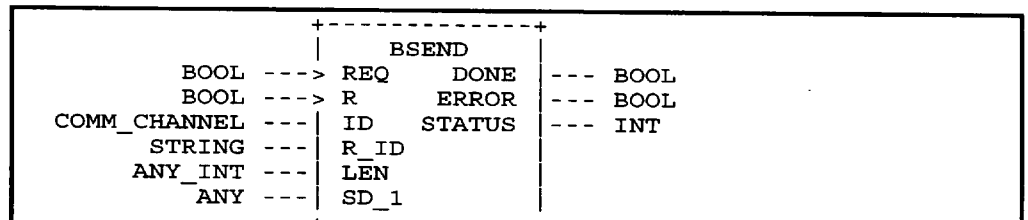
- either the value at the LEN input of the BSEND instance is greater than the total length in bytes of the variable connected to the SD_1 input,
- or the total length in bytes of the received data is greater than the total length in bytes of the variable connected to the RD_1 output of the BRCV instance.

The data transfer phase of the BSEND instance starts with the raising edge at the REQ input. It ends when the DONE or the ERROR output is set to 1. The DONE output shall be set to 1 for one cycle after the complete block of data to be sent is completely transmitted. During the data transfer phase, the implementer may restrict the access to the variable containing the data to be sent. The RD_1 output of the BRCV instance is valid when the NDR output has the value 1.

One BSEND instance sends data to one BRCV instance; that means, they are corresponding instances, if the value of the ID parameter reference the same communication channel and if the value of the R_ID parameters are equal within the scope of this communication channel.

The data transfer shall be cancelled if a raising edge is detected at the R input of the BSEND instance. If the data transfer is cancelled the ERROR and the STATUS outputs of the BRCV instance are set. In case the values of the RD_1 and LEN outputs are undefined.

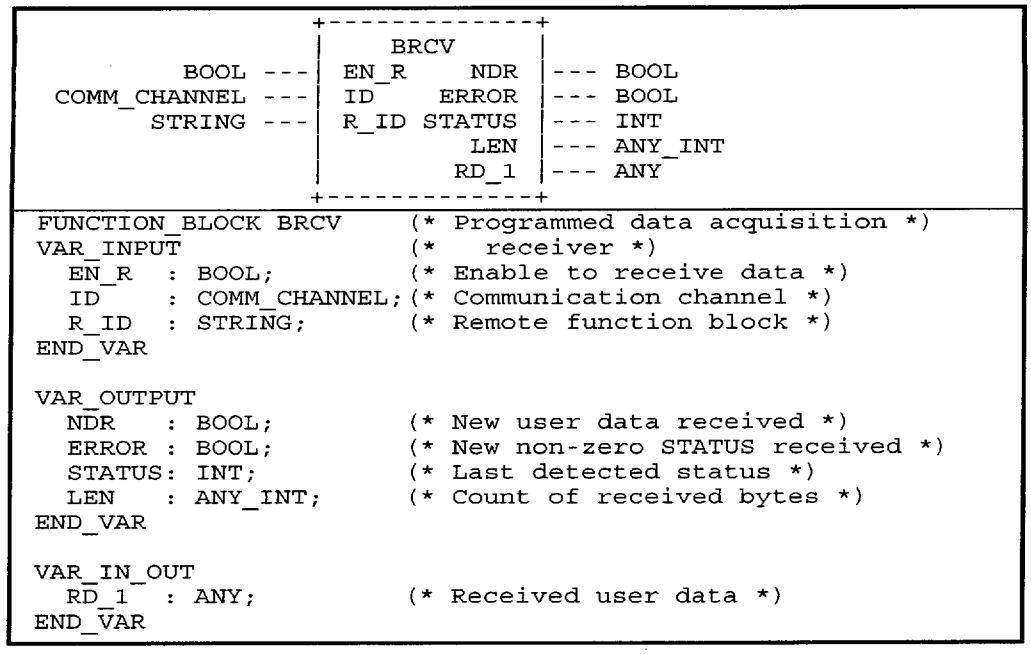
If an error occurred, the ERROR output pulses one cycle to indicate an error and the STATUS output contains the error code.




```
FUNCTION_BLOCK BSEND    (* Programmed data acquisition *)
VAR_INPUT               (*    requester *)
  REQ    : BOOL R_EDGE; (* Request to send *)
  R      : BOOL R_EDGE; (* Reset *)
  ID     : COMM_CHANNEL;(* Communication channel *)
  R_ID   : STRING;      (* Remote function block *)
  LEN    : ANY_INT;     (* Bytes to send *)
  SD_1   : ANY;         (* User data to send *)
END_VAR

VAR_OUTPUT
  DONE   : BOOL;        (* Function performed *)
  ERROR  : BOOL;        (* New non-zero STATUS received *)
  STATUS: INT;          (* Last detected status *)
END_VAR
```

IEC 2272/2000

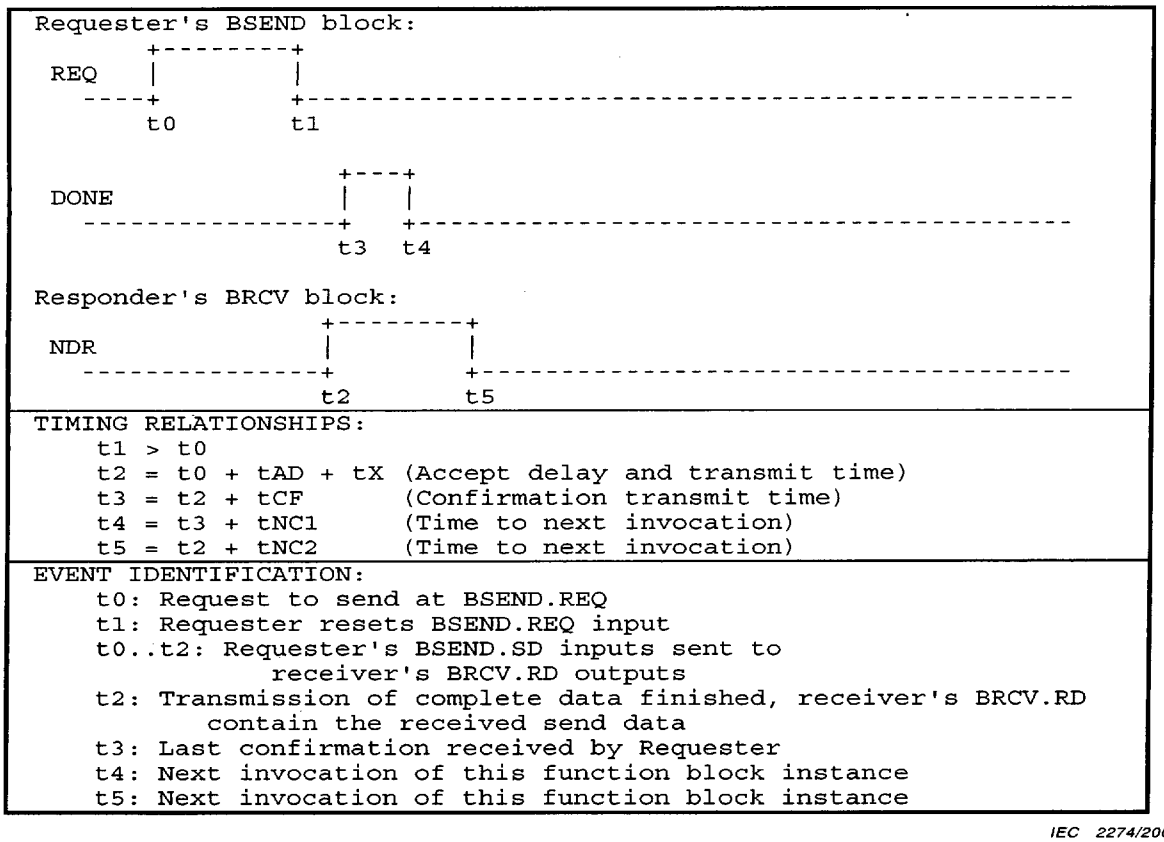
Figure 26 – BSEND function block




```
FUNCTION_BLOCK BRCV     (* Programmed data acquisition *)
VAR_INPUT               (*   receiver *)
  EN_R   : BOOL;        (* Enable to receive data *)
  ID     : COMM_CHANNEL;(* Communication channel *)
  R_ID   : STRING;      (* Remote function block *)
END_VAR

VAR_OUTPUT
  NDR    : BOOL;        (* New user data received *)
  ERROR  : BOOL;        (* New non-zero STATUS received *)
  STATUS: INT;          (* Last detected status *)
  LEN    : ANY_INT;     (* Count of received bytes *)
END_VAR

VAR_IN_OUT
  RD_1   : ANY;         (* Received user data *)
END_VAR
```

IEC 2273/2000

Figure 27 – BRCV function block




```
TIMING RELATIONSHIPS:
    t1 > t0
    t2 = t0 + tAD + tX (Accept delay and transmit time)
    t3 = t2 + tCF      (Confirmation transmit time)
    t4 = t3 + tNC1     (Time to next invocation)
    t5 = t2 + tNC2     (Time to next invocation)

EVENT IDENTIFICATION:
    t0: Request to send at BSEND.REQ
    t1: Requester resets BSEND.REQ input
    t0..t2: Requester's BSEND.SD inputs sent to
              receiver's BRCV.RD outputs
    t2: Transmission of complete data finished, receiver's BRCV.RD
          contain the received send data
    t3: Last confirmation received by Requester
    t4: Next invocation of this function block instance
    t5: Next invocation of this function block instance
```

IEC 2274/2000

Figure 28 – Timing diagram of BSEND and BRCV function blocks

The state diagram shown in figure 29 describes the algorithm of the BSEND function block. Tables 35 and 36 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the BSEND function block outputs.

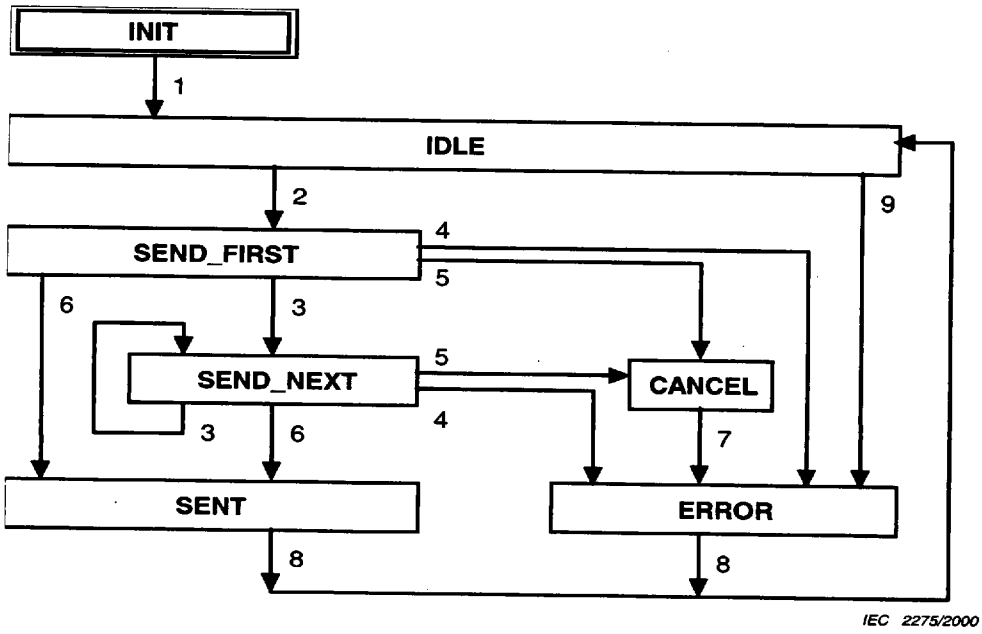


Figure 29 – State diagram of BSEND function block

Table 35 – Transitions of the BSEND state diagram

Transition	Condition
1	Initialization done
2	At raising edge of REQ input
3	Positive confirmation received and more data to send
4	Negative confirmation received or communication problems detected
5	At raising edge of R input
6	Positive confirmation received and no more data to send
7	Immediate
8	After next invocation of this instance
9	Communication problems detected

Table 36 – Action table for BSEND state diagram

State	Actions	FB outputs		
		DONE [c]	ERROR [c]	STATUS
INIT [a]	Initialize outputs	0	0	0
IDLE	No actions	0	0	---
SEND_FIRST	Send first block of data given at the SD_1 input to remote communication partner, send a maximum of LEN bytes in total	---	–1	---
SEND_NEXT	Send next block of data given at the SD_1 input to remote communication partner, send a maximum of LEN bytes in total	---	---	---
SENT	Clear error indication	1	0	0
CANCEL	Stop the data transfer	---	---	---
ERROR	Indicate error	0	1	[b]

--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

The state diagram shown in figure 30 describes the algorithm of the BRCV function block. Tables 37 and 38 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the BRCV function block outputs.

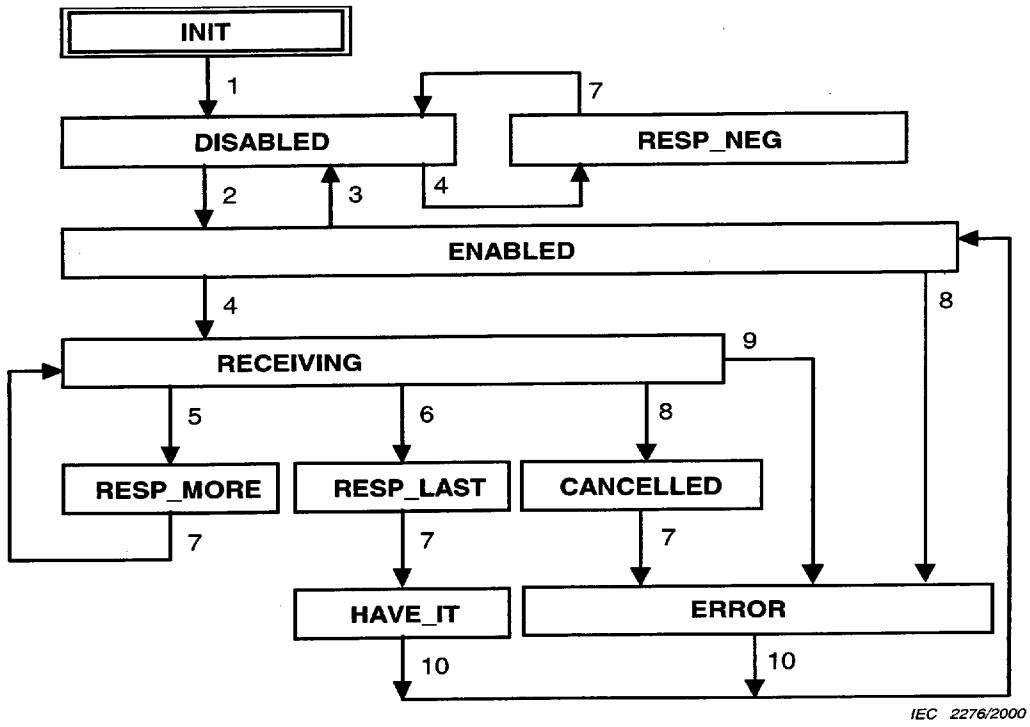


Figure 30 – State diagram of BRCV function block

Table 37 – Transitions of BRCV state diagrams

Transition	Condition
1	Initialization done
2	EN_R = 1
3	EN_R = 0
4	Data received from remote communication partner
5	More data follows is true
6	More data follows is false
7	Immediate
8	Communication problems detected
9	Indication received to cancel data transfer
10	After next invocation of this instance

Table 38 – Action table of BRCV state diagram

		FB outputs			
State	**Actions**	**NDR [c]**	**ERROR [c]**	**STATUS**	**RD_1, LEN**
INIT [a]	Initialize outputs	0	0	0	System null
DISABLED	No actions	0	0	---	---
RESP_NEG	Send negative response	---	---	---	---
ENABLED	No actions	---	---	---	---
RECEIVING	Verify data can be stored and store at the given index	---	---	[d]	New data [d]
RESP_MORE	Send positive response	---	---	---	---
RESP_LAST	Send positive response	---	---	---	---
CANCELLED	Send positive response	---	---	5	---
HAVE_IT	Deposit data	1	0	0	New data
ERROR	Indicate error	0	1	[b]	---

--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

[d] New data may be placed in the RD_1 output, in case the STATUS output shall be set to –1.

7.6 Parametric control

The PC communication function parametric control uses the WRITE function block.

One instance of a WRITE function block provides one instance of the PC function parametric control.

The ID parameter identifies the communication channel to the remote communication partner.

The VAR_i inputs of the WRITE function block contain a string which can be interpreted by the remote communication partner as variable identifier (access path) of it. The SD_i inputs reference the values to be written to the variables identified by the VAR_i inputs. The remote communication partner writes the values to these variables. The VAR_i and SD_i parameters are extensible. At least VAR_1 and SD_1 shall be present.

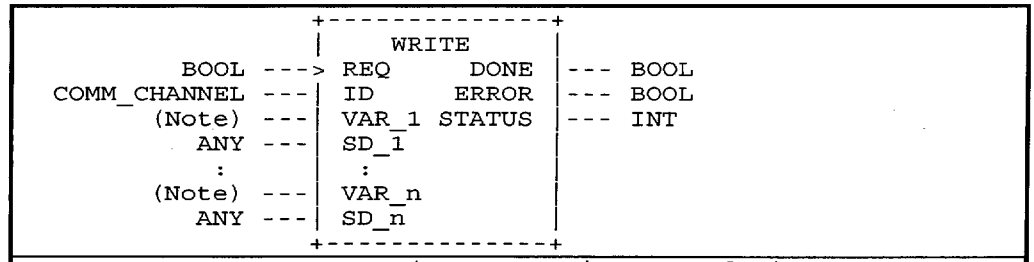
Each variable of the remote communication partner shall have the same data type as programmed at the SD_i inputs of the WRITE instance.

If the remote communication partner is a PC, variables with an access path and variables with direct representation may be accessed with a WRITE function block. The variables with an access path are referenced in the VAR_ACCESS construction of the PC programming languages (see 2.7.1 of IEC 61131-3). The access name specified in this construction shall be used as the identifier of the variable in the VAR_i input. If a variable with direct representation shall be accessed with a WRITE function block, the VAR_i input shall contain the direct representation, for example %IW17, as a string. It is possible to mix the access to variables with an access path and with direct representations in one invocation of a WRITE function block instance.

If a variable shall be written via an access path, which is declared inside a program (see 2.5.3 of IEC 61131-3), the REMOTE_VAR function shall be used. The name of the program instance shall be used at the SC_ID input, the name of the variable at the NAME input, for example to write the variable AB12 in the program DO7 the REMOTE_VAR function shall be invoked with REMOTE_VAR (2, "DO7", "AB12", "").

If a sub-element of a structured variable or an element of an array shall be written, the SUB input of the REMOTE_VAR function shall be used to identify this sub-element or element in the VAR_i inputs.

If an error occurred, the ERROR output pulses one cycle to indicate an error and the STATUS output contains the error code.




```
FUNCTION_BLOCK WRITE    (* Parametric control *)
VAR_INPUT
  REQ    : BOOL R_EDGE; (* Request *)
  ID     : COMM_CHANNEL;(* Communication channel *)
  VAR_1  : (Note);      (* Identifier and *)
  SD_1   : ANY;         (*   value of variable to be set *)
   :                    (*   extensible and any type *)
  VAR_n  : (Note);
  SD_n   : ANY;
END_VAR

VAR_OUTPUT
  DONE   : BOOL;        (* Function performed *)
  ERROR  : BOOL;        (* New non-zero STATUS received *)
  STATUS: INT;          (* Last detected status *)
END_VAR
```

NOTE The VAR_i inputs are extensible and can be of STRING type or of the VAR_ADDR data type.

IEC 2277/2000

Figure 31 – WRITE function block

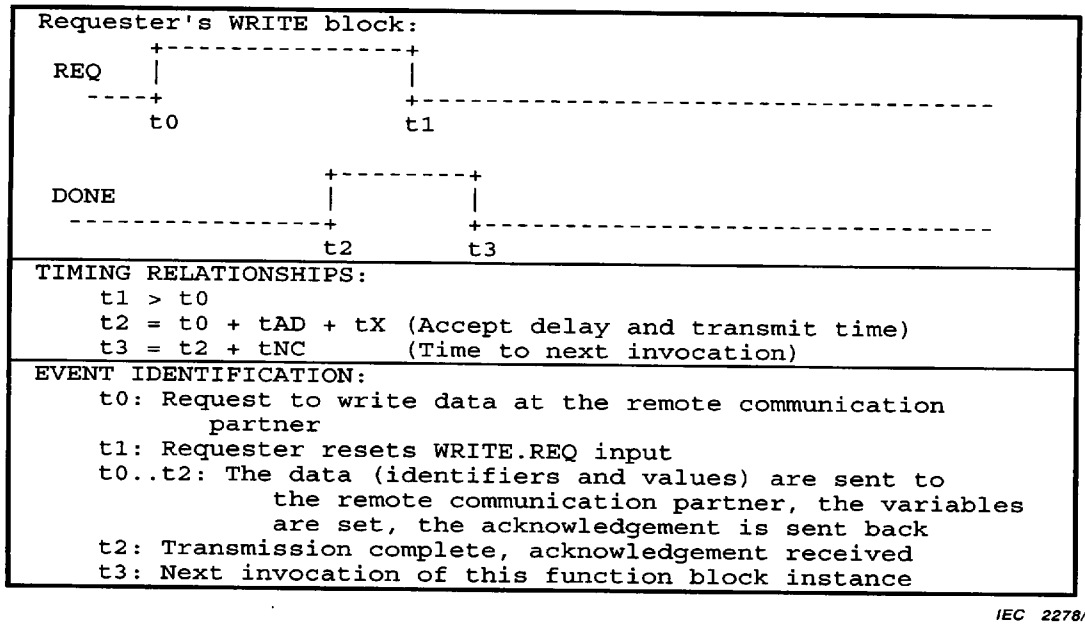


Figure 32 – Timing diagram of WRITE function block

The state diagram shown in figure 33 describes the algorithm of the WRITE function block. Tables 39 and 40 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the WRITE function block outputs.

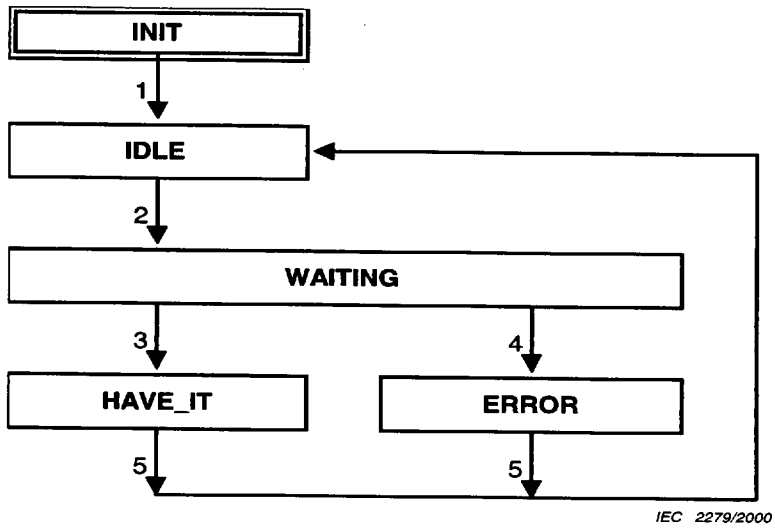


Figure 33 – State diagram of WRITE function block

Table 39 – Transitions of the WRITE state diagram

Transition	Condition
1	Initialization done
2	At raising edge of REQ input
3	Positive response of remote communication partner
4	Negative response from remote communication partner or other communication problems detected
5	After next invocation of this instance

Table 40 – Action table for WRITE state diagram

		FB outputs		
State	Actions	DONE [c]	ERROR [c]	STATUS
INIT [a]	Initialize outputs	0	0	0
IDLE	No actions	0	0	---
WAITING	Request to write variables into remote communication partner	---	---	–1
HAVE_IT	Indicate success	1	0	0
ERROR	Indicate error	0	1	[b]

--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

7.7 Interlocked control

The PC communication function interlocked control uses the SEND and the RCV function blocks.

Corresponding instances of one SEND and of one RCV function block type provide one PC function interlocked control. Two instances of the SEND and RCV function block are corresponding, if the value of the ID parameters reference the same communication channel and if the value of the R_ID parameters are equal within the scope of this communication channel.

The SEND instance requests the RCV instance to execute an application operation and to inform the SEND instance of the result of the operation. This has two aspects, the synchronization of the application program of the SEND and RCV instances and the exchange of information between them. This function can be used to have the effect of a remote procedure call from one application program to another.

The interlocked control function is requested by a raising edge of the REQ input of the SEND function block instance. When requested the SEND instance takes the data from its SD_i inputs and transmits it to the corresponding RCV instance.

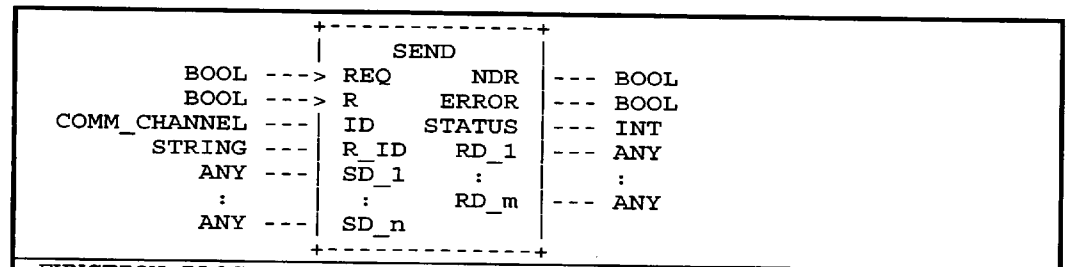
When the EN_R input of the RCV instance has the value of 1, it is enabled to receive data from the corresponding SEND instance and to perform the intended operation of the application program. When the RCV instance receives the data from the SEND instance, it passes the received data to the application program via its RD_i outputs. The NDR output of the RCV instance pulses one cycle to indicate that new data were received. After performing the intended operation of the application program, the result data are taken via the SD_i inputs and the response is initiated on a raising edge of the RESP input of the RCV instance.

When the SEND instance receives this response, it passes the received data to its RD_i outputs. The NDR output of the SEND instance pulses one cycle to indicate that new data are ready.

A raising edge on the R input of the SEND instance resets both the SEND and the corresponding RCV instance.

The number and each of the data types of the SD_i inputs of the SEND instance and the RD_i outputs of the corresponding RCV instance shall be compatible. The same is required for the SD_i inputs of the RCV instance and the RD_i outputs of the SEND instance. The SD_i inputs and the RD_i outputs of the SEND and RCV function blocks are extensible. Either the send data or the response data or both may be empty, that is, the user did not program any SD_i inputs and corresponding RD_i outputs.

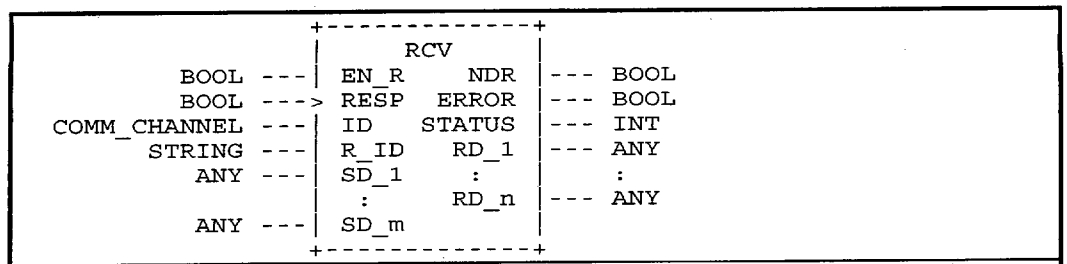
If the received data did not match the RD_i outputs of the RCV function block or an error occurred, the ERROR output pulses one cycle to indicate an error and the STATUS output contains the error code.




```
FUNCTION_BLOCK SEND     (* Interlocked control, requester*)
VAR_INPUT
  REQ    : BOOL R_EDGE; (* Request to send with raising edge*)
  R      : BOOL R_EDGE; (* Reset local, remote function *)
  ID     : COMM_CHANNEL;(* Communication channel *)
  R_ID   : STRING;      (* Remote function block *)
  SD_1   : ANY;         (* User data to send *)
   :                    (*   extensible and any type *)
  SD_n   : ANY;
END_VAR

VAR_OUTPUT
  NDR    : BOOL;        (* New user data received *)
  ERROR  : BOOL;        (* New non-zero STATUS received *)
  STATUS: INT;          (* Last detected status *)
END_VAR

VAR_IN_OUT
  RD_1   : ANY;         (* Received user data *)
   :                    (*   extensible and any type *)
  RD_m   : ANY;         (*   It is not required that m = n *)
END_VAR                 (*   either m, n, or both may be 0*)
```

IEC 2280/2000

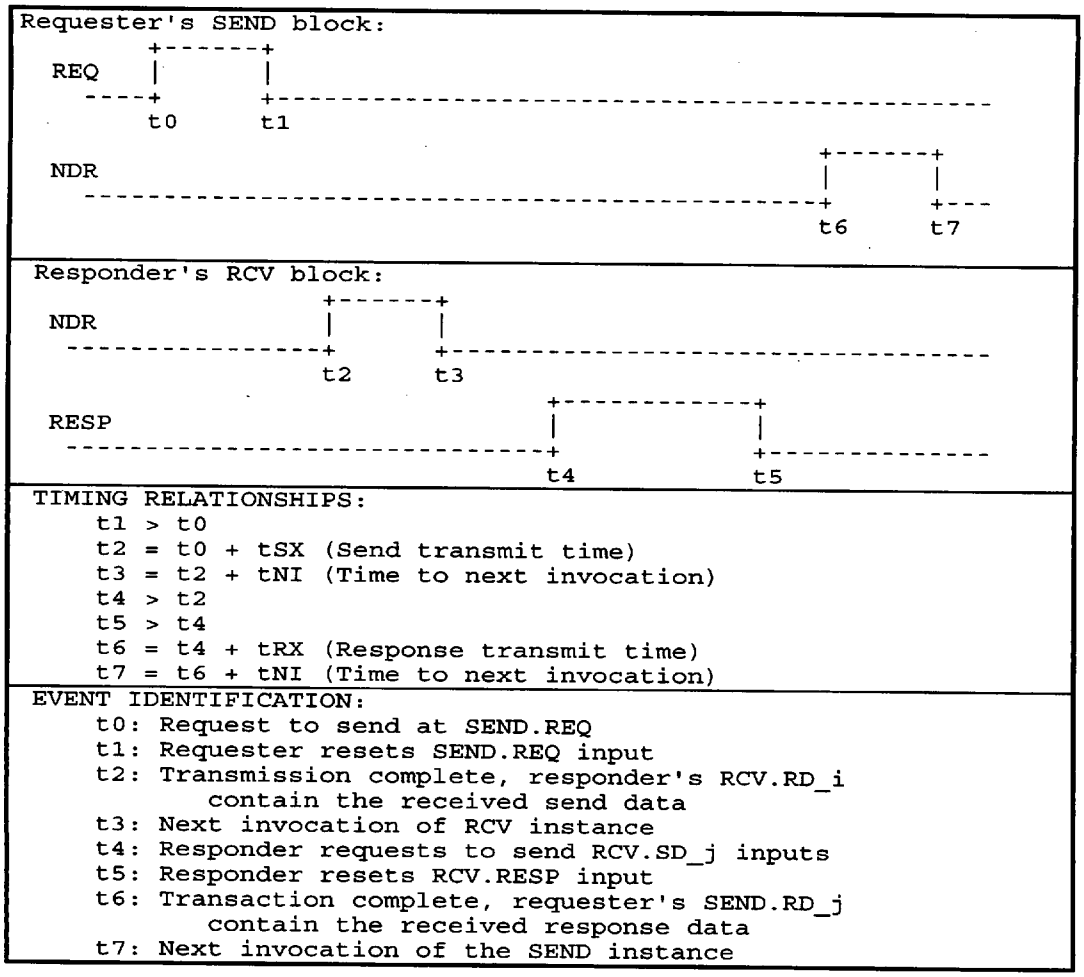
Figure 34 – SEND function block




```
FUNCTION_BLOCK RCV      (* Interlocked control, responder*)
VAR_INPUT
  EN_R   : BOOL;        (* Enable to receive data *)
  RESP   : BOOL R_EDGE; (* Request to send response data *)
  ID     : COMM_CHANNEL;(* Communication channel *)
  R_ID   : STRING;      (* Remote function block *)
  SD_1   : ANY;         (* User data to send *)
   :                    (*   extensible and any type *)
  SD_m   : ANY;
END_VAR

VAR_OUTPUT
  NDR    : BOOL;        (* New user data received *)
  ERROR  : BOOL;        (* New non-zero STATUS received *)
  STATUS: INT;          (* Last detected status *)
END_VAR

VAR_IN_OUT
  RD_1   : ANY;         (* Received user data *)
   :                    (*  extensible and any type *)
  RD_n   : ANY;         (*  It is not required that m = n *)
END_VAR                 (*  either m, n, or both may be 0*)
```

IEC 2281/2000

Figure 35 – RCV function block



IEC 2282/2000

Figure 36 – Timing diagram of SEND and RCV function blocks

The state diagram shown in figure 37 describes the algorithm of the SEND function block. Tables 41 and 42 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the SEND function block outputs.

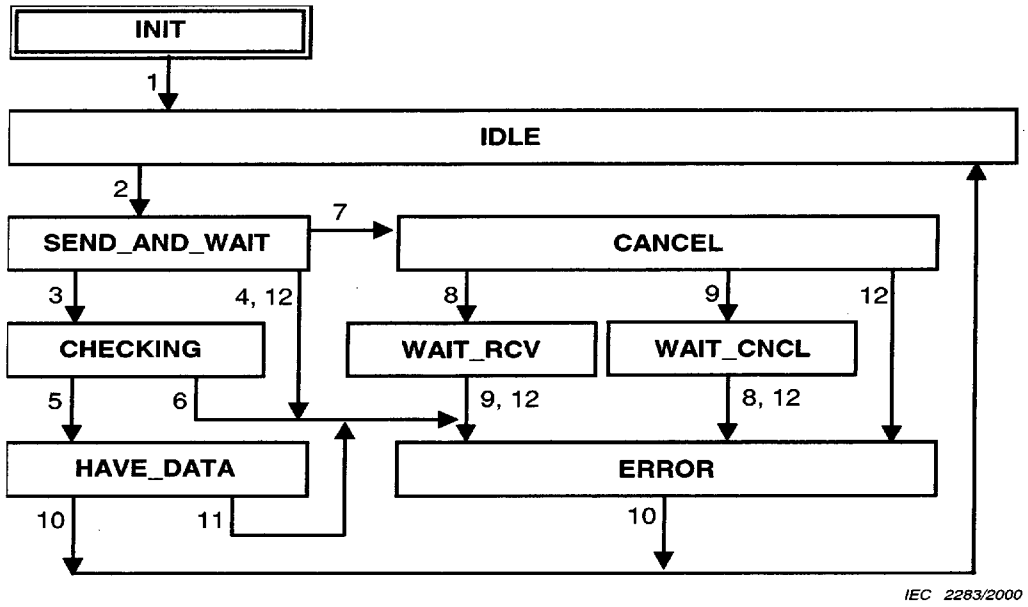


Figure 37 – State diagram of SEND function block

Table 41 – Transitions of the SEND state diagram

Transition	Condition
1	Initialization done
2	At raising edge of REQ input
3	Positive response from RCV
4	Negative response from RCV
5	Data types of received data and RD_1 to RD_m match
6	Data type of received data and RD_1 to RD_m mismatch
7	At raising edge of R input
8	Positive or negative response to the reset request
9	Positive or negative response from RCV
10	After next invocation of the instance
11	Local resource problems detected
12	Communication problems detected

Table 42 – Action table for SEND state diagram

State	Actions	FB outputs			
		NDR [c]	ERROR [c]	STATUS	RD_1 ... RD_m
INIT [a]	Initialize outputs	0	0	0	System null
IDLE	No actions	0	0	---	---
SEND_AND_WAIT	Send data to RCV, evaluate transition 7 first	---	---	–1	---
CHECKING	Verify data type match	---	---	---	---
HAVE_DATA	Deposit data in instance	1	0	0	New data from RCV
ERROR	Indicate error	0	1	[b]	---
CANCEL	Request to reset RCV	---	---	5	---
WAIT_RCV	No actions	---	---	---	---
WAIT_CNCL	No actions	---	---	---	---

--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

The state diagram shown in figure 38 describes the algorithm of the RCV function block. Tables 43 and 44 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the RCV function block outputs.

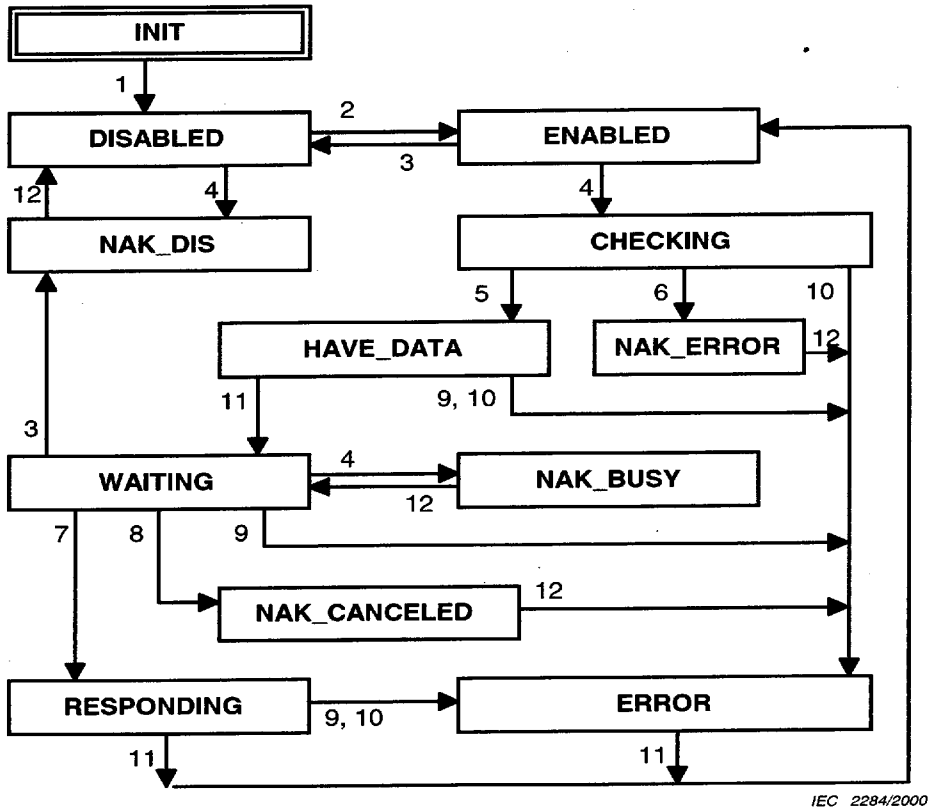


Figure 38 – State diagram of RCV function block

Table 43 – Transitions of RCV state diagrams

Transition	Condition
1	Initialization done
2	EN_R = 1
3	EN_R = 0
4	When data received from SEND
5	Data types of received data and RD_1 to RD_n match
6	Data types of received data and RD_1 to RD_n mismatch
7	Raising edge of RESP input
8	When reset is requested by SEND
9	Communication problems detected
10	Local resource problems detected
11	After next invocation of the instance
12	True, i.e. condition is empty

Table 44 – Action table of RCV state diagram

State	Actions	FB outputs			
		NDR [c]	ERROR [c]	STATUS	RD_1 ... RD_n
INIT [a]	Initialize outputs	0	0	0	System null
DISABLED	No actions	0	0	---	---
ENABLED	No actions	0	0	---	---
CHECKING	Verify data type match	---	---	---	---
HAVE_DATA	Deposit data	1	0	0	New data from SEND
NAK_ERROR	Send negative response to SEND	---	---	---	---
WAITING	No actions	0	0	---	---
NAK_BUSY	Send negative response to SEND	---	---	---	---
NAK_CANCELED	Send positive response to the reset request and then send negative response to SEND	---	---	---	---
RESPONDING	Send positive response with user data to SEND	---	---	---	---
ERROR	Indicate error	0	1	[b]	---
NAK_DIS	Send negative response to SEND	---	---	---	---

--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

7.8 Programmed alarm report

The PC communication function programmed alarm report uses the NOTIFY and the ALARM function blocks.

One instance of one NOTIFY function block or one instance of one ALARM function block provides one instance of the PC function programmed alarm report.

A PC can be programmed using the ALARM function block to report an alarm message with an acknowledgement capability. Or, it can be programmed using the NOTIFY function block to report an alarm message without an acknowledgement capability.

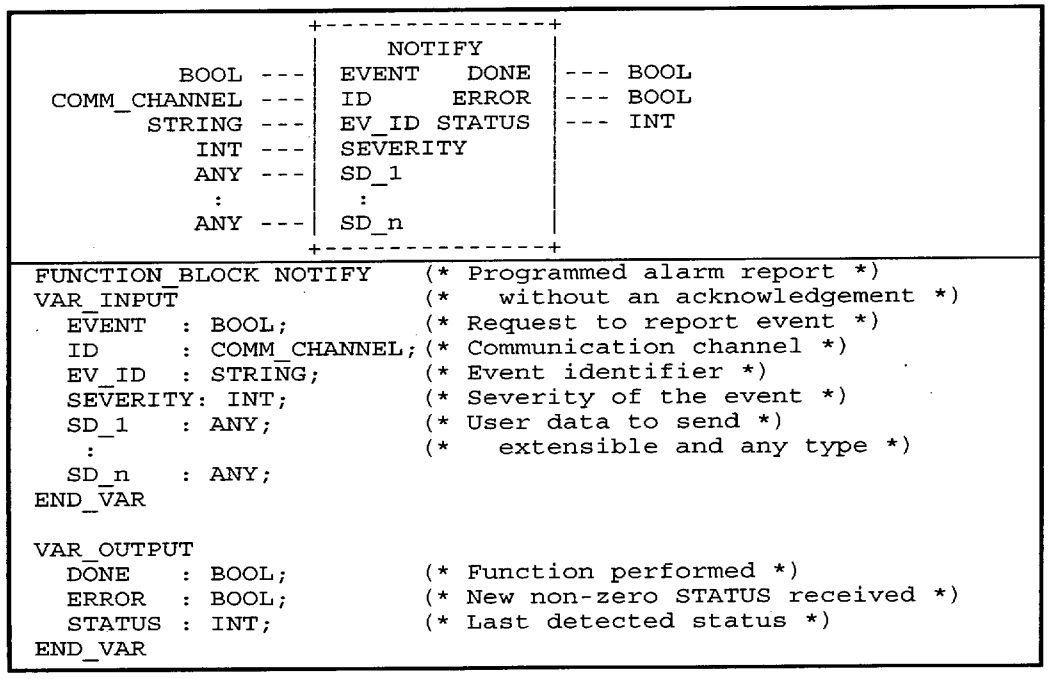
The raising edge at the EVENT input reports an alarm message of a coming event, the falling edge at the EVENT input reports the going of this event. The reason for the event can be given with the EV_ID input, its severity given at the SEVERITY input of the function blocks. The severity shall have a range from 0 to 127, inclusive. 0 shall represent the highest severity, 64 a normal severity, and 127 the lowest severity. Additional data at the SD_i inputs may be used to specify more details of the occurred event.

The ACK_UP output of the ALARM function block shall contain an indication, whether or not the coming of the event was acknowledged by the remote communication partner. The ACK_DN output shall contain this indication for the going of the event. Only the acknowledgement of the most recent event shall set the acknowledgement outputs. The same behavior shall be true for the falling edge of the EVENT input and the ACK_DN output.

The ID parameter identifies the communication channel to the remote communication partner. If the communication system provides communication channels which support one-to-many or one-to-all connections, these function blocks may be used to program an alarm report function from one PC to many. In this case the first valid acknowledgement sets the appropriate ALARM acknowledgement output.

The send data may provide additional information in the alarm message. The send data may be empty, i.e. no SD_i inputs are programmed.

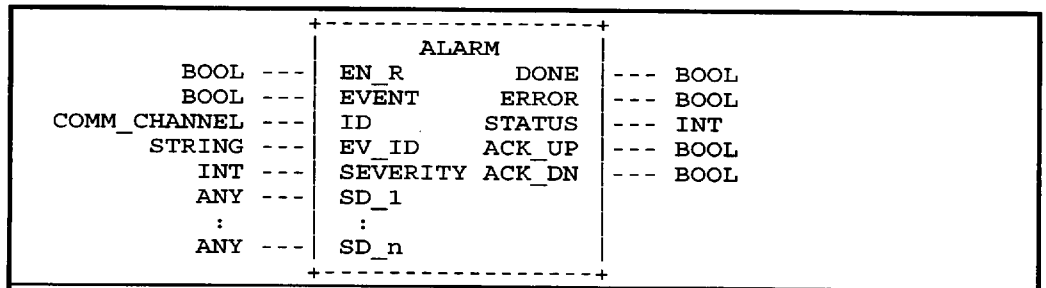
If an error occurred, the ERROR output pulses one cycle to indicate an error and the STATUS output contains the error code.




```
FUNCTION_BLOCK NOTIFY    (* Programmed alarm report *)
VAR_INPUT                (*   without an acknowledgement *)
  EVENT   : BOOL;        (* Request to report event *)
  ID      : COMM_CHANNEL;(* Communication channel *)
  EV_ID   : STRING;      (* Event identifier *)
  SEVERITY: INT;         (* Severity of the event *)
  SD_1    : ANY;         (* User data to send *)
   :                     (*   extensible and any type *)
  SD_n    : ANY;
END_VAR

VAR_OUTPUT
  DONE    : BOOL;        (* Function performed *)
  ERROR   : BOOL;        (* New non-zero STATUS received *)
  STATUS  : INT;         (* Last detected status *)
END_VAR
```

IEC 2285/2000

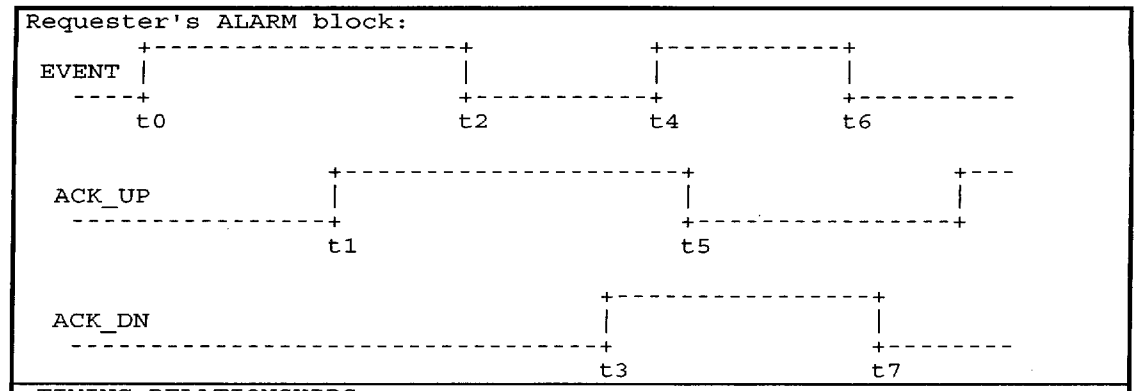
Figure 39 – NOTIFY function block




```
FUNCTION_BLOCK ALARM      (* Programmed alarm report *)
VAR_INPUT                 (*   with an acknowledgement *)
  EN_R    : BOOL;         (* Enable alarming function *)
  EVENT   : BOOL;         (* Request to report event *)
  ID      : COMM_CHANNEL; (* Communication channel *)
  EV_ID   : STRING;       (* Event identifier *)
  SEVERITY: INT;          (* Severity of the event *)
  SD_1    : ANY;          (* User data to send *)
   :                      (*   extensible and any type *)
  SD_n    : ANY;
END_VAR

VAR_OUTPUT
  DONE    : BOOL;         (* Function performed *)
  ERROR   : BOOL;         (* New non-zero STATUS received *)
  STATUS  : INT;          (* Last detected status *)
  ACK_UP  : BOOL;         (* Acknowledged coming event *)
  ACK_DN  : BOOL;         (* Acknowledged going event *)
END_VAR
```

IEC 2286/2000

Figure 40 – ALARM function block



IEC 2287/2000

Figure 41 – Timing diagram of ALARM function block

The state diagram shown in figure 42 describes the algorithm of the NOTIFY function block. Tables 45 and 46 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the NOTIFY function block outputs.

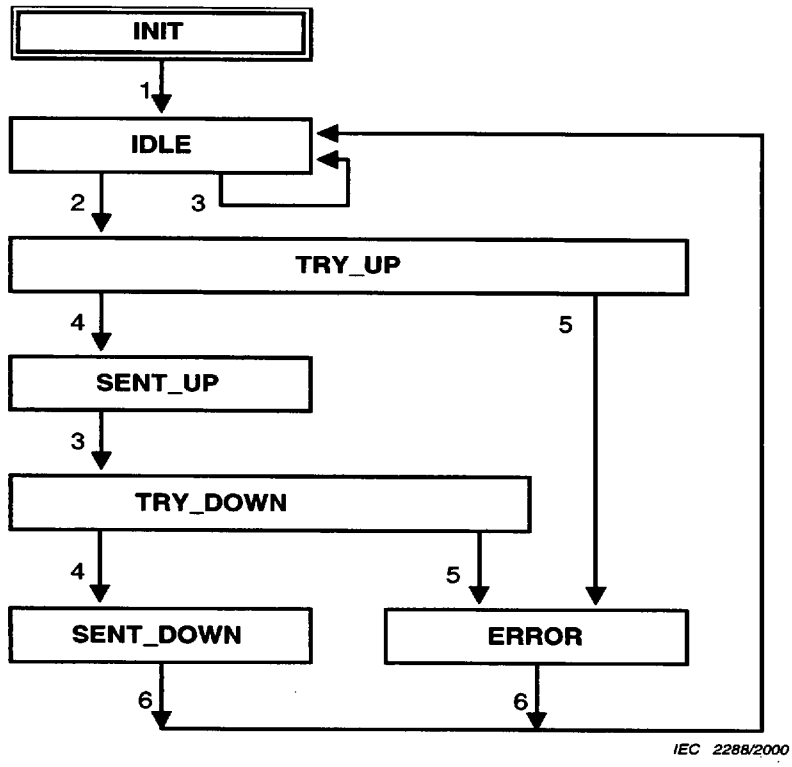


Figure 42 – State diagram of NOTIFY function block

Table 45 – Transitions of the NOTIFY state diagram

Transition	Condition
1	Initialization done
2	Raising edge of EVENT input
3	Falling edge of EVENT input
4	Communication system indicates "Sent to remote communication partner"
5	Communication system indicates "Cannot send to remote communication partner"
6	After next invocation of this instance

Table 46 – Action table for NOTIFY state diagram

		FB outputs		
State	**Actions**	**DONE** [c]	**ERROR** [c]	**STATUS**
INIT [a]	Initialize outputs	0	0	0
IDLE	No actions	0	0	0
TRY_UP	Request to report the coming alarm to the remote communication partner	0	0	---
SENT_UP	No actions	1	0	---
TRY_DOWN	Request to report the going alarm to the remote communication partner	0	0	---
SENT_DOWN	No actions	1	0	---
ERROR	Indicate error	0	1	[b]

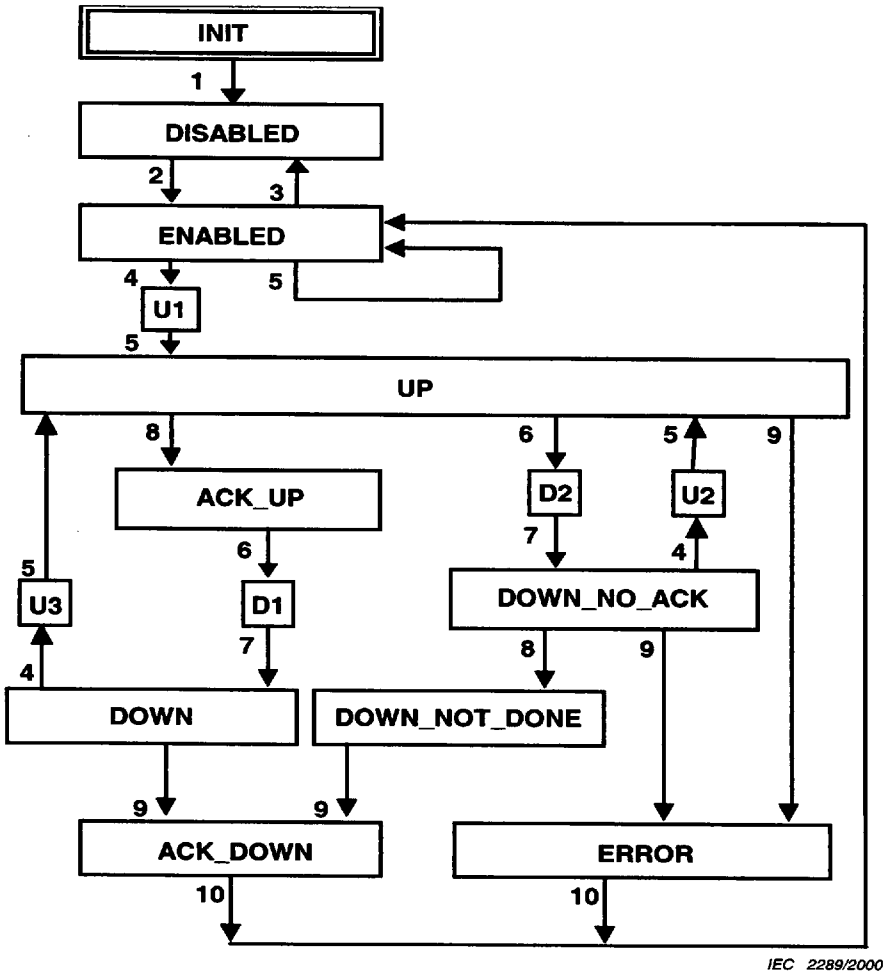
--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

The state diagram shown in figure 43 describes the algorithm of the ALARM function block. Tables 47 and 48 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the ALARM function block outputs.



NOTE The states labelled U1, U2, U3, D1, and D2 may also transition to the ERROR state if the lower layers detect an error while trying to send the event notification.

Figure 43 – State diagram of ALARM function block

Table 47 – Transitions of the ALARM state diagram

Transition	Condition
1	Initialization done
2	EN_R=1
3	EN_R=0
4	Raising edge of EVENT input
5	Coming event notification sent by communication system
6	Falling edge of EVENT input
7	Going event notification sent by communication system
8	Receive acknowledge of the report of the coming alarm
9	Receive acknowledge of the report of the going alarm
10	After next invocation of this instance

Table 48 – Action table for ALARM state diagram

		FB outputs				
State	Actions	DONE [c]	ERROR [c]	STATUS	ACK_UP	ACK_DN
INIT [a]	Initialize outputs	0	0	0	0	0
DISABLED	No actions	0	0	---	0	0
ENABLED	No actions	0	0	0	---	---
U1, U2, U3	Request to report the coming alarm to the remote communication partner	0	0	---	0	---
UP	No actions	1	---	---	---	---
ACK_UP	Confirm received acknowledgement positively	---	0	0	1	---
D1, D2	Request to report the going alarm to the remote communication partner	0	0	---	---	0
DOWN_NO_ACK	No actions	1	---	---	---	---
DOWN	No actions	1	---	---	---	---
DOWN_NOT_DONE	No actions	0	---	---	---	---
ACK_DOWN	Confirm received acknowledgement positively	---	0	0	---	1
ERROR	Indicate error and confirm received acknowledgement negatively	0	1	[b]	0	0

--- indicates "unchanged" FB outputs.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] See figure 10.

7.9 Connection management

The PC communication function connection management uses the CONNECT function block.

One instance of one CONNECT function block provides one instance of the PC function connection management. This communication function allows to establish a connection between the calling communication partner and the remote communication partner.

A PC can request a remote communication partner to establish a connection between this PC and the remote communication partner. The remote communication partner is identified using its name. (The name shall be specified by means of the implementer of the remote communication partner.) A communication channel to the remote communication partner is defined.

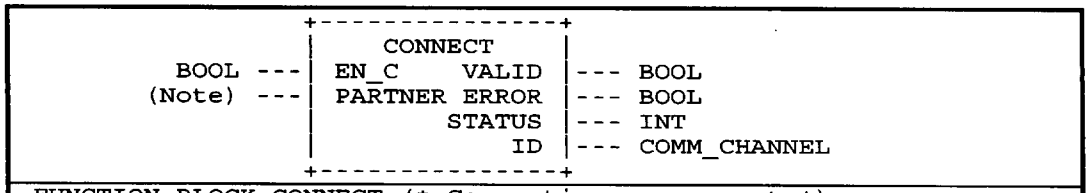
The remote communication partner shall decide whether or not to establish the connection.

If the invocation of a CONNECT function block establishes a communication channel to a remote communication partner, the ID output shall provide the communication channel descriptor which can be used as an input for the ID input to other communication function blocks which communicates with this remote communication partner.

The remote communication partner itself may also use this connection for its communication as a client. The remote communication partner can get the necessary value of the ID parameter by calling a CONNECT function block referencing the communication partner which has already established the connection.

If an error occurred, the ERROR output pulses one cycle to indicate an error and the STATUS output contains the error code.

A communication channel may also be established by local means of the PC on one or both sides of the communication channel. In this case the PC shall show the same behavior as if the CONNECT function block for this communication channel is invoked at the beginning of the application program cycle with the EN_C parameter fixed to 1. The implementer shall define how the application program can get the appropriate value for the ID parameter to use this communication channel.

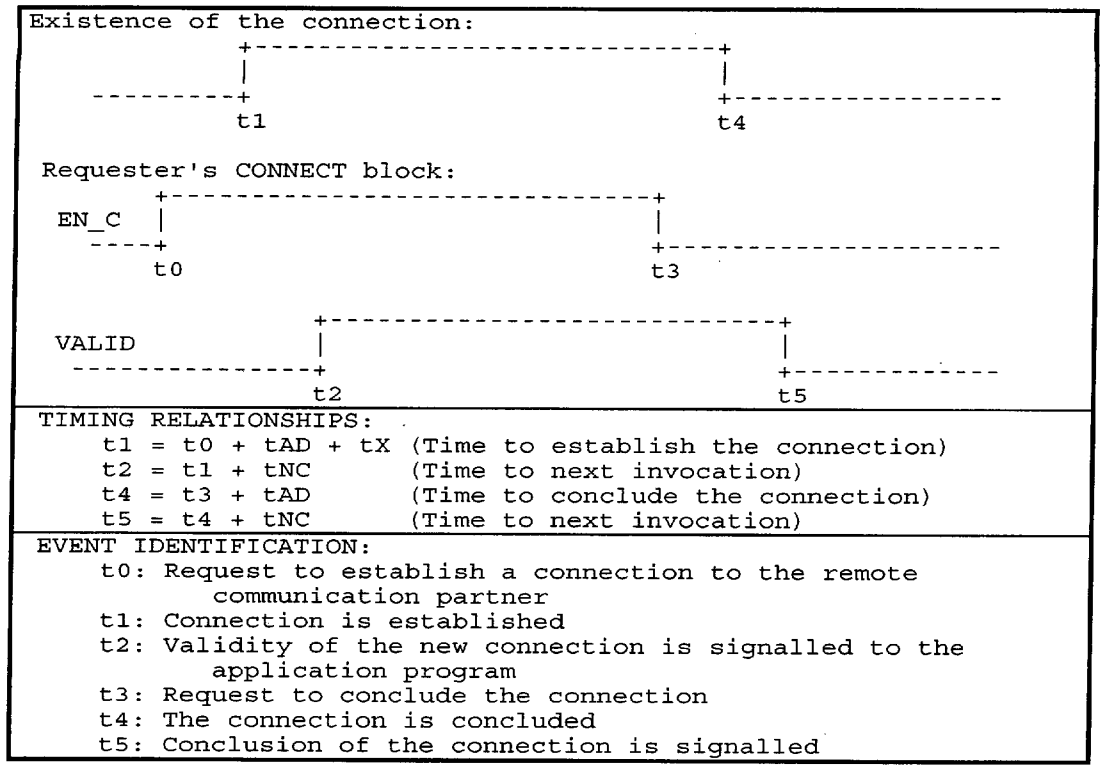



```
FUNCTION_BLOCK CONNECT (* Connection management *)
VAR_INPUT
  EN_C   : BOOL;         (* Enable connection *)
  PARTNER: (Note);       (* Name of the remote communication *)
                         (* partner *)
END_VAR

VAR_OUTPUT
  VALID : BOOL;          (* Connection ID valid *)
  ERROR : BOOL;          (* New non-zero STATUS received *)
  STATUS: INT;           (* Last detected status *)
  ID    : COMM_CHANNEL;  (* Communication channel *)
END_VAR
```

NOTE The data type of the input PARTNER is implementer specific. Additional information may be provided with this parameter which may be used to establish the communication channel, for example, a password or some communication subsystem specific parameters.

IEC 2290/2000

Figure 44 – CONNECT function block



IEC 2291/2000

Figure 45 – Timing diagram of CONNECT function block

The state diagram shown in figure 46 describes the algorithm of the CONNECT function block. Tables 49 and 50 describe the transitions of this state diagram and the actions to be performed within the states and the settings of the CONNECT function block outputs.

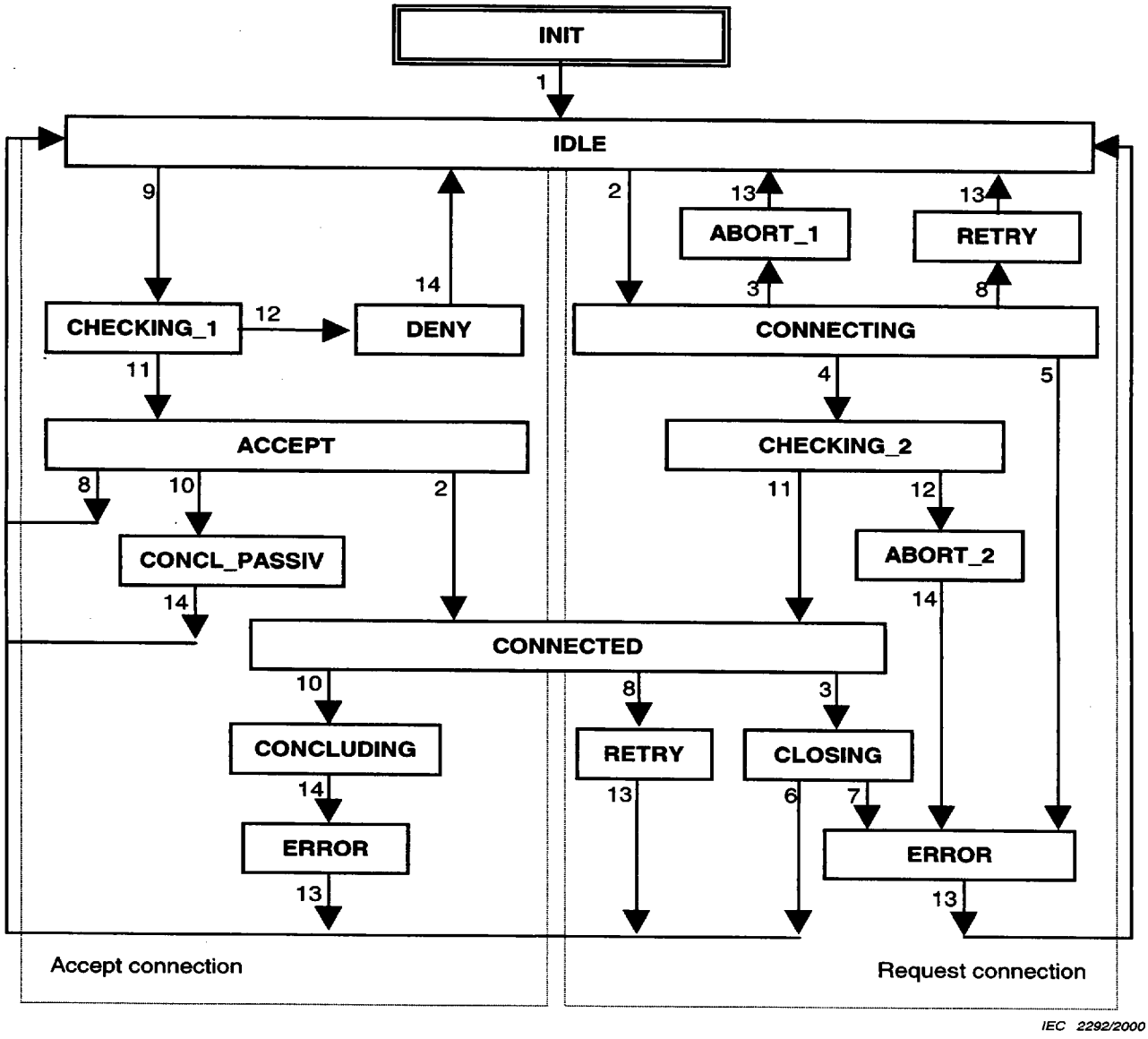


Figure 46 – State diagram of CONNECT function block

Table 49 – Transitions of the CONNECT state diagram

Transition	Condition
1	Initialization done
2	EN_C=1
3	EN_C=0
4	Receive a positive confirmation to the request to establish a new connection from the remote communication partner
5	Receive a negative confirmation to the request to establish a new connection from the remote communication partner
6	Receive a positive confirmation to the request to conclude the connection from the remote communication partner
7	Receive a negative confirmation to the request to conclude the connection from the remote communication partner
8	Loss of connection
9	Receive a request to establish a new connection to the remote communication partner
10	Receive a request to conclude the connection to the remote communication partner
11	Accept to establish a connection
12	Deny to establish a connection
13	Next invocation
14	Immediately

Table 50 – Action table for CONNECT state diagram

		FB outputs			
State	Actions	VALID	ERROR [d]	STATUS	ID [c]
INIT [a]	Initialize outputs	0	0	0	NG
IDLE	No actions	0	---	---	NG
CHECKING_1	Check if the connection can be established	0	---	---	NG
DENY	Send negative response to the request of the connection	0	---	---	NG
ACCEPT	Accept to establish a connection and a send a positive response	0	0	---	NG
CONCL_PASSIV	Send a positive response to conclude the connection	0	---	---	NG
CONNECTING	Request a connection to the remote communication partner	0	0	–1	NG
ABORT_1	Request to abort communication	0	---	---	NG
CHECKING_2	Check if the connection can be established	0	0	---	NG
ABORT_2	Request to abort communication	0	---	---	NG
CONNECTED	No action	1	0	0	OK
RETRY	No action	0	1	1	NG
CLOSING	Request to conclude the connection	0	0	–1	NG
CONCLUDING	Send positive response to conclude the connection	0	0	---	NG
ERROR	Indicate error	0	1	[b]	NG

--- indicates "unchanged" FB output.

[a] INIT is the cold start state.

[b] The error code is placed in the status output.

[c] NG indicates "invalid connection ID"
OK indicates "valid connection ID".

[d] See figure 10.

7.10 Example for the use of communication function blocks

7.10.1 Establishing a communication channel

Two PCs want to establish a communication channel. Both of the PCs want to use the channel for client and server function, i.e. both need to get an appropriate value for their ID parameter of the Communication function blocks. In this example, it is assumed that the data type COMM_CHANNEL stands for a handle or index of the communication channel. The example is given using the Structured Text programming language as defined in IEC 61131-3.

Extract of the application program of PC1:

```
(* Declaration of the data and the CONNECT instance, e.g. at the beginning
     of an application program *)
VAR
TO_PC2:   COMM_CHANNEL; (* Variable which is set by CONNECT *):
CO1:      CONNECT;      (* Declaration of the CONNECT instance *)
END_VAR;

(* somewhere inside the body of the program *)

CO1(EN_C:=1, PARTNER:='PC2');     (* Invokes the CONNECT instance CO1 and
                                  establishes a communication channel to PC2 *)
IF CO1.ERROR THEN   (* It is recommended to define some error handling *):
IF CO1.VALID THEN   (* Store reference of the communication channel  *)
TO_PC2:= CO1.ID;
```

Extract of the application program of PC2:

```
(* Declaration of the data and the CONNECT instance, e.g. at the beginning
     of an application program *)
VAR
TO_PC1:   COMM_CHANNEL; (* Variable which is set by CONNECT *):
CO2:      CONNECT;      (* Declaration of the CONNECT instance *)
END_VAR;

(* somewhere inside the body of the program *)

CO2(EN_C:=1, PARTNER:='PC1');     (* Invokes the CONNECT instance CO2 and
                           establishes a communication channel to PC1 *)
IF CO2.ERROR THEN   (* It is recommended to define some error handling *):
IF CO2.VALID THEN   (* Store reference of the communication channel  *)
TO_PC1:= CO2.ID;
```

These parts of the application program of PC1 and PC2 may be nearly identical. The communication channel is established by the PC which invokes its CONNECT instance earlier. The later invoking PC gets the communication channel already established.

7.10.2 Transferring data

Two PCs want to communicate using an already established communication channel. Some data shall be transferred from PC1 to PC2 using the USEND and URCV function blocks. The following parts of the applications programs show how this can be achieved. How the application programs provide and process the data to be transferred is not shown in this example. The example is given using the Structured Text programming language as defined in IEC 61131-3.

Extract of the application program of PC1 which uses an instance of the USEND function block to send the data:

```
(* Declaration of the data and the USEND instance, e.g. in the definition
     of a function block *)
VAR
SENDREQ:  BOOL;           (* Flag to request the send *)
TO_PC2:   COMM_CHANNEL;   (* Variable which allows to use the communication
                             channel to PC2 *)
SDAT1:    ARRAY[0..20] OF BYTE;   (* Declaration of the data to send *)
SDAT2:    REAL;
US1: USEND;               (* Declaration of the USEND instance *)
END_VAR;

(* somewhere inside the body of the function block *)

US1(REQ:=SENDREQ, ID:=TO_PC2, R_ID='PACK1', SD_1:=SDAT1, SD_2:=SDAT2);
     (* Invokes the USEND instance US1 and will send the data on raising
          edge of SENDREQ Boolean *)
IF US1.ERROR THEN  (* It is recommended to define some error handling *):
```

Application program of PC2 which uses an instance of the URCV function block to receive the data sent by PC1:

```
(* Declaration of the data and the URCV instance, e.g. in the definition of a function block *)
VAR
TO_PC1: COMM_CHANNEL;    (* Variable which allows to use the communication
                            channel to PC1 *)
RDAT1: ARRAY[0..20] OF BYTE; (* Declaration of the variable where the data
                        shall be stored, the count of variables and their
                        data type must correspond with the data sent *)
RDAT2: REAL;
UR1: URCV;      (* Declaration of the URCV instance *)
S: REAL;        (* Declaration of an arbitrary floating point variable *)
END_VAR;

(* somewhere inside the body of the function block *)

UR1(EN_C:=1, ID:=TO_PC1, R_ID='PACK1', RD_1:=RDAT1, RD_2:=RDAT2);
              (* Invokes the URCV instance UR1 to wait for data from PC1 *)
IF UR1.NDR THEN     (* process the received data *)
BEGIN
S:= S + RDAT2;      (* e.g. add the received floating point number to a
                    variable *)
IF UR1.ERROR THEN   (* It is recommended to define some error handling *);
```

7.10.3 Using a timer to supervise communication

A PC (PC1) wants to request a process function from PC2. It uses an instance of a SEND function block to transfer the request. It waits for the response from PC2. But if PC2 does not respond within 5 s, it resets the request. The example is given using the Structured Text programming language as defined in IEC 61131-3.

Extract of the application program of PC1 which uses an instance of the SEND function block to request the process function:

```
(* Declaration of the data and the SEND instance, e.g. in the definition of
a function block *)
VAR
SREQ:     BOOL;          (* Flag to send the request *)
FCT1:     INT;           (* Code of the function to request *)
DAT1:     REAL;          (* 1st parameter of this function *)
RDAT1:    INT;           (* Response parameter *)

SR1:      SEND;          (* Instance of the FB SEND *)
M1:       RS;            (* to hold the IN parameter of the timer *)
T1:       TON;           (* Timer for timeout control of the SEND *)
END_VAR;

(* somewhere inside the body of the function block *)

SR1 (REQ:= SREQ,         (* Request on raising edge of SREQ bool *)
     R:= T1.Q,           (* Reset on timeout, i.e. the timer fired *)
     ID:= TO_PC2, R_ID:= 'ORD1',     (* Identifies remote partner and
RCV instance *)
     SD_1:= FCT1, SD_2:= DAT1,  (* Data for the process function *)
     RD_1:= RDAT1);             (* Variables for the results *)

M1 (S:= SREQ,            (* Set when the request is sent *)
     R1:= T1.Q OR SR1.NDR OR SR1.ERROR);
                         (* Reset when the timer fired or the SEND gets a
                         good (NDR=1) or a bad response (ERROR=1) *)

T1 (IN:=M1.Q1,           (* Hold the timer during the request *)
     PT:= T#5s);         (* is active for 5 seconds *)
```

The same program part using the function block diagram as defined in IEC 61131-3 is shown in figure 47:

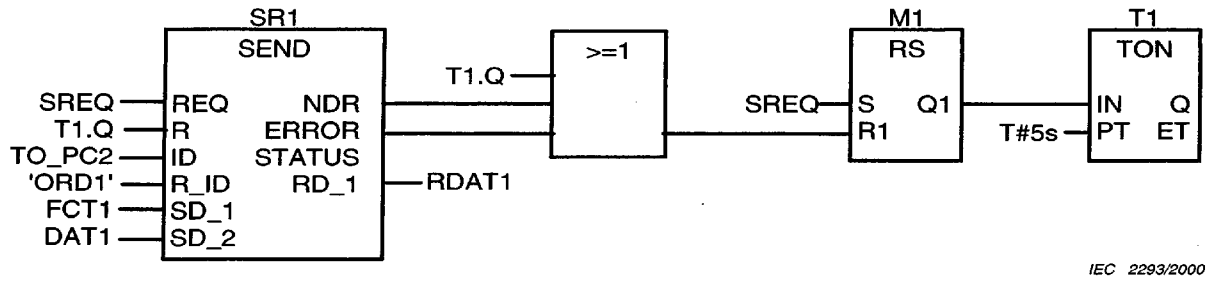


Figure 47 – Example in function block diagram language

8 Compliance and implementer specific features and parameters

8.1 Compliance

A PC system, as defined in IEC 61131-1, which claims to comply, wholly or partially, with the requirements of this part of IEC 61131 shall do so only as described below.

A compliance statement shall be included in the documentation accompanying the system, or shall be produced by the system itself. The form of the compliance statement shall be:

"This system complies with the requirements of this part for the following features:" followed by a set of compliance tables in the following format:

Table title

Table number	Feature number	Feature description

Table and feature numbers and descriptions are to be taken from the tables given in the relevant subclauses of this part of IEC 61131. The table titles and the relevant tables are to be taken from the following table 51.

Table 51 – Table titles and relevant tables for compliance

Table title	For features in table
PC status	Tables 1 to 9
Application specific functions	Tables 10 to 20, except 15
PC communication function blocks	Table 21

A PC system complying with the requirements of this part of IEC 61131 shall

a) not require the inclusion of substitute or additional features in order to accomplish any of the features specified in this part;

b) be accompanied by a document that specifies the values of all implementer specific features or parameters as listed in the following table and in the table 'Implementation specific features and parameters' of the appropriate annex;

c) be accompanied by a document that separately describes any communication relevant feature that is prohibited or not specified in this part. Such features shall be described as being "extensions to the PC communication as defined in IEC 61131-5";

d) not use any of the function or function block names defined in clause 7 for implementer defined features whose functionality differs from that described there.

8.2 Implementation specific features and parameters

Implementation specific features and parameters defined in this part of IEC 61131 and the most relevant subclause for each are listed in the following table 52.

Table 52 – Implementation specific features and parameters

Subclause	Implementation specific features and parameters
6.1	The definition of major and minor faults of the subsystems of the PC
6.1.8	The number of the subsystems of the PC providing status information
6.1.8	The types of the subsystems of the PC providing status information
6.1.8	The maximum size of the string containing names of the PC and of its subsystems
6.1.8	The semantic of the values in the sub-element STATE for the implementer specific subsystems
6.1.8	The size of the sub-element SPECIFIC of the status information
6.1.8	The semantic of the sub-element SPECIFIC of the status information
6.2.2	Restrictions of the access of variables with direct representation
6.2.2	The algorithm to access a variable with direct representation
6.2.2	The conditions (size, location, etc.) under which each data type supported by the PC can be uninterruptedly accessed
6.2.6	The supported values of I/O state
6.2.6	The definition of the outputs if the implementer specified value is requested
6.2.6	The definition of the mechanisms to specify the outputs if the user specified value is requested
6.2.7	Other language elements, for example, function types or function block types which are loadable and the conditions and restrictions for downloading and uploading these
6.2.7	What other clients can do with a PC when one client is downloading it
7.2	The COMM_CHANNEL type used at the ID input of the communication function blocks identifying the remote communication partner
7.2	Data type of the VAR_ADDR output of the REMOTE_VAR function and the restrictions using the output of the REMOTE_VAR function
7.2	Name scopes the implemeter supports for use at SCOPE parameter of the REMOTE_VAR function
7.2	Mapping of the implementer specific name scopes onto the communication system
7.2	The number of SD_i, RD_i, and VAR_i parameters which are supported with one invocation of a communication function block
7.2	The meaning of codes less than –1 or greater than 20 of the STATUS output of the communication function blocks
7.2	Additional means (if there are some) to control the time by which the communication channel is established, if not explicitly controlled using the CONNECT function block
7.3	The used length and the semantics of the additional status information of the LOCAL output of the FB STATUS and FB USTATUS
7.9	How the user can get the information of the communication channel for the use at the ID input of the communication function blocks

Annex A
(normative)

Mapping to ISO/IEC 9506-5

A.1 General

This annex specifies the mapping of the PC communication functions to the MMS objects and services defined in ISO/IEC 9506-1 and extensions defined in ISO/IEC 9506-5. This mapping shall be used when a PC is communicating in the abstract syntax defined in ISO/IEC 9506-5.

Normative references

ISO 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*

ISO/IEC 9506-1:1990, *Industrial automation systems – Manufacturing Message Specification – Part 1: Service definition*
Amendment 1:1993, *Data exchange*

ISO/IEC 9506-2:1990, *Industrial automation systems – Manufacturing Message Specification – Part 2: Protocol specification*
Amendment 1:1993, *Data exchange*

ISO/IEC 9506-5:1999, *Industrial automation systems – Manufacturing Message Specification – Part 5: Companion standard for programmable controllers*

Definitions from other publications

ISO 7498-1

application entity (AE)

ISO/IEC 9506-1

domain

program invocation (PI)

server

Virtual Manufacturing Device (VMD) (clause 7)

Abbreviations

Cnf This is the confirmation primitive of a communication service
Ind This is the indication primitive of a communication service
Req This is the request primitive of a communication service
Rsp This is the response primitive of a communication service
VMD Virtual Manufacturing Device

A.2 Application specific functions

A.2.1 Device verification

A PC can provide some very general status to a requesting device via the MMS Status service. The contents of this status is defined by MMS. The implementer can provide Local Detail (bit string with a maximum length of 128 bits) that contains additional information. The PC can initiate an unsolicited status report of this same information using the MMS UnsolicitedStatus service.

NOTE The 16 lowest numbered bits of Local Detail may provide, for example the same information as in the P_PCSTATE variable (see table 2 and 6.1.8).

A PC can provide detailed status information about the PC and its subsystems via MMS Named Variables or MMS Unnamed Variables or both (see 6.1.8). These variables can be read using the MMS Read service. For the specification of these variables (see 6.1.8).

A.2.2 Data acquisition

Data contained in a PC is presented as PC variables. Selected PC variables are mapped onto MMS Named Variables, using the access path language construct (see A.3.2). Additionally, variables with direct representation are mapped onto MMS Unnamed Variables, with implementer specified restrictions. The content of these variables can be provided to a client using the MMS Read and InformationReport services.

A.2.3 Parametric control

Parametric control is when the operation of the PC is directed by writing values to PC variables. This change in operation is determined by either the application program or other local mechanisms. The MMS Write service is used to write a new value to a PC variable.

A.2.4 Interlocked control

Interlocked control is when the client requests the server to execute an application operation and to inform the client of the result of the operation. The SEND and RCV function blocks are used to provide this function. See A.4 for the mapping of these function blocks onto MMS objects and services.

A.2.5 Synchronization between user applications

User applications may need a synchronization service. This PC function is provided by the communication function interlocked control (see 6.2.3 and A.2.4).

A.2.6 Alarm reporting

The PC can have the ability to signal alarm messages to a client when a predetermined condition occurs. The ALARM and NOTIFY function blocks are used to provide this function. See A.4 for the mapping of these function blocks onto MMS objects and services.

A.2.7 Application program execution and I/O control

Program execution and I/O control uses the language elements configuration and resource of IEC 61131-3 (see 6.2).

The configuration and resource are mapped onto MMS Program Invocation objects.

The state of the I/O (inputs and outputs) associated with a resource is specified using the various MMS services which operate on Program Invocations using the I/O State parameter, as defined in ISO/IEC 9506-5.

A.2.8 Application program transfer

Application program transfer allows the client to upload the complete contents of the programmable memory or portions thereof for archiving or verification or to download it for restoring the PC to a known state. The portions of the programmable memory which can be uploaded or downloaded were specified in 6.2.7. These loadable units are mapped onto the MMS Domain object. They are transferred using the MMS Domain services.

A.2.9 Connection management

The MMS Environment and General Management services are used to manage the connections.

A.3 PC object mapping

ISO/IEC 9506 supports an object-oriented view to the communication. A PC communicating in the abstract syntax of ISO/IEC 9506-5 is mapped onto a virtual device. This virtual device contains all objects visible to a remote communication partner and services all requests coming from a remote communication partner.

A.3.1 VMD

One PC, a part of a PC, or a set of several PCs may be mapped onto one VMD. The communication to this VMD shall conform to ISO/IEC 9506-5.

The implementer shall specify this mapping. This part of IEC 61131 does not define any restrictions to the attributes of the VMD.

A.3.2 Named Variables

Each access path is mapped onto one MMS Named Variable. The attributes of the MMS Named Variable are as follows:

Object: Named Variable

Attribute: Variable Name – This shall be the access name from the access path declaration. If the access path definition references variables with direct representation, program inputs or outputs, or global variables of configurations or resources (see 2.7.1 of IEC 61131-3), the name shall have VMD-specific scope. If the access path definition is at program level (see 2.5.3 of IEC 61131-3), the name shall be domain specific of the domain which is associated with the program which contains the referenced variable (see A.2.9).

Attribute: Reference to Access Control List – If the access path contains the READ_ONLY language element this object shall reference the Access Control List object M_ReadOnly otherwise M_NonDeletable.

Attribute: Type Description – This shall be the data type as specified in the access path declaration mapped to MMS according to table A.1.

Table A.1 – Type description mapping

No.	Access path data type keyword	MMS type description class and size	Notes
1	BOOL	boolean	
2	SINT	integer 8	4
3	INT	integer 16	4
4	DINT	integer 32	4
5	LINT	integer 64	4
6	USINT	unsigned 8	4
7	UINT	unsigned 16	4
8	UDINT	unsigned 32	4
9	ULINT	unsigned 64	4
10	REAL	floating-point 32,8	4
11	LREAL	floating-point 64,11	4
12	TIME	unsigned 32	4
13	DATE	binary-time true	1
14	TIME_OF_DAY, TOD	binary-time false	1
15	DATE_AND_TIME, DT	binary-time true	1
16	STRING[N]	octet-string N	2
17	BYTE	bit-string 8	4
18	WORD	bit-string 16	4
19	DWORD	bit-string 32	4
20	LWORD	bit-string 64	4
21	enumerated_specification	integer	3
22	subrange_specification	basic data type of the subrange	
23	ARRAY	array	
24	STRUC	structure	

NOTE 1 The values true and false indicate that data is included or not included, respectively.

NOTE 2 The implementer shall specify the maximum length permitted, the given size N is the maximum size of the string.

NOTE 3 The size of the integer shall be selected to hold all possible enumerated values.

NOTE 4 The given size is fixed.

Variables may be addressed using the REMOTE_VAR function. The mapping of the parameters SCOPE and SC_ID are as follows:

Table A.2 – Mapping of the SCOPE and SC_ID parameter

Value of SCOPE parameter	MMS name scope	Usage of the SC_ID parameter
0	VMD	Not used
1	VMD	Not used
2	Domain	Domain name
3	Domain	Domain name
10	VMD	Not used
11	Domain	Domain name
12	Application Association	AA name

A.3.3 Unnamed Variables

Object: Unnamed Variable

Attribute: Address – The Kind of Address parameter has the value 'Symbolic Address'. The value of the Symbolic Address parameter shall be the direct representation of the PC variable.

Attribute: Type Description – This shall be the data type derived from the size prefix of the direct representation mapped according to the following table.

Table A.3 – Size prefix of direct representation

Number	Size prefix of direct representation	MMS type description class and size
1	(none)	boolean
2	X	boolean
3	B	bit-string 8
4	W	bit-string 16
5	D	bit-string 32
6	L	bit-string 64
NOTE The programming languages of IEC 61131-3 define the means of representing variables symbolically, or alternatively in a manner which directly represents the association of the data element with physical or logical locations in the programmable controller's input, output, or memory structure. The Unnamed Variable object is used to access the variables with direct representation.		

A.3.4 Program Invocations

Object: Program Invocation

Attribute: Program Invocation Name – This shall be the name of the associated configuration or resource.

Attribute: Reusable – This shall have the value TRUE.

Attribute: Additional Detail – This consists of the following attributes defined in ISO/IEC 9506-5:

1. Independent – This attribute has the value TRUE if the associated PC language element is a configuration, otherwise it has the value FALSE.
2. Constraint: Independent = FALSE

   Program Invocation Reference – This attribute has the value of the identifier of the configuration.
3. I/O state

The implementer may define additional means to create additional Program Invocation objects.

A.3.5 Domains

Object: Domain

Attribute: Domain Name – This shall be the name of the associated loadable unit.

Attribute: List of Subordinate Objects – If the Named Variable P_DDATE is supported by the implementation, it shall appear in this attribute.

The implementer may define additional means to create additional Domain objects.

A.4 Communication function block mapping to MMS objects and services

The communication function blocks are described using state diagrams with transitions and actions. In this part of the annex, all transitions and actions which refer to the PC communication system are mapped onto ISO/IEC 9506-5.

A.4.1 Using communication channels

Only one-to-one communication channels are provided with ISO/IEC 9506-5.

All requests and all responses mentioned in the following clauses are transmitted using the application association which is referenced by the ID parameter of the communication function blocks. Indications or confirmations have effect to a certain communication function block instance only if they were received using the application association referenced by its ID parameter.

A.4.2 Rules for data type compatibility

The following rules shall apply, when a data protocol unit is received and the action requests to verify if the data type of the received variable object matches with the data type of an application program variable programmed at an RD_i output parameter of the receiving function block.

a) If the application program variable programmed at the RD_i parameter is of a signed or unsigned integer data type, any received variable of signed or unsigned integer type, the value of which can be stored without loss of information shall pass the type check. The application program variable shall get the value of the received variable object.

b) If the application program variable programmed at the RD_i parameter is of BYTE, WORD, DWORD, or LWORD data type, any received variable of bit-string type with a length of which is not bigger than the bit length of the application program variable shall pass the type check. The application program variable shall get the value of the received variable object, storing bit 0 of the received bit-string into bit 0 of the application program variable and so on. The application program variable is filled up with 0 if its length is bigger.

c) If the application program variable programmed at the RD_i parameter is of STRING data type, any received variable with a byte length of which is not bigger than the byte length of the application program variable shall pass the type check. The application program STRING variable shall get the value of the received variable object, storing byte 1 of the received variable into byte 1 of the application program STRING variable and so on. The length of the string shall be set to the count of the received and stored bytes.

d) If the received variable object has the data type octet string the type check shall be passed, if the application program variable has a byte length which is not smaller than the length of the received octet string. The application program variable shall get the value of the received octet string, storing byte 1 of the received variable into byte 1 of the application program variable and so on. The application program variable is filled up with 0 if its length is bigger.

e) If the application program variable programmed at the RD_i parameter is of a data type not mentioned in rule a) to c) and rule d) does not apply, the type check shall be passed if the data type of the received MMS variable object corresponds with the data type of the application program variable using tables A.1 and A.3. The application program variable shall get the value of the received variable object.

A.4.3 Device verification

The STATUS function block uses the Status service as a client.

Table A.4 – Transition mapping of the STATUS state diagram

Transition	Condition
3	Positive response from remote communication partner: Status.Cnf(+)
4	Negative response from remote communication partner received or communication problems detected: Status.Cnf(–) or lower layers indicate error

Table A.5 – Action mapping for STATUS state diagram

State	Actions
WAITING	Request status information from remote device: Status.Req: Extended Derivation: FALSE
HAVE_DATA	Deposit status information in instance: Status.Cnf(+): VMD Logical Status to LOG output VMD Physical Status to PHYS output Local Detail to LOCAL output

The USTATUS function block uses the Unsolicited Status service as a receiver.

Table A.6 – Transition mapping of USTATUS state diagram

Transition	Condition
4	Status information received from remote communication partner: UnsolicitedStatus.Ind
5	Communication problems detected: Lower layers indicate error

Table A.7 – Action mapping of USTATUS state diagram

State	Actions
HAVE_DATA	Deposit status information in instance: UnsolicitedStatus.Ind: VMD Logical Status to LOG output VMD Physical Status to PHYS output Local Detail to LOCAL output

A.4.4 Polled data acquisition

The READ function block uses the Read service as a client.

The strings and the outputs of the REMOTE_VAR function given in the VAR_i input as identifiers of the variables to be read are mapped onto the Variable Access Specification parameter of the Read request. Each identifier of a VAR_i input forms one element of the List of Variable selection.

If the string of a VAR_i input starts with a "%" character, an Unnamed Variable object with a Symbolic Address shall be read. The string of the VAR_i input is used in the symbolicAddress parameter. Otherwise a VMD-specific variable shall be read. The Name Scope parameter of the Object Name parameter shall be set to VMD-specific. The string is used as the identifier.

If a REMOTE_VAR function output is used to identify the remote variable to be read, the Name Scope parameter of the Object Name parameter shall be set as given in the SCOPE input of the REMOTE_VAR function and mapped using table A.2. If the scope is VMD-specific or AA-specific, the value of the NAME input is used as the identifier. If the scope is domain specific the value of the SC_ID input shall be used as identifier of the Domain, and the value of the NAME input as item identifier.

If a derived variable is to be read, the Alternate Access option of the Variable Access Specification is used to describe which sub-element of a structure or element of an array is to be read. The List of Alternate Access Selections shall contain exactly one element. If the SUB input of the REMOTE_VAR function is an integer (signed or unsigned), it shall be used as the Index of the array element to be read. If the SUB input is a not empty string, it shall be used as the component name of the sub-element to be read.

Table A.8 – Transition mapping of the READ state diagram

Transition	Condition
3	Positive response from remote communication partner: Read.Cnf(+)
4	Negative response from remote communication partner or other communication problems detected: Read.Cnf(–) or lower layers indicate error

Table A.9 – Action mapping for READ state diagram

State	Actions
WAITING	Request variables from remote device: Read.Req Specification With Result= FALSE Variable Access Specification
CHECKING	Verify data type match: Check all elements of the List of Access Results against the RD_i output declaration: If Success is false, the check fails If the Kind of Data parameter does not match (see A.4.2) with the data type of the appropriate RD_i output, the check fails. If the check of one data element fails, the complete check fails.
HAVE_DATA	Deposit data: Deposit all data elements of the List of Access Results in the RD_i outputs

A.4.5 Programmed data acquisition

The USEND function block uses the Information Report service as a requester.

One instance of an USEND function block defines a Named Variable object with AA-specific scope. The attributes of this object are as follows:

Object: Named Variable

Attribute: Variable Name – The string given at the R_ID input parameter is the name of the variable with AA-specific scope.

Attribute: Reference to Access Control List – This object shall reference the Access Control List object M_ReadOnly.

Attribute: Type Description – If only one send data parameter is given, the type of the Named Variable object is exactly the type of the send data using tables A.1 and A.3. If more than one send data parameter is programmed, the type of the Named Variable object is a structure containing the send data as components in the same order and with the same type as given as send data parameters.

Table A.10 – Transition mapping of the USEND state diagram

Transition	Condition
3	Communication system indicates "Sent to Remote Communication partner" Lower Layers indicate no errors
4	Communication system indicates "Cannot Send to Remote Communication partner" or other communication problems detected: Lower layers indicate error

Table A.11 – Action mapping for USEND state diagram

State	Actions
TRYING	Send data given at the SD_i inputs to remote communication partner: InformationReport.Req Variable Access Specification Kind Of Variable= NAMED Name Name Scope= AA-SPECIFIC Item Identifier= Content of R_ID input List of Access Results

The URCV function block uses the Information Report service as a receiver.

The string given in the R_ID input is used as the name of the Named Variable object with AA-specific scope which shall be received by the instance of the URCV function block. If only one data output RD_1 is given the type of this parameter shall be checked with the type of the received variable, see A.4.2. If more than one data output RD_1 ... RD_n is given, the type of the received variable object shall be a structure containing the data for the different parameters as components in the same order and with the same type as given in the function block instance.

Table A.12 – Transition mapping of URCV state diagram

Transition	Condition
4	Data from remote communication partner received: InformationReport.Ind Variable Access Specification List of Variable Variable Specification Name Name Scope= AA-SPECIFIC Item Identifier= Value of R_ID parameter List of Access Results
5	Communication problems detected: Lower layers indicate error

6	Data types of SD_i of USEND and RD_i of URCV match: Data parameter of the Access Result parameter match with the count and data type of the RD_i outputs of the URCV instance (see A.4.2).
7	Data types of SD_i of USEND and RD_i of URCV do not match: Data parameter of the Access Result parameter do not match with the count and data type of the RD_i outputs of the URCV instance (see A.4.2).

Table A.13 – Action mapping for URCV state diagram

State	Actions
CHECKING	Verify data type match: Check all elements of the List of Access Results against the RD_i output declaration: If Success is false, the check fails If the Kind of Data parameter does not match with the data type of the appropriate RD_i output (see A.4.2), the check fails If the check of one data element fails, the complete check fails
HAVE_DATA	Deposit data: Deposit all data elements of the List of Access Results in the RD_i outputs

The BSEND function block uses the Write service as a client.

The Named Variable object with AA-specific scope which is written is defined by the corresponding instance of the BRCV function block. The attributes of this object are as follows:

Object: Named Variable

Attribute: Variable Name – The string given at the R_ID input parameter is the name of the variable with AA-specific scope.

Attribute: Reference to Access Control List – This object shall reference the Access Control List object M_ReadOnly.

Attribute: Type Description – The data type is a structure containing an index of data type unsigned integer 32, a more_follows mark of data type boolean and the data to send as an octet string.

```
structure {
    components {
        {component Name = "Index",
         component Type = unsigned -32},
        {component Name = "More_Follows",
         component Type = boolean},
        {component Name = "Data",
         component Type = octet-string} } }
```

Table A.14 – Transition mapping of the BSEND state diagram

Transition	Condition
3	Positive confirmation received and more data to send: Write.Cnf(+)
4	Negative confirmation received or communication problems detected: Write.Cnf(–) or lower layers indicate error
6	Positive confirmation received and no more data to send: Write.Cnf(+)
9	Communication problems detected: Lower layers indicate error

Table A.15 – Action mapping for BSEND state diagram

State	Actions
SEND_FIRST	Send first block of data given at the SD_1 input to remote communication partner, send a maximum of LEN bytes in total: Write.Req Variable Access Specification List of Data with component Index= 1 (= element number of the first byte in the byte array to send) component More_Follows= true if not all data to send are contained in component Data component Data= the first bytes out of the data to send
SEND_NEXT	Send next block of data given at the SD_1 input to remote communication partner, send a maximum of LEN bytes in total: Write.Req Variable Access Specification List of Data with component Index= Element number of the first byte of the octet string in the byte array to send component More_Follows= true if not all data still to send are contained in component Data component Data= bytes out of the data to send starting with the byte the number of which is contained in component Index
CANCEL	Stop the data transfer: Write.Req Variable Access Specification List of Data with component Index=0 with component More_Follows= false with component Data= null

The BRCV function block uses the Write service as a server.

The string given in the R_ID input is the name of the Named Variable object with AA-specific scope, which is defined by the instance of the BRCV function block.

Table A.16 – Transition mapping of BRCV state diagram

Transition	Condition
4	Data received from remote communication partner: Write.Ind
5	More data follows is true: Component More_Follows= true
6	More data follows is false: Component More_Follows= false
7	Indication to cancel data transfer received: Write.Ind with component Index= 0
9	Communication problems detected: Lower layers indicate error

Table A.17 – Action mapping for BRCV state diagram

State	Actions
RECEIVING	Verify data type match: The check fails if the length of octet string of the just received component Data plus the value contained in the just received component Index minus 1 is greater than the element count of the RD_1 array of byte
RESP_MORE	Send positive response: Write.Rsp(+)
RESP_LAST	Send positive response: Write.Rsp(+)
HAVE_IT	Deposit data: Store the bytes of the component Data successively starting with the element whose number is given in the component Index
CANCELLED	Send positive response: Write.Rsp (+)

A.4.6 Parametric control

The WRITE function block uses the Write service as a client.

The strings and the outputs of the REMOTE_VAR function given in the VAR_i input as identifiers of the variables to be written are mapped onto the Variable Access Specification parameter of the Write request. Each identifier of a VAR_i input forms one element of the List of Variable selection.

If the string of a VAR_i input starts with a "%" character, an Unnamed Variable object with a Symbolic Address shall be written. The string of the VAR_i input is used in the symbolicAddress parameter. Otherwise a VMD-specific variable shall be written. The Name Scope parameter of the Object Name parameter shall be set to VMD-specific. The string is used as the identifier.

If a REMOTE_VAR function output is used to identify the remote variable to be written, the Name Scope parameter of the Object Name parameter shall be set as given in the SCOPE input of the REMOTE_VAR function and mapped using table A.2. If the scope is VMD-specific or AA-specific, the value of the NAME input is used as the identifier. If the scope is domain specific the value of the SC_ID input shall be used as identifier of the Domain, and the value of the NAME input as item identifier.

If a derived variable is to be written, the Alternate Access option of the Variable Access Specification is used to describe which sub-element of a structure or element of an array is to be written. The List of Alternate Access Selections shall contain exactly one element. If the SUB input of the REMOTE_VAR function is an integer (signed or unsigned), it shall be used as Index of the array element to be written. If the SUB input is a not empty string, it shall be used as component name of the sub-element to be written.

The data given at the SD_i inputs give the List of Data parameter of the Write request.

Table A.18 – Transition mapping of the WRITE state diagram

Transition	Condition
3	Positive response of remote communication partner: Write.Cnf(+)
4	Negative response from remote communication partner or other communication problems detected: Write.Cnf(–) or lower layers indicate error

Table A.19 – Action mapping for WRITE state diagram

State	Actions
WAITING	Request to write variables into remote communication partner: Write.Req Variable Access Specification List of Data

A.4.7 Interlocked control

The SEND function block uses the Exchange Data service as a client.

The string given in the R_ID input is used as Item Identifier of the AA-specific data exchange object. The data inputs SD_1 ... SD_n form the List of Request Data parameter of the Data Exchange request in the same order and with the same type as given in the SEND function block invocation. The data of the List of Response Data parameter of the Data Exchange confirmation is stored in the data outputs RD_1 ... RD_m in the same order as given in the SEND function block invocation.

Table A.20 – Transition mapping of the SEND state diagram

Transition	Condition
3	Positive response from RCV: ExchangeData.Cnf(+)
4	Negative response from RCV: ExchangeData.Cnf(–)
5	Data types of the received data and RD_1 to RD_m match: Data of the List of Response Data parameter and RD_1 to RD_m match
6	Data type of the received data and RD_1 to RD_m mismatch Data of the List of Response Data parameter and RD_1 to RD_m mismatch
8	Positive or negative response to the reset request: Cancel.Cnf
9	Positive or negative response from RCV: ExchangeData.Cnf
12	Communication problems detected: Lower layers indicate error

Table A.21 – Action mapping for SEND state diagram

State	Actions
SEND_AND_WAIT	Send Data to RCV: ExchangeData.Req Data Exchange Name Name Scope= AA-SPECIFIC Item Identifier= Value of R_ID parameter List of Request Data
CHECKING	Verify data type match: Check data type of List of Response Data parameter of the ExchangeData.Cnf(+), see A.4.2
CANCEL	Request to reset RCV: Cancel.Req Original Invoke ID

The RCV function block uses the Exchange Data service as a server.

One instance of an RCV function block defines a Data Exchange object with AA-specific scope. The attributes of this object are as follows:

Object: Data Exchange

Attribute: Data Exchange Name – The string given at the R_ID input parameter is the name of the Data Exchange object with AA-specific scope.

Attribute: Reference to Access Control List – This object shall reference an Access Control List object M_NonDeletable.

Attribute: List of Request Type Specifications – The List of Request Type Specifications contains exactly the types of the receive data given at the RD_i outputs using tables A.1 and A.3.

Attribute: List of Response Type Specifications – The List of Response Type Specifications contains exactly the types of the send data given at the SD_i inputs using tables A.1 and A.3.

Attribute: Linked – This attribute shall have the value FALSE.

Table A.22 – Transition mapping of RCV state diagram

Transition	Condition
4	When data received from SEND: ExchangeData.Ind Data Exchange Name Name Scope= AA-SPECIFIC Item Identifier= Value of R_ID parameter List of Request Data
5	Data types of received data and RD_1 to RD_n match: Data of the List of Request Data parameter and RD_1 to RD_n match
6	Data types of the received data and RD_1 to RD_n mismatch: Data of the List of Request Data parameter and RD_1 to RD_n mismatch
8	When reset is requested by SEND: Cancel.Ind Original Invoke ID
9	Communication problems detected: Lower layers indicate error

Table A.23 – Action mapping of RCV state diagram

State	Actions
CHECKING	Verify data type match: Check result of the verification of the conformance of the List of Request Type Specification attribute and the List of Request Data parameter (see A.4.2).
NAK_ERROR	Send negative response to SEND: ExchangeData.Rsp(–) Error Class= DEFINITION Error Code= TYPE-INCONSISTENT
NAK_BUSY	Send negative response to SEND: ExchangeData.Rsp(–) Error Class= SERVICE Error Code= OBJECT-STATE-CONFLICT
NAK_CANCELLED	Send positive response to the reset request and then send negative response to SEND: Cancel.Rsp(+) ExchangeData.Rsp(–) Error Class= SERVICE-PREEMPT Error Code= CANCEL
RESPONDING	Send positive response with user data to SEND: ExchangeData.Rsp(+) List of Response Data= Data given at the SD_i inputs
NAK_DIS	Send negative response to SEND: ExchangeData.Rsp(–) Error Class= ACCESS Error Code= OBJECT-NON-EXISTENT

A.4.8 Programmed alarm report

The NOTIFY and the ALARM function block use the Event Notification service as a requester. Additionally, the ALARM function block uses the Acknowledge Event Notification service as a server.

One instance of a NOTIFY or an ALARM function block defines a Named Variable object with AA-specific scope. This variable object shall be transmitted in a Read response of the Confirmed Service Response selection of the Action Result parameter. The attributes of this object are as follows:

Object: Named Variable

Attribute: Variable Name – The string given at the EV_ID input parameter is the name of the variable with AA-specific scope.

Attribute: Reference to Access Control List – This object shall reference an Access Control List object M_ReadOnly.

Attribute: Type Description – If only one send data parameter is given, the type of the Named Variable object is exactly the type of the send data using tables A.1 and A.3. If more than one send data parameter is programmed, the type of the Named Variable object is a structure containing the send data as components in the same order and with the same type as given as send data parameters.

One instance of a NOTIFY or an ALARM function block defines a Event Condition object with AA-specific scope. The attributes of this object are as follows:

Object: Event Condition

Attribute: Event Condition Name – This attribute shall have the value of the EV_ID input parameter.

Attribute: Event Condition Class – This attribute shall have the value MONITORED.

Attribute: Reference to Access Control List – This object shall reference an Access Control List object M_NonDeletable.

Attribute: Priority – The value of this attribute shall be specified by the implementer.

Attribute: Severity – This attribute is taken from the SEVERITY input parameter of the function block invocation.

Attribute: List of Event Enrolment Reference – This attribute contains the reference to the Event Enrolment object predefined by this function block instance.

Attribute: Enabled – This attribute is taken from the EN_R input parameter of the function block invocation.

Attribute: Alarm Summary Reports – This attribute shall have the value FALSE.

Attribute: Monitored Variable Reference – This attribute shall have the value UNSPECIFIED.

Attribute: Evaluation Interval – This attribute is not supported, because the Parameter CBB and CEI is not requested in any conformance class of ISO/IEC 9506-5.

One instance of a NOTIFY or an ALARM function block defines a Event Enrolment object with AA-specific scope. The attributes of this object are as follows:

Object: Event Enrolment

Attribute: Event Enrolment Name – This attribute shall have the value of the EV_ID input parameter.

Attribute: Reference to Access Control List – This object shall reference an Access Control List object M_NonDeletable.

Attribute: Enrolment Class – This attribute shall have the value NOTIFICATION.

Attribute: Event Condition Reference – The Event Condition predefined by this function block instance is referenced.

Attribute: Notification Lost – The value of this attribute is specified by the implementer.

Attribute: Event Action Reference – This attribute contains the reference to the Event Action object predefined by this function block instance.

Attribute: Duration – This attribute has the value PERMANENT.

Attribute: Alarm Acknowledgement Rule – This attribute shall have the value NONE, if a NOTIFY function block is programmed. It shall have the value ACK-ALL, if an ALARM function block is programmed.

If one or more event data inputs SD_i are programmed at the instance of a NOTIFY or an ALARM function block, this instance defines an Event Action object with AA-specific scope. The attributes of this object are as follows:

Object: Event Action

Attribute: Event Action Name – This attribute shall have the value of the EV_ID input parameter.

Attribute: Reference to Access Control List – This object shall reference an Access Control List object M_NonDeletable.

Attribute: Confirmed Service Request – The Read service is used as Event Action. The service arguments shall be:

Attribute: Specification with Result – FALSE

Attribute: Variable Access Specification – This argument shall specify the associated variable of the function block instance.

Attribute: List of Modifier – This attribute shall be empty.

Attribute: List of Event Enrolment Reference – This attribute contains the reference to the Event Enrolment object predefined by the function block instance.

Table A.24 – Transition mapping of the NOTIFY state diagram

Transition	Condition
4	Communication system indicates "Sent to remote communication partner": Lower layers indicated no error
5	Communication system indicates "Cannot send to remote communication partner": Lower layers indicate error

Table A.25 – Action mapping for NOTIFY state diagram

State	Actions
TRY_UP	If the Event Condition is in DISABLED state, an error with status code 10 shall be reported, otherwise request to report the coming alarm to the remote communication partner: EventNotification.Req Event Enrolment Name Name Scope= AA-SPECIFIC Item Identifier= Value of EV_ID parameter Event Condition Name Name Scope= AA-SPECIFIC Item Identifier= Value of EV_ID parameter Severity= Value of SEVERITY parameter Current State= ACTIVE Alarm Acknowledge Rule= NONE Action Result Event Action Name Name Scope= AA-SPECIFIC Item Identifier= Value of EV_ID parameter Success Confirmed Service Response
TRY_DOWN	If the Event Condition is in DISABLED state, an error with status code 10 shall be reported, otherwise request to report the going alarm to the remote communication partner: EventNotification.Req Event Enrolment Name Name Scope= AA-SPECIFIC Item Identifier=Value of EV_ID parameter Event Condition Name Name Scope= AA-SPECIFIC Item Identifier=Value of EV_ID parameter Severity= Value of SEVERITY parameter Current State= IDLE Transition Time= Time the raising edge of the EVENT parameter was detected Alarm Acknowledge Rule= NONE Action Result Event Action Name Name Scope= AA-SPECIFIC Item Identifier= Value of EV_ID parameter Success Confirmed Service Response

Table A.26 – Transition mapping of the ALARM state diagram

Transition	Condition
6	Receive acknowledge of the report of the coming alarm: AcknowledgeEventNotification.Ind Event Enrolment Name Name Scope= AA-SPECIFIC Item Identifier= Value of EV_ID parameter Acknowledged State=ACTIVE
7	Receive acknowledge of the report of the going alarm AcknowledgeEventNotification.Ind Event Enrolment Name Name Scope= AA-SPECIFIC Item Identifier= Value of EV_ID parameter Acknowledged State=IDLE

Table A.27 – Action mapping for ALARM state diagram

State	Actions
U1, U2, U3	If the Event Condition is in DISABLED state, an error with status code 10 shall be reported, otherwise request to report the coming alarm to the remote communication partner: EventNotification.Req Event Enrolment Name Name Scope= AA-SPECIFIC Item Identifier= Value of EV_ID parameter Event Condition Name Name Scope= AA-SPECIFIC Item Identifier= Value of EV_ID parameter Severity= Value of SEVERITY parameter Current State= ACTIVE NO-ACK-A Transition Time= Time the raising edge of the EVENT parameter was detected Alarm Acknowledge Rule= ACK-ALL Action Result Event Action Name Name Scope= AA-SPECIFIC Item Identifier=Value of EV_ID parameter Success Confirmed Service Response
ACK_UP	Confirm received acknowledgement positively: AcknowledgeEventNotification.Rsp(+) Set the states of all event enrolments identified by the EV_ID parameter to ACTIVE ACKED
D2	If the Event Condition is in DISABLED state, an error with status code 10 shall be reported, otherwise request to report the going alarm to the remote communication partner, see state U1 but: EventNotification.Req Current State= IDLE NO_ACK_A
D1	If the Event Condition is in DISABLED state, an error with status code 10 shall be reported, otherwise request to report the going alarm to the remote communication partner, see state U1 but: EventNotification.Req Current State= IDLE ACKED
ACK_DOWN	Confirm received acknowledgement positively: AcknowledgeEventNotification.Rsp(+) Set the states of all event enrolments identified by the EV_ID parameter to IDLE ACKED
ERROR	Confirm received acknowledgement negatively: AcknowledgeEventNotification.Rsp(–) Error Class= SERVICE Error Code= OBJECT-STATE-CONFLICT

A.4.9 Connection management

The CONNECT function block uses the Initiate service and the Conclude service as a client and a server.

The PARTNER input is used to identify the application entity to which a connection is requested.

Table A.28 – Transitions of the CONNECT state diagram

Transition	Condition
4	Receive a positive confirmation to the request to establish a new connection from the remote communication partner: Initiate.Cnf(+)
5	Receive a negative confirmation to the request to establish a new connection from the remote communication partner: Initiate.Cnf(–)
6	Receive a positive confirmation to the request to conclude the connection from the remote communication partner: Conclude.Cnf(+)
7	Receive a negative confirmation to the request to conclude the connection from the remote communication partner: Conclude.Cnf(–)
8	Loss of connection, i.e. loss of the application association
9	Receive a request to establish a new connection to the remote communication partner: Initiate.Ind
10	Receive a request to conclude the connection to the remote communication partner: Conclude.Ind

Table A.29 – Action mapping for CONNECT state diagram

State	Actions
CHECKING_1	Check if the connection can be established: Check if the constraints identified in the Initiate.Ind primitive can be accepted, or if alternate values can be proposed
DENY	Send a negative response to the request of the connection: Initiate.Rsp(–) Error Type Error Class= INITIATE Error Code= OTHER
ACCEPT	Accept to establish a connection and send a positive response: Initiate.Rsp(+)
CONCL_PASSIV	Send positive response to conclude the connection: Conclude.Rsp(+)
CONNECTING	Request a connection to the remote communication partner: Initiate.Req
ABORT_1	Request to abort communication: Abort.Req
CHECKING_2	Check if the connection can be established: Check if the application association can be established
ABORT_2	Request to abort communication: Abort.Req

CLOSING	Request to conclude the connection: Conclude.Req
CONCLUDING	Send positive response to conclude the connection: Conclude.Rsp(+)

A.5 Implementation specific features and parameters

Implementation specific features and parameters defined in this annex and the most relevant subclause for each are listed in the following table.

Table A.30 – Implementation specific features and parameters

Subclause	Implementation specific features and parameters
A.6.1	Mapping of the PC system onto the VMD of ISO/IEC 9506-5
A.6.2	The maximum length permitted for data of data type STRING when communicating in the abstract syntax of ISO/IEC 9506-5
A.6.4	Means to create additional Program Invocation objects
A.6.5	Means to create additional Domain objects
A.7	If communication channels established using the FB CONNECT are reusable or not
A.7.6	The value of the Priority attribute of the MMS Event Condition object
A.7.6	The value of the Notification Lost attribute of the MMS Event Enrolment object

Annex B
(normative)

PC behavior using ISO/IEC 9506-2

B.1 PC communications mapping to MMS

This annex specifies the behavior of a PC when it is communicating in the abstract syntax defined by ISO/IEC 9506-2.

ISO/IEC 9506-1/2 specifies the model of a VMD and specifies how services are provided by a VMD. ISO/IEC 9505-5 extends the VMD for a PC e.g. by adding the concept of I/O state. It also extends the services provided by a PC to specify the behavior of a PC.

The general approach is that the PC behaves as if it is communicating in the abstract syntax defined in ISO/IEC 9506-5, with defaults applied where the services has been extended in ISO/IEC 9506-5.

For the CreateProgramInvocation Service, the following defaults shall be used:

Table B.1 – CreateProgramInvocation service defaults

PC language element of IEC 61131-3	Independent attribute	Program Invocation Reference attribute
Configuration	TRUE	
Resource	FALSE	Identifier of the Program Invocation of the configuration
Others	TRUE	

For the following services, the PC shall behave according to the service extensions defined in ISO/IEC 9506-5 with the value of the I/O State used in the following table, including the service procedure extensions related to the Independent and Program Invocation Reference attributes.

Table B.2 – Program Invocation service defaults for I/O State parameter

MMS service	I/O State value
Start	0 – Controlled
Resume	0 – Controlled
Stop	3 – Implementer State
Kill	3 – Implementer State

The service procedure extensions defined for the GetProgramInvocationAttributes service shall not be used.

B.2 Implementation specific features and parameters

Implementation specific features and parameters used in this annex of IEC 61131-5 and the most relevant subclause for each are listed in the following table.

Table B.3 – Implementation specific features and parameters

Subclause	Implementation specific features and parameters
A.6.1	Mapping of the PC system onto the VMD of ISO/IEC 9506-1
A.6.2	The maximum length permitted for data of data type STRING when communicating in the abstract syntax of ISO/IEC 9506-1
A.6.4	Means to create additional Program Invocation objects
A.6.5	Means to create additional Domain objects
A.7	If communication channels established using the FB CONNECT are reusable or not
A.7.6	The value of the Priority attribute of the MMS Event Condition object
A.7.6	The value of the Notification Lost attribute of the MMS Event Enrolment object

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