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Building automation and control systems (BACS) —

Part 3:
Functions

Systèmes de gestion technique du bâtiment (SGTB) —

Partie 3: Fonctions

Reference number
ISO 16484-3:2005(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16484-3 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 247, *Building automation, controls and building management*, in collaboration with Technical Committee ISO/TC 205, *Building environment design*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement)

This corrected version of ISO 16484-3:2005 contains numerous changes to be consistent with EN/ISO 16484-3:2005.

ISO 16484 consists of the following parts under the general title *Building automation and control systems (BACS)*:

— *Part 2: Hardware*

— *Part 3: Functions*

— *Part 5: Data communication protocol*

— *Part 6: Data communication conformance testing*

Two parts are under development:

— Part 4 dealing with applications

— Part 7 dealing with project implementation

Annex A (normative): *BACS function list (BACS FL),* forms a normative part of this standard.

The Annex B (informative): *Examples for control schematic and BACS function list,* and Annex C (informative): *Bibliography,* are for information only.

NOTE   National annexes may contain information provided for easier implementation of the standard, e.g. an alphabetical index or national footnotes.

Introduction

This series of standards is intended for design of new buildings and retrofit of existing buildings for an acceptable indoor environment, practical energy conservation, and efficiency.

The application of this series of standards for BACS is envisaged as follows:

- the environmental design for all building types requires complex methods for automation and control. The functional integration of services other than HVAC is a general task for all parties employed to develop an integrated multi-application system. The Integration comprises, e.g. lighting and electric power distribution control, security control, transportation, maintenance management, or facilities management. This system integration allows the user to take advantage of synergies between the different applications. This standard will give guidance to architects, consultants, and contractors as well as to users on how to share such resources;

- the innovation cycles between devices, systems, and networks vary. To make it possible to add and to change existing devices, and extend the building automation and control network, several interfaces both proprietary and standardized are defined between the BACS network and the other systems. A manufacturer can design a product, both to meet his specific marketing objectives and to give the option to integrate that special device into a multi-application BACS. Interfaces are also defined in appropriate parts of this standard along with the necessary communications protocol and conformance test required to support the inter-working of devices;

- a manufacturer, a systems house, or an electrical or mechanical contractor can assemble an implementation of a building automation and control system;

- the application of this standard is not to standardize the hardware and software design or the architecture of a System, but to define the process for the creation of project specifications, where functionality and the quality of the solution are clearly defined.

The purpose of this series of standards is intended for use by those involved in the design, manufacture, engineering, installation, commissioning, operational maintenance and training of BACS when contracted, i.e.:

— as a guide to the terminology of the building automation and control trade. Unambiguous terminology is required for a complete and accurate conveyance of the intent and details of this standard;

— in product development, to avoid unnecessary duplication of function or terminology, but should not place a restraint on the evolution of new products, systems or applications;

— as a basis for interfacing products and systems. In order to interoperate, the elements of a BACS require a unified data communication protocol and information model;

— as a basis for drawing up a project specification for the procurement of building automation and control products for systems suppliers and customers;

— as a code of practice for expertly commissioning prior to handover of a system;

— by educational establishments wishing to train people in the field of building automation and control systems.

This entire series of BACS standards consists of the following contents:

Part 1:   Overview and definitions (withdrawn)

Part 2:   Hardware

Part 2 of this standard specifies the requirements for the hardware to perform the tasks within a BACS. It provides the terms, definitions, and abbreviations for the understanding of Part 2 and Part 3.

Part 2 relates only to physical items/devices, i.e.:

— operator stations and other human system interface devices;

— devices for management functions;

— control devices, automation stations and application specific controllers;

— field devices and their interfaces;

— cabling and interconnection of devices;

— engineering and commissioning tools.

This part of this standard shows a generic system model to which all-different types of BACS and their interconnections (BACS network) can fit. A graphical concept of the BACS network in terms of LAN and inter-network topology will be provided in Part 5 of this standard.

National annexes:

National annexes may specify the local requirements of physical and electrical characteristics, the verifications for BACS devices and equipment, and the code of practice for the physical installation of systems. The annexes shall refer to the regional implementations of the relevant IEC standards.

Part 3:   Functions (refer to the scope of this part)

Part 4:   Applications

Part 4 of this standard specifies the requirements for specific communicating applications/devices, e.g. for general room automation and for sophisticated optimization of controls for heating, fan coil and induction units, CAV, VAV and radiant cooling.

This work will be coordinated at expert level with standards work from ISO/TC 205 WG 3 and CEN/TC 247.

Part 5:   Data Communication – Protocol

Part 5 of this standard specifies data communication services and objects for computer equipment and controllers used for monitoring and control of HVAC&R and other systems of building services.

This protocol provides a comprehensive set of object types for conveying encoded binary, analog, and alphanumeric data between devices including, but not limited to:

— input measuring: analog input object;

— output positioning/setpoint: analog output object;

— binary input counting;

— input state: binary input object, multi-state input;

— output switching: binary output object, multi-state output;

— values: analog value, binary value, multi-state value, accumulated value, averaging object, trend log object;

— text string;

— schedule information;

— alarm and event information;

— files; and

— control programs and parameters respectively.

This protocol models each building automation and control system as a collection of data structures called object types, the properties of which represent various aspects of the hardware, software, and operation of the device. These objects provide a means of identifying and accessing information without requiring knowledge of the details of the device's internal design or configuration.

NOTE   An overview of possible integration with other systems in buildings, e.g. fire, security, access control, maintenance and facilities management, is shown in Figure 1 of Part 2 of this standard.

Part 6:   Data communication conformance testing

Part 6 of this standard specifies the technical requirements of the conformance test suite and the methods for testing the products for the conformance with the protocol. It provides a comprehensive set of procedures for verifying the correct implementation of each capability claimed on a BACS network protocol implementation conformance statement (PICS) including:

— support of each claimed BACS network service, either as a client (initiator), server (executor), or both;

— support of each claimed BACS network object-type, including both required properties and each claimed optional property;

— support of the BACS network layer protocol;

— support of each claimed data link option, and

— support of all claimed special functionality.

Part 7:   Project implementation

Part 7 of this standard specifies methods for project specification and implementation of BACS and for integration of other systems into the BACS. This standard defines terms to be used for project specifications and gives guidelines for integration of other systems.

a)   Project specification and implementation:

This clause of the standard describes the procedures (codes of practice) required for the following:

— project specification:
    These procedures also contain an example for a plant/system/customer premises wide unique structured addressing system for data point identification;

— engineering;

— installation;

— project handover.

b)   System integration:

This clause of the standard describes the special requirements/procedures for the integration and implementation of intersystem communication with foreign systems and the interconnection of other units/devices with integrated communications interfaces, e.g. chillers, elevators.

Building automation and control systems (BACS) —

Part 3:
Functions

1 Scope

This International Standard specifies the characteristics of software and functions used in Building automation and control systems as well as a method for documentation of the design. It gives guidelines for the engineering. It specifies a template for documentation of plant/application specific datapoints and functions, called BACS function list in annex A.

The informative function block examples explain a method to display the referenced functions in system documentation; they do not standardize the method for programming functions and applications.

This International Standard covers the following:

Requirements and definitions regarding BACS and application software, generic function types for plant/project specific applications and engineering functions for building controls and operations. It provides communication functions for the integration of other dedicated special system processes. The functional requirements in this part of the standard are subdivided as follows:

— System management and application software:

This clause describes the requirements for plant independent system and human system interface programs related to a project, including the operating system. This standard does not dedicate the following system functionality to any particular hardware, e.g.:

    — system diagnostics, watchdog, redundancy, time keeping, access control, log lists;

    — point identification, event message handling, print control;

    — database, statistics, data archiving, remote access;

    — system communications.

— Human system interface (HSI), point information presentation, graphics, alarms, time scheduling

— Engineering process and tool software:

This clause describes the requirements for configuring of the hardware and control strategies, the system management, and the commissioning process.

— BACS application processing programs and plant/application specific function types:

This clause describes the requirements for plant, application, and / or project specific functions and a method for the documentation of a project. The functions are subdivided into the following types:

    — input and output functions;

    — processing functions;

— management functions and required communications;

— operator functions.

This International Standard defines a method for creating the procurement specifications containing all essential elements required for the operational functioning of a BACS. The successful installation and operation of a BACS requires that its procurement be based on a complete specification with accurate functions.

The standard provides a template called the 'BACS function list' that can be found in annex A (normative). Its purpose is to determine and document the options for plant / application specific functionality. Further explanations can be given in form of plant/control descriptions, control flow chart diagrams, and plant/control schematics. Examples are given in annex B (informative). The exact specifications will be project-specific. Information about the standardized functions is given in the form of informative examples as function-blocks, textual, and graphical descriptions in 5.5.

It is recognized, that functions can be described and implemented in many different ways, depending on:

— climatic differences;

— cultural and regional differences;

— national regulations.

2 Normative references

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

ISO 10628:1997, *Flow diagrams for process plants — General rules*

ISO 16484-2:2004, *Building automation and control systems (BACS) — Part 2: Hardware*

ISO 16484-5, *Building automation and control systems (BACS) — Part 5: Data communication protocol*

IEC 60617-12:1997[1], *Graphical symbols for diagrams — Part 12: Binary logic elements*

IEC 60617-13:1993[1], *Graphical symbols for diagrams — Part 13: Analogue elements*

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 16484-2:2004 apply.

4 Symbols, abbreviations and acronyms

For the purposes of this standard, the symbols, abbreviations and acronyms given in ISO 16484-2:2004 apply.

NOTE   The abbreviations used and explained within the tables for the function block examples are for information only.

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1) Withdrawn. Replaced by IEC 60617:2001.

5 Requirements

5.1 Overview

5.1.1 Structure of the requirements and functions

5.1.1.1 General

This standard does not dedicate the system functionality to any particular hardware. The functional requirements in this part of the standard are subdivided as follows:

— system application and management software:

describes the requirements for plant independent system programs and human system interface programs related to a project in general;

— engineering and commissioning tools:

describes the requirements for the configuration of hardware, of control strategies and management functions,
and the commissioning process;

— project/plant specific functions:

describes the requirements for plant applications and/or project specific functions and methods for the functional documentation of project and/or application specific systems.

The functions of a BACS in general are structured into three levels. These levels indicate functions for

— management,

— automation/control as processing functions, and

— input/output as interface to field devices.

Operator functions are not assigned to a specific level.

NOTE   Requirements for the hardware and communication means to perform the BACS software and functions that are specified in Part 2 of this standard.

5.1.1.2 Operator functions

Human system interface for plant operation, i.e. for supervision, alarm annunciation, state monitoring and human interaction are not assigned to any functional level.

The range of functionality covers:

a) system management, event management and state management, parameter adjustment and manual on/off control;

b) local room operation;

c) local override/indication device functions to provide restricted access for service operation;

d) system engineering and servicing, engineered operator functions are, e.g. dynamic display, event instruction text, remote messaging (see 5.5.5).

NOTE   Human system interface devices in a BACS are on different types of hardware, as specified in Part 2:
- direct acting elements, as switches and signal lights;
- local override and/or indication devices;
- handheld units;
- monitoring and operator units or panels;
- operator stations including visual display units and
- Internet based browsers.
A VDU can provide a graphical user interface.

5.1.1.3   Management functions

Management functions are performed by the software of a BACS. The plant/application specific management functions are for the activity of a user taking decisions for supervision of plant and evaluating energy use and operational costs. The required functionality at this level is:

a)   communications with devices of the control network, and any attached foreign systems;

b)   communications for data exchange with dedicated special, or foreign systems to provide for operator and management functions within the BACS;

c)   recording, archiving and statistical analysis;

d)   decision support for e.g. energy management.

5.1.1.4   Processing function types

The plant/project specific application software and parameters provide all automatic functionality for building services in real-time within self-contained controllers/automation stations. The required groups of processing function types are:

a)   monitoring;

b)   interlocks;

c)   closed loop and open loop control;

d)   calculation/cross plant/system optimization;

e)   room control functions, e.g. individual zone control, lighting control, shades/blinds control, details will be given in Part 4.

5.1.1.5   I/O function types

The I/O functions provide the interface between processing functions and the field devices. These function types are subdivided in

a)   physical input and output functions, and

b)   shared input and output functions for communication with foreign products.

5.1.1.6   Field devices

Field devices are generally sensors and actuators, coupling units and local override/indication devices that are connected to input/output interfaces of controllers/automation stations. Field devices can be connected to controllers via field network or direct wiring. The field devices perform connection to the physical items of plant providing the necessary information about the conditions, states, and values of the processes and effect the programmed operations. Functions supported by field devices are

a)   Switching;

b)   Positioning;

c)   state monitoring;

d)   counting, and

e)   measuring.

NOTE   For field device requirements see Part 2 of this standard.

5.1.2   Description of functions

The normative functional descriptions within this section are provided for use by the specifier, e.g. consultant, to describe the project functionality. The descriptions in 5.5 contain no direct hardware related specifications, but the number of input and output functions help to determine the required physical or communication inputs and outputs of a BACS, the processor performance, and memory size.

NOTE   For the required hardware components see Part 2 of this standard.

For each project the system programs and the plant/application specific functions are to be specified to determine the required engineering services.

The plant specific functions can be documented in plant/control schematics, control flow chart diagrams and the BACS function list, preferred as spreadsheet for further data processing, which is shown in annex A as a template.

Some complex projects and/or sophisticated control algorithms for optimal control performance require additional information and methods in order to describe the requirements clearly and completely. These additional requirements include plant and control descriptions, control flow charts, psychrometric charts, reset schedules, field device mounting instructions/illustrations.

Annex B provides informative examples to indicate methods for creation of accurate documentation for a design project.

5.1.3   Description of function block examples

This standard has adopted (where appropriate) a function block (FB) method of describing BACS applications. The FB examples are designed according to the graphical symbols for diagrams in IEC 60617-12[2], Binary logic elements and in IEC 60617-13[2], Analog elements.

The information in the FB examples provides common wording and descriptions of BACS functions. The terminology provided by these descriptions should be used in any discussions and documents that represent BACS applications. This involves describing inputs, outputs, parameters and functions in a common textual and graphic format. A complete application scheme can be engineered using a series of interconnected function blocks as shown in the informative examples. The function block principle can be used to introduce new BACS functions and can be referred to using the BACS FL.

5.1.4   Description of the BACS function list

5.1.4.1   Scope

The BACS FL shown in annex A is based on the definitions in 5.5, and it provides the following benefits:

⎯   the determination of functions is based on the plant/control schematic, the plant/control description and the control flow chart diagram if necessary;

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2)   Withdrawn. Replaced by IEC 60617:2001.

— it allows one to determine the number of engineered function types for specific projects by using a spread sheet program that provides for electronic data interchange;

— it provides a common structured method for the plant/system design and specifying process;

— it provides for the use of a unique structured point naming convention or addressing system, required in 5.3.2.7;

— the structured numbering scheme for the sections and columns of functions provides for the addition of individually defined functions in the given categories, if required.

5.1.4.2   Purpose

The BACS FL allows a supplier-independent description of the controls requirements. It can be used for tendering, costing, and billing purposes, although this aspect of its use is outside the scope of this standard. It should be considered that the main expenditure when implementing a BACS is in the engineering. These efforts are in direct relation to the number and type of functions required for the application.

BACS specifications shall contain all relevant detailed documents required to fully interpret the overall functionality. This should enable comparable and thought through bids at tendering.

For each plant to be controlled and supervised a plant control schematic shall be drawn. The data points, processing functions, and communication functions for complete control, as well as human system interface for operation, energy, and maintenance management can be listed in a separate BACS FL by the specifier.

The control flow chart method or a state machine diagram can be used for description and documentation of extensive control strategies and interlocks.

5.2   General system criteria

A BACS mainly consists of field and control devices, switchgear assembly, cabling, network, communication, and computing devices (hardware), system software and functions achieved by engineering services.

Decisions regarding functionality are normally defined before determination of the structure and the hardware of a BACS.

The following descriptions define the performance criteria and options to be specified and stated in each project regarding the manufacturer specific and the project specific application software.

NOTE   For Hardware requirements refer to Part 2 of this standard.

5.3   Software

5.3.1   BACS programs general

For this standard the software of a BACS is subdivided into

— system management programs;

— communication programs;

— general application and optimization programs;

— human system interface programs;

— engineering programs.

5.3.2　System management programs

5.3.2.1　General

System management involves the initialization (see Part 2, 3.99), co-ordination, and maintenance of all configuration information (see Part 2, 3.47) relating to the operation of the system as a whole including network management. Each system function may be configured manually or automatically.

Remote system management and human system interface for system maintenance capabilities shall be specified. These programs need not be mandatory due to system size and resources.

5.3.2.2　System time keeping

The management methods for time, date, and calendar within all management and control functions shall be stated.

Performance criteria for system time keeping are:

1) internal/external clock, type of external clock;

2) system clock accuracy;

3) overall system time synchronization, e.g. by radio clock;

4) summer/winter time change handling for daylight savings;

5) change of time and date for local data processing device or server station;

6) change of time and date for networked and stand-alone devices.

5.3.2.3　Watchdog functions

Watchdog function requirements and system responses in case of a fault shall be specified for each project.

5.3.2.4　System diagnostics

Devices and functions of a BACS are supported by diagnostic tools to ensure constant operation, quality, and performance. The system's diagnostic features monitor a variety of functions and report on failure situations, or invoke corrective actions. Remote system diagnostics capabilities shall clearly be specified. The system diagnostic features shall indicate:

a) memory usage and system resources;

b) failure percentage of communication activity on all system networks;

c) causes of system failures.

Further system diagnostic features shall be stated for a specific project.

5.3.2.5　Power down management and recovery

Any consequences due to loss of power shall be specified, i.e. for:

a) power down;

b) power return;

c) associated internal system functions;

Additionally, the requirements shall be specified for

d) operator initiated power on/off operation,

e) system power failure return method, and

f) uninterruptible power supply (UPS) options.

5.3.2.6 System activity logbook

A record of all system activity and events should be kept with date and time for subsequent displaying, printing, and archiving. The full extent of system operations held within the system activity logbook is to be specified.

5.3.2.7 Point identification

For information accessing and processing within a BACS it is necessary to establish a project specific, unambiguous naming convention for identification of all physical and virtual data points. Point addresses are used for accessing and displaying information provided by functions throughout the system(s).

NOTE   Point addresses used by an operator at the HSI are referred to as mnemonics or user addresses.

Point addresses within a BACS have to be unique and shall exist within a unique structure for a plant, a system, or the entire customer premises. Associated descriptive text displayed with the information of data points should be provided. The means by which the user interface navigates to the data point information shall be specified.

For point information presentation requirements refer to 5.3.5.9.

Typical elements of user addresses in a BACS addressing system are: site, building, part, location (e.g. floor), plant type (e.g. HVAC), plant number, type of function, information number. There are also customer specific data point designation systems according to established standards possible.

5.3.2.8 System access control

A number of access levels defined in profiles shall be provided to protect the system from misuse. The number and relevance of these access levels have to be specified e.g.:

Table 1 — access control levels

Level	Activity
No password:	Read only, restricted access to specific information
Level 1:	Routine daily operations only allowed
Level 2:	Operator access to all non configurable functions
Level 3:	Engineering access, required to configure the entire system.

A BACS shall provide for all dialog oriented operator interfaces an operator/user authentication for corroboration that the operator logging on to a device is identified to be the entity claimed.

For user access control requirements refer to 5.3.5.5.

5.3.2.9 Operator activity logbook

The extent of operations held within the operator activity logbook for subsequent displaying, printing and archiving is to be specified. This can include a record of all operators logging in and out, with name, date and time, command, event acknowledgment, parameter, and password change.

5.3.2.10   Data usage and storage

Change of state or change of value data sent from I/O, processing or other management functions can be stored and shall be provided with a date and time stamp for subsequent analysis. This program refers to the management functions event storage/historical database, BACS FL, col. 7.3/7.4, as specified in 5.5.4.3.

The requirements are subdivided into system specific and project specific features.

5.3.2.10.1   System specific features for data storage

The features required shall be specified:

a)   type of inputs into log files;

   EXAMPLE   A Log entry can be: event, alarm, state message, measured value, totalized value, system failure log, user message log.

b)   minimum required number of records of each log file or database;

c)   post collection format of provided alarm/event/measure log/counter log and system information data;

d)   the means of retrieving the data;

e)   search facilities provided for querying each of the lists;

f)   print facilities offered.

Performance criteria:

   1)   maximum number of log lists as files on the data storage;

   2)   maximum number of entries per log list;

   3)   maximum number and types of records managed.

5.3.2.10.2   Project specific features of the database

The features required shall be specified:

a)   log lists for states and values (e.g. alarm and/or maintenance criteria);

b)   historical database, e.g. for statistical analysis, quality control;

c)   system documentation.

The supplier shall state the type of database management system (DBMS) software and original license provider with respect to copyright laws.

Performance criteria if DBMS software is used:

   1)   maximum number of entries in database;

   2)   data storage space used for application software and parameters;

   3)   data storage space proposed for user data;

   4)   method of filtering employed;

      EXAMPLE   Selection by message type, by plant address, by function type etc.

5)   accuracy of time stamping;

6)   resolution of time stamp.

5.3.2.11   Data archiving

Data gathered by the function historical data, described in 5.5.4.3, and other system data can be permanently archived using a data archiving method, e.g. file server, tape data storage, CD-ROM. For cross-reference see also backup and restore in 5.3.2.13.

Performance criteria:

1)   maximum number, size and types of records managed;

2)   if applicable: type of DBMS software and original license provider shall be stated with respect to copyright laws.

5.3.2.12   Data import/export

Data that is intended to be used by a dedicated special system, often a third party or foreign system, shall be made available by the source database, if required. Any capability that the data processing device or server station has for import/export data is to be clearly specified.

The data format and, e.g., record type, descriptors, texts, delimiter to separate variables are to be specified.

Performance criteria:

1)   import format of data for the data processing device or server station;

2)   import format of data for onward transmission to controllers/automation stations;

3)   export format of data collected from controllers/automation stations.

5.3.2.13   Backup and restore

At least one complete backup of all software and project specific data shall be given to the responsible user. The way in which a user can make a full back up and restore of all functions and their configuration data at all relevant levels shall be specified. Backup media to be used shall be specified.

Performance criteria:

⸺   Time needed for complete system backup and restoring.

5.3.2.14   Redundancy

Any capability for the use of multiple hardware to automatically overcome the failure of any piece(s) of equipment is to be stated. The requested capability for stand-by operation shall be stated with respect to:

a)   power supply;

b)   processing unit;

c)   input/output unit;

d)   network interface/access unit and data interface unit;

e)   hard disk e.g. RAID level;

f)   main memory;

g)   visual display;

h)   keyboard, mouse/other pointing device;

i)   printer failure/out of paper.

5.3.3   Communication programs

5.3.3.1   Communication interfaces

In case there is not a unique network for all functional network levels as shown in Figure 1 of Part 2 of this standard, the typical data exchange communication interfaces (hardware and drivers) can be manufacturer specific or standardized communication protocol(s).

For the management network (MN), proven international standards for LAN should be employed.

The failure of a part of a communication system shall not cause a disturbance or the failure of the whole communication system for the BACS.

The network/bus architecture shall allow for testing and analyzing for each communication partner.

Communication services and objects for system neutral data transmission in BACS applications are described in ISO 16484-5.

If manufacturer specific protocols are used, driver and protocol software for foreign data interfaces and their description shall be supplied to allow project implementation, if required.

Performance criteria:

1)   number of communication interfaces to be used simultaneously;

   EXAMPLE   Interface to router, gateway, MN, CN, FN, PU, MOU, DSS.

2)   supported standardized protocols, degree of conformance or statement of interoperability;

3)   peer to peer communication ability;

4)   maximum baud rate of each communication network;

5)   supported MODEM functionality;

   EXAMPLE   Capacity of phone numbers to be called automatically, automatic callback.

6)   performance of MODEM interface by means of baud rate, data compression, data encryption;

7)   conformance to international data transmission standards/national regulations.

5.3.3.2   Remote operation

The set up method for remote communications between management devices in distributed systems and MOU/PU, is to be specified.

The functions offered by remote access shall be specified:

a)   access to current live values and states;

b)   automatic dial-up to demand receipt of alarms;

c) remote graphic capability;

d) remote historical database access;

e) configuration data and program up/download access.

Performance criteria:

1) number of PSTN lines supported;

2) number of ISDN lines supported;

3) remote private network MODEMs/PADs supported;

4) remote public network MODEMs/PADs supported;

5) local MODEMs/PADs supported;

6) system use of MODEMs/PADs manual or automatic.

5.3.3.3 Dynamic data links to other applications

Any data links, which are available for other applications to use, shall be specified giving:

a) Features offered;

b) Syntax of connection;

c) Protocol supported.

EXAMPLE   Object linking and embedding.

5.3.3.4 Communication to dedicated special systems

In case of combinations of different systems, e.g. BACS and DSS, the capabilities for interoperability with other management systems shall be specified.

EXAMPLE   Connected DSS can be fire or intrusion alarm systems, maintenance systems, and facility management systems.

The functional communication requirements shall be fully specified, including:

a) communication interface standards and methods, hardware and software;

b) protocol types;

c) the application objects or standard application profiles;

d) naming conventions and/or addressing system;

e) type and specification of database access;

f) contents and rules of data file exchange;

g) maintenance message types;

h) methods for resetting of event messages, e.g. from run time totalization, event counting.

Where interoperability between different systems is required, it is to state the other systems' brand name(s) and type(s) of product/software version of the third party system, for allowing the identification of the grade of possible interoperability.

The following project or application specific requirements shall be specified:

i)   contractual and functional responsibilities for each third party system or foreign device;

j)   if the chosen protocol is not standardized as given in ISO 16484-5, then an adequate functional description is required to complete a project;

k)   shared data points and functions by using the BACS FL;

l)   all application functionality;

m) the requested testing methods.

5.3.4   BACS application programs

5.3.4.1   General

The BACS application program consist of all software required to perform the following general BACS specific tasks, the engineered functions described in 5.5, and, if required, the system engineering functions described in 5.4.

5.3.4.2   Alarm/event message handling

Alarm/event messages sent from controllers/automation stations by change of state information (COS) shall be provided with a date and time stamp, event type information, and be collected for immediate display and, if required, be stored by the management functions historical data according to 5.5.4.3 for subsequent interrogation or report/protocol printout.

Features required at the moment of collection shall be specified, including:

a)   warning mechanism type or event type;

b)   current state of alarms on the system, e.g. acknowledged, unacknowledged;

c)   indication of disable condition of a point or device;

d)   ability to drive the monitoring and operator unit to a pre defined screen display;

e)   type and contents of messages to operator/user;

   EXAMPLE   Date and time stamp, point name or user address, state, value, S.I. unit, limits, text.

f)   time resolution for date and time stamp;

g)   filtering of alarm/event details into different log files e.g. for event types;

h)   ability to start predefined actions.

   EXAMPLE   Start of programs, printout, physical output functions.

Post collection features shall also be specified, including:

i)   format of current alarm/event lists;

j)   search facilities provided for querying the alarm/event lists;

k) print facilities offered;

l) event table offered for allocation of defined actions.

Performance criteria:

— Maximum number of entries in event list.

5.3.4.3   Printer selection strategy

The method of automatic printer selection and message re-routing to different printers by predefined timetable and event class shall be specified.

Performance criteria:

— Recognition of printer failures, e.g. paper out, and indication of this as a system event.

5.3.4.4   Information routing

Information routing allows specified information to be provided to the appropriate output device(s) at specified time periods or at the request of an authorized operator. The program can provide the possibility of creating information filters, according to 5.3.4.2 g).

5.3.5   Human system interface programs

5.3.5.1   Operator programs general

Human system interface describes the interaction between an operator and a BACS for operating a plant. The following program functions shall be selected and specified for each project and operator interface type.

5.3.5.2   Basic human system interface functions

a) For the BACS-HSI the minimum basic requirements are to support the following functions:system management;

b) event management;

c) state management;

d) parameter adjustment;

e) system engineering.

On certain interface device types some functions are not available due to performance and/or technology limitations.

Time and application critical processing functions shall be performed independently of MOU's.

Performance criteria:

1) type of graphic supported;

2) color display supported;

3) display resolution supported, specified in pixels;

4) response time for alarm display.

5.3.5.3   Operator interface types

The following table shows the associations between different user groups, functions carried out, and typical equipment used.

Table 2 — BACS operator class – HSI association

Class of operator	Functions	Type of Human system interface
Caretaker	Action according to explicit instructions.	Text/icon based display, audible device.
Building operator	Event management; Operating parameter change State management.	Desktop computer with optional graphics, touch screen, pointing device, etc.
System operator	Control parameter change; system management/engineering.	As building operator.
Occupant	Local setpoint adjustment; local on/off control.	Local adjustment knob/display, often wall mounted.
Maintenance engineer	State management.	As building operator; service operator unit, paging device.
Service engineer commissioning eng.	Local configuration according to instruction.	Portable engineering tools e.g.: Portable computer, handheld device, local override/indication device.
NOTE The type of HSI depends on the project specific requirements.		

5.3.5.4   Login/logout

In order to prevent unauthorized commands and changes, a log in password will be required. After a period of inactivity (adjustable) the user shall be automatically logged out.

5.3.5.5   User access control

User access to a system requires a password. Other means of security may be used in addition or instead of, e.g. key cards. Individual identification of an operator is achieved by password according to 5.3.2.8 or by hardware devices as described in ISO 16484-2:2004, 5.2.3.2. j).

The system should have various profiles or levels of user access to distinguish between users of varying competence, e.g. a high-level user such as a building operator may have access to statistics and parameter changes, whereas a caretaker can have read only states shown in Table 2.

5.3.5.6   General information presentation

A user interface shall use a unique common methodology throughout the system to provide an intuitive human system interface.

5.3.5.7   Types of dialogue

5.3.5.7.1   Character based user interface

Character based user interfaces are subdivided into following types:

a)   Command language: The system offers the ability to input a command line at the MOU. The operator can input a command sequence containing a character string with a specific syntax.

b) Command with interactive dialogue: The system offers the ability to guide the operator with system texts and the user can input his command strings after a prompt from the system.

c) Command with interactive menu: The system offers the ability to offer the user a list of dialogues. The user can make a selection from a menu.

Performance criteria:

1) amount of text simultaneously displayed, e.g. 80 characters 25 lines;

2) input (command) verification for correct syntax.

5.3.5.7.2 Graphical user interface

In a system with a GUI the system provides the information to the user in a graphical form. The user may interact using a pointing device, e.g. mouse, to select, and/or the keyboard to type in information. It is recommended that a system with a GUI provide a graphical editor. The time to open a new schematic of given size and to update a given number of dynamic display items is to be stated.

Performance criteria:

1) number of schematics supported by an application;

2) symbols used;

3) scroll, zoom capability;

4) input (command) verification for correct syntax.

5.3.5.8 Accessing information

Data within a BACS is normally accessed by using user addresses as mnemonics to uniquely identify items of information. Where a point name structure is used, it shall be established on the basis of the user's requirements, independently of the technical system structure.

5.3.5.9 Point information presentation

Plant related information is represented by any or all of the following: date and time, user address, state, value and unit, limits, event type and optional text of functions, as stated in the BACS FL

A date/time stamp indicates the last change of state or value. The text describes the state of the function and the meaning of the state, e.g. incoming high limit alarm, state of operation. Additional text, digital voice, or pictures may be assigned and presented upon request by the operator.

The format of the date and time stamp is to be specified, e.g. yy.mm.dd – hh.mm.ss.

Displays should indicate if point states and values are not updated, or are not being refreshed.

Performance criteria:

1) amount of characters for each Item of displayed text;

2) refresh rate for displayed values.

5.3.5.10   State management

The operator will receive information from the system about the current or historical state of the plant in reports with specific dates and times. A status is indicated, where a point or device is inhibited from normal operation by a disable condition.

5.3.5.11   Parameter adjustment

This means switching or changing a value within a plant or system. This task can be supported by a check as to whether the command has been executed or not.

Performance criteria:

⎯ Input (command) verification for correct syntax.

5.3.5.12   Annunciation of alarms

The BACS shall have the ability to provide annunciation of an alarm and bring the information to the immediate attention of an operator.

The type of annunciation shall be specified, e.g.:

a) alarm detail automatically coming to foreground on screens;

b) flashing, change of brightness of visual devices;

c) overriding text messages on MOU.

5.3.5.13   Event management

Information about various events occurring in a plant/the system can be automatically presented at defined output devices without any operator intervention. Some of these events have to be acknowledged by an operator. In these cases the system shall keep the initial information until the operator has acknowledged the given message.

5.3.5.14   Display of trend logs

The display shows one or more selected logged values in x/y plot format against a time base.

Presentation in a sector of the recorded time with:

a) fixed scan time rates;

b) change of value (COV).

Performance criteria:

1) maximum number of different values simultaneously displayed;

2) range of x values;

3) range of y values and state if auto ranging;

4) method used to select y scale values;

5) method used for identification of values;

6) ability to extract more detailed information by e.g. zooming, cursor selection.

5.3.5.15 Time scheduling

Individual time schedule switching is normally a function of the controllers. The possibility of global changes to these schedules can be included within a data processing device, server station, or MOU. The method of entering and changing time entries shall be specified, e.g. by using keyboard/mouse etc.

Performance criteria:

1) the number of time profiles which can be changed as a group;

2) the number of different groups.

5.3.5.16 Analytical and statistical functions

5.3.5.16.1 General

Analytical and statistical functions provide for evaluation of current and historical values. The type of functions available shall be specified, e.g.:

a) calculation of mean, minimum and maximum;

b) correlation calculation;

c) regression calculation.

5.3.5.17 Alarm/event statistics

This function involves the processing of alarm inputs and event messages into some form of statistical report, which can be used to summarize the alarms and events received at an operator display. The analysis includes all of the alarms and events received, or can be a filtered analysis of the results.

5.3.5.18 Consumption statistics

The Consumption statistics function is an energy monitor that can accumulate energy data for set time periods to determine and report the energy used during a specific period.

To fulfill this requirement, the functions run time totalization, calculated values, and the related I/O functions measuring and/or counting, as described in 5.5, are required.

5.3.5.19 Statistical display

The ability to display the results in graphical formats shall be stated, e.g.:

a) trend plot;

b) pie chart;

c) histogram;

d) bar chart, stacked bar charts.

Performance criteria:

1) method used to select information and time periods, e.g. drag and drop of data points;

2) method used to select information by project specific groups;

3) any additional features for analysis of current and/or historical data, e.g. filters;

4) ability to customize reports.

5.3.5.20 Printing

The print content shall be specified as e.g.:

a) messages;

b) alarms;

c) schematics;

d) lists/protocols;

e) trend logs, on line or historic;

f) reports.

The type and quality of printing shall be specified, e.g.:

g) list protocols and/or formatted reports;

h) continuous line printing;

i) screen copy;

j) black and white/color;

k) quality, e.g. draft, letter, graphics.

And the methods of printing shall be specified, e.g.:

l) event triggered;

m) time and date triggered;

n) user initiated.

Performance criteria:

1) printer interfaces/protocols supported;

2) graphic standard supported;

3) print spool ability available.

5.3.5.21 Online help

The system should have a help system included. It shall be stated if a help system is required.

Performance criteria:

1) context based;

2) always available.

5.3.5.22 Electronic handbook

The BACS can contain an electronic handbook. It shall be stated if project specific documentation is to be included.

Performance criteria:

— Navigation method through the electronic handbook, e.g. by hypertext functions.

5.3.5.23 Multilingual operator interface

The degree of translation offered in the product shall be specified as follows:

a) operator entered data in local language;

b) project specific data and parameters in local language;

c) application software prompts and commands in local language;

d) operating system and software environment prompts and commands in local language;

e) possibility of using different languages simultaneously in different MOU's;

f) possibility of switching between languages on line;

g) whether and how new translations can be produced.

5.3.5.24 Remote management/operation functions

The following functions are the minimum requirements for remote management/operation:

a) system management;

b) event management;

c) state management;

d) parameter adjustment;

e) system engineering.

The remote management/operation functions are similar to the described human system interface functions.

Performance criteria:

1) access to current live values and states

2) automatic dial up on demand receipt of alarms;

3) remote graphic capability;

4) remote historical database access;

5) configuration data and program upload/download access, if required.

5.3.5.25 Local operation functions

The occupants of buildings often require the possibility to adapt space conditions (thermal comfort) to their individual needs by means of a local operating device. Since these users are not trained and are not expected to understand the operation of the mechanical building services equipment, in particular the HVAC controls, they are normally granted limited operating capability, such as:

a) manual temperature setpoint adjustment, relative (+/-) or absolute in units;

b) manual operation time extension to extend the present operation of the relevant plant beyond the normal time program;

c)   manually overriding the programmed room occupancy state, for operating mode occupied/unoccupied;

d)   being informed of plant failure by a group alarm indication.

NOTE   For local override and indication refer to ISO 16484-2.

5.3.6   Service and commissioning functions

The service and commissioning engineer shall be able to perform the following tasks by using the operator stations, portable computers, and hand held devices:

a)   verify and maintain application software;

b)   adjust control parameters;

c)   test the communication functions.

It is to specify if manual local override is required. In the case of plant failure, during commissioning or while performing a maintenance task, the components of a HVAC plant can be switched on/off or positioned by means of the manual operation using local override/indication devices,

NOTE   Details for LO/ID as given in ISO 16484-2.

5.3.7   Operating system

The data processing devices, e.g., computer, for monitoring and operation units, operator and server stations use operating system software. This operating system should have multitasking capability, e.g. alarm and history functions are permanently active in the background, a critical alarm shall be able to be brought to the attention of an operator and be displayed within a specified and acceptable time. Several MOU's can be run in parallel either by using a multi-user operating system and/or a network operating system with independent computers.

Other software programs, e.g. spreadsheets, external databases, can interchange data concurrently with the BACS data processing device's software. Proprietary software may be implemented within MOU's based on PC hardware if specified.

The supplier shall state the operating system type and version and the original license provider with respect to the copyright laws.

The functions supported by the data processing device's operating system shall be stated:

a)   management functions;

b)   number of concurrent users supported by the system;

c)   type of HSI, i.e. alpha-numeric/graphics;

d)   system response time permitted for human system interface;

e)   number of I/O, processing and management functions within the capacity of the data processing device(s);

f)   type and number of communication interfaces;

g)   type and number of peripherals and annunciation devices;

h)   any third party application software.

Performance criteria:

1) software environment type and version level;

2) memory and media requirements of the application programs;

3) any capabilities of recognizing and/or auto-correction of functional software faults;

4) database management system(s) supported;

5) any necessary third party application packages required;

6) compatible proprietary networking software;

7) maximum number of concurrent users supported;

8) graphic standard(s) supported;

9) maximum number of communication interfaces supported;

10) maximum number of controllers supported;

11) maximum number of addresses for data points;

12) language(s) for system related messages;

13) editor supplied for configuration changes.

5.4   System engineering programs

5.4.1   General description of the engineering process

This section describes tasks carried out in the process of engineering the various parts of a BACS. The tasks to perform are project/system specific. Further requirements and guidelines for project management and system implementation will be given in Part 7 of this standard.

System engineering includes the following items:

a)   project specific system design

b)   hardware configuration;

c)   control strategy configuration;

d)   management and operator functions configuration;

e)   commissioning;

f)   documentation.

Performance criteria:

1) coexistence of engineering tool/operator functions;

2) engineering tool included in system license;

3) remote engineering via MODEM, LAN, WAN etc.;

4) automatic documentation.

5.4.2 Project specific system design

In this stage the requirements defined by the consultant, plant supplier(s) and the end user specifications are determined for technical clarification and are documented to the final specification.

5.4.3 Hardware configuration

This stage takes input from the final specification process and generates the documentation for describing the equipment/devices required including the wiring diagrams physical parameters.

Hardware configuration includes the following items:

a) control schematic according to Annex B, or plant and instrumentation/flow diagrams according to ISO 10628;

b) a points list to configure the physical modules for binary/analog input/output functions, and as a preparation for the BACS FL with the processing functions to estimate processor performance and memory size;

c) system and network descriptions;

d) equipment lists;

e) Field device diagrams;

f) wiring schedules, network and field connection diagrams;

g) labels for equipment.

Performance criteria:

    1) number of times the same data needs to be entered for different parts of the system;

    2) automatic verification of:

        i) address duplication;

        ii) data point user address duplication;

        iii) correct usage of equipment;

        iv) accuracy of information entered, e.g., by syntax checking.

5.4.4 Control strategy configuration

This stage takes input from the final specification process and generates the input for programming/configuring one or more control strategies to be downloaded into controllers.

Control strategy configuration includes the following items:

a) download files of control strategy;

b) paper listing/drawing of the control strategy;

c) default parameter sets;

d) supplementing the BACS FL with processing functions.

Performance criteria:

1) program methodology;

    i) text based (programming languages),

    ii) graphic based (function block method),

    iii) object oriented.

2) number and type of application library functions available;

3) type of download supported;

    i) all controller/automation station software downloaded as one command,

    ii) partial download into one control device,

    iii) ability to partially download program segments without interrupting other functions running within the control device or on the network,

    iv) time required for download.

4) configuration upload capability;

    i) ability to upload configuration to a programming tool,

    ii) ability to regenerate program source,

    iii) ability to regenerate original source layout and comments,

    iv) ability to compare the upload with the original source.

5.4.5 Management and operator functions configuration

This stage takes the input from the final specification process and generates the input for configuring management functions.

Management and operator functions configuring includes the following items:

a) schematic pictures/graphics with dynamic items linked to point information;

b) alarms including identification of groups, classes and filtering;

c) user access rights;

d) report formats and associated links to data points;

e) system time schedules;

f) completion of the BACS FL with management and operator functions.

Performance criteria:

1) ability to input graphics/drawings generated on third party applications;

2) libraries supported;

    i) basic HVAC graphic symbols,

    ii) graphic symbols for HVAC plant items,

    iii) model building templates,

    iv) report templates.

3) ability to use data entered in previous engineering processes, e.g. user addresses/mnemonics of data points;

4) time schedule entry;

    i) text based,

    ii) graphic based,

    iii) diary oriented,

    iv) copy facilities.

5.4.6 Commissioning tool

Commissioning tools should support the following tasks:

a) field equipment and hardware connection checks;

b) communication system test and protocol analysis;

c) control strategy simulation/verification;

d) control strategy download and parameter initialization;

e) functional verification by plant operation and interlock simulation;

f) optimization/tuning of the parameters.

Performance criteria:

1) the ability to temporarily override values/states and parameters in the control strategies;

2) the ability to observe the behavior of the system through single program cycles.

5.5 BACS function types

5.5.1 General requirements for BACS functions

The normative descriptions of BACS function types within this section are provided for specifying the required engineering services for a BACS. The informative examples are provided to demonstrate methods for creating accurate functional documentation for a project.

For each project design, the types and the number of required functions are to be determined to ascertain the required application software and engineering work. The BACS FL (annex A) is a tool for determination and adding up the project specific functions. The basis for working with the BACS FL is the plant control schematic.

For data point identification in BACS there is a need for a unique structured addressing system. This has to apply throughout a plant, a complete BACS, or the entire customer premises.

Functions of derived (virtual) data points shall be assigned to a dedicated point name (or mnemonic) in a row of the BACS FL. Its remarks column may indicate the derived functions to each related data point, if necessary.

Events that cause safety functions to be performed shall be specified. It is necessary to determine whether or not actuator safety positions have to be ensured without auxiliary energy.

NOTE   For further performance criteria for actuators and electrical switchgear refer to 5.4.5 in ISO 16484-2:2004.

For each input and output function (physical and shared/communication) the following interlocking conditions and decisions for priorities shall be stated where applicable:

a)   automatic mode driven from a control device;

b)   manual override mode from an operator station in the management network;

c)   manual override mode from MOU in the control network;

d)   manual external override mode issued at a field device as a signal source, e.g. comfort mode extension switch or day extension switch;

e)   local manual override mode issued from an LOID;

f)   override mode by function of safety equipment, e.g. frost-protection temperature limiter.

Performance criteria:

⸺   Fault detection, e.g.: cable open/short circuit.

5.5.2   I/O function types

5.5.2.1   General

Input and output functions include all necessary software programs and engineering, commissioning, documentation, and user instruction services for recognizing the values and states of analog and binary inputs and commanding of positioning and switching outputs and for shared data points. The I/O function's information is available for further processing by all other BACS functions.

This I/O function parameters include e.g. data point address, sensor characteristic and range, S.I. unit, state and associated status descriptions, text and parameter assignments, but not the communication protocol for shared data points.

5.5.2.2   Physical input and output function types

5.5.2.2.1   Binary output switching/positioning

5.5.2.2.1.1   Switching

The physical output function switching comprises single stage (on/off) or multi stage commands. They are output as maintained-contact (steady state) or momentary-contact (pulsed) signals via physical binary outputs (BO).

Each switching function shall be specified by entering the quantity of stages in the BACS FL, see table 3.

Table 3 — Switching functions for maintained and momentary contact control

	Type of switching function	Stages of switched equipment	Number of switching functions and corresponding hardware outputs
1.	Steady state output for maintained contact control	1	1 BO
2.	Pulsed signal output for momentary contact control	1	2 BO
3.	Steady state output for maintained contact control	2	2 BO
4.	Pulsed signal output for momentary contact control	2	3 BO

Feedback or check back signals which logically belong to the switching commands as well as the local/remote switch or LO/ID information are to be specified in the column binary input state (Col. 1.3).

If required, the command execution check (Col. 3.5) has to be specified as a corresponding processing function.

5.5.2.2.1.2   Positioning

The physical function output positioning comprises either two binary on/off outputs (BO) in case of 3-point control or a single binary output (BO) in case of pulse width modulation, see table 4.

Table 4 — Binary output functions for positioning

	Type of positioning function	Number of positioning functions and corresponding hardware outputs
1.	Opening - stopped - closing	2 BO
2.	Pulse width modulation	1 BO

Feedback signals which logically belong to positioning commands as well as the local/remote switch or LO/ID information are to be specified in the column analog input measuring (Col. 1.5).

Feedback or check back indication of the fully open or fully closed positions shall be specified via binary input state functions.

5.5.2.2.2   Analog output positioning

The physical analog output function positioning converts analog positioning commands derived from processing, management, and operator functions to physical analog outputs (AO).

Feedback signals which logically belong to positioning commands as well as the local/remote switch or LO/ID information are to be specified in the column analog input measuring (Col. 1.5).

5.5.2.2.3   Binary input state

The physical function binary input state (BI) comprises binary coded digital information that is acquired via a physical binary input (BI). It provides information depending upon the defined state text. This function is not intended for system internal diagnostic messages.

Any binary pulse input that requires a fast response from the system shall be specified to ensure that the system will perform without missing events. Alarm signals should be configured to ensure a high degree of integrity i.e. a 'normally closed' loop is preferred so that accidental open circuits can be detected.

For dual state points a pair of binary inputs connected to separate on and off contacts from electrical switchgear is used to detect intermediate positions (or virtual exclusive-OR messages via command execution check).

Where change of state processing (Col. 3.6) is required, e.g. for event delay/suppression, Boolean logic in any plant condition, the function shall be specified.

The BACS FL should indicate other corresponding functions in the same row.

5.5.2.2.4   Binary input counting

The physical function binary input counting comprises processing and totalizing of pulses via physical counter inputs (CI) or binary inputs (BI). A facility for resetting the totalized value shall be provided.

The BACS FL should indicate other corresponding functions in the same row, e.g. a limit function.

Performance criteria:

— The function has to operate as a forward counter with a minimum totalizing range of 2^{16} (16 bit/5 digits) or 2^{32} (32 bit/10 digits) depending on the application. The value range is to be specified within each project.

5.5.2.2.5   Analog input

The physical function analog input comprises analog value information, derived from measured signal information from analog sensors. This includes the processing of physical position values, which logically belong to positioning commands.

The BACS FL should indicate other corresponding functions in the same row.

5.5.2.3   Input and output function types for shared data points

5.5.2.3.1   General

Input output functions for shared data points provide the mechanism for accessing virtual data points within different installers sub-systems of an integration project. The points are identified by a unique point address.

These I/O functions for shared data points make it possible to define the assignment of data points and functions to third party systems or DSS providing the exchange of data e.g. via a DIU or a network. For communication with devices or stations for management functions refer to 5.5.4.

Shared data points can be the result of a calculation and/or a logical result that needs to be communicated between systems, e.g. consumption from a boiler or chiller.

It shall explicitly be specified where peer-to-peer functionality between devices of distinct installers is required. The detail of the required interoperability for shared data points is to be specified in conformance with the selected communication protocol, see ISO 16484-5.

5.5.2.3.2   Binary output value, switching

The binary value output function for switching comprises a single or multi stage command, which is transferred as a task to processing or physical I/O functions in a distinct system, according to the project specific requirements.

5.5.2.3.3 Analog output value, positioning/setpoint

The analog value output function for positioning/setpoint comprises a positioning command or a setpoint value which is transferred as a task to processing or physical I/O functions in a distinct system, according to the project specific requirements.

5.5.2.3.4 Binary input value, state

The binary value input function for state monitoring provides the information about the change of a binary or a multi state input which is transferred from a distinct system.

The BACS FL should indicate other corresponding functions in the same row.

5.5.2.3.5 Accumulated/totalized input value

The input accumulated/totalized value function provides the information about an accumulated or totalized value, which is transferred from a distinct system.

The BACS FL should indicate other corresponding functions in the same row.

5.5.2.3.6 Analog input value, measuring

The analog input function for measuring provides the information about an analog value which is transferred from a distinct system.

The BACS FL should indicate other corresponding functions in the same row.

5.5.3 Processing function types

5.5.3.1 General

Processing functions provide logical or digital output values. Other functions can use these values as an input.

5.5.3.2 Monitoring function types

5.5.3.2.1 General

These processing functions are used to monitor input and output functions or the results of processing functions for defined criteria.

5.5.3.2.2 Fixed limit

The function fixed limit compares the measured or totalized input value with a high and/or low limit value under consideration of a hysteresis. Totalized values only are compared with high limit values. If limit is exceeded, the function causes an appropriate output signal. The limiting value and the hysteresis value have to be parameterized with the same unit as the input value.

Each limit monitoring function shall be specified by entering the quantity of limits in the BACS FL.

Graphical function description: fixed limit:
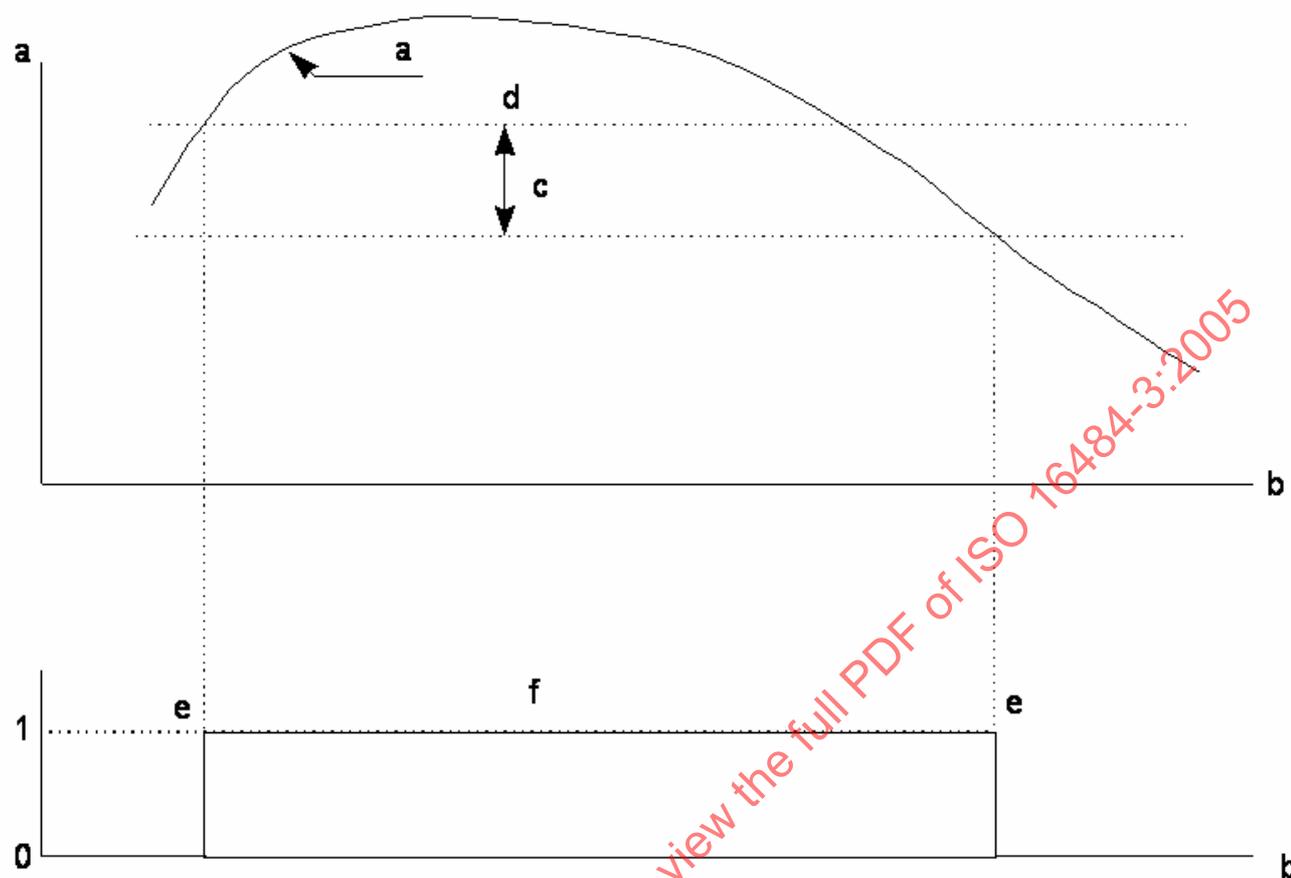
Key

a	Input value	d	High limit value
b	Time	e	Event
c	Hysteresis	f	High limit value reached

Figure 1 — Fixed limit function

Table 5 — Informative FB example (for fixed high/low limits):

Graphical FB representation

Inputs

                Real

Input value   ---------

Parameters

                Real

High limit value ---------

                Real

Low limit value ---------

                Real

Hysteresis ---------

Fixed limit

IV   HLVR

              LLVR

HLV

LLV

HYS

Outputs

Bool

------- High limit value reached

Bool

------- Low limit value reached

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
IV	Real	Input value	Phys. value
Outputs			
HLVR	Bool	High limit value reached	
LLVR	Bool	Low limit value reached	
Parameters			
HLV	Real	High limiting value	Phys. value
LLV	Real	Low limiting value	Phys. value
HYS	Real	Hysteresis	Phys. value

NOTE   Explanation of the example:
This function checks the input value, and provides an indication of when it exceeds the high or low limit value. Hysteresis is used to avoid the oscillation of the output signals when the input value fluctuates around a limiting value. If two, or more high/low limits are demanded for a common input value this function can be used two or more times. A more complex function block with additional limit parameters and corresponding outputs can be used for graphical display.

5.5.3.2.3   Sliding limit
(in some countries: floating limit)

The sliding limit function compares the measured input value with a variable high and/or low limit value depending on a different value, e.g. the setpoint of the corresponding closes loop control function. A hysteresis is to be considered. If limit is exceeded, the function causes an appropriate logic output. The sliding limiting value and the hysteresis value have to be parameterized with the same unit as the input value.

Each limit monitoring function shall be specified by entering the quantity of limits in the BACS FL.

Graphical function description: sliding limit
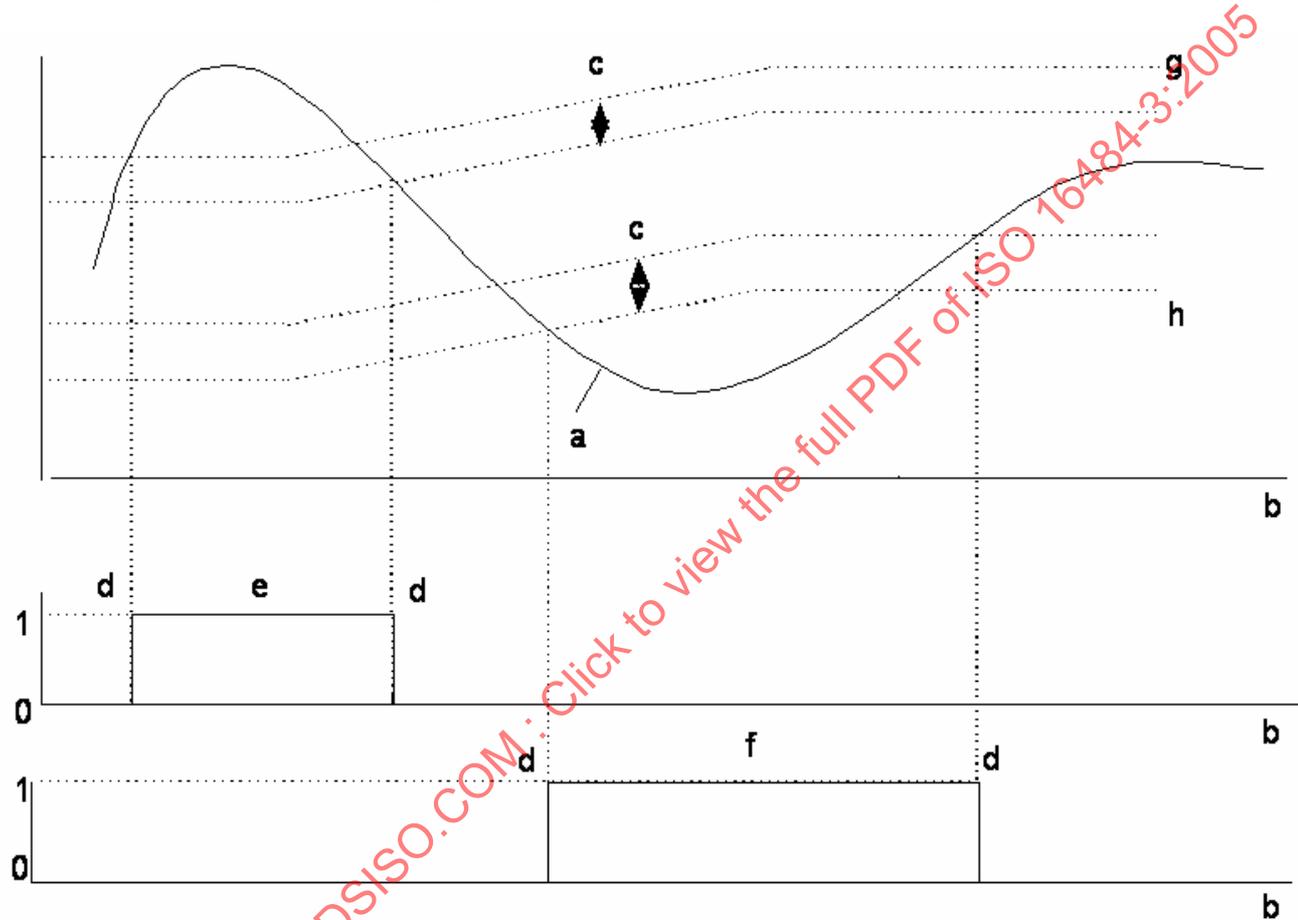
Key

a	Input value	e	High limit value reached
b	Time	f	Low limit value reached
c	Hysteresis	g	sliding setpoint value + high limit offset
d	Event	h	sliding setpoint value – low limit offset

Figure 2 — Sliding Limit Function

Table 6 — Informative FB example (sliding limit)

Graphical FB representation

Inputs					Outputs
	Real	**Sliding limit**		Bool	
Input value	---------	IV	HLVR	--------	High limit value reached
				Bool	
Sliding setpoint value	---------	SSPV	LLVR	--------	Low limit value reached
Parameters					
	Real				
High limit offset	---------	HLO			
	Real				
Low limit offset	---------	LLO			
	Real				
Hysteresis	--------	HYS			

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
Iv	Real	Input value	Phys. Value
SSPV	Real	Sliding setpoint value	Phys. Value
Outputs			
HLVR	Bool	High limit value reached	
LLVR	Bool	Low limit value reached	
Parameters			
HLO	Real	High limit offset	Phys. Value
LLO	Real	Low limit offset	Phys. Value
HYS	Real	Hysteresis	Phys. Value

NOTE   Explanation of the example:
This function checks the input value and indicates when a sliding limit value has been reached. Sliding limit values are defined as a sliding setpoint value plus high limit offset, minus low limiting offset. Hysteresis is used to avoid the oscillation of the output signals when the input value fluctuates around a limiting value. Hysteresis operates in the opposite direction to the setpoint and offset combined. E.g. for the high limit offset, the output stays set until the input has returned to a value less than high limit hysteresis.

5.5.3.2.4 Run time totalization

The run time totalization of a plant or an item of equipment, i.e. Boiler, chiller, pump, etc., is calculated by monitoring its start/stop states and the on duration is accumulated to the past totalized value as information for a virtual function counted value. It shall be possible to pre-set the starting value.

For limit monitoring of run time, if required, the fixed limit function (col. 3.1) is to be specified.

Performance criteria:

1)   Maximum totalized value possible;

2)   The accuracy of the totalized value.

Table 7 — informative FB example (run time totalization)

Graphical FB representation

Inputs		Run time totalization		Outputs	
	Bool			Real	
Start/stop state	--------- SSS		RTV	--------- Run-time value	
	Bool				
Reset	--------- RS				
Parameters					
	Real				
Starting value	--------- SV				

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
SSS	Bool	Start/stop state	
RS	Bool	Reset (set the current count to starting value)	
Outputs			
RTV	Real	Run time value	h
Parameters			
SV	Real	Starting value	h
NOTE Explanation of the example: This function calculates the run time of an item of equipment. The totalized run time is available as an output value. A starting value parameter and a signal on the reset input sets the run time to an initial value.			

5.5.3.2.5 Event counting

For event counting the number of events is calculated by accumulating the changes of state of the corresponding input information. to virtual totalized value. This function is used to count relevant events according to the project specific requirements, e.g. alarm messages, state information, and limit violations. It shall be possible to pre-set the starting value.

For limit monitoring of event counting, if required, specify the fixed limit function (Col. 3.1).

Performance criteria:

⎯ maximum count value possible.

Table 8 — Informative FB example (event counting)

Graphical FB representation			

Inputs		**Event counting**	**Outputs**
	Bool		Real
Event input	-------- EV	PCV	-------- present count value
	Bool		
Reset	-------- RS		
Parameters			
	Real		
Starting value	-------- SV		

FB example abbreviations			
Name	**Type**	**Description**	**Unit/symbol**
Inputs			
EV	Bool	Event	
RS	Bool	Reset.	
Outputs			
PCV	Real	present count value	h
Parameters			
SV	Real	Starting value	h
NOTE Explanation of the example: This monitoring function counts events. An event is a logic change of state on the event input. The direction of the change is to be specified. A starting value parameter and a signal on the reset input set the count to an initial value.			

5.5.3.2.6 Command execution check

For command execution check the execution of switching commands and positioning commands within a set time is monitored. An error message/alarm/signal is given after expiry of the set time if a feedback, check back or inhibit signal has not been effected. Inputs and outputs to this function block can be positive or negative logic. Whichever logic is chosen shall be stated.

This function shall be listed in the BACS FL per check back/feedback of the corresponding controlled output function. For virtual exclusive-OR monitoring of dual state points from electrical switchgear this function is required once per state (on and off).

Performance criteria:

1) minimum/maximum and resolution of set time;

2) logic polarity combinations.

Table 9 — Informative FB example (command execution check)

Graphical FB representation		
Inputs	**Command execution check**	**Outputs**
Command state ---------	Bool CS	Bool CNE --------- Command not executed
Command execution check back ---------	Bool CER	
Parameters		
Command execution check time ---------	Real CECT	

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
CS (PSV)	Bool (Real)	Command state (position/setpoint value)	
CER	Bool (Real)	Command execution check back	
Outputs			
CNE	Bool	Command not executed	
Parameters			
CECT	Real	Command execution check time	s
NOTE Explanation of the example: This function is used when a plant or part of a plant is to be switched on/off, or when a positioning/setpoint value is to be changed as a function of an event or time program. The new command state/value initiates a check of command execution function. If there is no check back/feedback signal within the command execution check time (CECT), a command not executed output (CNE) is provided for further processing (e.g. for alarm message).			

5.5.3.2.7 State processing

State processing includes any form of processing involving the conditional production of a logic output state as a consequence of a delay, suppression, or logical interlock.

The state processing function comprises:

a) logical interlock,

> EXAMPLE   Common alarm generation from a number of data point inputs.

b) change of state delay,
    used to disregard any action from the data point input, unless the input signal is sustained for a pre-set time;

c) change of state suppression,
    used to inhibit the propagation of an input change of state according to the state of other input functions, during defined real time or elapsed time. The time parameters are adjustable.

> EXAMPLE   Message suppression during main power restoration, or at off- state of a plant.

Each state processing function shall be listed in the BACS FL corresponding to the data point input function by the number of each type. If required, the type can be indicated in the remarks column using a), b), c).

Table 10 — Informative FB example (state processing)

Graphical FB representation				

Inputs

		State processing		Outputs
Point state 1	Bool ---------	PS1	Bool OS ---------	Output state
Point state n	Bool ---------	PSn		
Program enable	Bool ---------	PEN		

Parameters

Processing parameter	Real ---------	PP	

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
PS1 PSn	Bool	Point state (of a physical or virtual point)	
PEN	Bool	Program enable (may disable the output change of state generation)	
Outputs			
OS	Bool	Output state (generated by the processing function)	
Parameters			
PP		Processing parameters (customizing the behavior of the function)	
NOTE Explanation of the example: This function is used wherever further processing of inputs is depending on conditions.			

5.5.3.3   Interlock function types

5.5.3.3.1   General

In general, interlock functions require logic to derive output signals, which are some combination of a number of input signals.

The functions required to achieve this are in general made up from AND, OR, XOR, NOT. It is expected that these functions and timer delay functions are available for general program design, and are used by the more complex interlock functions described in the remainder of this sub clause.

Performance criteria:

1)   number of input signals to be combined;

2)   type of logical functions supported;

3)   number of logical links possible.

5.5.3.3.2   Plant control

The processing function plant control generates a control sequence for switching on or off the separate items of plant in a predefined sequence depending on the application, e.g. start up control. This action is necessary to protect damage to equipment.

All operating modes, input/output and processing functions and parameters, as well as parameters, e.g. pre set times; setpoints and events invoking safety control functions, which are for a specific plant, shall be considered when designing the overall plant control function. Each complex plant control sequence, including all operating modes, is to be specified in a verbal form, and if required, in a control flow chart form, and shall be listed in the BACS FL, Col. 4.1, per corresponding/controlled plant.

An operator function, time schedule function or further optimization functions can activate or enable a plant control function. But the optimization function event switching is intended for cross plant/system events only, it is not intended to be used for plant internal interlocks.

Example for plant control:
Normally after switching on, a sequence of commands such as open dampers, start pumps and fans, and enabling controllers, is performed. Variations of a sequence can be automatically initiated depending on variables, e.g. if the outdoor temperature is below a low limit, the pre heater pump starts first and the heating controller is activated.

NOTE   See examples in annex B.

5.5.3.3.3 Motor control

Motor control is a processing function for switching an electric drive. It includes all the necessary interlocks for considering conditions as with emergency off switching, plant control sequence, start/stop feedback, fan belt check, drive/device related timing and LO/ID's. The outputs of a motor control function can act on multiple physical binary switching functions to provide speed control.

This function is not used for positioning actuators.

If motor control is dedicated to a water pump, an internal blocking protection feature is a part of this function (periodic short on commands).

The star/delta starter is not a part of this function.

The number of stages is to be stated in the BACS FL under Col. 1.1, see Annex A, Note 1).

Table 11 — Informative FB example (motor control)

Graphical FB representation				
Inputs		**Motor control**		**Outputs**
Motor release interlock	Bool -------- MRI		MSS	Bool -------- Motor start/stop
Motor electrical fault	Bool -------- MEF		MS	Bool -------- Motor state
Start/Stop check back	Bool -------- SSF		MA	Bool -------- Motor alarm
Manual override	Bool -------- MOR			
Parameters				
Delay time	Real -------- DT			

FB example abbreviations			
Name	**Type**	**Description**	**Unit/symbol**
Inputs			
MRI	Bool	Motor release interlock	0/I
SSF	Bool	Start/stop check back	
MEF	Bool	Motor elec. fault (e.g. bimetal)	
MOR	Bool	Manual override	
Outputs			
MSS	Bool	Motor start/stop	
MS	Bool	Motor state	
MA	Bool	Motor alarm	
Parameters			
DT	Real	Delay time	s
NOTE Explanation of the example: The motor is switched on as a result of an event, e.g. start up control. The start/stop check back signal indicates that the motor is running. If there is a signal to indicate that the motor has failed, the motor start/stop output will be switched to off.			

5.5.3.3.4 Switch over

Identical devices such as twin or double pumps or compressors are switched over depending on a pre-set run time/schedule and/or event, e.g. a failure. The purpose of the function switchover is to achieve specific/similar run times for the associated devices.

This function is to be combined with e.g. time dependent switching, runtime totalization limit, interlocks (state processing) and motor control, as required. This function can be used to define the priorities, e.g. for boiler sequencing, chiller sequencing.

This function shall be listed in the BACS FL per corresponding/controlled device.

Table 12 — Informative FB example (switch over)

Graphical FB representation

Inputs		Switch over		Outputs
	Real	RD1	D1R Bool	Device 1 release
Runtime device1	---------		---------	
	Real	RD2	D2R Bool	Device 2 release
Runtime device2	---------		---------	
	Real	FD1	R1R Bool	Runtime 1 reset
Failure device 1	---------		---------	
	Real	FD2	R2R Bool	Runtime 2 reset
Failure device 2	---------		---------	
Parameters				
	Real	RL		
Runtime limit	---------			

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
RD1	Real	Runtime total of device 1	h
RD2	Real	Runtime total of device 2	h
FD1	Bool	Failure of device 1	
FD2	Bool	Failure of device 2	
Outputs			
D1R	Bool	Release of device 1	
D2R	Bool	Release of device 2	
R1R	Bool	Reset of runtime device 1	
R2R	Bool	Reset of runtime device 2	
Parameters			
RL	Real	Runtime limit	h
NOTE Explanation of the example:			
After a predefined runtime the function switches over the operation from device 1 to device 2. If a failure occurs (FD1/FD2), the function switches over to the other device.			

5.5.3.3.5   Step control

When two or more devices operate together load depending to meet demand, they can be step controlled via on/off thresholds. The step control sequence can be influenced by other parameters, e.g. the individual device rating, hysteresis, and times. This control type also is referred to as multistage if applied to one device.

This function is to be combined with e.g. time dependent switching, runtime totalization limit, interlocks (state processing) and motor control, as required. For step control of plants also with the processing functions optimization, as e.g. event switching.

This function shall be listed in the BACS FL per corresponding/controlled device.

Table 13 — Informative FB example (step control)

Graphical FB representation		
Inputs	**Step control**	**Outputs**
Load value — Real ——— LV	D1R	Bool ——— Device 1 release
On/off period — Bool ——— OOP	D2R	Bool ——— Device 2 release
Parameters		
Rating device 1 — Real ——— RD1		
Rating device 2 — Real ——— RD2		
Hysteresis — Real ——— HYS		

FB example abbreviations			
Name	Type	Description	Unit/symbol
Inputs			
LV	Real	Load value	kW
OOP	Bool	On off period	
Outputs			
D1R	Bool	Device 1 release	
D2R	Bool	Device 2 release	
Parameters			
RD1	Real	Rating device 1	kW
RD2	Real	Rating device 2	kW
HYS	Real	Hysteresis	kW
NOTE Explanation of the example: In this function block example the devices are switched on as a function of the load value and hysteresis when the plant is in an on mode. Devices are e.g.: boilers, chillers, pumps and AHUs.			

5.5.3.3.6   Safety/frost protection control

In this clause the essential criteria for safety control is the latching and locking facility set by an event. In case of several different safety control functions are involved within one plant; they shall be specified. As BACS function type the safety control is subdivided in:

a)   Safety control
is a function with a latching and locking/reset facility for switching a plant or part of a plant into a pre-defined and safe or protected state in order to avoid damage to the plant or building, and in specially specified cases to prevent harm to people. This function is triggered, e.g. by a pressure, temperature, or humidity limiter.
An acknowledge facility for reset shall be provided. If required, an operator shall manually instigate the reset.

EXAMPLE   This function can be set by a pressure, temperature, or humidity limiter.

b)   Frost protection control
is a safety control function for switching all relevant parts of a plant into a pre-defined state to avoid frost damage. It is triggered by a specific frost thermostat or if the measured temperature drops below a limit. Software latching and locking/reset requirements shall be specified for each project. If required, an operator shall manually instigate the reset. Frost protection control should remain active if the plant is switched off by a processing function. If the plant is switched off by manual override or power failure, then it shall be specified whether and how frost protection control will remain active.

This function shall be listed in the BACS FL per corresponding input function.

5.5.3.4   Closed loop control function types

5.5.3.4.1   General

Processing functions for closed loop control mainly process analog input functions and virtual functions. Other function types can use the results of these functions.

Closed loop control results from an algorithm, e.g. P, PI, PID, that requires feedback of the controlled variable (actual value) from the controlled medium, e.g. if temperature is being controlled to a setpoint (reference variable), the actual temperature value is fed back to the algorithm which will then decide to increase or decrease the manipulated variable for heating/cooling supply depending on the difference (error) between the feedback variable and the reference variable.

Each closed control loop includes one setpoint.

To define a complete control loop in the BACS FL, the combination of a P control loop or PI/PID control loop function and at least one control loop output function, e.g. proportional output stage, is necessary. Other functions can be combined as required.

For cascade control a process value is controlled by means of a master control loop function and one or more slave control loop functions. The output variable of the master control loop is used as setpoint input (reference variable) to the slave control loop.

In the BACS FL an on/off controller requires one processing function P/PI-control loop and additionally one proportional to on/off conversion function.

A 3-point controller (e.g. heating/cooling) requires two proportional to on/off conversion functions.

It shall be possible for the setpoint parameter to be changed via a MOU whilst in active operating mode.

5.5.3.4.2   P control loop

Proportional control provides an output that is proportional to the corresponding variation of the controlled variable under consideration of the error variable. The error variable results from the difference between the reference variable and the feedback variable (controlled variable). The level of the output depends on the value of the proportional action coefficient P.

The P control loop function includes a fixed setpoint and the associated parameters; it will combine with at least one output conversion function.

5.5.3.4.3   PI/PID control loop

a)   The proportional and integral control algorithm is the same as the P algorithm but with the influence of a function which alters the rate of change (time derivative) of the output variable proportional to the corresponding value of the input variable (controlled variable).

b)   The proportional, integral and derivative control algorithm is the same as the PI algorithm but with the additional influence of a function which alters the output variable proportional to the rate of change (time derivative) of the input variable (controlled variable).

The PI/PID-algorithm control loop functions include a fixed setpoint and the associated parameters and will combine with at least one output conversion function.

5.5.3.4.4   Sliding setpoint/curve setpoint
(in some countries: floating setpoint)

The sliding/curve setpoint function is used in closed loop control. The current setpoint value is defined by the magnitude of an input signal and/or a calculated function.

EXAMPLE 1   Sliding setpoint, summer compensation: This function provides a means to avoid thermal shock to the building occupants and save energy. The room temperature setpoint is linearly increased, starting from a predefined outdoor temperature value, the starting point.

EXAMPLE 2   Curve setpoint, winter compensation: This function provides a means to vary the temperature depending upon the outside temperature. The present setpoint of the heating supply temperature is calculated or defined by a reset schedule.

It shall be possible for a setpoint parameter and/or for the shape of the curve of the reset schedule to be changed via a MOU whilst in operation mode.

A setpoint limitation has to be specified by a separate setpoint/output limitation function.

Performance criteria:

1)   number of steps for the reset schedule;

2)   Setpoint calculation.

Graphical function example: sliding setpoint/curve setpoint:
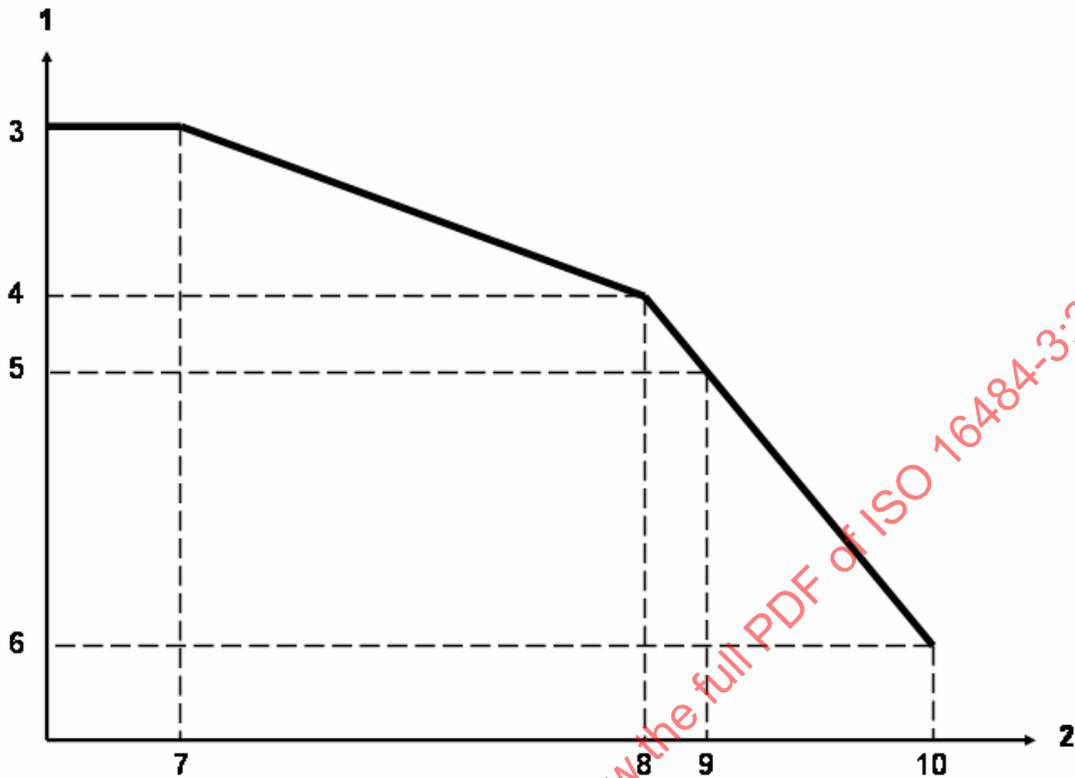
Key

1	Heating supply temperature	6	Setpoint 3
2	Outdoor temperature	7	Outdoor temperature 1
3	Setpoint 1	8	Outdoor temperature 2
4	Setpoint 2	9	Present outdoor temperature
5	Present setpoint	10	Outdoor temperature 3

Figure 3 — Setpoint curve function

5.5.3.4.5 Proportional output stage

The proportional output stage function converts the output value of a controller function into one of n virtual values when load sequencing is required. One output function can be split into two or more outputs with the magnitude and co-efficient defined.

Sequence control outputs are specified by 2 or more proportional output stages, each output stage shall be stated in the BACS FL.

Graphical function example 1: damper/valve sequence
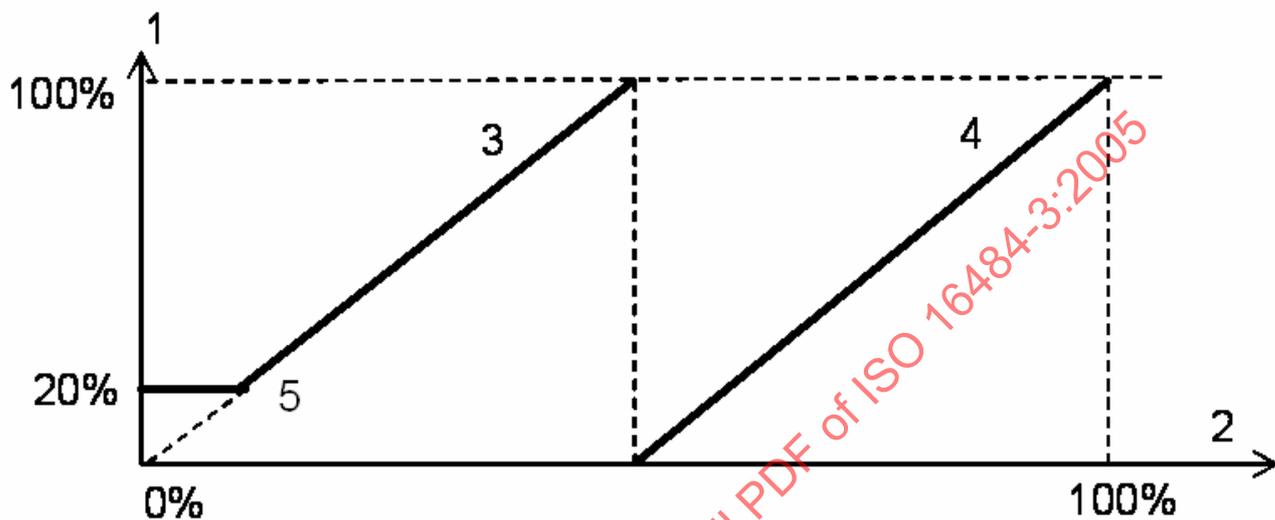
Key

1   Actuator position
2   Control loop algorithm output value
3   Output stage 1
4   Output stage 2
5   Output Limitation see 5.5.3.4.8

Figure 4 — Two proportional output stage functions for damper/valve sequence

Graphical function example 2: cooling/heating sequence
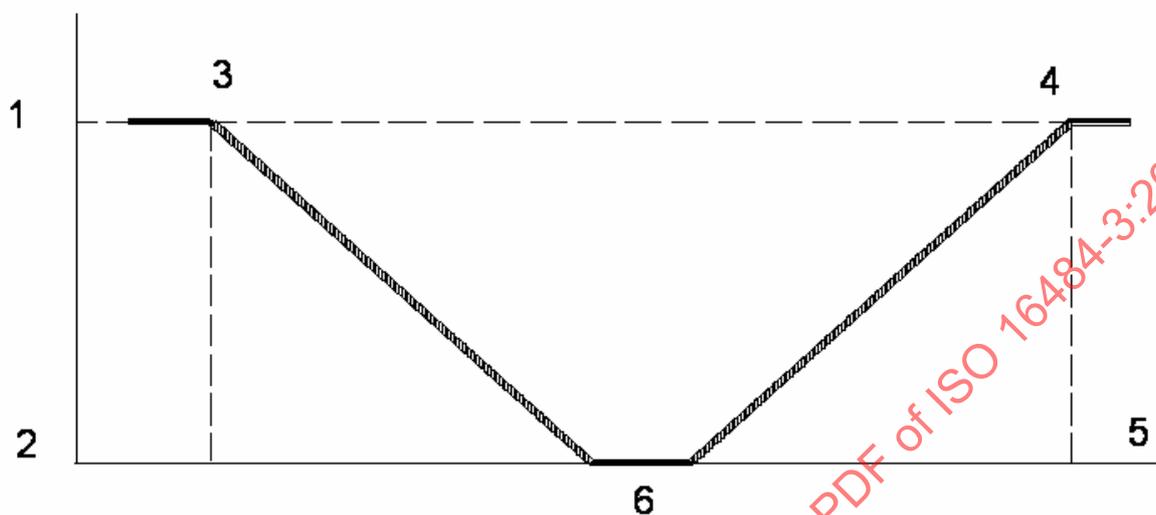
Key

1 Open
2 Closed
3 Cooling valve position
4 Heating valve position
5 Output in %
6 Dead zone

Figure 5 — Two proportional output stage functions for cooling/heating sequence

5.5.3.4.6   Proportional to on/off conversion

The proportional to on/off conversion function converts the output value of a controller function into a binary value for the output function switching/positioning. The conversion is done depending upon a conversion setpoint and hysteresis.

Graphical function example 1: on/off conversion
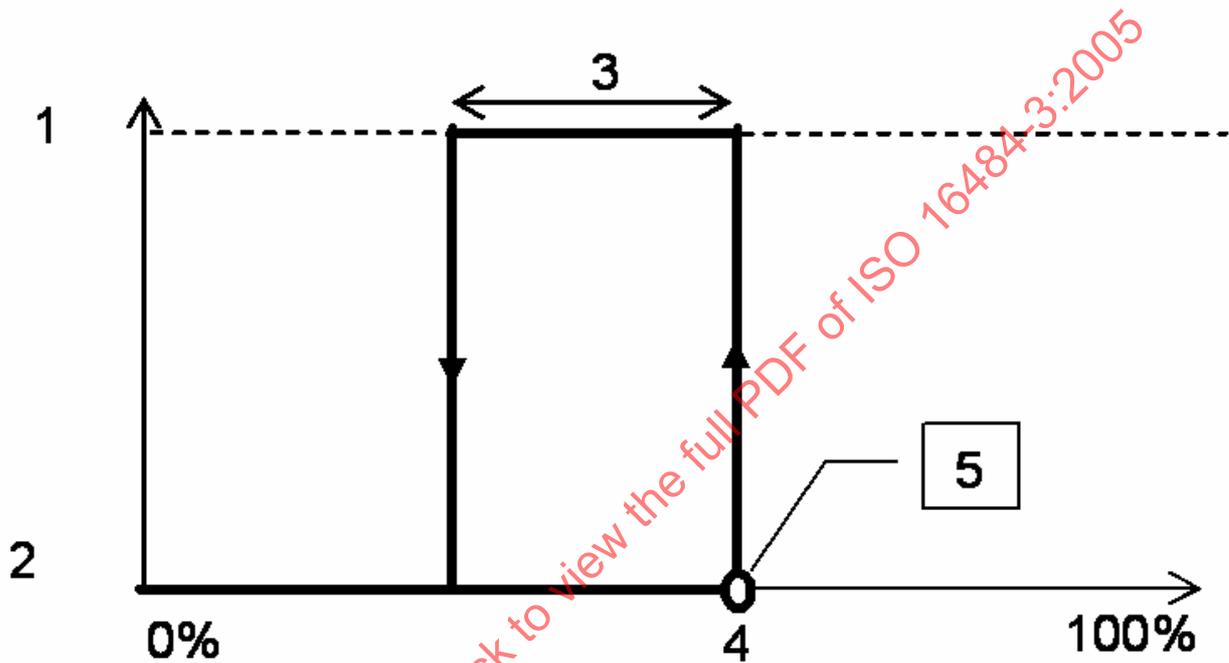
Key

1   On
2   Off
3   Hysteresis
4   Controller output value
5   Conversion setpoint

Figure 6 — On/off conversion

Graphical function example 2: two on/off conversions for 3-point control
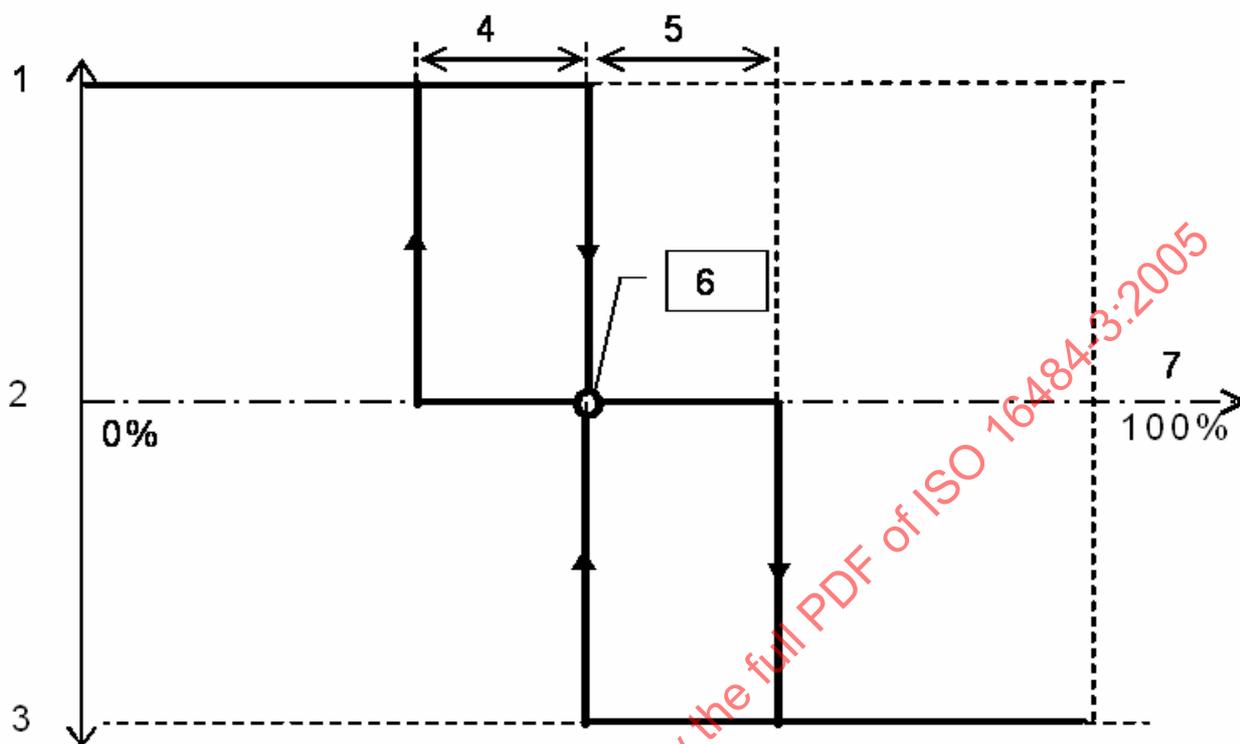
Key

1   On 1
2   Off
3   On 2
4   Hysteresis 1
5   Hysteresis 2
6   Conversion setpoint 1 and 2
7   Control loop algorithm output value

Figure 7 — Two on/off conversions for 3-point control

Table 14 — Informative FB example (on/off conversion)

Graphical FB representation

Inputs		On/off conversion		Outputs
Input value	Real ---------	IV OOS	Bool ---------	On/off state
Parameters				
Setpoint	Real ---------	SP		
Hysteresis	Real ---------	HY		

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
IV	Real	Input value	Phys. value
Outputs			
OOS	Bool	On/Off state	0/1
Parameters			
SP	Real	Setpoint value	%
HY	Real	Hysteresis	%

NOTE   Explanation of the example:
In this function block example the output value of a control loop function is converted into on/off states as a function of the internal triggering value (the setpoint for this conversion) and a hysteresis. The output of this function can control a physical or shared output function.

5.5.3.4.7   Proportional to pulse width modulation

The proportional to pulse width modulation function converts the output value of a controller function into pulses with a variable mark/space ratio that depends on the magnitude of the input value (the controller function output variable).

Example: the control of electro thermal actuators or electric heaters.

5.5.3.4.8   Setpoint/output limitation

The setpoint and/or output limitation function is used to limit an output value of a controller (manipulated variable) to an upper and/or lower limit value, e.g. to ensure a minimum fresh airflow rate. This function may be overridden by safety functions, e.g. frost protection control.

Each function setpoint/output limitation shall be specified by entering the quantity of limits in the BACS FL.

Table 15 — Informative FB example (setpoint/output limitation)

Graphical FB representation

Inputs		Setpoint/output limitation		Outputs	
	Real		Real		
Variable setpoint value	--------	VSPV	CLSP	--------	Current limited setpoint
Parameters					
	Real				
Low setpoint limit	--------	LSPL			
	Real				
High setpoint limit	--------	HSPL			

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
VSPV	Real	Variable setpoint value	Phys. value
Outputs			
CLSP	Real	Current limited setpoint	Phys. value
Parameters			
LSPL	Real	Low setpoint limit	Phys. value
HSPL	Real	High setpoint limit	Phys. value
NOTE Explanation of the example: This function block example implements a high and a low limit to the setpoint value.			

5.5.3.4.9   Switchover of parameters

The switchover of parameters function is used to modify the control loop parameters to optimize the control action depending on e.g. reaching a predefined value of the error variable (deviation), a valve position, an event.

5.5.3.5   Calculation/optimization function types

5.5.3.5.1   General

The processing functions calculation/optimization are implemented as pre-configured BACS application software not requiring project specific programming but parameters and commissioning.

a)   The calculation functions are used to calculate derived values for other functions and to provide complex data to a user to enable a consequential decision.

b)   The optimization functions cannot take the place of the basic monitoring, interlock and control functions described in 5.5.3. Optimization functions are used for cross plant or cross system energy management to reduce energy consumption and operating costs. For adaptation to varying application needs, the optimization functions have to be provided with adjustable parameters that give the flexibility for trained users to cope with varying types of building use and construction. Optimization needs commissioning additional to the normal operation of the controlled plants.

5.5.3.5.2   h,x- directed control strategy

The h,x- directed control strategy function provides output values for an energy optimized method of conditioning outdoor air. A calculation determines the required supply air values to achieve the specified room temperature and relative humidity. Employing an h,x- diagram, or psychrometric chart, the calculation determines the values of temperature and humidity within a comfort field.

This function shall be listed in the BACS FL with each of the corresponding input data points, e.g. temperature and humidity of outdoor air, supply air, return air/room.

5.5.3.5.3   Arithmetic calculation/high-low value selection

The arithmetic calculation function provides an output value available for use in other functions. It is the arithmetic combination of any number of input variables. The calculation result is presented in a virtual data point which has its own data point address/mnemonic.

This function also provides for a high or low value selection to pass through the higher or lower value of two inputs for other functions. If necessary, the type of selection (high/low) can be indicated in the remarks column.

This function shall be listed in the BACS FL with each of the corresponding input data points for the calculation/high-low selection. A reference to the result data point can be given in the remarks column.

Table 16 — Informative FB example (arithmetic calculation)

Graphical FB representation

```
Inputs                    Arithmetic calculation        Outputs
                   Real                           Real
Value 1            -------- VL1              CV    -------- Calculated value
                   Real
Value n            -------- VLn
                   Bool
Calculation enable -------- CE

Parameters
                   Real
Constant values    -------- COV
                   Real
Math. functions    -------- MF
```

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
VL1	Real	Value 1	
VLn	Real	Value n	
CE	Bool	Calculation enable	
Outputs			
CV	Real	Calculated value	
Parameters			
COV	Real	Constant values	
MF	Real	Mathematical functions	
NOTE Explanation of the example: Calculated values are produced by processing inputs through freely defined functions created by a set of algorithms and mathematical functions as e.g., +, -, x, /.,*.			

5.5.3.5.4   Event switching

The event switching function provides a logic output for plant control to optimize the operation. It processes the state message of a predefined event. The operating mode to be executed as the reaction shall be stated. The function can be initiated by a physical, a virtual, or a shared data point.

This function type is not to be used within one plant's internal interlock functions as e.g. motor control.

This function shall be listed in the BACS FL with the virtual data point effected by the event switching function, e.g. the data point for plant control. A reference to the triggering data point can be given in the remarks column.

5.5.3.5.5 Time schedule

The time schedule function provides a logic output for plant control, when a set time matches the real time value. The output can be inhibited if the real time matches with exception day data.

This function shall be listed in the BACS FL with the virtual data point effected by the time schedule function, e.g. the data point for plant control. The stated amount represents the dedicated on/off cycles per period, e.g. per day, of the assigned schedule.

Performance criteria:

1) Type of time schedule; daily, weekly, yearly as parameters programmable;

2) Number of exception days.

Table 17 — Informative FB example (time schedule)

Graphical FB representation

Inputs		Time schedule		Outputs	
	Real		Bool		
Present Time	--------- PT		PSS	---------	Plant start stop
	Real		Real		
Override	--------- OR		PPC	---------	Present program condition
Parameters					
	Real				
Time Table	--------- TT				

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
PT	Real	Present time	MM.DD; HH:MM
OR	Real	Manual override input e.g. on/off/auto	
Outputs			
PSS	Bool	Plant start/stop (time program output state)	
PPC	Bool	Present condition of the active time program, e.g. currently an exception day or override	
Parameters			
TT	Real	Time table, including plant start stop requirements on typically daily, weekly, and exceptional profiles for e.g. exception days or holidays	
NOTE Explanation of the example: The current time is provided by an internal or external reference source, see 5.3.2.2.			

5.5.3.5.6   Optimum start/stop

The optimum start/stop function provides a logic output for plant control. An algorithm of the function calculates an optimum time to switch on or off an item of plant in order to minimize energy usage. It processes the parameters of the time schedule function under consideration of outdoor and room temperature, the thermal behavior of the building and the supply capacity of the energy source.

This function shall be listed in the BACS FL with the virtual data point effected by the optimum start/stop function, e.g. the data point for plant control. It requires at least one time schedule function.

Performance criteria: Fixed set of parameters or self adaptive parameter calculation

Table 18 — Informative FB example (optimum start/stop)

Graphical FB representation			
Inputs		Optimum start/stop	**Outputs**
Outdoor temperature	Real ---------	TO PSS	Bool --------- Plant start/stop
Room temperature	Real ---------	TR PPC	Bool --------- Present program condition
Present time	Real ---------	PT	
Program enable	Bool ---------	PEN	
Parameters			
Time schedule reference list	Real ---------	TSRL	
Occupancy time schedule	Real ---------	OTS	
Basic parameters	Real ---------	BPAR	

FB example abbreviations			
Name	Type	Description	Unit/symbol
Inputs			
TO	Real	Outdoor temperature	°C
TR	Real	Room temperature	°C
PT	Real	Present time	HH:MM
PEN	Bool	Program enable	
Outputs			
PSS	Bool	Output State (plant start/stop)	
PPC	Bool	Present program condition,	
Parameters			
TSRL	Real	Time schedule reference list	
OTS	Real	Occupancy time schedule	
BPAR	Real	Basic parameters	

NOTE   Explanation of the example:
The optimum start function calculates the best possible starting time for the change between unoccupied and occupied mode depending upon the controlled temperature (e.g. room temperature). To achieve the desired conditions at the start of occupancy it is necessary to consider outdoor conditions and the thermal behavior of the building, it also is strongly recommended to consider the supply capacity of the energy source.
The optimum stop function calculates the earliest stop time for the change between occupied and unoccupied mode, normally depending upon outdoor temperature conditions. It is also necessary to consider the thermal behavior of the building in order to maintain the desired conditions until the end of occupancy mode.
The optimum start/stop function can have fixed parameters or be a self-adaptive function. Self-adaptive means that the function itself calculates and stores the required parameters.

5.5.3.5.7   Duty cycling

The duty cycling function provides a logic output for a plant start/stop ratio to reduce the run time of a plant during the occupied mode of a building. It is calculated from the value of a (reference) room temperature using an algorithm and considering the operation mode.

This function type is not to be used within one plant item's internal interlock functions as e.g. motor control.

This function shall be listed in the BACS FL with the virtual data point effected by the duty cycling function, e.g. the data point for plant control.

Table 19 — Informative FB example (duty cycling)

Graphical FB representation

Inputs

		Duty cycling		Outputs
	Bool		Bool	
Plant mode	--------- PM	PSS	---------	Plant start/stop
	Real			
Room temperature (reference)	--------- TR			
	Bool			
Program Enable	--------- PEN			

Parameters

	Real	
Duty cycling reference list	---------	DCRL
	Real	
Cycle time	---------	CT
	Real	
Off – time	---------	OT

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
PM	Bool	Plant mode (occupied, unoccupied)	0/I
TR	Real	(Reference-) room temperature	°C
PEN	Bool	Program enable	
Outputs			
PSS	Bool	Duty cycling output state (plant start/stop)	
Parameters			
DCRL	Real	Duty cycling reference list	
CT	Real	Cycle time	min
CT	Real	Off time	min
NOTE Explanation of the example: This function is active while the plant is in the occupied mode, e.g. an air-handling unit should be cycled on and off if its capacity exceeds considerable the required load.			

5.5.3.5.8   Night cooling

The night cooling function provides a logic output for a plant operation in free cooling operating mode during the protection or economy operating mode (unoccupied time) to minimize the energy use. The function processes the input values of the present (reference) room temperature, the outdoor air temperature and the setpoint of the comfort-operating mode. This function determines if a HVAC plant operating with 100% outdoor air can be used for free cooling of the building's structure. This is the case when the room temperature is

above the comfort mode temperature that will be required within the forthcoming occupancy period (in comfort operating mode) and the outdoor temperature is below the room temperature during the nighttime.

This function shall be listed in the BACS FL with the virtual data point effected by the night cooling function, e.g. the data point for plant control. It requires at least one time schedule function.

Table 20 — Informative FB example (night cooling)

Graphical FB representation		
Inputs	**Night cooling**	**Outputs**
Bool		Bool
Outdoor temperature ---------	TO NCSS	--------- Night cooling mode start/stop
Real		Real
Room temperature ---------	TR OADP	--------- Outdoor air damper position
Real		
Comfort operating mode setpoint ---------	COSP	
Bool		
Program enable ---------	PEN	
Parameters		
Real		
TR-TO difference temperature limit ---------	DTL	
Real		
Operating mode time/state list ---------	OTSL	

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
TO	Real	Outdoor temperature	°C
TR	Real	Room temperature	°C
COSP	Real	Comfort operating mode setpoint	°C
PEN	Bool	Program enable	
Outputs			
NCSS	Bool	Night cooling mode start/stop	0/1
OADP	Real	Outdoor air damper position	%
Parameters			
DTL	Real	TR-TO difference temperature limit	K
OTSL	Real	Operating mode time/state list	

NOTE   Explanation of the example:
This function provides free cooling. It uses the cooler outdoor air in the early morning to cool down the buildings internal fabric and inside air. Night cooling is started with outdoor air dampers fully open if, and as long as, outdoor air temperature is significantly cooler than inside air and inside air temperature is significantly higher than the setpoint for the comfort-operating mode.

5.5.3.5.9   Room temperature limitation

The room temperature limitation function provides a logic output for a plant operation during the protection-operating mode (in the unoccupied time). It prevents the room temperature from falling below or rising above acceptable limits. The calculation considers the value of the present (reference) room temperature, the temperature limit and a hysteresis for the protecting temperature.

This function shall be listed in the BACS FL with the virtual data point effected by the room temperature limitation function, e.g. the data point for plant control. It requires at least one time schedule function.

Table 21 — Informative FB example (room temperature limitation)

Graphical FB representation

Inputs

			Room temperature limitation			Outputs

Plant operating mode `--------` Bool `PO`   `PPSS` Bool `---------` Protecting mode plant start/stop

Room temperature `--------` Real `TR`

Program enable `--------` Bool `PEN`

Parameters

Upper protecting limit `--------` Real `UPL`

Lower protecting limit `--------` Real `LPL`

Hysteresis `--------` Real `HYS`

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
TR	Real	Room temperature	°C
PO	Bool	Plant operating mode	
PEN	Bool	Program enable	
Outputs			
PPSS	Bool	Protecting mode plant start/stop)	
Parameters			
UPL	Real	Upper protecting limit	°C
LPL	Real	Lower protecting limit	°C
HYS	Real	Hysteresis	°C

NOTE   Explanation of the example:
This function is active while the plant is in the protection-operating mode, e.g. a heating plant or an air-handling/air-conditioning unit is to be switched on if a reference room temperature exceeds the lower/higher protecting limit until it reaches again the required temperature under consideration of the hysteresis.

5.5.3.5.10   Energy recovery

The energy recovery function provides a logic output for plant control thus the desired space comfort condition can be achieved with a minimum of energy. This function processes the present outdoor air temperature (or enthalpy), the room or return air temperature (or enthalpy) for a comparison between the temperature values or the enthalpy values that have been calculated before with an extra function. It processes a strategy applied for recovering heating/cooling/humidity depending on the energy demand of a controlled space and the energy available from the extracted air from this space. The function overrides the mixing damper control or the control loop for heat recovery equipment. In case of mixing damper control the minimum outdoor air ratio is kept by the function output limitation, see 5.5.3.4.8.

This function shall be listed in the BACS FL with each of the corresponding input data points, e.g. temperature or enthalpy of outdoor, return/room air. A reference to the data point(s) of the corresponding/controlled device(s) can be given in the remarks column.

5.5.3.5.11 Backup power operation

The backup power operation function provides a logic output for plant control to optimize and secure operation. It processes the state message of stand-by-power supply operation or uninterruptible power supply (UPS) operation, to start entitled items of plant under consideration of available power and parameterized priority, or to stop non-entitled items of plant at UPS operation. It is to be stated if a measured power load shall be considered. Backup power operation is typically a system wide function.

This function shall be listed in the BACS FL with the virtual data point effected by the backup power operation function, e.g. the data point for plant control. A reference to the triggering data point can be given in the remarks column.

NOTE   Upon the return of the main power supply the restoration of normal operation can be performed by the mains power recovery program function, see 5.5.3.5.12.

5.5.3.5.12 Mains power recovery program

The mains power recovery program provides a logic output for plant control to optimize and secure operation after a power failure. It processes the state message mains supply in operation to start entitled items of plant under consideration of parameterized delay times and priority. Mains power recovery program is typically a system wide function.

This function shall be listed in the BACS FL with the virtual data point effected by the mains power recovery program function, e.g. the data point for plant control. A reference to the triggering data point can be given in the remarks column.

5.5.3.5.13 Peak load limitation

The peak load limitation function provides a logic output for plant control to stop or to reduce load thus the maximum energy level given from the energy supply contract is not exceeded within the given time period. This function processes the amount of energy being used at any instant provided by a (physical) counter input and performs a trend calculation for the maximum level of energy being reached within the period. The function considers that items of plant can be switched off in a predefined order of priority and minimum/maximum on/off times. The time period for which the energy level is calculated is determined in a variety of ways depending on the energy supply contract. Peak load limitation is typically a system wide function.

This function shall be listed in the BACS FL with the virtual data point effected by the peak load limitation function, e.g. the data point for plant control.

Table 22 — Informative FB example (peak load limitation)

Graphical FB representation

Inputs		Peak load limitation		Outputs
	Real		Bool	
Current consumption value	-------- ACV	PSS	--------	Plant start/stop
	Bool			
Charging period start	-------- CPS	PPC	--------	Present program condition
	Real			
Tariff state	-------- TARS			
	Bool			
Program enable	-------- PEN			
Parameters				
Program parameters	-------- PP			
Energy target	-------- ET			

FB example abbreviations

Name	Type	Description	Unit/symbol
Inputs			
ACV	Real	Current consumption value	KWh
CPS	Bool	Signal to indicate the start of the charging period.	
TARS	Real	Tariff states (limit for consumption within a cycle)	
PEN	Bool	Program enable, releases or blocks the function as a whole	
Outputs			
PSS	Bool	Plant start/stop	
CPC		Current program condition, e.g. current tariff	
Parameters			
PP		List of parameters that configure the precise nature of the algorithm.	
ET		Energy limit target to be used in the algorithm.	
NOTE Explanation of the example: The purpose of this function is to reduce load costs caused by peaks in consumption. The calculation considers the remaining time within the sample period and determines the current available load that can be reduced. The function determines whether the current demand and consumption would be within the defined target. Different algorithm/strategies can be used to achieve the target (e.g. predictive methods, sliding window, hierarchical, or rotating load shed). Additionally, in some cases, energy savings can be achieved as a by-product but are not the primary goal of this function.			

5.5.3.5.14   Energy tariff dependent switching

Energy tariff dependent switching provides a logic output for plant control to disable or to reduce load during higher cost energy periods. The function processes the state message depending on tariff state and tariff costs which may vary hourly, daily, and/or weekly, or seasonally, and the time program. The function considers that items of plant can be switched off in a predefined order of priority and minimum/maximum on/off times. This function is mainly used in the case of multi tariff electrical energy distribution also in conjunction with the function optimum start/stop for electrical heating. Energy tariff dependent switching is typically a system wide function.

This function shall be listed in the BACS FL with the virtual data point effected by the energy tariff dependent switching function, e.g. the data point for plant control. A reference to the triggering data point(s) can be given in the remarks column. The function time schedule is to be stated according to the number of tariff states, if required.

5.5.4 Management function types

5.5.4.1 General

Management functions are used to provide data for storage, evaluation, and display of information by application programs/management functions. This selected information can be processed and stored in data files and databases.

Management communication functions are used for definition and selection of data point information from I/O functions, processing functions and of shared data point functions to be selected for interoperable system integration and to be engineered for management functions.

5.5.4.2 Management communications functions

Management communications functions are the handling of data points and communication objects that are exchanged between I/O or processing functions and management functions. These functions apply twice for interoperable heterogeneous systems: for the server system and for the client system. The different communication object types are grouped separately within two columns of section seven in the BACS FL, which differ in complexity of the data being transferred to and from the management functions.

The detailed implementation of management communication interoperability must be specified in accordance with the selected communication protocol, see Protocol Implementation Conformance Statement (PICS) and BACnet Interoperability Building Blocks (BIBBs) in ISO 16484-5. In the BACS FL it may be indicated whether a data point applies to client functions "A" or server functions "B", if required.

NOTE   See ISO 16484-5 for amendments.

5.5.4.2.1 Input/output objects

The communication functions for Input/output object types cover data passed to or from the management functions which is considered to be simple, e.g. I/O data point information, including states, values and other information as described in 5.5.2. The analog and binary data objects are described in ISO 16484-5. The indication of these functions and objects in the BACS function list is required in case of data sharing with foreign systems for management and operator functionality.

The following list provides a mapping from I/O functions and associated functions to I/O communication object types:

a)   Binary value (output), switching; BACS FL function 1.1 and 2.1:

1)   binary output object;

2)   binary value object;

3)   multi-state output object;

4)   multi-state value object.

b)   Analog value (output), positioning/setpoint; BACS FL function 1.2 and 2.2:

1)   analog output object;

2)   analog value object.

c)   Binary value (input), state; BACS FL function 1.3 and 2.3:

1)   binary input object;

2)   binary value object;

   3)   multi-state input object;

   4)   multi-state value object.

d) Accumulated/totalized value (input), counting; BACS FL function 1.4 and 2.4:

   1)   counter input object;

   2)   accumulated value object.

e) Analog value (input), measuring; BACS FL function 1.5 and 2.5:

   1)   analog input object;

   2)   analog value object;

   3)   averaging object.

5.5.4.2.2 Complex objects

The communication function for complex object types covers data passed to or from the management functions which is considered to be complex. For interoperability of heterogeneous systems the communication objects described in ISO 16484-5 shall be specified in detail using the BACS FL and additional documents.

One shared data point or networked device/station can refer to multiple complex BACS object types, the application should be referenced in the remarks column of the BACS FL, e.g.:

a) command object,

b) group object;

c) life safety point object;

d) life safety zone object;

e) loop object;

f) notification class object, i.e. alarm and event notification for message routing;

g) schedule object.

The following objects are not to be indicated as functions, but can be stated in the BACS function list, if required:

h) calendar object;

i) device object;

    NOTE   A Device object should not be indicated as function, but can be stated, if required.

j) event enrollment object;

k) file object;

l) life safety device object;

m) program object;

n) trend log object.

5.5.4.3   Historical data

Historical data functions comprise the assignment of data points to system functions performing the non-volatile storage of any type of events and measured values, including managing the retrieval of information as described in 5.3.2.10.

5.5.4.3.1   Event storage, event logging

The event storage function of the data logging program provides for the storage of the point address, state, and information text, resulting from I/O and processing functions respectively. Time and date stamps shall be stored with each item of information at change of state (COS).

The number functions to be stored shall be indicated per data point in the BACS FL. For selection criteria refer to the example in 5.5.5.3, Table 23.

5.5.4.3.2   Historical database

The historical database function provides for the storage of the point address, value, and state and information text, resulting from I/O and processing functions. Time and date shall be stored with each item of information at chance of value and/or change of state (COV/COS). Measured values may be sampled over interval times and/or in the event of reaching a predefined threshold value (COV).

The number of functions to be stored in the historical database shall be indicated per data point in the BACS FL. For selection criteria refer to the example in 5.5.5.3, Table 23.

5.5.5   Operator function types

5.5.5.1   General

Operator functions are provided by the human system interface. They comprise the drawing up of project specific user interfaces and text information and the assigning of data points to categories and displays to define the complexity of requirements, i.e.:

a)   dynamically updating data within a static background graphic, where the system reports current state and/or value of data items, and/or the user is able to alter the appropriate parameters;

b)   any instructions and/or context sensitive graphics that are presented to the system user as a result of an event within the monitored plant.

Output data for operator functions is sent to visual displays, printers, audible and optical indicating devices or is provided to other functions within the BACS, or is transferred to dedicated special systems (DSS) for further processing. Input data from operator functions are processed by other functions.

5.5.5.2   Graphic/plant schematic

Graphic/plant schematics are pictorial descriptions of the plant/building/application, being monitored/controlled, displayed on a graphical user interface.

The schematic can take the form of several pages of graphical drawings; the number of pages to be included in a particular application is to be indicated in the BACS FL. The number of terminals to display the same graphic is not relevant for the BACS FL.

5.5.5.3   Dynamic display

The dynamic display presents the current states or values of the required functions within a plant schematic. The BACS FL shall indicate the number of functions for dynamic display per data point.

Table 23 — Example dedication of dynamic display functions

	Type of data point and functions	Number of I/O and processing functions	Selected for dynamic display (example)	Number of dynamic display functions
1.	Plant, 2 step control:			9
	mode command (0)-I-II	2	2	
	command execution check back (0)-I-II	2	2	
	monitoring run time	1	1	
	runtime limit	1	1	
	interlocks, plant control	1	0	
	optimization, e.g.:			
	time schedule	2	0	
	optimum start/stop	1	1	
	night cooling	1	0	
	mains power recovery program	1	0	
	peak load limitation	1	1	
	back up power operation	1	1	
2.	Temperature value with	1	1	3
	2 limits	2	2	
3.	motor control	1	0	7
	Steady state output (0)-I-II	2	2	
	with check back per step	2	2	
	run time	1	1	
	runtime limit	1	1	
	command execution check	1	1	
4.	Cascade control:			4
	input value (room temp.)	1	1	
	P master loop (requires block communication)	1	1	
	input value (supply temperature)	1	1	
	sliding limit (low);	1	1	
	PI slave loop	1	0	
	sliding slave setpoint	1	0	
	setpoint limitation	1	0	
	output limitation	1	0	
	2 proportional output stages	2	0	

5.5.5.4 Event instruction text

Event instruction text is added to an event message to instruct or guide an operator for different dedicated activities. The required number of lines per instruction text is to be specified.

Performance criteria: Number of lines, number of characters per line.

5.5.5.5 Remote messaging

When triggered the remote messaging function sends event text to a data interface unit which forwards the data to a specified destination e.g. short message service, fax, e-mail, or personal address system. This function is the interface between the BACS and another system and provides the functions necessary to manage re-transmission of events (i.e. acknowledgement). The remote messaging function can trigger an output function switching. If required, this is to be indicated as binary output function in the BACS FL.