NORSOK STANDARD I-005

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System control diagram

Standards Norway
Strandveien 18, P.O. Box 242
N-1326 Lysaker
NORWAY

Telephone: + 47 67 83 86 00
Fax: + 47 67 83 86 01
Email: petroleum@standard.no
Website: www.standard.no/petroleum

Figures

Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are, as far as possible, intended to replace oil company specifications and serve as references in the authorities' regulations.

The NORSOK standards are normally based on recognised international standards, adding the provisions deemed necessary to fill the broad needs of the Norwegian petroleum industry. Where relevant, NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

The NORSOK standards are developed according to the consensus principle generally applicable for most standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with support by The Norwegian Oil and Gas Association, The Federation of Norwegian Industry, Norwegian Shipowners' Association and The Petroleum Safety Authority Norway.

NORSOK standards are administered and published by Standards Norway.

Annex A, B, D and F are normative. Annex C, E and G are informative.

Introduction

The success of a plant development project depends on good and efficient means of communication between the involved parties, during all phases of the project.

Present extensive use of computerized systems and 3D modeling provide efficient tools for specifying and handling of physical equipment in a standardized manner. However, the development of methods and tools to specify functional relationships has not reached a corresponding level.

During the plant development the process engineers specify the process through the development of the P&IDs. Throughout this work process the process engineers acquire a thorough understanding of the total plant behavior. However, the P&IDs provide limited facilities for documentation of the overall functionality as well as operational aspects of the plant.

It's the control system engineer's task to design the control system so as to fulfill the process functionality required to achieve product specifications as well as the requirements imposed by the overall operating and control philosophy and manning levels. To conserve the functional relationships implicitly specified by the P&IDs, the control system engineers have to transform the process engineers understanding of plant behavior into the control system design and implementation.

The operator's evaluation of the operational efficiency of the plant is a difficult task without any proper documentation of the overall control and monitoring functions available. Often, operational problems within the different systems cannot be identified until the system is in operation, leading to major modifications in late project phases in the worst case.

The logic and arithmetic functions available for implementing the required control system functionality are accurate, but vendor specific. In-depth system knowledge is required to understand both the available functions as well as their interconnections. There is no intuitive link between the control system functions and their interconnections, and the process flow itself. The interactions between the process and the control functions are identified through single tags only.

Due to the missing link between the functions implemented in the control system and the P&IDs defining the process flow, the process engineer's possibility to verify that all process aspects have been properly catered for in the implementation of the control system is very limited.

The SCD approach has been introduced in order to eliminate this missing link. The SCD approach represents a structured methodology based on the development of the SCD.

This NORSOK standard consists of the definition of two elements:

- the function templates;
- the diagram.

The functional requirements are defined through Annex A "*SCD Function Standard*" while the drawing requirements are defined through Annex B "*SCD drawing standard*" and Annex D "*SCD legend*".

This NORSOK standard will also establish a general framework for implementation of the SCD approach in terms of Annex C "*Project execution guidelines*" and Annex E "*Application guidelines*".

Annex C "*Project execution guidelines*" defines a strategy for project execution and is intended for project responsible engineers. Annex E "*Application guidelines*" provides a basis for application design and is intended for application engineers responsible for developing SCDs.

Annex G "*Readers manual*" contains a simplified introduction for engineers and operators using SCDs for verification and documentation of control functionality.

Annex F "*SCD Control function template behaviour*" defines the functions in an unambiguous manner.

The main updated items in this edition of this NORSOK standard are as follows:

- 7 new function templates have been defined;
  - HA – analogue input command
  - HB – binary input command
  - KB – sequence logic interface
  - MAS – analogue measurement acquisition from subsystems
  - OA – analogue output
  - SBB – breaker control
  - SBC – coordinator for SBE
- 2 existing function templates have been deleted;
  - CB – binary control (replaced by recommended use of MA, ref figure E.19)
  - YA – process input calculation (replaced by recommended use of # function, ref figure E.3)
- CA function has been expanded with a terminal for feed forward (XFF), position high feedback XGH and confirmed high/low (BCH/BCL);
- for CS function terminal name BG has been corrected to YG;
- SB function have been expanded with a terminal for external fault and OS command for suppress;
- SBE function terminals have been aligned to fit the new SBC function, following input terminals have been removed XP1H, XP2H, XP1L, XP2L, BP1, BP2, BP1F, BP2F and expanded with terminals for safeguarding high;(LSH/FSH)

- further elementary functions have been defined, NOR, NAND, XOR and Analogue select;
- annex A function standard have been rewritten to a new format;
- annex B drawing standard have been more firm defined and expanded by
  - size for all symbols have been defined,
  - layer and colour use have been defined,
  - “dot” introduced as alternative for S split symbol,
  - “wall” introduced for multiple I/O connections,
  - sequence symbols are defined.
- generally this NORSOK standard has been rephrased where it has been found unclear;
- application guideline is redone in accordance with the updates in this edition;
- function template behaviour figures redone where they have been unclear or erroneous;
- for the general appearance of this NORSOK standard the IEC IECSTD format has been adapted;
- Appendix E is updated to reflect the changes in Appendix A and B.
- Appendix F is updated to include the changes in Appendix A and errors corrected.

1 Scope

This NORSOK standard is intended to cover functional as well as drawing related requirements for use of SCDs.

2 Normative and informative references

The following standards include provisions and guidelines which, through reference in this text, constitute provisions and guidelines of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet the requirements of the referenced standards.

2.1 Normative references

IEC 61131-3,	Programmable controllers – Part 3: Programming languages
API RP 14 C,	Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms
ISO 10418,	Petroleum and natural gas industries – Offshore production platforms – Analysis, design, installation and testing of basic surface safety systems

2.2 Informative references

NORSOK I-002,	Safety and Automation Systems (SAS)
NORSOK Z-DP-002,	Code Manual
NORSOK Z-004,	CAD Symbol Libraries
ISO 3511, (all parts)	Process measurement control functions and instrumentation – Symbolic representation – (all parts)
NS 1710,	Technical drawings – Drawing symbols for piping systems
NS 1438–1,	Process measurement control functions and instrumentation – Symbolic representation – Part 1: Basic requirements
IEC 61804,	Function Blocks for process control

3 Terms, definitions and abbreviations

For the purposes of this NORSOK standard, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

3.1.1
action alarm
alarm associated with an automatic action, both the alarm and action caused by one common discrete change of state

3.1.2
actual position
feedback-position of a flow element, independent of the state of the control output

3.1.3
alarm
HMI annunciation requiring operator response, caused by a discrete change of state

3.1.4
alarm categories
following categories are defined, not reflecting priority or criticality of the alarm:

Action alarm: see definition

Warning alarm: see definition

Fault alarm: see definition

3.1.5
alarm hysteresis
degree of normalization required to reset an active alarm state, measured from the alarm activation limit

NOTE Normally expressed in terms of a fraction (%) of the operating range

3.1.6
alarm suppression
see definition of suppression 3.1.50

3.1.7
auto mode
operation of process objects automatically performed by the control logic

3.1.8
blocked mode
function is in blocked mode when blocking is active

3.1.9
blocking
<u>For input functions</u>: alarm status signals from process variable limit checking are blocked within the function, giving annunciation, but not allowing all related automatic safeguarding actions. Associated safeguarding function disabled. Related alarm annunciation not disabled, i.e. no external signal outputs are blocked.

<u>For output functions</u>: disabling of a safeguarding action, but allowing associated alarm annunciation as well as manual/automatic control. Blocking applies to both individual action alarms and input signals effecting safeguarding and disable functions.

3.1.10
can
verbal form used for statements of possibility and capability, whether material, physical or casual

3.1.12
confirmed position
confirmative comparison between actual position and control output

NOTE True if no mismatch, and false if there is a mismatch.

3.1.13
conflict
requested safeguarding action being prevented because blocking is active

3.1.14
control options
pre-defined properties of the function template defined during the configuration of the system reflecting the specific control requirements

3.1.15
deviation warning
state calculated in a modulating controller by subtracting the measured value from the set point value

NOTE A warning will be announced if deviation is outside working area.

3.1.16
disabled mode
function not available for control commands

3.1.17
disable transition mode
transition high/low function not available

NOTE Safeguarding commands will not be affected in this mode.

3.1.18
duty/standby mode
intended for automatic supervision of flow element operating in parallel to increase the system availability

NOTE One flow element will be assigned duty (priority 1) and will thus normally be in operation. The other is assigned standby (priority 2) and will automatically be put in operation if duty fails. All flow elements will have to be selected auto to obtain automatic duty/standby function.

3.1.19
dynamic information
information displayed on the VDUs reflecting the state of the process or system

3.1.20
enabled mode
function available for external/remote control commands

3.1.21
event
HMI indication caused by a discrete change of state

NOTE Events may be associated with automatic actions.

3.1.22
external setpoint mode
sub-mode to auto mode used for controllers

NOTE The setpoint is from external functions in the control logic. Typically use in cascading PID controllers.

3.1.23
fault alarm
alarm associated to fault or failure in the instrument and/or control device

3.1.24
flow element
device used to control/shut down or manipulate a flow of fluid or electric energy

NOTE E.g. valve, pump. Where the flow device only has two positions, it is referred to as a binary flow device, High position: flow/Low position: no flow (motor - on/off, valve - open/close, electrical breaker – connected/disconnected).

3.1.25
force command
action overruling any other signal

NOTE The mode is reset to its original state when signal is no longer true.

3.1.26
function blocks
a function block is a configured package of defined logic functionality, with input terminals (receiving actions from other parts of the SAS logic or from the physical field interface) and output terminals (initiating actions toward other parts of the SAS logic or to the physical field interface).

NOTE Function blocks are generally capable of being manipulated by the operator, via the SAS HMI.

3.1.27
function template
function assembly including detailed requirements for operation and control

NOTE The general definition of any function block type is called a '"function template'", or just 'template'. A template is brought into practical use as a function block when a copy of the template is inserted into the SAS software configuration as a tagged object and given parameter values and logical connections

3.1.28
internal setpoint mode
sub-mode to auto mode used for PID controllers

NOTE The setpoint to be entered by the operator.

3.1.30
lock command
action overruling any other signal while being true

NOTE The new mode is maintained when lock signal is no longer true.

3.1.31
manual mode
flow element manually controlled by a operator

3.1.32
may
verbal form used to indicate a course of action permissible within the limits of this NORSOK standard

3.1.33
motor control centre
electrical relay assembly for control and protection of electrical equipment

3.1.34
mode
state of operation selected by the operator or resulting from an external event

The following operation modes are defined:

Auto: see definition
Outside: see definition
Manual: see definition
Duty/Standby: see. definition
Blocked: see definition
Suppress: see definition
Internal setpoint mode: see definition
External setpoint mode: see definition
Track: see definition
Safeguarding: see definition
Disabled: see definition

3.1.35
"output" track mode
normal function output follows another external signal

3.1.36
outside mode
flow element operated from a external device, i.e. local panel

3.1.38
process
sequence of chemical, physical, or biological activities for the conversion, transport, or storage of material or energy

3.1.39
position
state of flow element resulting from an external event

The following positions are defined:

Actual position: see definition
Confirmed position: see definition

3.1.41
safeguarding mode
flow device is in safe state

NOTE The term safe is related to the protection of equipment, environment and human beings.

3.1.42
safeguarding failure
safeguarding action not confirmed

3.1.43
set command
memory variable set to true state on being true

NOTE Signal latch included in the common signal path between a group of initiators and a group of flow elements.

3.1.44
"setpoint" tracking
setpoint tracks normal function input (measured value), in manual mode

3.1.45
shall
verbal form used to indicate requirements strictly to be followed in order to conform to this NORSOK standard and from which no deviation is permitted, unless accepted by all involved parties

3.1.46
should
verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required

3.1.47
shutdown
signal to set an element to safeguarding mode

3.1.48
shutdown level
signal latch included in the common signal path between a group of initiators and a group of flow elements

3.1.49
status
binary state

3.1.50
suppression
disable alarm annunciation as well as any associated automatic actions

NOTE For input objects like MA and MB templates suppression disables state alarm annunciation as well as actions.

For output objects like CA, CS, SB, SBE and SBV templates suppression disables fault alarm annunciation and feedback failure monitoring. External output is however maintained.

Alarm suppression according to YA-711 is not covered by this NORSOK standard. *Suppression* according to this NORSOK standard is the sum of YA-711's *alarm filtering* and *blocking/inhibit).Suppression* according to YA-711 is often called *hiding* in environments that use the NORSOK definition of *suppression.*

3.1.51
warning alarm
alarm not associated with any automatic action

NOTE A warning alarm may be used as a precursor to an action alarm.

3.2 Acronymes

BPCS	basic process control system
C&E	cause and effect
CCR	central control room
CPU	central processing unit
D&ID	duct and instrument diagram
EFB	elementary function block
ESD	emergency shutdown system
F&G	fire and gas
FAT	factory acceptance test
H/P	hydraulic/pneumatic
HIPPS	high integrity pressure protection system
HMI	human machine interface
HVAC	heating, ventilation and air condition
I/O	input/output (signals, cards, etc)
MCC	motor control center
NDE	normally deenergised
NE	normally energised
OS	operator station
PSA	Petroleum Safety Authority
P&ID	piping and instrument diagram
PCS	process control system
PFD	process flow diagram
PID	proportional integral derivative (controller)
PSD	process shutdown system
SAS	safety and automation system
SCD	system control diagram
SD	shutdown
SFC	sequential function chart
SIF	safety instrumented function
SIL	safety integrity level
SIS	safety instrumented system
UPS	uninterruptable power supply
USD	unit shutdown
VDU	visual display unit

4 The system control diagram (SCD) approach

4.1 Conceptual definition

The SCD concept returns to the basis of the P&ID, the process schematic. Information not required for the design of the control system is removed. The SCD shall focus on representing systems and functional relationships, not individual physical equipment.

The SCD combines all functional design requirements into a common unambiguous document and represents a top-down approach to the design of the system.

The process schematic includes a simplified representation of process lines and equipment. Instrumentation and control objects are represented by simplified symbols only.

The automation functions are represented by a limited number of high-level function templates. Each template represents a specific control philosophy selected for a class of objects. The control philosophy is defined/limited by a general range of attributes made available for the specific application. The application level is defined by using the applicable attributes.

Complex control and interlocking strategies are developed by inter-connecting templates. Additional logic and arithmetic functions may be used.

A functional description of the process objectives should follow the SCD.

The SCD function templates are vendor independent, thus a set of SCDs may serve as a functional SAS specification, even before the system vendor is selected. The vendor on his side has an unambiguous basis for system bid and eventually implementation. Functional monitoring and control solutions may be reused from one plant development to the other, even if different control systems are used to implement the functions.

Because the SCDs can be developed in parallel with the P&IDs, introduction of the SCD approach facilitate a parallel development of both the physical and functional relationships visualised on dedicated documents. This approach encourages team work between different disciplines during the process development phases and the traditional artificial split between the development of physical and functional relationships may be eliminated. Thus enhanced overall quality is achievable.

4.2 Framework

This NORSOK standard represents an open standard in terms of operation and control philosophy. The standard is based on a basic core made up by function elements and terminology. The function elements are further combined into functional templates. These templates represent a level of standardisation intended for the system application design. Templates may be adapted and combined differently in order to represent various control strategies.

This NORSOK standard is neither based on nor limited to any specific control system. A reduced number of attributes may thus be implemented in order to accomplish an optimized implementation for a specific control system. However, suppliers should consider an initial effort in order to implement the complete range of attributes for the templates defined within this NORSOK standard.

The SCD approach has been developed with a view to industrial processes controlled by state-of-the-art process control systems, but as it provides a general process oriented approach for development of the documents, no field of application are explicitly excluded.

However, global safeguarding functions as well as fire and gas functions are less suitable for the SCD representation as such, see Figure 1.

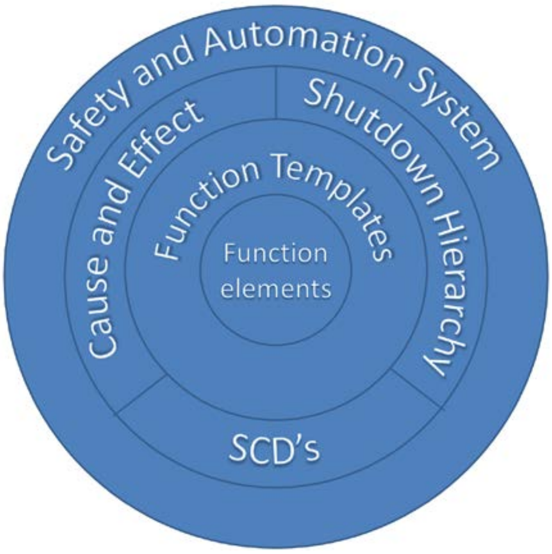

Figure 1 - SCD framework

Typical applications proven suitable for the SCD representation are as follows:

- control of process and utility systems;
- process shutdown applications;
- package control;
- HVAC.

A shutdown hierarchy should be made to provide a complementary overview of ESD and PSD levels.

A C&E representation will typically be used for F&G and ESD. C&Es may additionally be used for high level PSD levels in order to provide a complementary overview. However, the SCD should be defined master to ensure system consistency.

4.3 Life cycle concept

This NORSOK standard is intended to cover the complete life cycle of a process plant.

The SCD will form the single source of documentation for the SAS control and shutdown functions for all life cycle phases as follows:

- engineering;
- implementation;
- commissioning;
- operations;
- modifications.

The objectives will be different within each phase. Annex C provides an introductory overview of what the SCD approach implies for the different life cycle phases.

Annex C is only intended to provide an overview of this NORSOK standard as well as an initial starting point for inexperienced users.

4.4 Basic design (informative)

4.4.1 General

The basic system design is closely related to the overall engineering strategy for the SAS system focusing on the following main design activities:

- basic system design;
- basic function design;
- basic application design.

See Figure 2 for an introductory overview.

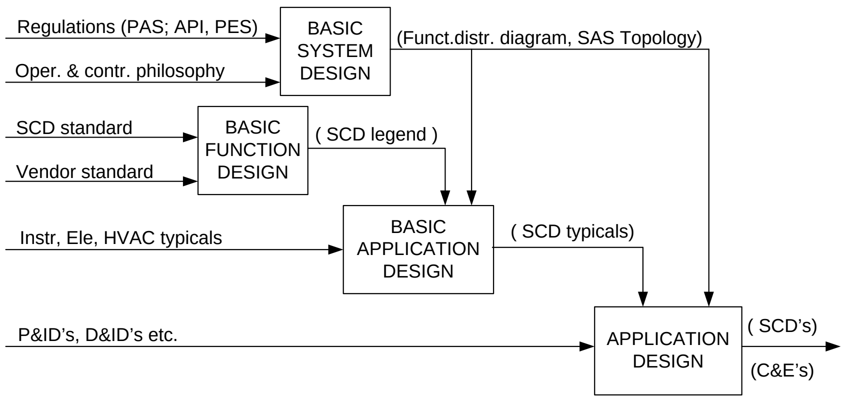

Figure 2 - Basic design

4.4.2 Basic system design

The basic system design is a general control system design activity, but is closely allied to the SCD functional template development. Based on authority regulations as well as company operational and control philosophies the actual system distribution is developed. The system distribution defines the interface between the different types of field components and the control system in terms of sub-system connection, see Figure 3.

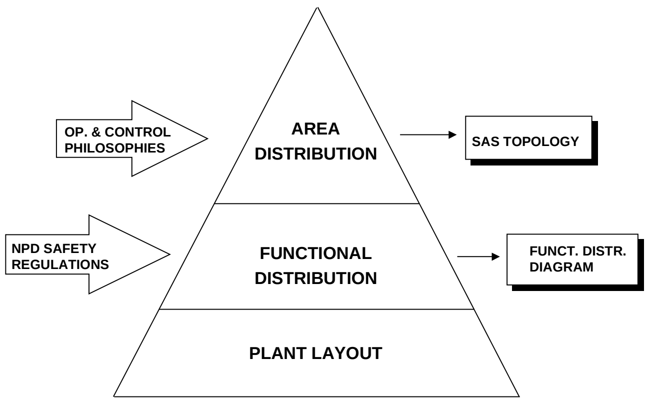

Figure 3 - Basic system design

4.4.3 Basic function design

The basic function design should be based on a joint effort between the involved parties in order to achieve an optimized use of the supplier standard functionality. Each functional element should be referred to the corresponding supplier standard functions and combined into an optimal set of templates. It is important that the resulting templates are consistent with the general standard, see Figure 4.

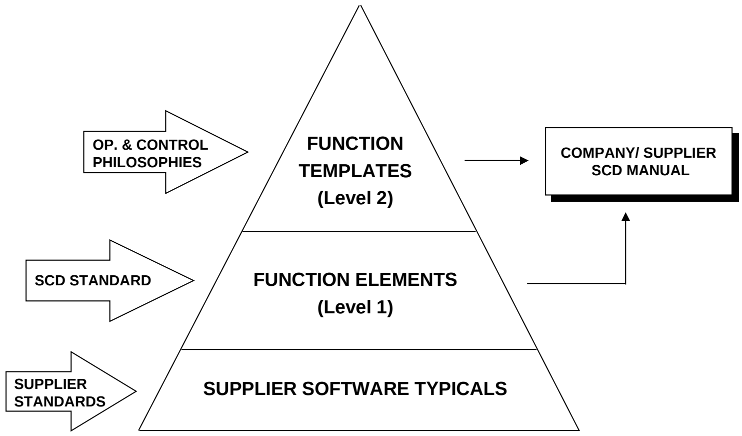

Figure 4 - Basic function design

4.4.4 Basic application design

The basic application design focuses on developing typical solutions that will form the basis for the development of the actual SCDs. The typical is developed on the following two levels:

- object typical;
- SCD applications.

See Figure 5.

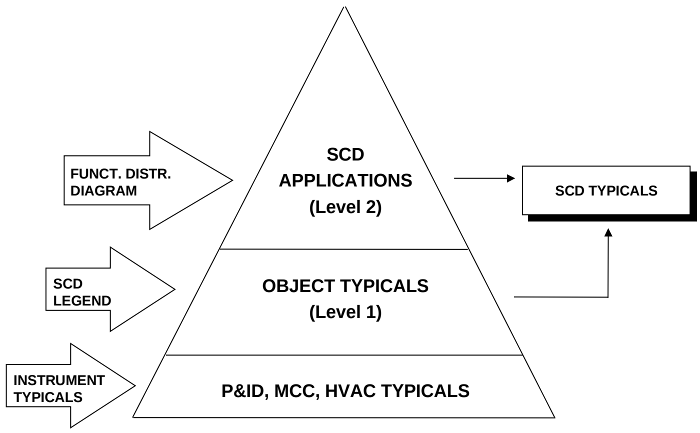

Figure 5 - Basic application design, application typical

The purpose of the object typical is to reflect a typical signal interface for a specific control object as well as the functional operator interface. The main objectives are as follows:

- verify the completeness of the function templates;
- reduce the number of typical solutions;
- improve the quality of the SCD development;
- standardised solutions.

See Figure 6.

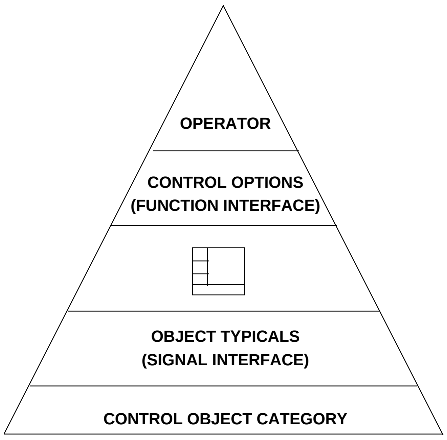

Figure 6 - Object typical

The purpose of the application typical is to reflect comprehensive application in order to reduce the number of different solutions as well as verify the completeness of the object typical.

4.4.5 Application design

The SCDs should be jointly developed by the system disciplines, driven by user requirements, not by technology/discipline organisation.

The SCDs should as far as possible be developed in parallel with the P&IDs. The application design may be represented by means of a traditional water fall model, see Figure 7.

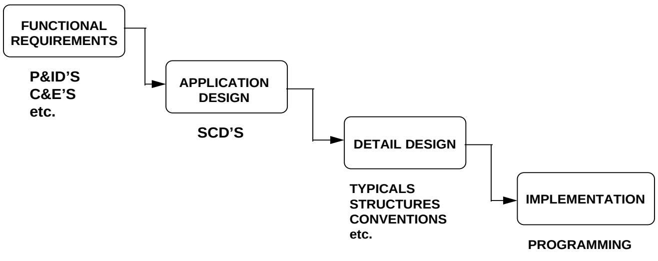

Figure 7 - Object typical

Development of SCDs are made up of the following main steps:

1. establish process schematic and identify all control objects;
2. describe the process and control objectives;
3. define applicable function templates;
4. develop basic interlocking strategies based on an overall interlocking hierarchy/philosophy;
5. develop automatic control strategies, e.g. package start/stop, duty/standby, sequencing;
6. develop alarm strategies including automatic suppression of secondary alarms.

4.5 Alarm management

The templates defined in this NORSOK standard do contain some alarm management functionality as they through the definition of the concept of suppress prevent the alarm from being initiated.

Any project may select to separate the actual alarm from the action if they have separate additional functionality for alarm management. Even so they should maintain the function of suppress defined herein.

In this NORSOK standard alarms are divided in the classic categories action, warning and fault alarms, see §3.1. The new alarm management guides EEMUA 191, NAMUR NA102 and ISA18.2 all recommend that alarms should be prioritised. A priority-setting of an alarm should be possible to do independently of the alarm category. This NORSOK standard does not contain any recommendations for priorities of the different alarms.

It is not defined with this NORSOK standard any symbolic or notification to reflect the priority of each alarm. It is important to maintain the readability of the document and therefore is it not recommended to show these details on the SCD diagram. But if the project finds it beneficial to do so this standard will not prevent it. In any case it is recommend to add such information on a separate and dedicated layer.

The term alarm is generally used throughout this specification of functionality in this NORSOK standard. This shall be understood as statuses that will be available for generating alarms if required by the alarm philosophy of the actual plant.

Annex A
(Normative)
System control diagram (SCD) function standard

A.1 Introduction

A.1.1 General

This annex contains a collection of definitions, explanations and descriptions of function templates, the main building components for the SCD approach. It defines the functional templates and their terminal names.

In this NORSOK standard the defined logic functionality, with input terminals (receiving actions from other functions) and output terminals (initiating actions towards other functions) is called function templates. A template is brought in to use as a function block when a copy of the template is inserted into to the SAS software configuration as a tagged object and given parameter values and logical connections.

A.1.2 Compliance

There is no certification procedures defined for this standard. It is up to each individual project to define whether it complies or not. There may be many reasons to not limit the function template or diagram produced to the content defined herein. It is permitted to reject terminals or introduce additional terminals on the templates to meet special requirements. However, the terminals that are included from this annex, shall have the same functionality as described. This allows for SAS suppliers to include for additional functionality specific to their system.

It is strongly recommended that the function templates are tested thoroughly upon completion and prior to use in any project. It is assumed that the tests will follow SAS suppliers well defined test and quality control procedure.

A.1.3 Positive logic

Only positive logic shall be used. This implies that a defined state of terminal is true when it is logical equal to ' 1 ', e.g. are as follows:

- for terminal ALL on MA ‘1’ means value lower than the limit;
- for terminal Y on SBV ‘1’ means open command;
- for terminal LSL on SBE ‘1’ means function template set to safeguarding low state.

The positive logic shall always be applied for function terminals i.e. there shall be no parameters to invert the signals inside the functions which negate the terminal meaning.

An exception is made for input X on MB where an inverter is added to make it possible to adapt to normally energised or non-energised input signal.

A.1.4 Execution sequence of logic

The SCD’s do not specify the sequence of execution. This must be defined during implementation in SAS system.

A.1.5 Functions used in SIF

Safety application development should comply with IEC 61508/OLF070.

For these applications the function template development has to obtain SIL approval. The different vendors will have different implementations. This NORSOK standard does not define the SIL specific requirements to the implementation.

For safety functions documented by SCD the NORSOK function templates shall be used.

OLF 070 specifies that any blocking and suppress shall be removed when required by a common operation, to ensure SIL requirement is met. This functionality will not be shown on SCD's.

A.1.6 HMI presentation

For each function template there are listed a set of elements under the heading operator station in the function template schematic. This shall be regarded as a minimum requirement to the HMI symbol/faceplate for that specific function template. How this information is structured between the function template and the HMI is not the scope of this NORSOK standard.

When the term Alarm is used in the description of the function it is meant as the possibility to generate an alarm on the actual information. It will be up to each plant alarm philosophy to define what to alarm to the operator.

A.2 Terminal codes

A.2.1 General

Each function has defined input and output signals. Input denoted with X is acting on the output Y and/or on operator presentation as described by the main function tag.

The general syntax for terminals code is as follows: NNNN (max 4 characters).

The codes are established from the following table. If numbers are used in the code, it shall always be considered to be a modifier to the proceeding letter (letter + number = one code).

Table A.1 – Terminal codes identification letters

Letter	1.Character	Succeeding characters
A	Action alarm	Auto mode
B	Binary status	Blocked mode
C		Confirmed
D		Disabled transition mode
E		Enabled status
F	Force command	Fault/Failed/Forward
G		Position
H		High
I		Internal set point mode
J		Not used
K		Not used
L	Lock command	Low
M		Manual mode
N		Hold
O		Outside mode
P	Parameter	Reserved as start letter for parameter naming if required.
Q		Quantity
R	Reset command	Reference signal

Letter	1.Character	Succeeding characters
S	Set command	Safeguarding mode
T		Track mode
U		Suppressed mode
V		Variance/Deviation
W	Warning alarm	Warning alarm
X	External input	Multifunctions see terminal description.
Y	Normal function output	Not used
Z		Not used

A.2.2 Signal types (1.Character)

A.2.2.1 Inputs

X = normal function input (related to main function of template)

A.2.2.2 Commands

S = set

R = reset

F = force

L = lock

A.2.2.3 Outputs

Y = normal function output (related to main function of element)

A = action alarm

W = warning alarm

B = binary status

A.2.2.4 Special characters

= User defined (to be shown on SCDs). Could be used as 1st.letter on a pin not in accordance with this NORSOK standard.

NOTE Some SAS systems may not support this special character.

A.2.3 Explanatory code (succeeding characters)

A.2.3.1 Modes

A = auto mode

B = blocked mode

D = disabled transition mode

I = internal set point mode

M = manual mode

O = outside mode (locally - field - operated)

S = safeguarding mode

T = track mode

U = suppressed mode

X = multifunction see terminal description external set

A.2.3.2 Signal identifiers

C = confirmed

E = enabled status

F = Fault/Failed

G = position

Q = quantity

R = reference

S = safeguarding

W = warning

X = external

A.2.3.3 Sub functions

H = high

HH = high high

L = low

LL = low low

V = variance/deviation

A.2.4 Terminal description for function templates

Index of normative terminal codes used in this annex are described in Table 2. New terminal codes shall be created according to A.2.2.

Table A.2 – Terminal codes

Terminal code	Signal type	Terminal name	Supplementary description
AHH	binary output	Action alarm high-high	True, when X-value >AHH limit.
ALL	binary output	Action alarm low-low	True, when X-value <ALL limit.
BA	binary output	Status auto/man. mode	True: auto, false: manual.
BB	binary output	Status blocked mode	The function is in blocked mode (no action output). I.e. all safeguarding signals are blocked.
BBHH	binary output	Action alarm high-high is blocked	True if FBHH or OS blocking is active.
BBLL	binary output	Action alarm low-low is blocked	True if FBLL or OS blocking is active.

Terminal code	Signal type	Terminal name	Supplementary description
BCH	binary output	Output position high confirmed	Output Y compared to feedback position high from MCC or limit switch and validated as true.
BCL	binary output	Output position low confirmed	Output Y compared to feedback position low from MCC or limit switch and validated as true.
BCQ	Analogue output	Number of SBEs running	The amount of confirmed running SBE units.
BE	Binary output	Status enable mode	BE= 1 if XE=1
BGT	binary output	Status test mode	Status breaker in test position
BH	binary output	Output high confirmed	BH=1 if sequence is running, BH=1 also when sequence in hold.
BHH	binary output	Status alarm high-high	Status Alarm annunciation (HH) unaffected by blocking
BLL	binary output	Status alarm low-low	Status Alarm annunciation (LL) unaffected by blocking
BL	binary output	Status sequence ended	BL = 1 if the sequence is completed normally (see functional description)
BN	binary output	Status hold	BN=1 if sequence is held by operator
BO	binary output	Status outside mode	The control function is in outside mode
BS	binary output	Status safeguarding mode	A safeguarding signal of the process function is true
BT	binary output	Status tracking mode	In tracking mode as long as signal is true. Ex. Set point tracking.
BU	binary output	Status suppressed mode	True if the template is in suppressed mode (any process output function is suppressed).
BX	binary output	Status external mode or function input	True: external, false: internal or image of input.
BXH	binary output	Status event high	True, when X-value > Event high limit. No alarm annunciation, event only.
BXHH	binary output	Status event high-high	True, when X-value > Event high-high limit. No alarm annunciation, event only.
BXL	binary output	Status event low	True, when X-value < Event low limit. No alarm annunciation, event only.
BXLL	binary output	Status event low-low	True, when X-value < Event low-low limit. No alarm annunciation, event only.
FB	binary input	Force blocked mode	Logic input: alarm action is blocked as long as input signal is true.
FBHH	binary input	Force blocked for alarm high-high	Logic input: AHH action is blocked as long as input signal is true.
FBLL	binary input	Force blocked for alarm low-low.	Logic input: ALL action is blocked as long as input signal is true.
FDH	binary input	Force disable transition high.	Prevents element to be started / opened / connected when true. Subject to blocking.
FDL	binary input	Force disable transition low.	Prevents element to be stopped / closed / disconnected when true. Subject to blocking.
FN	binary input	Force hold	FN = 1 will temporarily hold the sequence in the current step.
FQ	binary input	Force totalizing	Totalizing as long as true.
FSH	binary input	Force safeguarding high	Safeguarding – Signal overrules operator inputs (forcing the template Y-output high). After signal returns to normal, template will react to actual terminal status again. Signal is subject to blocking. If in Manual mode the output remains high after signal returns to normal.

Terminal code	Signal type	Terminal name	Supplementary description
FSL	binary input	Force safeguarding low	Safeguarding – Signal overrules operator inputs (forcing the template Y-output low). After signal returns to normal, template will react to actual terminal status again. Signal is subject to blocking. If in Manual mode the output remains low after signal returns to normal.
FT	binary input	Force track mode	Track signal: XT-value
FU	binary input	Force suppression mode.	For input objects the alarm action and alarm annunciation is suppressed. For output objects the feedback will be neglected and hence alarm annunciation suppressed.
FUHH	binary input	Force suppression mode for alarm high-high.	Logic input: alarm HH action and annunciation is suppressed as long as input true.
FULL	binary input	Force suppression mode for alarm low-low.	Logic input: alarm LL action and annunciation is suppressed as long as input true.
FUWH	binary input	Force suppression mode for alarm WH	Logic input: alarm WH annunciation is suppressed as long as input true.
FUWL	binary input	Force suppression mode for alarm WL	Logic input: alarm WL annunciation is suppressed as long as input true.
LA	binary input	Lock auto mode.	Locks the control function to auto mode, overruling the operator. After signal disappears, template keeps in auto mode.
LI	binary input	Lock internal set point mode.	Locks the control function to internal mode, overruling the operator. After signal disappears the logic keeps in internal set point operation mode.
LM	binary input	Lock manual mode.	Locks the control function to manual mode, overruling the operator. After signal disappears the logic keeps in manual mode.
LO	binary input	Lock outside operation mode.	Locks the control function to outside system operation mode, overruling the operator. After signal disappears the logic keeps in manual mode.
LSH	binary input	Lock safeguarding high.	Safeguarding - signal overrules operator inputs (locking the template to manual mode with Y- output to high -open valve-). Input is subject to blocking. After signals disappear the template remains in manual mode and the output high.
LSL	binary input	Lock safeguarding low.	Safeguarding - signal overrules operator inputs (locking the template to manual mode with Y- output to low -stop motor-). Input is subject to blocking. After signals disappear the template remains in manual mode and the output low.
LX	binary input	Lock external set point mode.	Locks the logic function to external mode, overruling the operator. After signal disappears template keeps in external set point operation mode.
RX	binary input	Reset logic function	Reset latched logic output or safeguarding.
RXQ	binary input	Reset external totalizer	Logic signal to reset.
WH	binary output	Warning alarm – high	True, when X-value >WH limit. This output should not be used for downstream logic. Subject to suppression.
WL	binary output	Warning alarm – low	True, when X-value <WL limit. This output should not be used for downstream logic. Subject to suppression.
WV	binary output	Warning deviation	
X	binary/analogue input	External function input	Binary or analogue input signal from process or logic.
X1-X4	binary/analogue input	External function input 1 to 4	Binary or analogue input signal from process or logic.
X4H	binary input	Call for minimum 4	If =1, then at least 4 SBE shall run.

Terminal code	Signal type	Terminal name	Supplementary description
X3H	binary input	Call for minimum 3	If =1, then at least 3 SBE shall run.
X2H	binary input	Call for minimum 2	If =1, then at least 2 SBE shall run.
X1H	binary input	Call for minimum 1	If =1, then at least 1 SBE shall run.
X3L	binary input	Call for maximum 3	If =1, then a maximum of 3 SBE shall run.
X2L	binary input	Call for maximum 2	If =1, then a maximum of 2 SBE shall run.
X1L	binary input	Call for maximum 1	If =1, then a maximum of 1 SBE shall run.
XAHH	binary input	External alarm HH	Subsystem input: alarm HH is set as long as this signal is true.
XALL	binary input	External alarm LL	Subsystem input: alarm LL is set as long as this signal is true.
XE	binary input	Function externally enabled	Electrical available used for electr. equipm. only.
XEQ	binary input	External enable totalizing	Input to logic enable/disable totalizing.
XF	binary input	External fault	Fault status received from template external source. Loop failure, i.e. input card broken.
XFF	analogue input	Feed forward	Signal representing a disturbance which is converted into a corrective action to minimize deviations of controlled variable. The feed forward function is only active when the controller is in auto mode.
XFX	binary input	Link fault	There is a communication link fault.
XG	analogue input	Position read as measured value	Position read as measured value.
XGH	binary input	Position high feedback	Signal from MCC (running) or limit switch high.
XGL	binary input	Position low feedback	Signal from MCC (stopped) or limit switch low.
XGX	binary input	Breaker test position	Breaker truck in test position.
XGZ	binary input	External earthed	Breaker is earthed and connect command shall not be performed.
XH	binary input	External set high	From logic or process to control template, i.e. valve/ damper in auto mode. Set high signal (open valve) only.
XWH	binary input	External warning alarm WH	Subsystem input: warning alarm WH is set as long as this signal is true.
XWL	binary input	External warning alarm WL	Subsystem input: warning alarm WL is set as long as this signal is true.
XL	binary input	External set low	From logic or process to control template. , i.e. valve/ damper in auto mode. Set low signal (close valve) only.
XOH	binary input (positive edge)	External outside set high	From process to control template, i. i.e. valve/damper in outside mode. Set high signal (positive edge) to open valve.
XOL	binary input (positive edge)	External outside set low	From process to control template, i.e. valve/damper in outside mode. Set low signal (positive edge) to close valve.
XP	binary input	Rotate priority.	Signal goes high will execute the rotate priority function.
XQ	Analogue input	Number of requested SBE's to run	In auto. The amount of requested running SBE units. Value.
XQHH	analogue input	Limit value of XHH	Subsystem input: the value in engineering units of the HH limit used by the subsystem.
XQH	analogue input	Limit value of XWH	Subsystem input: the value in engineering units of the WH limit used by the subsystem.
XQL	analogue input	Limit value of XWL	Subsystem input: the value in engineering units of the WL limit used by the subsystem.

Terminal code	Signal type	Terminal name	Supplementary description
XQLL	analogue input	Limit value of XLL	Subsystem input: the value in engineering units of the LL limit used by the subsystem.
XR	analogue input	External set point value	Used in external – auto – mode.
XS	binary input	External safeguarding	Safeguarding signal from other shutdown level.
XT	binary output	Tracking value	Used in tracking mode.
Y (Y1,Y2)	analogue/ binary output	Normal function output	Output value / status that can be used in downstream logic
YF	binary output	Function failed.	YF = 1 if XF = 1 or if an internal error has been detected by the template.
YH	binary output pulsed	Pulsed normal function output high	Pulse open/start command. YH = 1 (one pulse).
YL	binary output pulsed	Pulsed normal function output low	Pulse close/stop command. YL=1 (one pulse).
YG	analogue output	Output of valve position	Position of the valve-for use in downstream logic.
YQ	Analogue output	Number of requested SBE's to run	The current amount of requested running SBE units.
YR	analogue output	Reference set point value.	Actual setpoint for use in downstream logic.
YX	analogue/ binary output	Function output	Binary or analogue output signal from function template.

A.3 SCD control function template behavior

For a complementary specification and better visualization of the control function behavior, see Annex F.

A.4 Function templates

A.4.1 Introduction

Function templates shall contain all necessary functions concerning an object with its interfaces towards the process, other function templates or logic and operator station. An object is considered to be a physical instrument, an equipment with its measurements or a control function

All function templates in this specification are related to one object (one function symbol on the SCD). It is a requirement for a function template that it covers a complete function that can be represented by one symbol with its in- and out-puts to process, operator station and other logic. The templates shall be presented in any "logic view", printed or electronically as one single symbol. The interconnections between the function templates shall be recognizable within the automation system. Thus, a function template can be said to represent an object as defined above, on the SCD.

The SCDs represent a graphical documentation of the application software. The SCDs are the interface for process related users (e.g. process engineers, operators, etc.) and more instrumentation related users, e.g. instrument engineers, automation engineers, etc.

The SCDs are a precise specification for the control system application and should be available on an electronic format allowing extraction of its detailed data for function blocks, connections etc.

These data extracted from the SCDs, could be used to automatically generate the initial part of the control system configuration, in order to improve the quality and efficiency related to the control system configuration work.

Additionally the SCDs can serve as a fault finding and debugging tool. The unified way of configuring with function templates assures consistency in operation, alarm handling and indication of variables on the operator stations over the whole plant. The SCDs shall have a function oriented approach towards the operator.

A.4.2 Function template name convention

A.4.2.1 General

Function templates shall be given a name (abbreviation) compound by minimum two-characters, identifying the main function of the software item.

The name syntax should be: < Primary function> [by means of < Control type>] of < Device>

S B _

Device (Option)

Control Type

Primary function

Table A.3 – Function template letter identification

Letter	1.Character (Primary function)	2.Character (Control type)	Succeeding characters (Device (optional use, if required))
A		Analogue (function)	
B		Binary (function)	Breaker
C	Continuous control		Coordination
D			
E			Electrically motor/heaters
F			
G			
H	Hand		
I			
J			
K	Sequencing		
L	Latching		
M	Monitoring		
N			
O	Output		
P			
Q	Totalize		
R			
S	Switching control	Step (automatic function)	Serial communicated

Letter	1.Character (Primary function)	2.Character (Control type)	Succeeding characters (Device (optional use, if required))
T			
U			
V			Valve/dampers
W			
X			
Y			
Z			
#	Optional [1)]		

Note 1) Identifies supplier/project specific function which is not in accordance with this NORSOK standard.

A.4.2.2 Primary function

C - continuous control

H - hand

K - sequencing

L - latching

M – monitoring

O - output

S - switching control

Q - totalize

A.4.2.3 Control type

A - analogue (automatic function)

B - binary (automatic function)

S - step (automatic function)

A.4.2.4 Device (optional use, if required)

B - Breaker

C – coordination

E - electrically motor/heaters (MCC)

S – Serial communication

V - valve/dampers

A.4.2.5 Special character

- this character is optional to use. It is recommended to use it to identify that the function is not in accordance with this NORSOK standard. It shall be shown on SCDs as 1.letter in template identification code.

NOTE! Some SAS systems may not support this special character.

A.4.2.6 List of function templates

Table A.4 – List of function templates described in this annex

Primary function	Control type	Device	Description
C	A		Continuous control by means analogue control action.
C	S		Continuous control by means step control action.
H	A		Hand entering of an analogue value
H	B		Hand entering of a binary value
K	B		Sequence (K) control by means of collecting binary statuses
L	B		Latching of Binary signal, i.e. PSD level block.
M	A		Monitoring of analogue process value.
M	A	S	Monitoring of analogue process value and serial communicated alarm limits
M	B		Monitoring of binary process value.
O	A		Output of analogue signal
Q	A		Totalizing (quantum) of analogue process value.
S	B		Switching control be means of binary signal for shutdown.
S	B	B	Breaker control by means of binary control action of an electrical breaker
S	B	C	Switching control by means of a binary action and coordination control of multiple electrical power devices
S	B	E	Switching control by means of a binary control action of electrical power devices.
S	B	V	Switching control by means of a binary control action of H/P power devices, e.g. valves.

A.4.2.7 Template description

The templates descriptions included in this annex will have following chapters:

A.x .x XX – Annex A function template paragraph number
A.x.x.1 Intended use
A.x.x.2 Technical description
A.x.x.2.1 Functional template schematic
A.x.x.2.2 I/O terminals
A.x.x.2.3 Template parameters with default values
A.x.x.3 Functional description
A.x.x.3.1 General
A.x.x.3.2 Operation modes
A.x.x.3.3 Control requirements
A.x.x.3.4 Safeguarding
A.x.x.3.5 Error handling

A.4.2.8 Function template schematic – content

A.x.x.2.1 “Functional template schematic” contains a schematic illustration of the template with input and output terminals respectively on left and right side of the square symbolising the template.

The terminals are listed under following headings:

<u>Inputs/Outputs</u>: The terminals listed under these headings are normally those used to connect in from and out to field instrumentation and to other function templates. (logic).

<u>Operator stations</u>: Here the information is listed without terminals, because they will not be connected on the SCD diagram. How this information is communicated to the HMI is not defined by this NORSOK standard. The information is regarded as required by the operator to be able to operate the object in a safe manner.

<u>Logic:</u>

Inputs	AA		Outputs
Aaaaa aaaaa aaaaa	AAA	AAA	Aaaaa aaaaa aaaaa
Aaaaa aaaaa aaaaa	AAA	AAA	Aaaaa aaaaa aaaaa
Aaaaa aaaaa aaaaa	AAA	AAA	Aaaaa aaaaa aaaaa
Aaaaa aaaaa aaaaa			Aaaaa aaaaa aaaaa
Aaaaa aaaaa aaaaa			Aaaaa aaaaa aaaaa
Aaaaa aaaaa aaaaa			Aaaaa aaaaa aaaaa
Operator station:			Operator station:
Aaaaa aaaaa aaaaa	AAA	AAA	Aaaaa aaaaa aaaaa
Aaaaa aaaaa aaaaa	AAA	AAA	Aaaaa aaaaa aaaaa
Aaaaa aaaaa aaaaa	AAA	AAA	Aaaaa aaaaa aaaaa

Figure A.1 - Typical function template schematic

A.4.3 CA – PID controller

A.4.3.1 Intended use

The CA function template shall be used for continuous control, i.e. proportional, integral and derivative control (PID control).

A.4.3.2 Technical description

A.4.3.2.1 Function template schematic

Inputs	CA		Outputs
Normal function input	X	Y	Normal function output
External fault	XF	YF	Function failed
External setpoint value	XR	YR	Reference setpoint value
External tracking value	XT	YX	Measured value output
Position low feedback	XGL	BCL	Output position low confirmed
Position high feedback	XGH	BCH	Output position high confirmed
Feed forward	XFF	BS	Status safeguarding
Lock safeguarding high	LSH	BB	Status blocked
Lock safeguarding low	LSL	BU	Status suppressed
Force safeguarding high	FSH	BA	Status auto/man
Force safeguarding low	FSL	BX	Status external/internal
Force tracking	FT	BT	Status tracking
Force blocking	FB	WV	Deviation warning[2)]
Force suppression	FU	WH	Warning alarm H[2)]
Lock auto	LA	WL	Warning alarm L[2)]
Lock manual	LM		
Lock external setpoint	LX		
Lock internal setpoint	LI		
Operator station:			Operator station:
Auto/Manual			Alarms and faults
Internal/External			Closed
Internal setpoint			Auto/Manual
Set output value			Internal/External
Blocking on/off			Tracking
Suppression on/off			Blocked
			Suppressed
			Safeguarding
			Conflict

2) Shall not be used for downstream logic, see 3.1.

Figure A.2 - CA function template schematic

A.4.3.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
X	Analogue input	Normal function input	Analogue input signal representing the process value to be controlled.
XF	Binary input	External fault	Fault indication from outside the template.

Terminal code	Signal type	Terminal name	Supplementary description
XR	Analogue input	External setpoint value	The external setpoint value to be used when the controller is in auto and external mode, e.g. the setpoint used if this controller is part of a cascade control.
XT	Analogue input	External tracking value	The output value Y equals the input value XT, when the controller is in auto and tracking mode.
XGL	Binary input	Position low feedback	Signal from limit switch low (optional). XGL = 1 is closed flow element. Enabling the closed limit switch shall be defined by a parameter.
XGH	Binary input	Position high feedback	Signal from limit switch high (optional). XGH = 1 is open flow element. Enabling the open limit switch shall be defined by a parameter.
XFF	Analogue input	Feed forward	Signal representing a disturbance which is converted into a corrective action to minimize deviations of controlled variable. The feed forward function is only active when the controller is in auto mode.
LSH	Binary input	Lock safeguarding high.	Safeguarding – LSH = 1. Overrules operator possibility to set Auto/Manual mode. Locks template in manual mode, and Y goes to highest output value regardless of failure state. Input is subject to blocking. When signal goes low, the template remains in manual mode and Y remains unchanged.
LSL	Binary input	Lock safeguarding low.	Safeguarding – LSL = 1 Overrules operator possibility to set Auto/Manual mode. Locks template to manual mode and Y to lowest output value regardless of failure state. Input is subject to blocking. When signal goes low, the template remains in manual mode and Y remains unchanged.
FSH	Binary input	Force safeguarding high	Safeguarding – FSH = 1. Sets Y to highest output value regardless of failure state. When signal is reset, the template will react to actual terminal statuses again if in auto mode. In manual mode, the output (Y) remains unchanged after signal returns to normal. Signal is subject to blocking.
FSL	Binary input	Force safeguarding low	Safeguarding – FSL = 1. Sets Y to lowest output value regardless of failure state. When signal is reset, the template will react to actual terminal statuses again if in auto mode. In manual mode, the output (Y) remains unchanged after signal returns to normal. Signal is subject to blocking.
FT	Binary input	Force tracking	The object is forced to tracking mode when FT = 1, and the Y output starts tracking the XT input if in auto mode.
FB	Binary input	Force blocking	FB = 1. Safeguarding actions LSH, LSL, FSH and FSL will be blocked.
FU	Binary input	Force suppression	Alarm annunciation is suppressed, WH,WL,WV, YF = 0 and statuses X, XGL and XGH are neglected as long as FU=1.
LA	Binary input	Lock Auto	LA = 1. Locks the template in auto mode. When LA is reset, the template remains in auto mode.

Terminal code	Signal type	Terminal name	Supplementary description
LM	Binary input	Lock Manual	LM=1. Locks the template in manual mode. When LM is reset, the template remains in manual mode. LM has higher priority than LA.
LX	Binary input	Lock external setpoint	Locks the control function template to use external setpoint, overruling the operator. When LX is reset, the object remains in external mode.
LI	Binary input	Lock internal setpoint	Locks the control function template to use internal setpoint, overruling the operator. When LI is reset, the object remains in internal mode. LI has higher priority than LX.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Analogue output	Normal function output	Control signal to flow element. Y is normally 0 % to 100 %, e.g. for a valve, 0 % is fully closed and 100 % is fully opened, independent of the valve's fail open/close setting.
YF	Binary output	Function failed	YF = 1 if external or function fault. See error handling.
YR	Analogue output	Reference setpoint value	Actual setpoint being used.
YX	Analogue output	Measured value output	The controller measurement value. The YX is normally equal to X**,** except if the signal is faulty. If the signal is faulty, YX is set to a predefined value.
WV	Binary output	Deviation alarm (warning)	The absolute difference between the measured value X and the used setpoint is above a predefined limit for a predefined time. The deviation warning is enabled only when the controller is in auto internal or auto external. WV is disabled by alarm suppression.
BCL	Binary output	Output position low confirmed	If the closed limit switch is enabled, the output Y is compared to the low limit switch feedback and validated as true (BCL = 1) if Y within "limit confirmed state closed" and XGL = 1. If the closed limit switch is disabled, BCL = 1 when Y is within "limit confirmed state closed".
BCH	Binary output	Output position high confirmed	If the open limit switch is enabled, the output Y is compared to the high limit switch feedback and validated as true (BCH = 1) if Y within "limit confirmed state opened" and XGH = 1. If the closed limit switch is disabled, BCL = 1 when Y is within "limit confirmed state opened".
BS	Binary output	Status safeguarding	BS = 1 if any safeguarding input is active.
BB	Binary output	Status blocked	BB = 1 when the template is blocked from operator station or FB = 1.
BU	Binary output	Status suppressed	BU = 1 when suppressed from operator station or FU = 1.
BA	Binary output	Status auto/man	BA = 1 when auto mode is set from operator station or LA=1.

Terminal code	Signal type	Terminal name	Supplementary description
BX	Binary output	Status internal / external	BX = 1 when set in external mode from operator station or LX = 1.
BT	Binary output	Status tracking	BT = 1 when FT = 1 and in auto mode.
WH	Binary output	Warning alarm H	True, when X3)-value >WH limit. Subjected to suppression. Should not be used for downstream logic.
WL	Binary output	Warning alarm L	True, when X3)-value <WL limit. Subjected to suppression. Should not be used for downstream logic.

3) The X value used for comparison with the alarm limit shall be given in measurement unit (%, barg, bara, Kg/h, mm, etc)

A.4.3.2.3 Template parameters with default values

Parameters

Parameter code	Signal type	Parameter name	Supplementary description	Default
1)	Enum	Position feedback configuration	0: No feedback 1: Only XGL 2. Only XGH 3. Both XGL and XGH	0
1)	Analogue	Deviation limit	Deviation alarm limit between the measured value X and the used setpoint YR.	5%
1)	Analogue	Time delay deviation alarm	Delay of deviation alarm between X and YR.	5 s
1)	Analogue	Limit confirmed state closed	When XGL is configured, XGL is used for closed state monitoring. When no closed limit switch is configured: Closed state is calculated by comparing to the operating range. The % value is calculated in relation to the full range, e.g. if the full range is 0 % to 100 % and the confirmed limit state is set to 2 %, confirmed closed limit is 2 % or less.	2%
1)	Analogue	Limit confirmed state opened	When XGH is configured, XGH is used for open state monitoring. When no limit switch is configured: Open state is calculated by comparing to the operating range. The % value is calculated in relation to the full range, e.g. if the full range is 0 % to 100 % and the confirmed limit open state is set to 98 %, confirmed open limit is 98 % or higher.	98%
1)	Analogue	WH limit	Alarm limit for WH	-
1)	Analogue	WL limit	Alarm limit for WL	-
1)	Analogue	Time delay warning alarms	Delay before alarm is raised after limit has been reached.	0
1)	Analogue	Hysteresis value	The hysteresis should be defined in % of display range. The hysteresis shall only effect the return of alarms and events not initiation. Common for all limits.	2%
1)	Analogue	Minimum range input	Minimum range value in.	-
1)	Analogue	Maximum range input	Maximum range value in.	-
1)	Analogue	Minimum setpoint range	Minimum allowed setpoint value. This value is greater or equal to minimum range in.	-

Parameter code	Signal type	Parameter name	Supplementary description	Default
1)	Analogue	Maximum setpoint range	Maximum allowed setpoint value. This value is less or equal to maximum range in.	-
1)	Analogue	Minimum range output	Minimum range value out.	0
1)	Analogue	Maximum range output	Maximum range value out.	100
1)	Analogue	Minimum operating range	Minimum allowed output value. This value is greater or equal to minimum range out.	0
1)	Analogue	Max. operating range	Maximum allowed output value. This value is less or equal to maximum range out.	100
1)	Binary input	Limitation by operating range in Manual mode	0 = No limit for manual. 1 = Manual output limited by operating range.	1
1)	Analogue	Ext-P	Proportional parameter in PID algorithm from external source.	-
1)	Analogue	Ext-I	Integral time in PID algorithm from external source.	-
1)	Analogue	Ext-D	Derivate time in PID algorithm from external source.	-
1)	Binary	Enable ext PID parameters	0 = use internal parameters 1 = use external parameters	0
1)	Analogue	P	Proportional parameter in PID algorithm.	1.0
1)	Analogue	I	Integral time in PID algorithm.	0s
1)	Analogue	D	Derivate time in PID algorithm.	0s
1)	Analogue	KFF	Proportional parameter in feed forward algorithm.	0.0
1)	Binary	Control direction	0: The controller is direct acting, i.e. increased input compared to setpoint shall cause increased output. 1: The controller is reverse acting, i.e. increased input compared to setpoint shall cause decreased output.	1
1)	Analogue	Ramp setpoint up/down	Ramp time when switching between different modes, e.g. manual to auto internal. Engineering units/sec (value 0 disables function)	0
1)	Analogue	Ramp output up/down	Ramp time when switching between different modes, e.g. into output tracking. %/s (value 0 disables function)	0
1)	Binary	Fault options	For external fault, output Y options 0: Freeze (to manual and keep last value) 1: Output Y is set to substitute value.	0
1)	Binary	Restart options	0: Enter manual mode and substitute value 1: Enter auto mode	0
1)	Analogue	Substitute value	If substitute value option is selected for external fault or restart, the output Y is set to defined substitute value.	0
1)	Binary	X outside range	Reaction if X outside range see error handling 0: Function disabled 1: Function enabled	0
1)	Analogue	Travel time	Time value defining full travelling time in sec.	10 s

1) Parameter code to be defined if used on a terminal. It shall then start with the letter P.

A.4.3.3 Functional description

A.4.3.3.1 General

The CA function template shall be used for continuous control of e.g control valves, variable speed drive motors and thyristor heaters.

The function template may act e.g. as a P,PI,PD or PID controller.

The controller can be operated in either manual or auto mode. In manual mode the PID algorithm is not active and the output is set manually from the template. In auto mode the PID algorithm is active. The setpoint used in the PID algorithm is either the internal or external setpoint, depending on the internal/external setting of the template.

The controller can be switched to output tracking mode by input FT. The output value Y will then be clamped to the input XT.

The feed forward function may be incorporated according to system vendor standards, but shall as a minimum include a proportional factor that is multiplied with the feed forward signal and added to the output signal.

The controller shall be parameterised as either direct or reverse acting.

All limit checking and alarm annunciation resides within the template.

The template includes safeguarding, together with suppress and blocking functions.

See Figure F.19 for complementary function behaviour description of the CA template.

A.4.3.3.2 Operation modes

Modes functions

Function	Description
Auto	In auto mode the CA template calculates the control signal using the PID control algorithm. The setpoint used in this calculation may be either internal or external. The auto mode may be set by the operator or by logic. It shall be possible to enable auto mode even if the template is in force safeguarding mode (FSL,FSH) or in fault state (YF = 1). Auto mode does not necessarily indicate that the control algorithm is running, if e.g. the template is in force safeguarding mode, tracking mode or in a fault state. The auto mode works in combination with internal, external and tracking mode. When in auto mode, the BA output is set.
Manual	In manual mode the output control signal (Y) is set by the operator, unless forced by safeguarding. The PID control algorithm is disabled.
Internal	Internal mode has only effect in auto mode. The PID control algorithm uses the value set by the operator as setpoint. The internal mode shall be possible to enable when the template is in manual/auto mode, safeguarding mode or in a fault state.

Function	Description
External	External mode has only effect in auto mode. The PID control algorithm uses the value from XR as setpoint. The external mode shall be possible to enable when the template is in manual/auto mode, safeguarding mode or in a fault state.
Tracking	Tracking mode has only effect in auto mode. The controller output Y is equal to the XT input. Switching in and out of tracking should be bumpless. The tracking mode shall be possible to enable when the template is in manual/auto mode, safeguarding mode or in a fault state.
Feed forward	The feed forward function shall as a minimum include a proportional factor that is multiplied with the feed forward signal (XFF) and added to the output value.
Block	Blocking disables safeguarding mode (LSH/LSL/ FSH/FSL).
Suppression	Suppresses YF, WV, WH and WL, and sets these outputs to 0. Position feedback XGL and XGH are disregarded, and the control template will use output Y to calculate closed and/or open position.

A.4.3.3.3 Control requirements

Control functions

Function	Description
Set point	Setpoint definition : Operator setpoint: value available for operator manipulation Stored setpoint: operator setpoint stored in specific mode changes (defined below) External setpoint: value equal to XR Actual setpoint: value used by PID algorithm (one of the above) The operator setpoint is: In auto mode: set by operator In manual mode: equal to X (setpoint tracking) Set to stored setpoint when switching from manual to auto internal by logic (LA). Set to stored setpoint when switching from auto external to auto internal by logic (LX). The last setpoint used is stored and displayed as the stored setpoint when: - switching from auto internal to manual, - switching from auto internal to auto external. - switching from auto internal to tracking mode. The actual setpoint is: In manual mode: equal to X. In auto internal mode: equal to operator setpoint In auto external mode: equal to XR In tracking mode: not affected Actual setpoint transitions are subject to bumpless transfer.

Function	Description
Algorithm	The flow element (e.g. valve, VSD motor, etc.) is operated by an analogue output signal. Possibility for direct or reverse control action. There shall be anti-windup protection. Controller deviation dead band shall be available. Remote setting of K, Td and Ti parameters shall be possible.
Bumpless	There shall be bumpless switching of actual setpoint between operation modes. There shall be bumpless transfer of operator setpoint changes. The setpoint shall be clamped to the measured value in manual mode to assure a bumpless transfer from manual to automatic mode (the setpoint tracks the measured value while the controller is in manual mode). When the controller is forced to auto by logic, the setpoint shall automatically be ramped back to the stored setpoint value. When the controller is switched to auto by the operator, the operator can manually adjust the set point and ramp it back to the stored setpoint value to accomplish a bumpless transfer to that value.
Cascade	There shall be a synchronization functionality between master and slave controllers to secure controlled interaction. This function is not shown on the SCD.
Restart	After restart of the controller node, the function template will be set to a predefined state selected by ”Restart options” parameter.

A.4.3.3.4 Safeguarding

Safeguarding functions

Function	Description
Lock	Set the output to safeguarding position and sets the function template to manual mode
Force	Set the output to safeguarding position, but the mode of function template is not changed
Conflict	True if any safeguarding action is requested when the template is in blocked state. It shall be possible to generate an alarm on this event. If any safeguarding action is enabled and the object is blocked

A.4.3.3.5 Error handling

Error functions

Function	Description
External fault	XF = 1 [4)]: Shall be possible to generate alarm and set YF = 1. The template will enter manual mode. The output Y will be either substitute value or freeze value (depending on parameter).

Function	Description
Function fault	Feedbacks XGL and XGH can be monitored and compared with the output value. If a mismatch is detected, it shall be possible to generate an alarm and set YF = 1. When Y > “Limit confirmed state % closed” and XGL=1 delayed by a predefined “travel time”. When Y < “Limit confirmed state % open” and XGH=1 delayed by a predefined “travel time”. It shall be possible to disable this function.
Setpoint limits	High and low setpoint limits shall be available. Manual input, which exceeds these limits, shall not be used. The operator shall retype a value. Where it is not desirable to allow switching a controller to external setpoint with setpoint outside these limits, it shall be possible to generate an alarm and prevent the controller to be set in external modus. External input, which exceeds these limits, clamp to threshold value. Shall be possible to generate an alarm.
Warning deviation	WV=1. Shall have the possibility to generate warning when measured value passes defined deviation alarm parameter.
X outside range[4)]	Shall be possible to generate alarm and set YF = 1. The template will enter manual mode. The output Y will be either substitute value or freeze value (depending on parameter). It shall be possible to disable this function.

4) Signal quality may be transferred as system internal information.

A.4.1 CS – Step control

A.4.1.1 Intended use

The CS function template shall be used for control and monitoring of position controlled valves. The valves are operated by either pulsed or steady output signals. One output for opening and one for closing the valve.

For subsea choke valves it is expected to be requirement for adaption.

A.4.1.2 Technical description

A.4.1.2.1 Functional block schematic

Inputs	CS		Outputs
Position reading	XG	YH	Normal function output high
External fault	XF	YL	Normal function output low
External setpoint value	XR	YF	Function failed
Position low feedback	XGL	YG	Output valve position
Lock safeguarding low	LSL	WV	Warning deviation
Force disable transition high	FDH	BCL	Output position low confirmed
Force blocking	FB	BS	Status safeguarding
Force suppression	FU	BB	Status blocked
Lock auto	LA	BU	Status suppressed
Lock manual	LM	BA	Status Auto/Man
Lock external setpoint	LX	BX	Status external/internal
Lock internal setpoint	LI		
			Operator station
Operator station			Alarms and faults
Auto/Manual			Open/Closed
Internal/External			Auto/Manual
Step open			Internal/External
Step close			Blocked
Setpoint			Suppressed
Blocking on/off			Safeguarding
Suppression on/off			Moving transition high
			Moving transition low
			Conflict

Figure A.3 - CS function template schematic

A.4.1.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
XG	Analogue input	Position reading	Position read as measured value.
XF	Binary input	External fault	Loop failure e.g. I/O card broken
XR	Analogue input	External setpoint value	Used in external – auto mode
XGL	Binary input	Position low feedback	Limit switch low
LSL	Binary input	Lock safeguarding low	Safeguarding – LSL = 1. Overrules operator possibility to set Auto/Manual mode. Locks template in manual mode, and Y goes to lowest output value regardless of failure state. Input is subject to blocking. When signal goes low, the template remains in manual mode and Y remains unchanged.
FDH	Binary input	Force disable transition high	Permissive to open when FDH = 0 and prevents template from being open when FDH = 1.
FU	Binary input	Force suppression	Alarm annunciation is suppressed, WH,WL,WV, YF = 0 and statuses XF and XGL are neglected as long as FU = 1.
FB	Binary input	Force blocking	FB = 1. Safeguarding action LSL will be blocked.
LA	Binary input	Lock Auto	LA = 1. Locks the template in auto mode. When LA is reset, the template remains in auto mode.
LM	Binary input	Lock Manual	LM = 1. Locks the template in manual mode. When LM is reset, the template remains in manual mode. LM has higher priority than LA.
LX	Binary input	Lock external setpoint	Locks the control function template to use external setpoint, overruling the operator. When LX is reset, the object remains in external mode.
LI	Binary input	Lock internal setpoint	Locks the control function template to use internal setpoint, overruling the operator. When LI is reset, the object remains in internal mode. LI has higher priority than LX.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
YH	Binary output	Normal function output high	Output pulse to open valve. Pulse train. Pulse defined by parameters.
YL	Binary output	Normal function output low	Output pulse to close valve. Pulse train. Pulse defined by parameters.
YF	Binary output	Function failed	For use in downstream logic. See error handling.
BCL	Binary output	Output position low confirmed	State set when XGL = 1 or XG closed position (selectable by parameter) and compared with output setpoint below closed position. (Parameter defined for feedback low limit)
YG	Analogue output	Output valve position	Position of the valve for use in downstream logic

Terminal code	Signal type	Terminal name	Supplementary description
WV	Binary output	Warning deviation	The absolute difference between the measured value X and the used setpoint is above a predefined limit for a predefined time. The deviation warning is enabled only when the controller is in auto internal or auto external. WV is disabled by alarm suppression.
BS	Binary output	Status safeguarding	BS = 1 if any safeguarding input is active.
BB	Binary output	Status blocked	BB = 1 when the template is blocked from operator station or FB = 1.
BU	Binary output	Status suppressed	BU = 1 when suppressed from operator station or FU = 1.
BA	Binary output	Status auto/man	BA = 1 when auto mode is set from operator station or LA=1.
BX	Binary output	Status internal / external	BX = 1 when set in external mode from operator station or LX = 1.

A.4.1.2.3 Template parameters with default values

Parameters

Parameter code	Signal type	Parameter name	Supplementary description	Default
1)	Binary	Steady output	Specifies if the output should be a steady signal or a pulse train. Parameter = 1 if output shall be steady.	0
1)	Analogue	Length on-pulse YH	Specifies the length of on-pulse for output signal YH. Given in seconds.	1 s
1)	Analogue	Total length pulse YH	Specifies the total length of pulse for output signal YH. Given in seconds.	1 s
1)	Analogue	Length on-pulse YL	Specifies the length of on-pulse for output signal YL. Given in seconds.	1 s
1)	Analogue	Total length pulse YL	Specifies the total length of pulse for output signal YL. Given in seconds.	1 s
1)	Analogue	Number of pulses for full range	Specifies the total amount of pulses required to open the valve from closed position to open position.	-
1)	Analogue	Closed position	Specifies low limit for closed position. (Used for both for XG and setpoint for BCL)	2 %
1)	Analogue	Comparison value	Specifies acceptable deviation between XG and output setpoint, in %.	2 %
1)	Analogue	Warning deviation timer	Specifies timeout for full range travel.	600 s
1)	Binary	BCL function selection	Parameter = 1 if XGL to give BCL. Parameter = 0 if XG low limit to be compared with output setpoint.	0
1)	Binary	Fault option	For external or function fault , outputs YH/YL options: 0: Freeze (manual and YH/YL = 0) 1: Continue (keep last values)	0

1) Parameter code to be defined if used on a terminal. It shall then start with the letter P.

A.4.1.3 Functional description

A.4.1.3.1 General

Control and monitoring of position controlled valves. The valves are operated by either pulsed or steady output signals. The output YH will cause the valve to step/move towards the open position.

The output YL will cause the valve to step/move towards the closed position.

When commanded to a specific position, either in auto or external, the valve will be commanded using YH/YL until the position reading (XG) is within the commanded setpoint +/- the acceptable deviation (comparison value).

See Figure F.20 for complementary function behavior description of the CS template.

A.4.1.3.2 Operation modes

Mode functions

Function	Description
Auto	In auto (and internal) mode, the operator can enter a setpoint for the position and the valve will automatically travel to the setpoint position.
Manual[5)]	In manual (and internal) mode the operator can manoeuvre the valve step by step towards either open or closed position.
Internal	In internal mode, the valve can be controlled as described for auto/manual depending on which of these modes are selected.
External	In external mode, the external setpoint value (XR) will be used.
Block	Blocking disables safeguarding mode (LSL) and the disable transition mode (FDH).
Suppression	Suppression will prevent alarms on the YF terminal from being generated and the function template will neglect the feedback signals.
Disable transition mode	Transition to high/low state is prevented.

5) If both LA and LM are true, then the LM has priority and the block will be in manual mode.

A.4.1.3.3 Control requirements

Control functions

Function	Description
Set point	The setpoint shall be either internal or external. The external setpoint is set to input terminal XR. The operator gives the internal setpoint.
Controller output	The valves are operated by either pulsed or steady output signals. There is one output for opening and one for closing the valve.

A.4.1.3.4 Safeguarding

Safeguarding functions

Function	Description
Lock	Set the output to safeguarding position and sets the function template to manual mode. If the safeguarding signal is reset before the valve has reached its closed position, the valve should freeze in the current position and manual mode. Closing of the valve in safeguarding shall not be done by commanding the setpoint, i.e. the last setpoint shall be available during and after a safeguarding situation.
Conflict	If any safeguarding action is requested when blocking is true. It shall be possible to generate an alarm on this event.

A.4.1.3.5 Error handling

Error functions

Function	Description
External fault	XF = 1: Shall be possible to generate alarm and set YF = 1. The template will either enter manual mode and stop, or continue as before. This behaviour is controlled by parameter.
Function fault	When XGL goes high, position feedback from flow element (XGL) will be compared with the position read (XG< (Closed position) %). It shall be possible to generate function failed alarm if mismatch is detected. It shall be possible to disable this function. The template will either enter manual mode and stop, or continue as before. This behaviour is controlled by parameter.
Travel monitoring	Shall be possible to generate a warning deviation when the valve does not travel to the expected position (set point) within a calculated time. The time shall be calculated for every command as a percentage of the warning deviation timer based on the commanded change in position (setpoint).

A.4.2 HA – Analogue input command

A.4.2.1 Intended use

The HA function template shall be used for entering an analogue value from the HMI. This analogue value can be used in logic, calculations etc. It is possible to follow an external value by setting the block in auto (LA). The operator can disable this function by setting the block in manual (LM).

A.4.2.2 Technical description

A.4.2.2.1 Functional template schematic

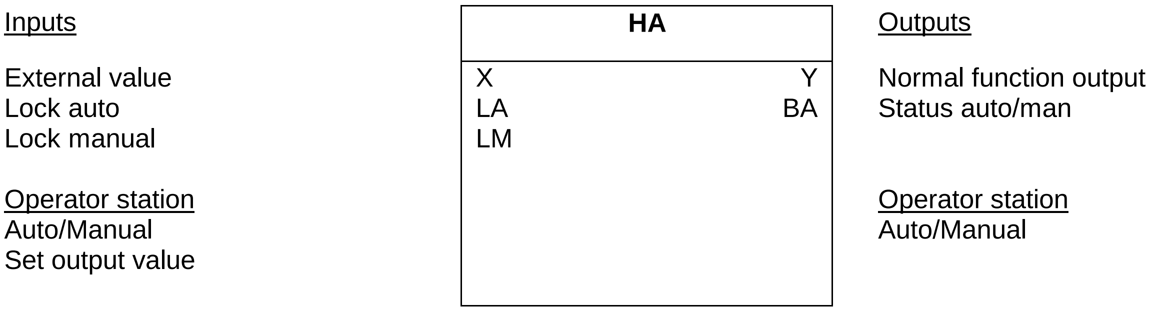

Figure A.4 - HA function template schematic

A.4.2.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
X	Analogue input	External value	Analogue value tracked in auto mode.
LA	Binary input	Lock auto	Locks the template to auto mode, overruling the operator. After signal disappears, template keeps in auto mode.
LM	Binary input	Lock manual	Locks the template to man mode. After signal disappears, template keeps in manual mode.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Analogue output	Normal function output	Manual/ auto selected analogue output to be used in logic.
BA	Binary output	Status auto/man mode	True: auto, false: manual

A.4.2.2.3 Template parameters with default values

Parameters

Parameter code	Signal type	Parameter name	Supplementary description	Default
1)	Analogue input	Ramp time external value (EU/sec)	Specifies the ramping of the external value when switched from manual to auto mode. The ramp time is specified in engineering unit per second. If the ramp time is set to zero, this means the ramping is disabled.	0
1)	Analogue input	Maximum input value	Defining the highest allowed input value	-
1)	Analogue input	Minimum input value	Defining the lowest allowed input value	-

1) If parameter is defined on a terminal, it shall be coded and start with character P.

A.4.2.3 Functional description

A.4.2.3.1 General

Function template for storing an analogue value from the HMI. This analogue value can be used in logic, calculations etc. It is possible to follow an external value by setting the function in Auto (LA). The operator can disable this function by setting the function in manual (LM).

See Figure F.21 for complementary function behavior description of the HA template.

A.4.2.3.2 Operation modes

Mode functions

Function	Description
Auto	In auto mode the normal function output (Y) will follow the external set value (X) according to a ramp rate defined by an input parameter.
Manual5)	In manual mode the analogue output (Y) is set directly by the operator from HMI.

5) If both LA and LM are true, then the LM has priority and the block will be in manual mode.

A.4.2.3.3 Control requirements

Not applicable for this function template.

A.4.2.3.4 Safeguarding

Not applicable for this function template.

A.4.2.3.5 Error handling

Not applicable for this function template.

A.4.3 HB – Binary input command

A.4.3.1 Intended use

The HB function template shall be used for entering a binary value from the HMI. This binary value can be used in logic, calculations etc. It is possible to follow an external value by setting the function in auto (LA). The operator can disable this function by setting the function in manual (LM).

A.4.3.2 Technical description

A.4.3.2.1 Functional template schematic

Inputs	HB		Outputs
External value	X	Y	Normal function output
Reset latched output	RX	BA	Status auto/man
Force disable transition high	FDH		
Force disable transition low	FDL		
Lock auto	LA		
Lock manual	LM		
Operator station			Operator station
Auto/Manual			Auto/Manual
Set output on(high)/off(low)			

Figure A.5 - HB function template schematic

A.4.3.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
X	Binary input	External value	Binary value tracked in auto mode
FDH	Binary input	Force disable transition high	Permissive to set output on when FDH = 0 and prevents transition to on when FDH = 1.
FDL	Binary input	Force disable transition low	Permissive to set output off when FDL = 0 and prevents transition to off when FDL = 1.
LA	Binary input	Lock auto	Locks the template to auto mode, overruling the operator. After signal disappears, template keeps in auto mode.
LM	Binary input	Lock manual	Locks the template to man mode. After signal disappears, template keeps in manual mode.
RX	Binary input	Reset latched ouput	Resets the output Y when RX goes high.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Binary output	Normal function output	-If the template is set not to latch, Y = X. Dependent on parameter selection, the output can be pulsed. -If the template is set to latch, Y is set when X goes high, and reset when RX goes high.
BA	Binary output	Status auto/man	True: auto, false : manual

A.4.3.2.3 Template parameters with default values

Parameters

Parameter code	Signal type	Parameter name	Supplementary description	Default
1)	Binary	Latched output	If the parameter is set the Y output is latched.	0
1)	Binary	Pulsed output	If the parameter is set an on-pulse is generated on the output Y when the input is set high. This parameter will have no effect when latched output is selected.	0
1)	Analogue	Pulse time output	Pulse length for Y when pulsed output selected	2 s

1) Parameter code to be defined if used on a terminal. It shall then start with the letter P.

A.4.3.3 Functional description

A.4.3.3.1 General

Function template for setting a binary from the HMI. This binary value can be used in logic, calculations etc. It is possible to follow an external value by setting the function in auto (LA). The operator can disable this function by setting the function in manual (LM). The output can be pulsed, latched or merely following the input, based on parameter settings.

See Figure F.22 for complementary function behavior description of the HB template.

A.4.3.3.2 Operation modes

Mode functions

Function	Description
Auto	In auto mode the binary output (Y) is controlled from an external value (X).
Manual5)	In manual mode the binary output (Y) is controlled directly by the operator from HMI.

5) If both LA and LM are true, then the LM has priority and the function will be in manual mode.

A.4.3.3.3 Control requirements

Not applicable for this function template.

A.4.3.3.4 Safeguarding

Not applicable for this function template.

A.4.3.3.5 Error handling

Not applicable for this function template.

A.4.4 KB – Sequence logic interface template

A.4.4.1 Intended use

The KB function template shall be used for sequences as an interface for controlling the sequence from HMI and/or other control logic. The normal operations are start (continue), hold and terminate.

A.4.4.2 Technical description

A.4.4.2.1 Function template schematic

Inputs	**KB**		Outputs
External set high	XH	YF	Function failed
External set low	XL	BH	Sequence running
Lock safeguarding low	LSL	BS	Status safeguarding
Force disable transition high	FDH	BB	Status blocked
Force hold	FN	BA	Status auto/man
Lock auto	LA	BN	Status hold
Lock manual	LM	BL	Status completed
Operator station			Operator station
Auto/Manual			Alarms and faults
Start/Stop			Running/Stopped
Blocking on/off			Completed
Hold/Continue			Auto/Manual
Next step			Blocked
			Disabled
			Safeguarding
			Hold

Figure A.6 - KB function template schematic

A.4.4.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
XH	Binary input	External set high	From logic to function template which start the sequence. If the sequence is in hold, it will continue the sequence.
XL	Binary input	External set low	From logic to function template which stops the sequence. The function is according to description of stop in “control requirements”.
FDH	Binary input	Force disable transition high	Permissive to start when FDH = 0 and prevents template from being started when FDH = 1.
FN	Binary input	Force hold	FN = 1 will temporarily hold the sequence in the current step.
LA	Binary input	Lock auto mode	Locks the template in auto mode. When LA goes low, the template remains in auto mode.
LM	Binary input	Lock manual mode	Locks the template in manual mode. When LM goes low, the template remains in manual mode.
LSL	Binary output	Lock safeguarding low	Safeguarding – LSL = 1 terminates and resets the sequence.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
YF	Binary output	Function failed	YF = 1 if the total sequence has timed out or error from the step.
BH	Binary output	Sequence running	BH = 1 if sequence is running. BH = 1 also when sequence is in hold.
BS	Binary output	Status safeguarding	BS = 1 if any safeguarding input is active.
BB	Binary output	Status blocked	BB = 1 if blocked mode
BA	Binary output	Status auto/man	BA = 1 when in auto mode
BN	Binary output	Status hold	BN = 1 if sequence is in hold
BL	Binary output	Status completed	BL = 1 if the sequence is completed normally (see A.4.8.3)

A.4.4.2.3 Template parameters with default values

Parameters

Parameter code	Parameter type	Parameter name	Supplementary description	Default
1)	Enumeration	Operation mode options	Manual and auto mode Manual mode	Manual

1) Parameter code to be defined if used on a terminal. It shall then start with the letter P.

A.4.4.3 Functional description

A.4.4.3.1 General

The following control options shall be made available selected by parameter:

– manual operation + automatic control;

– manual operation only.

The template gives the minimum requirements for a sequence control template to be able to show the interface between the logic and the sequence. It also describes how the interface terminals shall behave to satisfy these requirements..

It shall be possible to define different actions for the different stop commands; normal stop (XL or manual stop by operator) and safeguarding (LSL). The content of these shall be defined during implementation of each sequence and the realization will be dependant of the control system and process requirements.

See Figure F.23 for complementary function behavior description of the KB template.

A.4.4.3.2 Operation modes

Mode functions

Function	Description
Auto	The input terminals XH, XL will start or stop the sequence.
Manual[5)]	The operator is able to start the sequence.
Disable transition mode	See definition.
Block	Blocking disables FDH.

5) If both LA and LM are true, then the LM has priority and the block will be in manual mode.

A.4.4.3.3 Control requirements

Control functions

Function	Description
Start	Starts the sequence. Have no effect when sequence is running.
Stop	The sequence will stop. When the sequence is stopped, it will be ready for a new start. Available for operator both in manual and auto.
Hold	The sequence is temporarily stopped in the current step. The status of the sequence is still running (BH = 1). If the step is a timer step the timeout timer is stopped. Available for operator both in manual and auto.
Continue	Continues the sequence when in hold. Available for operator both in manual and auto.
Force next step	The sequence is forced to the next step unconditionally. Available for operator both in manual and auto.

Function	Description
Complete	The complete status goes high when the sequence has gone through all the defined steps. The complete status goes low when the sequence is started again.

A.4.4.3.4 Safeguarding

Safeguarding functions

Function	Description
Lock	Terminates and resets the sequence immediately and sets the function template to manual mode.

A.4.4.3.5 Error handling

Error functions

Function	Description
Sequence error	Includes errors from the steps. The YF shall be set. The sequence enters hold.

A.4.5 LB – Safeguarding shutdown level

A.4.5.1 Intended use

The LB function template shall be used for control of safety shutdown levels in PSD and ESD nodes etc. requiring SIL-level. It may additionally be used for control of utility shutdown levels located in PCS node. One LB function template shall be used per shutdown level. The shutdown levels should form a shutdown hierarchy. The LB shall supervise the shutdown performance per level. All shutdown initiators and shutdown action elements shall have the possibility to group alarms and status up to the LB.

The LB function template is typically used in a safety system, where the action signals from shutdown initiators (e.g. ALL from MA, AHH from MA and/or Y from MB) are combined into an OR-gate before it is connected to the X-input on the LB. For the highest level in the shutdown hierarchy the XS-input on the LB shall not be used. The Y-output from the LB is linked to shutdown action elements, e.g. X on SB and/or LSL on SBV. If any lower shutdown levels exist, the YX-output from the LB on the highest level shall be linked to the XS-input on the LB function that represents the next lower level.

A.4.5.2 Technical description

A.4.5.2.1 Functional template schematic

Inputs	LB		Outputs
Normal function input	X	Y	Normal function output
External shutdown input	XS	YX	External shutdown output
Reset latched output	RX		
Operator station			Operator station
Set safeguard			Level released
Reset safeguard			External level released
Blocking XS on/off			Group fault status
Blocking YX on/off			Group conflict status
			Group blocked status
			Blocked XS
			Blocked YX

Figure A.7 - LB function template schematic

A.4.5.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
X	Binary input	Normal function input	Action signal from shutdown initiators (e.g. MA or MB function templates) setting the block to shutdown mode (signal is latched in function block).
XS	Binary input	External shutdown input	Action signal from higher shutdown level blocks. That could be another LB function template or an external shutdown signal coming from another safety system.
RX	Binary input	Reset latched output	Terminal is resetting the latch on Y-output terminal when no shutdown

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Binary output	Normal function output	Connected to shutdown input on shutdown devices
YX	Binary output	External shutdown output	Connected to external shutdown input XS on lower shutdown level blocks.

A.4.5.2.3 Template parameters with default values

Parameters

Parameter code	Parameter type	Parameter name	Supplementary description	Default
1)	Binary	Latched output	If the parameter is set the Y output is latched. This parameter only affects input X.	1

1) Parameter code to be defined if used on a terminal. It shall then start with the letter P.

A.4.5.3 Functional description

A.4.5.3.1 General

This template has latched and/or unlatched inputs. The unlatched input (YS) shall be used when the shutdown originates from a higher shutdown level.

The latched input (X) shall be used for causes with input to this level. This latched input (X) can be configured as unlatched by a parameter. Latch can be reset by operator or logic (RX). If a shutdown is initiated from operator (i.e. not from higher shutdown level), RX cannot reset the shutdown.

Conflict and fault from the shutdown devices should be grouped into the LB. The same should be done for status blocked from the primary shutdown initiators. The group status can be displayed on the LB HMI object. This is as repeated information in addition to the individual alarms on the shutdown objects. The grouping into the LB shall not be shown on the SCD diagram.

See Figure F.24 for complementary function behavior description of the LB template.

A.4.5.3.2 Operation modes

Mode functions

Function	Description
OS Block	Two separate blocking functions from OS. Block XS, blocking only function input XS. Block YX, blocking only function output YX. These blocking facilities shall not affect the input X and output Y.

A.4.5.3.3 Control requirements

Control functions

Function	Description
Alarm	Shutdown level alarm shall be possible to be generated due to the primary shutdown actions (input X). If the external shutdown input (XS) is initiated the shutdown level block shall not report any alarm.

A.4.5.3.4 Safeguarding

Safeguarding functions

Function	Description
External shutdown	Action signal from higher shutdown level blocks. That could be another LB function template or an external shutdown signal coming from another safety system.

A.4.5.3.5 Error handling

Not applicable

A.4.6 MA - Monitoring of analogue process variables

A.4.6.1 Intended use

The MA function template shall be used for scaling, display (indication) and monitoring (alarming) of process variable or control variable. The template comprises handling of field instrument and signaling faults.

A.4.6.2 Technical description

A.4.6.2.1 Function template schematic

Inputs	MA		Outputs
Normal function input	X	Y	Normal function output
External fault	XF	YF	Function failed
Force blocking alarm HH	FBHH	AHH	Action alarm HH
Force blocking alarm LL	FBLL	BHH	Status alarm HH
Force suppression alarm HH	FUHH	WH	Warning alarm H 2)
Force suppression alarm WH	FUWH	WL	Warning alarm L 2)
Force suppression alarm WL	FUWL	ALL	Action alarm LL
Force suppression alarm LL	FULL	BLL	Status alarm LL
		BBHH	Action alarm HH is blocked
		BBLL	Action alarm LL is blocked
		BU	Status suppressed
		BB	Status blocked
		BXHH	Status event HH
		BXH	Status event H
		BXL	Status event L
		BXLL	Status event LL
Operator station:			Operator station:
Blocking HH on/off			Alarms and faults
Blocking LL on/off			Alarm and event limits
Suppression on/off			Blocked
			Suppressed

2) Shall not be used for downstream logic.

Figure A.8 - MA function template schematic

A.4.6.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
X	Analogue input	Normal function input	Analogue input signal from process
XF	Binary input	External Fault	Fault indication from outside the template.

Terminal code	Signal type	Terminal name	Supplementary description
FBHH	Binary input	Force blocking alarm HH	Logic input: alarm HH action is blocked as long as input signal is true.
FBLL	Binary input	Force blocking alarm LL.	Logic input: alarm LL action is blocked as long as input signal is true.
FUHH	Binary input	Force suppression alarm HH	Logic input: alarm HH action and annunciation is suppressed as long as input is true.
FUWH	Binary input	Force suppression alarm WH	Logic input: alarm WH annunciation is suppressed as long as input true. This output should normally not be used for downstream logic.
FUWL	Binary input	Force suppression alarm WL	Logic input: alarm WL annunciation is suppressed as long as input true. This output should normally not be used for downstream logic.
FULL	Binary input	Force suppression alarm LL	Logic input: alarm LL action and annunciation is suppressed as long as input true.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Normal function output	Normal function output	Analogue output signal from function template
YF	Binary output	Function failed	YF = 1 if XF = 1 or if an internal error has been detected in the template or if an error is detected on the input X.
AHH	Binary output	Action alarm HH	True, when X*-value >AHH limit. Subjected to blocking and suppression.
BHH	Binary output	Status alarm HH	Status alarm annunciation (HH) without blocking logic. Subjected to suppression.
WH	Binary output	Warning alarm – WH.	True, when X*-value >WH limit. Subjected to suppression. Should not be used for downstream logic.
WL	Binary output	Warning alarm – WL	True, when X*-value <WL limit. Subjected to suppression. Should not be used for downstream logic.
ALL	Binary output	Action alarm LL	True, when X*-value <ALL limit. Subjected to blocking and suppression.
BLL	Binary output	Status alarm LL	Status alarm annunciation (LL) without blocking logic. Subjected to suppression.
BBHH	Binary output	Action alarm HH is blocked	True if FBHH or OS blocking is active.
BBLL	Binary output	Action alarm LL is blocked	True if FBLL or OS blocking is active.
BU	Binary output	Status suppressed	True if the template is in suppressed mode (any of the process output function is suppressed).
BB	Binary output	Status blocked	True if the template is in blocked mode (any of the process output functions are blocked).
BXHH	Binary output	Status event HH	True, when X*-value > Event high-high limit No Alarm annunciation, event only
BXH	Binary output	Status event H	True, when X-value > Event high limit. No Alarm annunciation, event only

Terminal code	Signal type	Terminal name	Supplementary description
BXL	Binary output	Status event L	True, when X-value < Event low limit No Alarm annunciation, event only
BXLL	Binary output	Status event LL	True, when X-value < Event low-low limit No alarm annunciation, event only

A.4.6.2.3 Template parameters with default values

Parameters

Parameter code	Signal type	Parameter name	Supplementary description	Default
1)	Analogue	Limit AHH	Alarm limit for AHH	-
1)	Analogue	Limit WH	Alarm limit for WH	-
1)	Analogue	Limit WL	Alarm limit for WL	-
1)	Analogue	Limit ALL	Alarm limit for ALL	-
1)	Analogue	Limit BXHH	Event limit for BXHH	-
1)	Analogue	Limit BXH	Event limit for BXH	-
1)	Analogue	Limit BXL	Event limit for BXL	-
1)	Analogue	Limit BXLL	Event limit for BXLL	-
1)	Analogue	Time delay action alarms	Delay before alarm and action is raised after limit has been reached.	0s
1)	Analogue	Time delay warning alarms	Delay before alarm is raised after limit has been reached.	0s
1)	Analogue	Hysteresis value	The hysteresis should be defined in % of display range, and be common for all limits given by parameter inputs. The hysteresis shall only affect the return of alarms/events not initiation.	0 %
1)	Analogue	Maximum range	Maximum display range value	-
1)	Analogue	Minimum range	Minimum display range value	-
1)	Analogue	Fault function	1 X = Freeze value (last good value) 2 X = Show current measured value 3 X = Substitute value	1
1)	Analogue	Fall back value	Value for fall back situation. Only possible to enter value within range.	0
1)	Analogue	Dead band	Threshold value' to avoid calculation when X is close to zero (Worn out flow transmitters).	0%

1) If parameter is defined on a terminal, it shall be coded and start with character P.

A.4.6.3 Functional description

A.4.6.3.1 General

The template includes suppress and blocking functions. Suppression from operator station suppresses all alarm and fault outputs, whilst by logic it is possible to suppress individual alarm outputs. Faults cannot be suppressed by logic input. All limit checking and alarm annunciation resides within the template.

Where features for signal modification (e.g. square-root extraction and/or features for smoothing (low pass filtering) of the analogue input is included in the MA template the input signal (X) to the template shall be available for trending.

See Figure F.25 for complementary function behavior description of the MA template.

A.4.6.3.2 Operation modes

Mode functions

Function	Description
Suppress HH	Suppresses AHH action and alarm and sets the AHH output from the template to 0.
Suppress LL	Suppresses ALL action and alarm and sets the ALL output from the template to 0.
Suppress WH	Suppresses WH alarm and sets the WH output from the template to 0.
Suppress WL	Suppresses WL alarm and sets the WL output from the template to 0.
Block HH	Blocking the AHH action but not the alarm. Sets the AHH output from the template to 0.
Block LL	Blocking the ALL action but not the alarm. Sets the ALL output from the template to 0.
OS Suppress	Suppresses AHH, ALL, WH, WL, YF and sets these outputs from the template to 0.

A.4.6.3.3 Control requirements

Control functions

Function	Description
Action alarm	Shall have the possibility to generate action alarms when input parameter passes defined alarm parameter according to the logic output terminals. Ref output terminal.
Warning alarm	Shall have the possibility to generate warning alarms when input parameter passes defined alarm parameter according to the logic output terminals. See output terminal.
Event	Shall have the possibility to generate event output when input parameter passes defined event parameter according to the logic output terminals. See output terminal.
Adjustable warning level	The parameter-values for the warning levels shall be adjustable from the operator-station.

A.4.6.3.4 Safeguarding

Not applicable for this template.

A.4.6.3.5 Error handling

Error functions

Function	Description
Function Fault	If XF is 1 or bad signal quality[4)] on X, YF is 1. It shall be possible to configure for freeze or fall back values. It shall be possible to generate an alarm.

4) Signal quality may be transferred as system internal information.

A.4.7 MAS – Analogue measurement acquisition from subsystems

A.4.7.1 Intended use

The MAS function template shall be used for analogue measurements acquired from other control systems such as vibration monitoring, metering, analysers, etc. The subsystem performs the alarm limit supervision and is interfaced to the main control system by a communication link, e.g. Modbus, Profibus, etc. It serves only as an object for display information.

It is a prerequisite that any trip signal from external system is an additional hardwired signal.

A.4.7.2 Technical description

A.4.7.2.1 Function template schematic

Inputs	MAS		Outputs
Normal function input	X	Y	Normal function output
External fault	XF	YF	Function failed
External link fault	XFX	BU	Status suppressed
External alarm HH	XAHH		
External warning alarm WH	XWH		
External warning alarm WL	XWL		
External alarm LL	XALL		
Limit value of XHH	XQHH		
Limit value of XWH	XQWH		
Limit value of XWL	XQWL		
Limit value of XLL	XQLL		
Force suppression	FU		
Operator station:			Operator station:
Suppression on/off			Alarms and faults
			Suppressed
			Alarm limits

Figure A.9 - MAS function template schematic

A.4.7.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
X	Analogue input	Normal function input	The measurement value in engineering units.
XF	Binary input	External fault	Subsystem input: the measurement has been detected

Terminal code	Signal type	Terminal name	Supplementary description
			as erroneous by the subsystem
XFX	Binary input	External link fault	There is a communication link fault.
XAHH	Binary input	External alarm HH	Subsystem input: alarm HH is set as long as this signal is true
XWH	Binary input	External warning alarm WH	Subsystem input: warning alarm WH is set as long as this signal is true
XWL	Binary input	External warning alarm WL	Subsystem input: warning alarm WL is set as long as this signal is true
XALL	Binary input	External alarm LL	Subsystem input: alarm LL is set as long as this signal is true
XQHH	Analogue input	Limit value of XHH	Subsystem input: the value in engineering units of the HH limit used by the subsystem.
XQWH	Analogue input	Limit value of XWH	Subsystem input: the value in engineering units of the WH limit used by the subsystem.
XQWL	Analogue input	Limit value of XWL	Subsystem input: the value in engineering units of the WL limit used by the subsystem.
XQLL	Analogue input	Limit value of XLL	Subsystem input: the value in engineering units of the LL limit used by the subsystem.
FU	Binary input	Force suppression	If FU is true, YF is set to 0 and OS alarms are set to 0

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Analogue output	Normal function output	The measurement output value. Equal to the input value (X). It shall be possible to generate a warning or action alarm on this output. In these cases the letters WH, WL, AHH or ALL shall be used as the terminal name on the SCD diagram.
YF	Binary output	Function failed	YF = 1 if XF1=1 or XF2 = 1. Subjected to suppression.
BU	Binary output	Status suppressed	True if template is in suppress mode (FU = 1 or Suppression set from OS).

A.4.7.2.3 Template parameters with default values

Parameters

Parameter code	Signal type	Parameter name	Supplementary description	Default
1)	Analogue	Maximum range	Maximum display range value	100 %
1)	Analogue	Minimum range	Minimum display range value	0 %
1)	Analogue input	Default value of XHH	If XHH is not used, default value shall be 110 %	110 %
1)	Analogue input	Default value of XWH	If XWH is not used, default value shall be 110 %	110 %
1)	Analogue input	Default value of XWL	If XWL is not used, default value shall be -10 %	-10 %
1)	Analogue input	Default value of XLL	If XLL is not used, default value shall be -10 %	-10 %

1) If parameter is defined on terminal, it shall be coded and start with character P.

A.4.7.3 Functional description

A.4.7.3.1 General

The main function of the template is to provide operator interface with monitoring status from the subsystem.

The MAS function template has no alarm or event detection based on the normal function input from the subsystem. Alarms are detected in the subsystem, which transfers the alarm states as well as the corresponding limit settings.

No data or commands are transferred from the MAS function template to the subsystem.

Suppression from operator station or logic suppresses all alarms and fault output.

Blocking functionality is not applied to this template as this will not have the same effect as in a MA template. It will not affect the trip which is performed in the external system.

See Figure F.26 for complementary function behavior description of the MAS template.

A.4.7.3.2 Operation modes

Mode functions

Function	Description
Suppress	Suppresses the output YF and sets it to 0. Suppresses AHH, ALL, WH and WL alarms.

A.4.7.3.3 Control requirements

Control functions

Function	Description
Action alarm	Shall have the possibility to generate action alarm based on relevant input from subsystem, preferably with time stamping from the subsystem.
Warning alarm	Shall have the possibility to generate warning alarm based on relevant input from subsystem, preferably with time stamping from the subsystem.

A.4.7.3.4 Safeguarding

Not applicable for this template.

A.4.7.3.5 Error handling

Error functions

Function	Description
Function fault	If XFX is 1, communication link has failed and/or if XF is 1, bad signal quality2) on X is detected in the subsystem, YF is 1.

2) Signal quality may be transferred as system internal information.

A.4.8 MB – Monitoring of binary (digital) process variables

A.4.8.1 Intended use

The MB function template shall be used for automatic monitoring (alarming), display and latching of binary process variable.

A.4.8.2 Technical description

A.4.8.2.1 Function template schematic

Inputs	MB		Outputs
Normal function input	X	Y	Normal function output
External fault	XF	YF	Function failed
Reset latched output	RX	BB	Status blocked
Force blocking	FB	BU	Status suppressed
Force suppression	FU	BX	Status normal function input
Operator station:			Operator station:
Blocking on/off			Alarms and faults
Suppression on/off			Latched value
Reset latched output			Blocked
			Suppressed

Figure A.10 - MB function template schematic

A.4.8.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
X	Binary input	Normal function input	Binary input signal from process.
XF	Binary input	External fault	Fault indication from outside the template.
RX	Binary input	Reset latched output	Resets the output Y when RX goes high.
FB	Binary input	Force blocking	If FB is true, Y is set to 0.
FU	Binary input	Force suppression.	If FU is true, Y is set to 0, YF is set to 0 and OS alarm is set to 0.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Binary output	Normal function output	-If the template is set not to latch, Y = X -If the template is set to latch, Y is set when X goes high, and reset when RX goes high. Subjected to blocking and suppression. It shall be possible to generate a warning or action alarm on this output. In these cases the letter W (warning) or A (action) shall be used as the terminal name on the SCD diagram.

Terminal code	Signal type	Terminal name	Supplementary description
YF	Binary output	Function failed	YF = 1 if XF = 1 or if an internal error has been detected in the template. Subjected to suppression.
BB	Binary output	Status blocked	True if the template is in blocked mode (FB = 1 or Blocking set from OS).
BU	Binary output	Status suppressed	True if template is in suppress mode (FU = 1 or Suppression sett from OS).
BX	Binary output	Status function input	BX=X

A.4.8.2.3 Template parameters with default values

Parameters

Parameter code	Signal type	Parameter name	Supplementary description	Default
1)	Binary	Invert input	If the parameter is set the X input is inverted.	0
1)	Binary	Latched output	If the parameter is set the Y output is latched.	0
1)	Analogue	Time delay alarm	Delay before alarm is raised and Y output is set after X input goes high.	0s

1) If parameter is defined on a terminal, it shall start with character P.

A.4.8.3 Functional description

A.4.8.3.1 General

The template includes alarm suppression and blocking functions. Additionally the template shall have the possibility to invert input, latch the normal function output and delay the output signal via a parameter. The type of annunciation as well as the alarm priority assigned shall be incorporated according to system vendor standards.

See Figure F.27 for complementary function behavior description of the MB template.

A.4.8.3.2 Operation modes

Mode functions

Function	Description
Block	Blocking the output Y and sets it 0. Does not reset the latched value.
Suppress	Suppresses the output Y and YF and sets them to 0. Resets the latched value.

A.4.8.3.3 Control requirements

Not applicable for this template.

A.4.8.3.4 Safeguarding

Not applicable for this template.

A.4.8.3.5 Error handling

Error functions

Function	Description
External fault	It shall be possible to generate an alarm.

A.4.9 OA – Analogue output

A.4.9.1 Intended use

The OA function template shall be used for analogue control of flow device of medium (electricity, heat or fluid) where the CA block do not represent required functionality, e.g. split range output. The controlled element is a unit such as motor, pump, heater, fan etc.

A.4.9.2 Technical description

A.4.9.2.1 Function template schematic

Inputs	OA		Outputs
Normal function input	X	Y	Normal function output
Position feedback	XG	YF	Function failed
Position high feedback	XGH	YG	Output valve position
Position low feedback	XGL	BCH	Output position high confirmed
External fault	XF	BCL	Output position low confirmed
Lock safeguarding high	LSH	BA	Status auto/man
Lock safeguarding low	LSL	BS	Status safeguarding
Force safeguarding high	FSH	BB	Status blocked
Force safeguarding low	FSL	BU	Status suppressed
Force blocking	FB	WV	Warning deviation
Force suppression	FU		
Lock auto	LA		
Lock manual	LM		
Operator station:			Operator station:
Auto/Manual			Alarms and faults
Blocking on/off			Auto/Manual
Suppression on/off			Blocked
Set output value			Suppressed
			Safeguarding
			Conflict
			Track value
			Output position

Figure A.11 - OA function template schematic

A.4.9.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
XG	Analogue input	Position feedback	
XGH	Binary input	Position high feedback	Calculated feedback confirmed high based on the feedback configuration.
XGL	Binary input	Position low feedback	Calculated feedback confirmed low based on the feedback configuration.
X	Analogue input	Normal function input	External value that will control the output Y by means of a ramp function.
XF	Binary input	External fault	Loop failure, e.g. I/O card broken.
LSH	Binary input	Lock safeguarding high.	Safeguarding – LSH = 1 Overrule operator possibility to operate output value. Locks template in manual mode and Y is set to max operating range value regardless of failure state. Input is subject to blocking. When signal goes low, the template remains in manual mode the output (Y) remains unchanged.
LSL	Binary input	Lock safeguarding low.	Safeguarding – LSL = 1 Overrule operator possibility to operate output value. Locks template in manual mode and Y is set to min operating range value regardless of failure state. Input is subject to blocking. When signal goes low, the template remains in manual mode the output (Y) remains unchanged.
FSH	Binary input	Force safeguarding high	Safeguarding – FSH = 1 Overrule operator possibility to operate output value. Sets Y to operating range high regardless of failure state. When signal is reset, the template will react to actual terminal statuses again. Signal is subject to blocking. If in manual mode, the output (Y) remains unchanged after signal returns to normal.
FSL	Binary input	Force safeguarding low	Safeguarding FSL = 1 Overrule operator possibility to operate output value. Sets Y to operating range low regardless of failure state. When signal is reset, the template will react to actual terminal statuses again. Signal is subject to blocking. If in manual mode, the output (Y) remains unchanged after signal returns to normal.
FB	Binary input	Force blocked	FB = 1. Safeguarding action LSH, LSL, FSH and FSL will be blocked.
FU	Binary input	Force suppression	FU = 1. Alarm annunciation is suppressed, YF = 0. and statuses XF, XG, XGL and XGH are neglected.
LA	Binary input	Lock auto	Locks the template in auto mode. When LA is reset, the template remains in auto mode.
LM	Binary input	Lock manual	Locks the template in manual mode. When LM is reset, the template remains in manual mode.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Analogue output	Normal function output	Normal output
YF	Binary output	Function failed	YF = 1 if XF = 1.
YG	Analogue output	Output valve position	YG is a output of the position feedback XG.
BCH	Binary output	Output position high confirmed	Output Y value is high operating range and feedback is confirmed as high based on the feedback configuration.
BCL	Binary output	Output position low confirmed	Output Y value is low operating range and feedback is confirmed as low based on the feedback configuration.
BA	Binary output	Status auto/man	BA = 1 when in auto mode
BS	Binary output	Status safeguarding	BS = 1 if any safeguarding input is active and not blocked.
BB	Binary output	Status blocked	BB = 1 when blocking from operator station is true or FB = 1.
BU	Binary output	Status suppressed	BU = 1 when suppressed from operator station is true or FU = 1.
WV	Binary output	Warning deviation	WV=1, If deviation between XG and Y is larger than given limit for a time that exceed alarm delay. Also inconsistency between XG, XGH and XGL.

A.4.9.2.3 Template parameters with default values

Parameters

Parameter code	Parameter type	Parameter name	Supplementary description	Default
1)	Analogue	Maximum range input (Xmax)	Maximum range value in	100
1)	Analogue	Minimum range input (Xmin)	Minimum range value in	0
1)	Analogue	Maximum range output (Ymax)	Maximum range value out	100
1)	Analogue	Minimum range output (Ymin)	Minimum range value out	0
1)	Analogue	Maximum operating range	Maximum allowed output value. This value is less or equal to maximum range out.	100
1)	Analogue	Minimum operating range	Minimum allowed output value. This value is greater or equal to minimum range out.	0
1)	Time	Alarm delay	Deviation alarm XG compared to Y	30s
1)	Analogue	Deviation limit %	Deviation in % of output range between Y and XG	2 %
1)	Binary	Fail safe position	1 = High, 0 = Low	0
1)	Analogue	Limit confirmed state %	Compared to operating range high or low. The % value is calculated in relation to the full range.	2 %

Parameter code	Parameter type	Parameter name	Supplementary description	Default
1)	Binary	Manual limited by operating range.	1 = Manual output limited by operating range 0 = No limit for manual	1
1)	Enumeration	Feedback configuration	No feedback Only XGL Only XGH XGH and XGL Analogue feedback XG Analogue and XGL Analogue and XGH Analogue , XGH and XGL	-
1)	Time	Y ramp to X. Switch to auto	Ramp time while switch to auto. Y ramp to X.Time to travel the whole range.	0s
1)	Time	Y ramp to X. In auto.	Ramp time while in auto. Y ramp to X.Time to travel the whole range.	0s
1)	Binary	Substitute value if XF	1 = Substitute value to be used as Y if XF. 0 = Freeze (to manual and keep last valid value).	0
1)	Analogue	Substitute value	Value to be used.	0
1)	Binary	Reaction if X outside range	0 – No reaction (Y= operating limit) 1 – YF and reaction as XF=1.	0
1)	Enumeration	Restart options	Enter manual mode and substitute value Enter manual mode and failsafe position Enter auto mode Y = XG	0

1) If parameter is defined on a terminal, it shall start with character P.

A.4.9.3 Functional description

A.4.9.3.1 General

This template shall be used as analogue output control. This template may be run in auto or manual mode. In auto the value X is tracked to the output Y by means of a ramping function. In manual the operator may enter the Y value.

As long as X is inside the defined range, the scaling of the Y value is based on the following equation:

$$Y = Y_{min} + ((X-X_{min})*(Y_{max} – Y_{min})/(X_{max} – X_{min}))$$

The resulting Y value will be limited by the maximum/minimum operating range.

The function gives out an analogue value. The function can be operated in auto or manual mode. The function has feedback supervision. The function includes safeguarding. The function includes suppression and blocking functions.

To be able to compare XG with Y, XG shall have same scaling as Y.

See Figure F.28 for more detailed function behavior description of the OA template.

A.4.9.3.2 Operation modes

Mode functions

Function	Description
Auto	The input X will control the output Y by means of a ramp function.
Manual	The operator is able to enter the desired Y value. When the template enter Manual mode the current value of Y will be kept.
Block	Blocking disables safeguarding mode LSH/LSL/FSH/FSL.
Suppression	Suppression sets YF = 0. Disables alarm annunciation. The control template will use the output Y as feedback (XG).
Safeguarding	Flow device is set to safe state.

A.4.9.3.3 Control requirements

Control functions

Function	Description
Restart	After restart of the controller node the function will be set to a predefined state selected by a parameter.
Ramping	There are two ramps defined. One is for the transfer from manual to auto. When the value Y is equal to X, then the ramp value for normal operation will take over and will be used while in auto mode.
Feedback confirm high – BCH	Based on the feedback configuration this will be calculated via different algorithms. If XG is connected, then high is confirmed when compared to operating range high and not more than a defined % value less. If XGH is connected only this value will be used.
Feedback confirm low – BCL	Based on the feedback configuration this will be calculated via different algorithm. If XG is connected, then low is confirmed when compared to operating range low and not more than a defined % value higher. If XGL is connected only this value will be used.
Warning deviation	Discrepancy between XG and Y is more than a given limit for a time that exceed alarm delay. Deviation between feedback statuses (XG, XGH and XGL). Possibility for alarm annunciation, but no action.

A.4.9.3.4 Safeguarding

Safeguarding functions

Function	Description
Lock	Set the output to safeguarding position and sets the function template to manual mode.
Force	Set the output to safeguarding position, but the mode of function template is not changed.
Conflict	True if any safeguarding action is requested when the template is in blocked state. It shall be possible to generate an alarm on this event.

A.4.9.3.5 Error handling

Error functions

Function	Description
External fault	If XF is 1: Shall be possible to generate alarm and set output YF. The template will enter manual mode. The output Y will be either substitute value or freeze value (depending on parameter).

A.4.10 QA – Totalizer

A.4.10.1 Intended use

The QA function template shall be used for accumulation (totalizing) of process values based on time intervals.

A.4.10.2 Technical description

A.4.10.2.1 Functional block schematic

Inputs	QA		Outputs
Normal function input	X	Y1	Previous total
External fault	XF	Y2	Current total
External enabling totalizing	XEQ	YF	Function failed
External reset totalizing	RXQ		
Force totalizing	FQ	AHH	Action alarm HH
Force blocking alarm HH	FBHH	BHH	Status alarm HH
Force suppression alarm HH	FUHH	WH	Warning alarm H
Force suppression alarm WH	FUWH	BBHH	Status blocked alarm HH
		BU	Status suppressed
		BXH	Status event H
Operator station			Operator station
Totalizer on/off			Alarms and faults
Reset totalizer			Totalizing on/off
Blocking on/off			Blocked
Suppression on/off			Suppressed

Figure A.12 - QA function template schematic

A.4.10.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
X	Analogue input	Normal function input	Analogue input signal from process
XF	Binary input	External fault	Failure in upstream function.
XEQ	Binary input	External enabling totalizing	Input to logic enable/disable totalizing. True = enable.
RXQ	Binary input	External reset totalizing	Logic signal to reset accumulation function. When reset is true the current total Y2 replaces the current previous total on Y1 and Y2 set to 0.
FQ	Binary input	Force totalizing	Forcing totalizer to start accumulation when true.
FBHH	Binary input	Force blocking alarm HH	Logic input: AHH action is blocked as long as input signal is true.
FUHH	Binary input	Force suppression alarm HH	Logic input: alarm HH action and annunciation suppressed as long as input signal is true.
FUWH	Binary input	Force suppression alarm WH	Logic input: alarm WH action and annunciation suppressed as long as input signal is true.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y1	Analogue output	Previous total	Stored value for previous total
Y2	Analogue output	Current total	Accumulated total value
YF	Binary output	Function failed	Overflow of counter or external fault (XF) from source.
AHH	Binary output	Action alarm HH	True when Y2 – value > AHH limit. Subjected to blocking and suppression.
BHH	Binary output	Status alarm HH	Status alarm annunciation (HH) not affected by blocking, but subjected to suppression.
WH	Binary output	Warning alarm H	True when Y2 – value > WH limit. Subjected to suppression. Should not be used in downstream logic.
BBHH	Binary output	Status blocked alarm HH	True if FBHH or OS blocking is active.
BU	Binary output	Status suppressed	True if the template is in suppressed mode (any of the process output function is suppressed).
BXH	Binary output	Status event H	True when Y2 – value > Event high limit No alarm annunciation, event only.

A.4.10.2.3 Template parameters with default values

Parameters

Parameter code	Signal type	Parameter name	Supplementary description	Default
1)	Binary	Count negative	If set to 1 the totalizer should allow for negative counting.	0
1)	Analogue	Scaling factor	Optional scaling factor to obtain required output	
1)	Analogue	Initial value	Defines the real value totalizer will start counting with after reset operation.	0
1)	Analogue	Maximum value	Defines the maximum real value totalizer will allow (overflow). Passing this limit will result in a fault state initiating the XF output.	999999
1)	Analogue	Limit AHH	Alarm limit for AHH	-
1)	Analogue	Limit WH	Alarm limit for WH	-
1)	Analogue	Limit BXH	Event limit for BXH	-
1)	Analogue	Hysteresis value	The hysteresis should be defined in % of display range, and be common for all limits given by parameter inputs. The hysteresis shall only affect the return of alarms/events not initiation.	0 %
1)	Enumeration	Fault function	1 Y2 = freeze accumulation 2 Y2 = 0	1

1) If parameter is defined on a terminal, it shall start with character P.

A.4.10.3 Functional description

A.4.10.3.1 General

The totalizing function can be started and stopped by the operator or logic. The totalizing can be enabled and disabled from logic or HMI. The template shall have display (indication) and automatic monitoring (alarming) of totalized value.

The function includes suppression and blocking functions, but no safeguarding.

See Figure F.29 for complementary function behavior description of the QA template.

A.4.10.3.2 Operation modes

Mode functions

Function	Description
Suppress HH	Suppresses AHH action and alarm and sets the AHH output from the template to 0.
Suppress WH	Suppresses WH alarm and sets the WH output from the template to 0.
OS Suppress	Suppresses AHH, WH, YF and sets these outputs from the template to 0.
Block HH	Blocking the AHH action but not the alarm. Sets the AHH output from the template to 0.

A.4.10.3.3 Control requirements

Control functions

Function	Description
Totalizer	The totalizing can be enabled and disabled from logic by means of input terminal XEQ external enable totalizer. Start and stop of totalizer is possible from OS. When input terminal FQ (force totalizing) is set from the logic, the totalizer is forced to count unless, XEQ = 0, or external fault is set (XF = 1). If totalizer should count when X (Analogue input variable) lower than 0, is controlled by a parameter setting. (Count negative). To stop counter by logic is done by XEQ=0
OS Start / Stop	). Start and stop from HMI is possible when XEQ=1. Stop from HMI is impossible in forced mode (FQ = 1). Start from HMI when in forced mode (FQ=1) ensures that accumulation is continued even though FQ is set low.
Reset	Totalizing is reset when RXQ goes to 1 or by OS reset command. The current total value (Y2) will be stored in previous total value (Y1) when totalizer is reset.
Suppress and blocking	The template includes suppress and blocking functions. Suppression from operator station suppresses all alarm and fault outputs, whilst by logic it is possible to suppress individual alarm outputs. Faults cannot be suppressed by logic input. All limit checking and alarm annunciation resides within the template.
Action and warning alarm	The accumulated value is subjected to limit checking on AHH action alarm HH, as well as WH warning alarm H.
Event status	Status BXH output shall be provided for limit checking without alarm annunciation (event-handling).

A.4.10.3.4 Safeguarding

Not applicable for this template.

A.4.10.3.5 Error handling

Error functions

Function	Description
Function fault	If XF is 1 or bad signal quality[4)] on X, YF is 1, totalization value Y2 shall be set to freeze or null, and an alarm shall be generated. An overflow in the accumulation should freeze the accumulation and report the overflow as a function fault YF is set to 1.

4) Signal quality may be transferred as system internal information.

A.4.11 SB - Single binary signal for shutdown

A.4.11.1 Intended use

The SB function template shall be used for single binary shutdown of equipment. It is used to enable operator control of shutdown signal which has its main control template in another node or system.

A.4.11.2 Technical description

A.4.11.2.1 Functional template schematic

Inputs	SB		Outputs
Normal function input	X	Y	Normal function output
External fault	XF	YF	Function failed
Reset latched output	RX	BB	Status blocked
		BU	Status suppressed
		BX	Status normal function input
Operator station			Operator station
Set safeguard			Alarms and faults
Reset safeguard			Blocked
Blocking on/off			Suppressed
Suppression on/off			Conflict

Figure A.13 - SB function template schematic

A.4.11.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
X	Binary input	Normal function input	Binary input signal from other logic or signal from Shutdown level template LB
XF	Binary input	External fault	Loop failure, i.e. output card broken

Terminal code	Signal type	Terminal name	Supplementary description
RX	Binary input	Reset latched output	Reset the output Y when RX goes high and X = 0

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Binary output	Normal function output	Y = X. If the template is set to latch, Y is set when X is set and reset when RX goes high and X = 0. Subject to blocking
YF	Binary output	Function failed	For use in downstream logic, YF = 1 when XF = 1 and BU = 0
BB	Binary output	Status blocked	BB = 1 if blocking is enabled
BU	Binary output	Status suppressed	BU = 1 if suppression is enabled
BX	Binary output	Status normal function input	BX = X

A.4.11.2.3 Template parameters with default values

Parameters

Parameter code	Signal type	Parameter name	Supplementary description	Default
1)	Binary	Enable reset latched output	If the parameter is 0, output Y is not latched. If the parameter is 1, output Y is latched.	0
1)	Analogue	Output Time delay	Delay before normal output is set after normal input (X) is set.	0,0 s

1) If parameter is defined on a terminal, it shall start with character P.

A.4.11.3 Functional description

A.4.11.3.1 General

Function template for single binary shutdown of equipment. It is used to enable operator control of shutdown signal which has its main control template in another node or system, e.g. motor controlled by SBE in PCS where SB is used in PSD to trip the motor.

The safeguarding output signal Y is equal to input signal X unless the signal is blocked by the operator or the operator has set the safeguarding output directly from HMI. Additionally the template shall have the possibility to latch the output signal Y. Typically the SB is connected to a shutdown level hierarchy controlled by a LB function template.

Y-output from SB is repeated from the safety system to the process control system in order to update the status of the associated SBE (motor) function template, i.e. the Y-output from SB shall be connected to the LSL-input on SBE.

See Figure F.30 for complementary function behavior description of the SB template.

A.4.11.3.2 Operation modes

Mode functions

Function	Description
OS block	Blocking disables the shutdown output Y
OS suppress	Suppresses YF and sets this output to 0

A.4.11.3.3 Control requirements

Control functions

Function	Description
Set output	The operator can set the output Y = 1
Alarm	Function failed alarm (fault alarm) shall be generated on the operator station.

A.4.11.3.4 Safeguarding

Safeguarding functions

Function	Description
Conflict	If any safeguarding action is requested when blocking is true. It shall be possible to generate an alarm on this event.

A.4.11.3.5 Error handling

Error functions

Function	Description
Output fault	If XF is 1 and suppression from operator station is not activated, the function failed alarm shall be reflected directly on the output YF and also generated on operator station.

A.4.12 SBB – Breaker control template

A.4.12.1 Intended use

Function template for binary (on/off) control of electricity to switchboards or consumers. The function template shall be applied for all binary control of breakers both high and low voltage.

A.4.12.2 Technical description

A.4.12.2.1 Function template schematic

Inputs	SBB		Outputs
Position high feedback (connected/closed)	XGH	Y	Normal function output
Position low feedback (disconnected/open)	XGL	YH	Pulsed normal function output high (connect/close)
External set high	XH	YL	Pulsed normal function output low (disconnect/open)
External set low	XL	YF	Function failed
External outside set high	XOH	BCH	Output position high confirmed (connected/closed)
External outside set low	XOL	BCL	Output position low confirmed (disconnected/open)
External fault	XF	BE	Status enabled
Function externally enabled	XE	BA	Status auto/man
External test position	XGX	BO	Status outside
External earthed	XGZ	BS	Status safeguarding
Lock safeguarding high	LSH	BB	Status blocked
Lock safeguarding low	LSL	BU	Status suppressed
Force safeguarding high	FSH		
Force safeguarding low	FSL		
Force disable transition high	FDH		
Force disable transition low	FDL		
Force blocking	FB		
Force suppression	FU		
Lock auto	LA		
Lock manual	LM		
Lock outside	LO		
Operator station			Operator station
Auto/Manual			Alarms and faults
Close (high)/ Open (low)			Open (disconnected) / Closed(connected)
Blocking on/off			Suppressed
Suppression on/off			Auto/Manual/Outside
			Earthed
			Available
			Test mode
			Blocked
			Disabled
			Safeguarding
			Conflict

Figure A.14 - SBB function template schematic

A.4.12.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
XGH	Binary input	Position high feedback	Feedback from breaker - XGH = 1 means connected (closed) breaker
XGL	Binary input	Position low feedback	Feedback from breaker - XGL = 1 means disconnected (open) breaker
XH	Binary input	External set high	XH = 1 set Y to 1 in auto mode.
XL	Binary input	External set low	XL = 1 set Y to 0 in auto mode. XL is dominant over XH.
XOH	Binary input	External outside set high	Set high signal (positive edge) to close breaker in outside mode.
XOL	Binary input	External outside set low	Set low signal (positive edge) to open breaker in outside mode.
XF	Binary input	External fault	Loop failure-e.g. I/O card broken.
XE	Binary input	Function externally enabled (breaker)	XE = 1 is required for a connect command. The effect on Y when XE goes low while connected will be defined by parameter.
XGX	Binary input	External test	XGX = 1 means that the breaker is a position where it is possible to operate it, but without making connections in the power grid.
XGZ	Binary input	External earthed	XGX = 1 means that the breaker is earthed and that a connect command will not be performed.
LSH	Binary input	Lock safeguarding high	Safeguarding – LSH = 1 overrules operator inputs. Locks the template in manual mode with Y = 1 and send a pulse on YH. Input is subject to blocking. When signal is reset, the template remains in manual mode and Y = 1.
LSL	Binary input	Lock safeguarding low	Safeguarding – LSL = 1 overrules operator inputs. Locks the template in manual mode with Y = 0 and send a pulse on YL. Input is subject to blocking. When signal is reset, the template remains in manual mode and Y = 0.
FSH	Binary input	Force safeguarding high	Safeguarding – Signal overrules operator inputs. Forces the template Y to1 and send a pulse on YH. When signal goes low, the template will react to actual terminal status again if in auto mode. Signal is subject to blocking. If in Manual mode, the output (Y) remains high after signal returns to normal.
FSL	Binary input	Force safeguarding low	Safeguarding – Signal overrules operator inputs. Forces the template Y to 0 and send a pulse on YL. When signal goes low, the template will react to actual terminal status again if in auto mode. Signal is subject to blocking. If in Manual mode, the output (Y) remains low after signal returns to normal.
FDH	Binary input	Force disables transition high.	Permissive to activate breaker when FDH = 0 and prevents breaker from being connected when FDH = 1. Signal is subject to blocking.

Terminal code	Signal type	Terminal name	Supplementary description
FDL	Binary input	Force disables transition low.	Permissive to deactivate breaker when FDL = 0 and prevents breaker from being disconnected when FDL = 1. Signal is subject to blocking.
FB	Binary input	Force blocking	FB = 1. Safeguarding action LSL, FSL and disable transition function FDL and FDH will be blocked.
FU	Binary input	Force suppression.	Alarm annunciation will be suppressed and YF = 0
LA	Binary input	Lock auto	Locks the template in auto mode. When LA goes low, the template remains in auto mode.
LM	Binary input	Lock manual	Locks the template in manual mode. When LM goes low, the template remains in manual mode.
LO	Binary input	Lock outside	Locks the template to outside mode, and sets the template to manual mode. When LO goes low, the template remains in manual mode.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Binary output	Normal function output	Status of command to breaker, Y = 1 means last command on YH and: Y = 0 means last command on YL
YH	Binary output	Pulsed normal function output high.	Pulse connect command YH = 1 (one pulse)
YL	Binary output	Pulsed normal function output low.	Pulse disconnect command YL = 1 (one pulse).
YF	Binary output	Function failed	See error handling
BCH	Binary output	Output position high confirmed	Output Y compared to feedback position high signal and validated as true (BCH = 1 if Y = 1 and XGH = 1).
BCL	Binary output	Output position low confirmed	Output Y compared to feedback position low signal and validated as true (BCL = 1 if Y = 0 and XGL = 1)
BA	Binary output	Status auto/man. mode	BA = 1 if auto from operator station is true or LA = 1.
BE	Binary output	Status enabled	BE = 1 if XE = 1.
BO	Binary output	Status outside	BO = 1 when set outside from operator station or LO = 1.
BS	Binary output	Status safeguarding	BS = 1 if any safeguarding input is active.
BB	Binary output	Status blocked	BB = 1 if block from operator station is true or FB = 1.
BU	Binary output	Status suppressed	BU = 1 if suppressed from operator station is true or FU = 1.

A.4.12.2.3 Template parameters with default values

Parameters

Parameter code	Parameter type	Parameter name	Supplementary description	Default
[1]	Analogue	Travel time open	Maximum allowed time from open command is given to process element (Y set to 1) to connected feedback (XGH) is set.	10 s
[1]	Analogue	Travel time close	Maximum allowed time from close command is given to process element (Y set to 0) to disconnected feedback (XGL) is set.	10 s
[1]	Analogue	Pulse time high	Pulse length for YH	2 s
[1]	Analogue	Pulse time low	Pulse length for YL	2 s
[1]	Enumeration	Template start up state	Open Closed Based on feedback	Based on feedback
[1]	Enumeration	Template start up mode	Manual Auto	Manual
[1]	Enumeration	Operation Mode options	Possible to switch between outside, manual and automatic mode Possible to switch between manual and automatic mode Possible to switch between manual and outside mode Locked in manual mode Locked in outside mode	-
[1]	Enumeration	Outside mode type	Outside: output controlled by SAS Local: output controlled locally	Local
[1]	Enumeration	Action on external fault	No action Open breaker	No action
[1]	Enumeration	Action on loss of XE	No action Open breaker	No action

[1] Parameter code to be defined if used on a terminal. It shall then start with the letter P.

A.4.12.3 Functional description

A.4.12.3.1 General

The following control options shall be made available selected by parameter:

- manual operation + automatic control + outside control;
- manual operation + automatic control;
- manual operation + outside control;
- locked in outside control (CCR indication only);

– locked in manual operation (controlled from HMI in CCR).

The function template can be configured to operate with several options according to the type of application restricting the possibilities for changing modes. These options are fixed during run-time, but selected when structuring the control logic and thus called control options.

See Figure F.31 for complementary function behavior description of the SBB template.

A.4.12.3.2 Operation modes

Mode functions

Function	Description
Auto	The flow device is automatically operated. The breaker will not be operable from the HMI system. This shall be reflected by the indication on the operator stations. The actual output to the breaker is controlled by the automation system based on inputs (XH/XL) from a control function. Then the breaker will be subject to safeguarding (shutdown) or interlock functions overruling the control input. The error handling and statuses in the template shall be available.
Manual	The operator is able to give open/close commands which will change the output Y. The flow device will additionally be subject to safeguarding (shutdown) or interlock functions overruling the operator input. Last output position will be maintained when switched to manual, i.e. if it was open, it will stay open.
Outside	Breaker is locally controlled. The breaker will not be operable from the HMI system. This shall be reflected by the indication on the operator stations. Outside control may be implemented in two different ways: Status indication only based the on position high and/or position low feedback signal from breaker. The actual output to the breaker is controlled by the automation system based on inputs (XOH/XOL) from an outside (local) control function. Then the breaker will be subject to safeguarding (shutdown) or interlock functions overruling the control input. The error handling and statuses in the template shall be available.
Block	Blocking disables safeguarding mode (LSH/LSL/FSH/FSL) and the disable transition mode (FDH/FDL).
Suppression	Suppression sets YF = 0. Disables alarm annunciation.
Safeguarding	See definition.
Disable transition mode	See definition.

A.4.12.3.3 Control requirements

Control functions

Function	Description
Symbols	The symbols used on VDUs shall always show true position (based on XGH and XGL)/status of the breaker.
Restart	After restart of the controller node the function will be set to a predefined mode and state according to the parameters.
Test mode	When XGX = 1 the function template enters test mode. In test mode the function template can be operated as normal both form logic and operator independent of XE. It shall be possible to indicate test position on the operator station HMI

A.4.12.3.4 Safeguarding

Safeguarding functions

Function	Description
Lock	Sets the output to safeguarding position and sets the function template to manual mode. This is also done if the template is in outside mode and the actual control output to the flow element is wired through the automation system.
Force	Sets the output to safeguarding position, but the mode of function template is not changed
Conflict	True if any safeguarding action is requested when the template is in blocked state. It shall be possible to generate an alarm on this event.

A.4.12.3.5 Error handling

Error functions

Function	Description
External fault	If XF is 1, it will be reflected directly on the output YF. Shall be possible to generate alarm.
Loss of XE	Prevent operation. Shall be possible to generate alarm. The YF shall be set. Switch to manual mode if possible (not if LO =1 or only outside option) and disconnect the breaker (depending on parameter).
Opening timeout	Shall be possible to generate alarm. The YF shall be set. A dedicated alarm shall be possible to generate if the time has elapsed during a safeguarding action.
Closing timeout	Shall be possible to generate alarm. The YF shall be set. A dedicated alarm shall be possible to generate if the time has elapsed during a safeguarding action.
Both XGH and XGL set	Shall be possible to generate alarm. The YF shall be set.
Loss of XGL when open	Shall be possible to generate alarm. The YF shall be set.
Loss of XGH when closed	Shall be possible to generate alarm. The YF shall be set.
Safeguarding failure	Shall be possible to generate dedicated alarm when feedback failure obtained and safeguarding is set.

A.4.13 SBC – Coordinator for SBE

A.4.13.1 Intended use

The SBC function template shall be used for duty/standby or lead/lag control of multiple flow elements.

Priority for the SBE units is set by assigned HMI. The current priority for each SBE is available for monitoring on SBE HMI.

A.4.13.2 Technical description

A.4.13.2.1 Function template schematic

Inputs	SBC		Outputs
Auto start requested number	XH	Y1 – Y6[8)]	Normal function output
Auto stop all	XL	YF	Function failed
Enable function	XE	YQ	Number requested
Request number	XQ	BA	Status auto/man
Rotate priority	XP	BCH	One or more SBE in run
		BCL	All SBE in stop
Call for 6 - increasing	X6H	BCQ	Number running
Call for 5 - increasing	X5H		
Call for 4 - increasing	X4H		
Call for 3 - increasing	X3H		
Call for 2 - increasing	X2H		
Call for 1 - increasing	X1H		
Call for 5 - decreasing	X5L		
Call for 4 - decreasing	X4L		
Call for 3 - decreasing	X3L		
Call for 2 - decreasing	X2L		
Call for 1 - decreasing	X1L		
Lock auto	LA		
Lock manual	LM		
Operator station:			Operator station:
Start requested			For each SBE :
Stop all			Running/stopped
Increment			Alarms and faults
Decrement			Available (SBE in auto)
Shift			Start disabled (FDH)
Set priority for each SBE			Stop disabled (FDL)
Set number requested as value			Safeguarding
Suppression on/off			Current priority
			Suppressed
Information from SBE[6)7)]			Information to SBE[6)]
• Running			• Set high
• Failure			• Set low
• Enabled for duty/standby (auto mode)			• Priority
• Safeguarding			
• Start disabled (FDH)			
• Stop disabled (FDL)			

6) Dependent of vendor solution.

7) Will not be shown on SCD

8) Terminal name will be shown as Y1…Y6 connected to X on SBE 1 .. 6 on the SCD.

Figure A.15 - SBC function template schematic

A.4.13.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
XH	Binary input	Auto start requested number.	In auto, start command. Will start the amount that is set as requested.
XL	Binary input	Auto stop all	In auto, stop all SBE. Prior to other input.
XE	Binary input	Enable function	XE = 1 is required for enabling the function.
XQ	Analogue	Request number	In auto. The amount of requested SBE units. Value
XP	Binary input	Rotate priority.	Signal goes high will execute the rotate priority function.
X6H	Binary input	Call for 6- increasing	If = 1, then at least 6 SBE shall run.
X5H	Binary input	Call for 5- increasing	If = 1, then at least 5 SBE shall run.
X4H	Binary input	Call for 4- increasing	If = 1, then at least 4 SBE shall run.
X3H	Binary input	Call for 3- increasing	If = 1, then at least 3 SBE shall run.
X2H	Binary input	Call for 2- increasing	If = 1, then at least 2 SBE shall run.
X1H	Binary input	Call for 1- increasing	If = 1, then at least 1 SBE shall run.
X5L	Binary input	Call for 5- decreasing	If = 1, then a maximum of 5 SBE shall run.
X4L	Binary input	Call for 4- decreasing	If = 1, then a maximum of 4 SBE shall run.
X3L	Binary input	Call for 3- decreasing	If = 1, then a maximum of 3 SBE shall run.
X2L	Binary input	Call for 2- decreasing	If = 1, then a maximum of 2 SBE shall run.
X1L	Binary input	Call for 1- decreasing	If = 1, then a maximum of 1 SBE shall run.
LA	Binary input	Lock auto	Locks the template in auto mode. When LA goes low, the template remain in auto mode.
LM	Binary input	Lock manual	Locks the template in manual mode. When LM goes low, the template remains in manual mode.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
YF	Binary input	Function failed	Failure. Have not obtained desired number to run.
YQ	Analogue	Number requested	The current amount of requested SBE units.
BA	Binary output	Status auto/man	Set BA = 1 when in auto mode.
BCH	Binary output	One or more SBE in run	One or more SBE running.
BCL	Binary output	All SBE in stop	All SBE in stop.
BCQ	Analogue	Number running	The amount of confirmed running SBE units.

Parameters

Parameter code	Parameter type	Parameter name	Supplementary description	Default
1)	Time	Overlap time	Overlap time used for shift operation.	5s
1)	Time	Alarm delay	Time before alarm when deviation between requested number of running SBE and obtained.	20s
1)	Binary	Count manual SBE	0 = Only count SBE that is in auto 1 = When calculating the amount of running SBE also the units unavailable for control by SBC is counted. .	0
1)	Binary	Select control in auto	0 = The binary input (XH1/XL1)will define the amount of requested units. 1 = Value XREQ define the amount of requested units.	0
1)	Binary	Priority list	0 = No message when user fault. 1 = Alarm annunciation when a faulty priority list is tried activated.	1
1)	Binary	Take into account start/ stop disable.	0 = Even if SBE is disabled, the SBC will command it to start/stop. 1 = If SBE is disabled, SBC will not try to change status of this SBE. If SBE has FDH=1, SBC will not try to start this SBE but select the next SBE in line.	1

1) If parameter is defined on a terminal, it shall start with character P.

A.4.13.3 Functional description

A.4.13.3.1 General

Duty/standby or lead/lag functions with up to 6 SBE units. The main purpose by the SBC is to keep a defined amount of SBE units running. SBC can only interfere on SBE units which are in auto mode. SBC HMI handles the priority of the SBEs. A priority rotate function will alternate running SBEs. The SBC will monitor running SBEs and execute action if one fail.

The connection on the SCD diagram between SBC and the assigned SBE's shall be indicated by a single line.. Terminal names on SCD on SBC will be shown as Y1…Y6. Assigned terminal name on the SCD on SBE will be named X.

SBC can be controlled in manual or auto. In manual the numbers of requested SBE are set by the operator, in addition there will be possible to start and stop the group.

In SBC auto mode, control is made by input terminals on the SBC template.

See Figure F.32 for more detailed function behavior description of the SBC template.

A.4.13.3.2 Operation modes

Mode functions

Function	Description
Manual	Amount of requested SBE units is set by the operator. Start/stop is made via HMI. Start will start the preset requested units. Stop will stop all assigned SBE (if in auto).
Auto	The requested amount of running SBE is selected by XREQ or the input XnH/XnL. Start of the units is made by the XH input. Stop of all will be executed when XL goes high. Increment and decrement of the requested running units is made based on input terminals.
Suppression	Suppression sets YF = 0. Disables alarm annunciation.

A.4.13.3.3 Control requirements

Control functions

Function	Description
Priority	The priority for each SBE is entered via the SBC HMI. The system shall make sure that priority setting are according to the following rules: The priority value is less or equal to the amount of connected SBE. Each priority number is only used once. It shall be possible to disable SBEs from the SBC function. A disabled SBE is not handled or counted by the SBC. Each SBE will have the priority value available for monitoring purpose.
Rotate function	Input XP goes high or command from operator will change the priority in such a way that the highest priority SBE will be given the lowest priority. At the same time all other SBE will be moved one step up in priority. If the low priority SBE is running, this will be stopped and the highest priority SBE that is not running will be started. Dependent on the overlap time the low priority SBE will be stopped a delayed time after the one in line is started.
Startup of standby	SBC generates start command to standby if all of the following three conditions are true: Duty in auto mode and running or starting (Y = 1), Duty fails or is stopped caused by safeguarding, Standby shall be available and in auto. After a start of standby has been executed, no further action is made before a command or a change on the input terminals. I.e. if a high priority unit stop caused by failure, a switch back to this unit is not made immediately when the unit return to available.
Enable	If the SBC is not available (XE = 0), then SBC is inactive. All SBE will show priority inactive.

Function	Description
Requested amount of running SBE based on XnH/XnL	Selection of requested amount of running SBE based on boolean input, XnH define the minimum number (n) of running SBE. An XnH input with n higher than requested SBE (YQ) will increment the requested amount. To decrement requested SBE, an input on XnL is required. XnL define the maximum number (n) of requested SBE. For instance, an input on X1L will set the requested amount down to 1 if more SBE's are requested.. If both X2L and X1L = 1, X1L will be the valid control signal (smallest maximum amount). If both X1H and X2H = 1, X2H will be the valid control signal (largest minimum amount). If any XnH/XnL and XL = 1, XL will be the valid control signal. XnL has priority to XnH.

A.4.13.3.4 Safeguarding

Not applicable for this template.

A.4.13.3.5 Error handling

Error functions

Function	Description
Cannot start requested amount of SBE.	YF = 1 Shall be possible to generate alarm. No action. If all SBE's safeguarded, then no alarm.
Loss of XE	YF = 1. All SBE's will show priority inactive. Shall be possible to generate alarm. No action.
Priority list faulty	Operator enters a faulty priority list. This will not be activated. Shall be possible to generate alarm. No action.

A.4.14 SBE – Control of electrical equipment

A.4.14.1 Intended use

The SBE function template shall be used for binary (on/off) control of flow element of medium (electricity, heat or fluid). The controlled element is a unit, e.g. motor, pump, heater, fan etc.

A.4.14.2 Technical description

A.4.14.2.1 Function template schematic

Inputs	SBE		Outputs
Pos high feedback (MCC)	XGH	Y	Normal function output
External set high	XH[9]	YH	Pulsed normal function output high
External set low	XL[9]	YL	Pulsed normal function output low
External outside set high	XOH	YF	Function failed
External outside set low	XOL	BCH	Output position high confirmed
External fault	XF	BCL	Output position low confirmed
Externally enabled (MCC)	XE	BA	Status auto/man
Lock safeguarding high	LSH	BO	Status outside
Lock safeguarding low	LSL	BS	Status safeguarding
Force safeguarding high	FSH	BB	Status blocked
Force safeguarding low	FSL	BU	Status suppressed
Force disable transition high	FDH	BXH	Status external set high
Force disable transition low	FDL	BXL	Status external set low
Force blocking	FB		
Force suppression	FU		
Lock auto	LA		
Lock manual	LM		
Lock outside	LO		
Operator station:			Operator station:
Auto/Manual/Outside			Alarms and faults
Set output on(high)/off(low)			Running/Stopped
Blocking on/off			Auto/Manual/Outside
Suppression on/off			Blocked
			Suppressed
			Disabled
			Safeguarding
			Conflict
			Priority
Information from SBC[6)9)]			Information to SBC[6)7)]
External set high			Run
External set low			Fault
			Available (SBE in auto)
Priority provided by SBC			Start disabled (FDH)
			Stop disabled (FDL)
			Safeguarding

6) Dependent of vendor solution.

7) Will not be shown on SCD.

9) Terminal name will be shown as X connected to Y1....Y6 on SBC on the SCD.

Figure A.16 - SBE function template schematic

A.4.14.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
XGH	Binary input	Position high feedback	Signal from MCC, running status high (XGH = 1 is motor running)
XH	Binary input	External set high	XH = 1 set Y to 1 in auto mode.
XL	Binary input	External set low	XL = 1 set Y to 0 in auto mode. XL is dominant over XH.
XOH	Binary input	External outside set high	XOH = 1 set Y to 1 in outside mode.
XOL	Binary input	External outside set low	XOL = 1 set Y to 0 in outside mode.
XF	Binary input	External Fault	Loop failure, e.g. I/O card broken.
XE	Binary input	Externally enabled (MCC)	XE = 1 is required for a start. The effect on Y when XE goes low while running will be defined by parameter.
LSH	Binary input	Lock safeguarding high.	Safeguarding – LSH = 1. Overrule operator possibility to operate Start/Stop and Auto/Manual. Locks template in manual mode and Y to 1 regardless of failure state. Input is subject to blocking. When signal goes low, the template remains in manual mode and Y = 1.
LSL	Binary input	Lock safeguarding low.	Safeguarding – LSL = 1 Overrule operator possibility to operate Start/Stop and Auto/Manual. Locks template to manual mode and Y to 0 regardless of failure state. Input is subject to blocking. When signal goes low, the template remains in manual mode and Y = 0.
FSH	Binary input	Force safeguarding high	Safeguarding – FSH = 1 Overrule operator possibility to operate Start/Stop. Sets Y to1 regardless of failure state. When signal is reset, the template will react to actual terminal statuses again. Signal is subject to blocking. If in Manual mode, the output (Y) remains 1 after signal returns to normal.
FSL	Binary input	Force safeguarding low	Safeguarding FSH = 0 Overrule operator possibility to operate Start/Stop. Sets to 0 regardless of failure state. When signal is reset, the template will react to actual terminal statuses again. Signal is subject to blocking. If in manual mode, the output (Y) remains 0 after signal returns to normal.
FDH	Binary input	Force disable transition high.	Permissive to start when FDH = 0 and prevents equipment from being started when FDH = 1. Signal is subject to blocking.
FDL	Binary input	Force disable transition low.	Permissive to stop when FDL = 0 and prevents equipment from being stopped when FDL = 1. Signal is subject to blocking.
FB	Binary input	Force blocking	FB = 1. Safeguarding action LSH, LSL, FSH, FSL and FDH and FDL will be blocked.
FU	Binary input	Force suppression	FU = 1. Alarm annunciation is suppressed, YF = 0. and statuses XF, XE and XGH are neglected.

Terminal code	Signal type	Terminal name	Supplementary description
LA	Binary input	Lock auto	Locks the template in auto mode. When LA is reset, the template remains in auto mode.
LM	Binary input	Lock manual	Locks the template in manual mode. When LM is reset, the template remains in manual mode.
LO	Binary input	Lock outside	Locks the template in outside mode. When LO goes low the template will be set to manual mode.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Binary output	Normal function output	Command to flow element. Start Y = 1 and stop Y = 0.
YH	Binary output	Pulsed normal function output high	Pulse start command YH = 1 (one pulse).
YL	Binary output	Pulsed normal function output low	Pulse stop command YL = 1 (one pulse).
YF	Binary output	Function failed	Set YF = 1 if XF = 1 or feedback time exceeded or change in feedback while in run or stop or XE = 0.
BCH	Binary output	Output position high confirmed	Output Y compared to feedback position high limit switch and validated as true (set BCH = 1 if Y = 1 and XGH = 1). XF has no impact on BCH.
BCL	Binary output	Output position low confirmed	Output Y compared to feedback position low limit switch and validated as true (set BCL = 1 if Y = 0 and XGH = 0). XF has no impact on BCL.
BS	Binary output	Status safeguarding	BS = 1 if any safeguarding input is active.
BB	Binary output	Status blocked	BB = 1 when block from operator station is true or FB = 1.
BU	Binary output	Status suppressed	BU = 1 when suppressed from operator station is true or FU = 1.
BA	Binary output	Status auto/man	BA = 1 when in auto mode.
BO	Binary output	Status outside	BO = 1 when outside mode set from operator station or LO = 1.
BXH	Binary output	Status external set high	BXH = 1 when SBE is in auto and XH=1 or start signal from SBC..
BXL	Binary output	Status external set low	BXL = 1 when SBE is in auto and XL=1 or stop signal from SBC..

A.4.14.2.3 Template parameters with default values

Parameters

Parameter code	Parameter type	Parameter name	Supplementary description	Default
1)	Analogue	Feedback time	Maximum allowed time from start/stop command is given (Y set to 1) to flow element running/stop feedback (XGH) is set/reset.	2 s
1)	Analogue	Time before action when loss of feedback.	Time from XGH is lost until actions are performed. Dependent of parameter that select if there shall be action on loss of XGH.	2 s
1)	Analogue	Pulse time high	Pulse length for YH	2 s
1)	Analogue	Pulse time low	Pulse length for YL	2 s
1)	Enumeration	Template start up settings	Manual and run Manual and stop As previous state	Manual and stop
1)	Enumeration	Operational mode options	Possible to switch between outside, manual and automatic mode Possible to switch between manual and automatic mode Possible to switch between manual and outside mode Locked in manual mode Locked in outside mode	Possible to switch between manual and automatic mode
1)	Enumeration	Outside mode type	Outside: Output controlled by SAS Local: Output controlled locally	Local
1)	Binary	Action on external fault	Value: 0 Stop motor – 1 keep running	0
1)	Binary	Action on loss of XE while running.	Value: 0 Stop motor – 1 keep running	0
1)	Binary	Action on loss of run feedback (XGH)	Value: 0 Stop motor – 1 keep running	0
1)	Binary	Restart controller options	Value: 0 Manual mode and stopped Value: 1 Auto mode and follow XH/XL - stopped if both is ‘0’.	0

1) If parameter is defined on a terminal, it shall start with character P.

A.4.14.3 Functional description

A.4.14.3.1 General

The following operation mode options shall be made available selected by parameter:

– manual operation + automatic control+outside control;

– manual operation + automatic control;

– manual operation + outside control;

– locked in outside control (CCR indication only);

– locked in manual operation (controlled from HMI in CCR).

The function template can be configured to operate with several options according to the type of application restricting the possibilities for changing modes. These options are fixed during run-time, but selected when structuring the control logic and thus called control options.

See Figure F.33 for complementary function behavior description of the SBE template.

A.4.14.3.2 Operation modes

Mode functions

Function	Description
Auto	The input terminals XH/XL will change the output Y. The flow element is automatically operated. The flow element will not be operable from the HMI system. This shall be reflected by the indication on the operator stations. The actual output to the flow element is controlled by the automation system based on inputs (XH/XL) from a control function. The flow element will be subject to safeguarding (shutdown) or interlock functions overruling the control input. The error handling and statuses in the template shall be available.
Manual	The operator is able to give open/close commands which will change the output Y. The flow element will additionally be subject to safeguarding (shutdown) or interlock functions overruling the operator input. Last output position will be maintained when switched to manual, i.e. if it was running, it keeps running.
Outside	Flow element (motor) is locally controlled. The flow element will not be operable from the HMI system. This shall be reflected by the indication on the operator stations. Outside control may be implemented in two different ways: – status indication only based the on feedback signal (running - position high-) from the MCC; – the actual output to the flow element is controlled by the automation system based on inputs (XOH/XOL) from an outside (local) control function. Then the flow element will be subject to safeguarding (shutdown) or interlock functions overruling the control input. The error handling and statuses in the template shall be available.
Block	Blocking disables safeguarding mode (LSH/LSL/FSH/FSL) and the disable transition mode (FDH/FDL).

Function	Description
Suppression	Suppression sets YF = 0. Disables alarm annunciation. The control template will use the output Y as feedback (XGH).
Disable transition mode	See definition.

A.4.14.3.3 Control requirements

Control functions

Function	Description
Symbols	The symbols used on VDUs shall always show true status (XGH) of the electrical flow device.
Restart	After restart of the controller node the function will be set to a predefined state selected by a parameter.
Duty/standby operation	Intended for automatic supervision of flow elements operating in parallel to increase the system availability. The priority is selected by the coordinator block (SBC) and transferred to the template for visualisation purpose. Start/stop and status information from/to SBE to/from SBC to perform the required duty/standby actions is communicated. (vendor dependent). Automatic duty/standby function is further described in the SBC template documentation. If SBC is connected , input on terminals XH/XL are disregarded..

A.4.14.3.4 Safeguarding

Safeguarding functions

Function	Description
Lock	Set the output to safeguarding position and sets the function template to manual mode. This is also done if the template is in outside mode and the actual control output to the flow element is wired through the automation system.
Force	Set the output to safeguarding position, but the mode of function template is not changed.
Conflict	True if any safeguarding action is requested when the template is in blocked state. It shall be possible to generate an alarm on this event.

A.4.14.3.5 Error handling

Error functions

Function	Description
External fault	If XF is 1: Prevent start. Shall be possible to generate alarm and set output YF. Switch to manual mode if possible (not if LO = 1 or only outside option) and stop motor (depending on parameter).
Loss of XE	Prevent start. Shall be possible to generate alarm and set output YF. Switch to manual mode if possible (not if LO = 1 or only outside option) and stop motor (depending on parameter).

Function	Description
Feedback failure	Discrepancy between XGH status and Y status when feedback time is elapsed. Feedback time is active when shall change state. If XGH is lost when Y = 1, a timer will delay action. Shall be possible to generate alarm and set output YF. Switch to manual mode if possible (not if LO = 1 or only outside option). Stop motor.
Safeguarding failure	Shall be possible to generate dedicated alarm when feedback failure obtained and safeguarding is set.

A.4.15 SBV – Control of pneumatic/hydraulic equipment

A.4.15.1 Intended use

The SBV function template shall be used for binary (on/off) control of a flow element by means of changing flow of medium (heat or fluid). Typically controlled elements are valves, dampers etc.

A.4.15.2 Technical description

A.4.15.2.1 Function template schematic

Inputs	SBV		Outputs
Position high feedback	XGH	Y	Normal function output
Position low feedback	XGL	YH	Pulsed normal function output high
External set high	XH	YL	Pulsed normal function output low
External set low	XL	YF	Function failed
External outside set high	XOH	BCH	Output position high confirmed
External outside set low	XOL	BCL	Output position low confirmed
External fault	XF	BS	Status safeguarding
Lock safeguarding high	LSH	BB	Status blocked
Lock safeguarding low	LSL	BU	Status suppressed
Force safeguarding high	FSH	BA	Status auto/man
Force safeguarding low	FSL	BO	Status outside
Force disable transition high	FDH		
Force disable transition low	FDL		
Force blocking	FB		
Force suppression	FU		
Lock auto	LA		
Lock manual	LM		
Lock outside	LO		
Operator station:			Operator station:
Auto/Manual/Outside			Alarms and faults
Set output open(high)/ close(low)			Open/Opening/Closed/Closing
			Auto/Manual/Outside
Blocking on/off			Blocked
Suppression on/off			Suppressed
			Disabled
			Safeguarding
			Conflict

Figure A.17 - SBV function template schematic

A.4.15.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
XGH	Binary input	Position high feedback	Signal from limit switch high (XGH = 1 is open flow device).
XGL	Binary input	Position low feedback	Signal from limit switch low (XGL = 1 is closed flow device).
XH	Binary input	External set high	From process or logic to function template which set high signal (Y = 1) to flow device in auto mode.
XL	Binary input	External set low	From process or logic to function template which set high signal (Y = 0) to flow device in auto mode.
XOH	Binary input	External outside set high	Set high signal (positive edge) to open flow device in outside mode.
XOL	Binary input	External outside set low	Set low signal (positive edge) to close flow device in outside mode.
XF	Binary input	External fault	Loop failure-e.g. I/O card broken.
LSH	Binary input	Lock safeguarding high	Safeguarding – LSH = 1 overrules operator inputs. Locks the template in manual mode with Y = 1. Input is subject to blocking. When signal is reset, the template remains in manual mode and Y = 1.
LSL	Binary input	Lock safeguarding low	Safeguarding – LSL = 1 overrules operator inputs. Locks the template in manual mode with Y = 0. Input is subject to blocking. When signal is reset, the template remains in manual mode and Y = 0.
FSH	Binary input	Force safeguarding high	Safeguarding – Signal overrules operator inputs forces the Y to 1. When signal goes low, the template will react to actual terminal status again if in auto mode. Signal is subject to blocking. If in manual mode, the output (Y) remains high after signal returns to normal.
FSL	Binary input	Force safeguarding low	Safeguarding – Signal overrules operator inputs Forces the template Y to 0). When signal goes low, the template will react to actual terminal status again if in auto mode. Signal is subject to blocking. If in manual mode, the output (Y) remains low after signal returns to normal.
FDH	Binary input	Force disable transition high	Permissive to open when FDH = 0 and prevents element from being opened when FDH = 1. Signal is subject to blocking.
FDL	Binary input	Force disable transition low	Permissive to close when FDL = 0 and prevents element from being closed when FDL = 1. Signal is subject to blocking.

Terminal code	Signal type	Terminal name	Supplementary description
FB	Binary input	Force blocking	FB = 1. Safeguarding action LSH, LSL, FSH, FSL and disable transition function FDH, FDL will be blocked.
FU	Binary input	Force suppression	Alarm annunciation is suppressed, YF = 0 and status XGL, XGH and XF are neglected as long as FU = 1.
LA	Binary input	Lock auto	Locks the template in auto mode. When LA goes low, the template remains in auto mode.
LM	Binary input	Lock manual	Locks the template in manual mode. When LM goes low, the template remains in manual mode.
LO	Binary input	Lock outside	Locks the template to outside mode, and sets the template to manual mode. When LO goes low, the template remains in manual mode.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Y	Binary output	Normal function output	Command to flow device, Open Y = 1 and close Y = 0.
YH	Binary output	Pulsed normal function output high	Pulse open command YH = 1 (one pulse).
YL	Binary output	Pulsed normal function output low	Pulse close command YL = 1 (one pulse).
YF	Binary output	Function failed	YF = 1 if XF = 1 ref. error handling definition.
BCH	Binary output	Output position high confirmed	Output Y compared to feedback position high limit switch and validated as true (BCH = 1 if Y = 1 and XGH = 1).
BCL	Binary output	Output position low confirmed	Output Y compared to feedback position low limit switch and validated as true (BCL = 1 if Y = 0 and BCL = 1).
BS	Binary output	Status safeguarding	BS = 1 if any safeguarding input is active.
BB	Binary output	Status blocked	BB = 1 if blocking from operator station is true or FB = 1.
BU	Binary output	Status suppressed	BU = 1 if suppressed from operator station is true or FU = 1.
BA	Binary output	Status auto/man	BA = 1 when in auto mode.
BO	Binary output	Status outside	BO = 1 when set outside from operator station or LO = 1.

A.4.15.2.3 Template parameters with default values

Parameters

Parameter code	Parameter type	Parameter name	Supplementary description	Default
1)	Analogue	Travel time open	Maximum allowed time from open command is given to process element (Y set to 1) to opened feedback (XGH) is set.	30 s

Parameter code	Parameter type	Parameter name	Supplementary description	Default
[1]	Analogue	Travel time close	Maximum allowed time from close command is given to process element (Y set to 0) to closed feedback (XGL) is set.	30 s
[1]	Analogue	Pulse time open	Pulse length for YH	2 s
[1]	Analogue	Pulse time close	Pulse length for YL	2 s
	Enumeration	Template start up state	Closed Open Based on feedback (XGH/XGL)	Closed
[1]	Enumeration	Template start up mode	Manual Auto As previous state[10]	Manual
[1]	Enumeration	Operation mode options	Possible to switch between outside, manual and automatic mode. Possible to switch between manual and automatic mode. Possible to switch between manual and outside mode. Locked in manual mode. Locked in outside mode.	-
[1]	Enumeration	Outside mode type	Outside: Output controlled by SAS Local: Output controlled locally	Local
[1]	Enumeration	Feedback type	No limit-switch feedback. Position high limit-switch feedback only. Position low limit-switch feedback only. Position high and low limit switches feedback.	Position high and low limit switches feedback
[1]	Enumeration	Action on fault	No action Close Open	No action

[1] Parameter code to be defined if used on a terminal. It shall then start with the letter P.

[10] If possible in the system.

A.4.15.3 Functional description

A.4.15.3.1 General

The following control options shall be made available selected by parameter:

- manual operation + automatic control + outside control;
- manual operation + automatic control;
- manual operation + outside control;
- locked in outside control (CCR indication only);
- locked in manual operation (Controlled from HMI in CCR).

The function template can be configured to operate with several options according to the type of application restricting the possibilities for changing modes. These options are fixed during run-time, but selected when structuring the control logic and thus called control options.

Duty/standby configurations for valves are not used.

See Figure F.34 for complementary function behavior description of the SBV template.

A.4.15.3.2 Operation modes

Mode functions

Function	Description
Auto	The flow device is automatically operated. The flow device will not be operable from the HMI system. This shall be reflected by the indication on the operator stations. The actual output to the flow device is controlled by the automation system based on inputs (XH/XL) from a control function. Then the flow device will be subject to safeguarding (shutdown) or interlock functions overruling the control input. The error handling and statuses in the template shall be available.
Manual	The operator is able to give open/close commands which will change the output Y. The flow device will additionally be subject to safeguarding (shutdown) or interlock functions overruling the operator input. Last output position will be maintained when switched to manual, i.e. if it was open, it will stay open.
Outside	Flow device (valve/damper) is locally controlled. The flow device will not be operable from the HMI system. This shall be reflected by the indication on the operator stations. Outside control may be implemented in two different ways: – status indication only based the on position high and/or position low feedback signal from flow device; – the actual output to the flow device is controlled by the automation system based on inputs (XOH/XOL) from an outside (local) control function. Then the flow device will be subject to safeguarding (shutdown) or interlock functions overruling the control input. The error handling and statuses in the template shall be available.
Block	Blocking disables safeguarding mode (LSH/LSL/FSH/FSL) and the disable transition mode (FDH/FDL).
Suppression	Suppression sets YF = 0. Disables alarm annunciation. The control template will act as the feedback option “no limit-switches” is selected.
Disable transition mode	See definition.

A.4.15.3.3 Control requirements

Control functions

Function	Description
Symbols	The symbols used on VDUs shall always show true position (based on XGH and XGL)/status of the valve.
Restart	After restart of the controller node the function will be set to a predefined mode and state according to the parameters.

Function	Description
Feedback monitoring	The SBV template shall have a parameter to define the four possibilities for limit-switch feedback constellation. The four possibilities are: <u>Feedback option 1: No limit-switches</u> The position of the element (valve/damper) is derived from the output of the function template and shown on the operator station and the confirmed position outputs follow the normal functional output Y. <u>Feedback option 2: Position high limit-switch feedback only</u> The position of the element (valve/damper) is taken from the high limit switch only, i.e. if not open, it is assumed to be closed. <u>Feedback option 3: Position low limit-switch feedback only</u> As in option 2, relying on the low switch, i.e. if not closed, it is assumed to be open. <u>Feedback option 4: Position high and low limit switches feedback</u> The position of the element is calculated out of the position of both limit switches. End positions as well as "moving" status can be shown on the operator stations.

A.4.15.3.4 Safeguarding

Safeguarding functions

Function	Description
Lock	Sets the output to safeguarding position and sets the function template to manual mode. This is also done if the template is in outside mode and the actual control output to the flow device is wired through the automation system.
Force	Sets the output to safeguarding position, but the mode of function template is not changed.
Conflict	True if any safeguarding action is requested when the template is in blocked state. It shall be possible to generate an alarm on this event.

A.4.15.3.5 Error handling

Error functions

Function	Description
External fault	If XF is 1, it will be reflected directly on the output YF. Shall be possible to generate alarm. Action according to parameter.
Opening timeout	Shall be possible to generate alarm. The YF shall be set. A dedicated alarm shall be possible to generate if the time has elapsed during a safeguarding action. Action according to parameter.
Closing timeout	Shall be possible to generate alarm. The YF shall be set. A dedicated alarm shall be possible to generate if the time has elapsed during a safeguarding action. Action according to parameter.
Both XGH and XGL set	Shall be possible to generate alarm. The YF shall be set.
Loss of XGL when closed	Shall be possible to generate alarm. The YF shall be set.
Loss of XGH when open	Shall be possible to generate alarm. The YF shall be set.
Safeguarding failure	Shall be possible to generate dedicated alarm when feedback failure obtained and safeguarding is set.

A.4.16 Sequence logic

A.4.16.1 Intended use

Sequential controls allow for processing sequential and parallel operations in a mode that is discrete with respect to time and events. They are used to coordinate different continuous functions as well as controlling complex process sequences. Sequence logic should be specified in a sequential function chart (SFC) format. Sequence oriented tasks shall be formulated using steps and transitions. The steps represent actions (to SCD functions) and the transition represents conditions that shall be fulfilled before moving to the next step.

The SFC should be drawn on separate sheets still coded as an SCD diagram. The symbols to be used are defined in Annex B.

The operation, control permissive and dependencies of each sequence is defined via the KB function template.

The SFC function templates will be supplier standard which shall be in accordance to IEC 61131-3.

A.4.16.2 Technical description

A.4.16.2.1 Functional template schematic

For sequential control there are defined two functions, **Step** and **Transition,** see Figure A.18

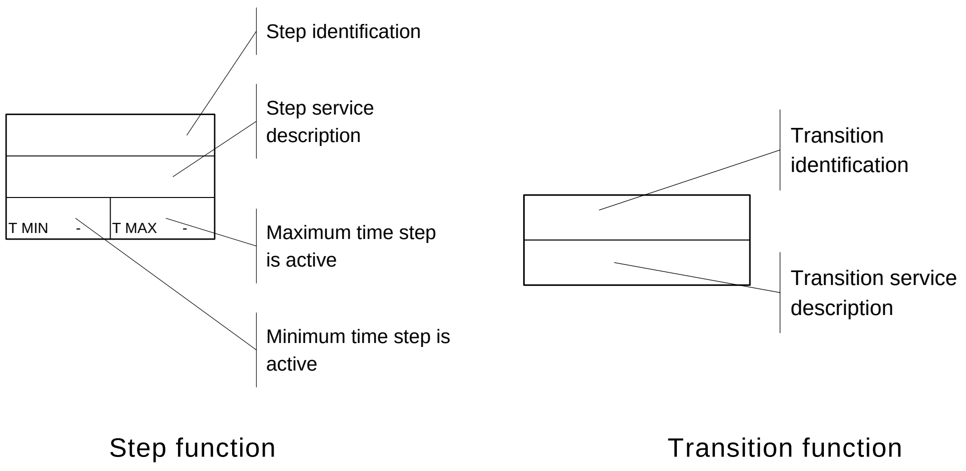

Figure A.18 - Sequential control functions

A.4.16.2.2 I/O terminals

Input terminals

Terminal code	Signal type	Terminal name	Supplementary description
Not applicable	Not applicable	Not applicable	There are not defined any input terminal names. Instead an transition input reference symbol shall be used. The inputs will only enter the Transition function. This symbol shall as a minimum include following fields: **Connection reference number** – An unique number within the actual sequence used for interfacing EFB logic or which can be used as short reference in textual supporting descriptions or other literature. **Drawing reference (optional)** – For unique reference to the SCD diagram where the connected signal is located when this is to a EFB and not a tagged function. **Tag.no/terminal /Comparator / Value**– reference to the terminal on the actual Function Template this transition is connected to and the conditions that should be fulfilled for this terminal. **Service description** – Service description for this condition.

Output terminals

Terminal code	Signal type	Terminal name	Supplementary description
Not applicable	Not applicable	Not applicable	There are not defined any output terminal names. Instead an output action reference symbol shall be used. The output will only be connected to the Step function. This symbol shall as a minimum include following fields: **Value** – value to be set. **Latch** – (Y/N) If yes the value (Previous field) shall be present when exiting the step. **Tag.no/terminal** – reference to the terminal on the actual Function Template. **Service description** – Service description for this action. **Connection reference number** – An unique number within the actual sequence which can be used for interfacing EFB logic or as short reference in textual supporting descriptions or other literature. **Drawing reference** – Reference to the SCD diagram where the connected Function Template is located.

A.4.16.2.3 Step function parameters with default values

Parameters

Parameter code	Signal type	Parameter name	Supplementary description	Default
1)	Analogue	Step T min	Minimum duration of step. Step is held until this timer has expired.	0 s
1)	Analogue	Step T max	Maximum duration of step. When this timer expire It shall give an event/alarm. The step will not automatically continue in this case. If the max time is set to zero, this means this function is disabled.	0

1) If parameter is defined on a terminal, it shall start with character P.

A.4.16.3 Functional description

A.4.16.3.1 General

A sequence is defined by steps and transitions. The individual steps activate certain actions. The transition conditions control the transition from one step to the next.

There shall be a possibility to do alternative steps, this is done by identifying alternative branches. The next step is then defined by an explicit transition.

There shall also be a possibility to do simultaneously steps. This is done by identifying parallel branches. The next steps are defined by a common transition. The end of parallel branches is synchronized.

A.4.16.3.2 Operation modes

Mode functions

Function	Description
Ref. KB	See control function descriptions for KB function template.

A.4.16.3.3 Control requirements

Control functions

Function	Description
Ref. KB	See control function descriptions for KB function template.

A.4.16.3.4 Safeguarding

Safeguarding functions

Function	Description
Ref. KB	See safeguarding function descriptions for KB function template.

A.4.16.3.5 Error handling

Error functions

Function	Description
Ref. KB	See error function descriptions for KB function template.

Annex B
(Normative)
SCD drawing standard

B.1 Introduction

For process and utility systems(e.g. HVAC) the SCDs are in general a simplified version of the P&IDs/D&IDs where all the piping details have been excluded and where functional templates and their logical connections have been included. A consequence of this is that the process is presented on a fewer number of sheets. This gives a better overview of the process.

For power grid control the SCDs are a simplified version of the single line diagrams where the functional templates and their logical connections have been included.

It is recommended to design the layout of the SCD independently and in parallel to the other documents (P&ID, D&ID and Single line diagrams).

The information on the SCD is in general divided in the following four categories:

- equipment;
- measuring instruments;
- functions;
- logical connections.

In general for design of symbols ISO/IEC 81714-1 is used as basis. For designs of lines ISO 128-20 is used as basis. However, the symbols introduced in this NORSOK standard are specific to SCDs. As there are no other standard for this type of diagram these symbols are not found in any other standard. They are unique to fit the main purpose of the SCD, easy readability of the precise functionality of the process control and the process shutdown logic.

For design of lines and valve symbols ISO 3511-1 is used as basis. This is again based on ISA 5-1, but there are some deviations. NORSOK being a European standard has a preference for IEC/ISO. Although this deviates from ISA5.1 on some few symbols.

For sequential function chart the design of symbols is based on IEC 61133-3 and IEC 60848. In general the symbols are expanded to give possibility to carry data and references to the interfacing control and shutdown logic.

Equipment symbols on the SCDs are not defined by this NORSOK standard. The equipment symbols used on SCDs are variants of the symbols used on PFD and P&ID, see also ISA 5.5 and examples listed in ISO 10628.

B.2 Content of SCDs

B.2.1 Equipment

B.2.1.1 Plant equipment

Plant equipment is defined as equipment used to process, transport or store process fluids: gas, liquids or solids. Such equipment includes

- tanks, pressurized vessels, columns,
- flow machines: fans, pumps, compressors, ejectors, turbines, conveyors and weight feeders,

- mixers,
- heat exchangers,
- filters,
- hydro cyclones, reactors or other special process equipment,
- complex or non-electrical drives.

Normally one will follow the symbols used on the projects/plants P&IDs for equipment. It is however recommended to pick a limited selection of symbols. The purpose is to only have a functional representation of the equipment. Construction details or internals may be shown only where essential for the understanding of associated instruments and control.

The equipment should be tagged.

B.2.1.2 Electrical equipment

For power distribution SCDs, the electrical equipment that shall be monitored or operated by the control room operator shall be included.

For process and utility system SCD's, electrical equipment shall as a general rule, be included.. A symbol with references to the electrical system shall always be used as interface between system function and electrical equipment.

NOTE Exception to this is for electrical actuators for valves. Electrical ref symbol shall not be included for electrical actuated valves.

All process inline electrical equipment shall be included on the SCD. Electrical equipment normally included on the SCDs is

- electrical heaters,
- electrical-chemical equipment,
- generators,
- motors with extensive instrumentation.

Examples of electrical equipment, which normally will not be shown on the SCDs are

- electrical motors directly connected to mechanical equipment forming an entity, e.g. standard motor/pump configuration,
- local emergency push buttons when these are provided as a standard feature.

Individual electrical consumers may require additional features associated with the electrical switchboard or starter circuitry. Additional electrical equipment may be inserted between the switchboard reference symbol and the consumer. The same reference symbol shall be used to give references to such.

Typical additional equipment is

- transformers (normally only included if instrumentation is involved),
- frequency converters (normally involves control).

B.2.1.3 Valves

Valves shall be included on the SCDs according to the following list:

- remotely controlled valves with actuator (including on/off valves and control valves);
- local self-actuated control valves or valves controlled from local controllers;
- pressure safety valves, (parallel valves may be shown as one common valve);

- check valves, manual valves, rupture discs, flow restriction orifices etc. where essential for understanding system operation.

B.2.2 Measuring instruments

All measuring instruments with input to the control system, or to local controllers shall be shown on the SCD.

Instruments connected to dedicated control systems with separate operator station shall be included where essential for understanding the system.

B.2.3 Functions

B.2.3.1 Control functions

The SCD shall include all control functions and their interrelation in form of exchange of status, measuring variables, interlocking and suppression. Both functions controlled by the SAS and in any package-supplied control system shall be identified to give a total understanding for the operation. These functions are represented with different symbols as specified later in this annex.

All control functions including locally mounted controllers shall be shown.

B.2.3.2 Shutdown functions

All shutdown functions within PCS and PSD shall be implemented on the SCDs. Shutdown functions within the PCS and non-latched shutdown functions within PSD shall be implemented as logical connections between the relevant output and inputs on the applicable control functions. Latched shutdown functions within PSD shall be implemented as logical connections between the relevant output and inputs on the applicable control functions and the shutdown function template, see Annex A.

Shutdown functions from the systems like HIPPS, F&G and ESD shall be identified by the triangle reference symbol which gives references to the system and logical connected to the relevant output and inputs on the applicable control functions.

B.2.4 Flow paths

B.2.4.1 Process flow

Flow paths (including recycle lines) which are required for understanding of system operation for normal operation, start-up and shutdown shall be included.

B.2.4.2 Signals

The following signals/logical connections shall be shown on the SCD, except when shown in the SCD legend or in a typical:

- signals between functions templates and field instruments/flow elements;
- signals interconnecting function templates and logical elements;
- signals between electrical equipment and function templates;
- signals between local control panels and function templates;
- signals from/to shutdown reference triangles;
- signals from/to sequence reference flags.

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B.2.5 Information not shown on the SCDs

The following information is not shown:

- minor flow paths as pipes and ducts not essential for understanding the control functionality of the system;
- flow paths from PSVs not important for process understanding
- pipes with valves etc. for maintenance purpose;
- pipe tagging;
- local instruments without connection to any control function;
- fire and gas detection and fire fighting equipment (but may, however, be shown on special printouts suited for these purposes);
- General utility functions as heat-tracing etc.

B.2.6 Black box representation

To keep the readability of the SCDs the following recommendation shall be adhered to:

- functions, which are not required for the general understanding of the process/system interactions, may be omitted or described in a short text with reference to a lower level SCD where the function may be fully shown. An example is the mechanical part of a compressor;
- elementary logic functions of some complexity may on the SCD be shown as a black box including textual description of the function. Details of the function may be included in supporting documentation such as SCD description document.

See Annex E and Figure E.56 as example of black box representation.

B.2.7 Parallel equipment

Where parallel, identical, complex equipment shall be shown, only one set may be fully drawn. The other sets may be shown as reference to the fully drawn set. Interface signals between parallel equipment shall be shown.

Where parallel, identical equipment have common instrumentation they may be illustrated as one unit on the SCD.

B.3 Layout

B.3.1 Readability

Proper layout of the SCDs is a key factor to obtain readability. The general guidelines below should be enforced in a way that does not make the readability suffer.

B.3.2 The extent of information on SCDs

Primarily the process shall be divided in functional standalone sections on each SCD. Natural process splits shall be considered to minimize the number of interfaces.

As a guideline for readability of the SCD the process may be sectionalized to provide a maximum number of objects requiring function templates, e.g. transmitters, valves, motors, etc. The maximum number should be 20 to 30 if the functions are dominated of control, and 40 to 50 if the functions are dominated of monitoring. These estimates will however be highly dependent of amount of equipment and logic complexity,

B.3.3 Location of information on the SCDs

Different type of information should be allocated as follows:

- references to associated SCDs should be located on the outermost right or left areas;
- shutdown applications should be located on the upper section of the SCD sheet;
- the process and associated function templates should be located in the remaining part.

B.3.4 Direction of flow

The main flow should normally be from left to right in the diagram. This statement is applicable for both process flow and for signal flow. However, control signal and process flow may by nature be contrary to this and exceptions will occur.

Flow direction arrows at process lines shall be used where needed to understand the flow direction. For signal lines it is limited to the in-terminal on function elements.

B.3.5 Page connectors

References to and from succeeding and preceding SCDs shall be included both for process flow and signals. They shall be by the defined page connector symbols. Due to the rules of flow direction normally both will go out of the diagram on right hand side and come in on left hand side of the diagram.

The direction of flow for the two types may be reversed. Such cases should be limited to where this will give improved readability. An example would be a signal for stop or trip of a pump upstream the process section shown on the SCD where the signals originate.

B.3.6 From P&ID/D&ID to SCD

It is recommended to design the SCD layout independently from the P&ID/D&IDs. The process from several P&IDs should be combined into one SCD. (One SCD pr 2-4 P&IDs).The SCD design should start by analyzing the P&IDs and stripping away all surplus information. Ref. B.2.4.

The expected total amount of logic must be considered when designing the initial SCDs.

Generally equipment sizes on the SCD are reduced compared to the P&ID to make more space for logic.

B.4 Symbols

B.4.1 General

The symbols used on the SCD shall in general adhere to the symbols used on the P&IDs, D&IDs and single line diagrams. However, modifications and additions to both the symbols itself and the range of symbols defined in the source document legend are permitted to reflect the extended information provided by the SCDs.

To enable use of extended functions the following SCD symbols are introduced:

- function templates;
- logic and arithmetic functions;
- signal lines;
- instruments;
- reference symbols.

B.4.2 Function template symbol

Function template shall be used for all tagged functions related to instrumentation and control.

System in SAS e.g.

PCS - C
PSD - P
ESD - E
F&G - F

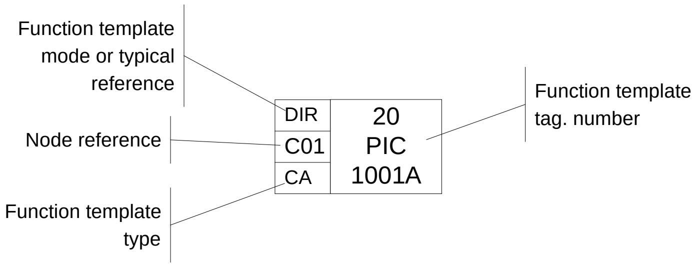


Figure B.1 - The function template symbol

The left-hand three rows column is dedicated for

- function template mode or typical (internal control mode/variant for specific template),
- node reference of Function Template. The controller unit in SAS or reference to external controller unit if function template is not in SAS. The controller unit consist normally of 3 digits where the first is a letter which indicates the system in SAS. E.g. C01 where C is the code for PCS.
- type of function template which this object represents, see Annex A.

Optionally there can be an additional text field in the bottom of the symbol. The text field is free for any additional information to the reader of the SCD.

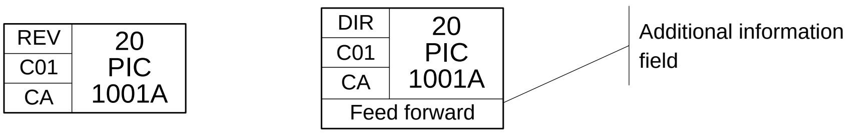
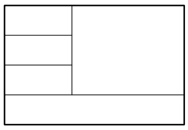
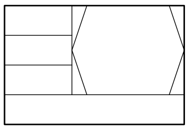
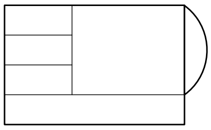


Figure B.2 - The additional information field

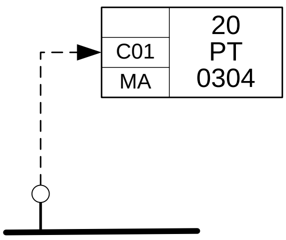
The symbol represents the complete control function covered by the function template, see A.4. The control function can be completely integrated in SAS (as shown in above example) or can be integrated in stand-alone packages.

To guide the operator to how the operation of the function is integrated in the main control system there has been made three different variants of the function template symbol.

Table B.1 - Control function integration definition

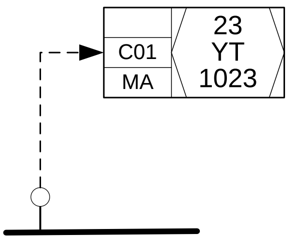
	Level	Definition
	**I**	Control function and HMI fully integrated in the main control system.
	**II**	Field device wired to an external control system, symbol only to be used when this external system is not shown separately on the SCD. HMI function integrated in the main control system.
	**III**	Control function and HMI are in a control system externally to the main control system. Object must be operated in the external system. Interface to the main control system should be shown separately if applicable. Symbol for Level I should then be used.

Examples:



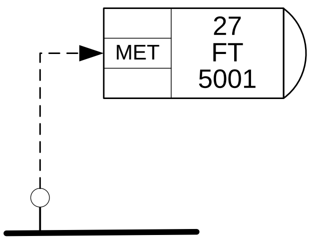
I. Control function and HMI fully integrated in the main control system.

Figure B.3 - Integration level I symbol



II. HMI function integrated in the main control system.

Figure B.4 - Integration level II symbol



III. External control function.

Figure B.5 - Integration level III symbol

B.4.3 Symbols for logic and arithmetic functions

As a general rule, positive logic shall be used on the SCDs.

Symbols for arithmetic and logic functions are unique for the SCD method.

The symbols for combination of multiple input signals can be shown differencing between software and hardware realization:

Software realisation Hardware realisation

Figure B.6 - Elementary functions symbol

To avoid ambiguities regarding hardware/software realization and system unit allocation of signals the following rules shall be strictly adhered to:

- signals from field devices shall always be routed directly to a function template; an exception is use of a hardware signal split, since the a hardware split is defined to be a field device;
- In special cases output from a hardware signal split can be routed to a local instrument.

The x notation is defining the function according to the following table:

Table B.2 - EFB function notations

Notation	Function	Extended connection line	Terminals to be shown
o	Logic "OR" (X1 or X2 = Y)	Can be used	NA
&	Logic "AND" (X1 and X2 = Y)	Can be used	NA
≠	Logical “XOR” (Exclusive X1 or X2, Y=1)	Can be used	NA
H	High selector (Y = the higher of X1 and X2)	NA	NA
L	Low selector (Y = the lower of X1 and X2)	NA	NA
>	Comparator high (Y = 1 when X1 > X2, otherwise Y = 0)	NA	X1,X2
<	Comparator low (Y = 1 when X1 < X2, otherwise Y = 0)	NA	X1,X2
+	Arithmetic plus (X1 + X2 = Y)	NA	NA
-	Arithmetic minus (X1 - X2 = Y)	NA	X1,X2
*	Arithmetic multiply (X1 * X2 = Y)	NA	NA
/	Arithmetic division (X1 / X2 = Y)	NA	X1,X2
M	Memory element (S=set, R=reset) 1)	NA	S,R
S	Split of signal	NA	NA
#	Optional formula – Terminal names users choice. See figure B.8.	Can be used	All
A	Analogue select by digital input Y=X1 when S=0, Y=X2 when S=1	NA	S,X1,X2

1) Dominant terminal to be indicated by underlining the terminal name. If no terminal is underlined R=reset is to be considered dominant.

The analog selector is defined with this illustration. The input/terminal name shall for this function be presented on the diagram. The inputs can then have a different position into the symbol.

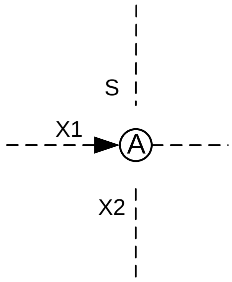
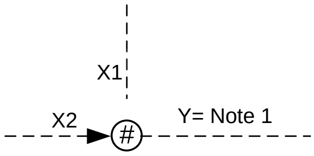


Figure B.7 - Analogue selector

When use of “#” (Optional) the formula may be written directly at the output signal line or referred to by a note.

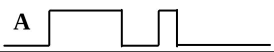
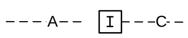
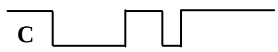
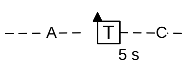
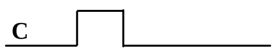
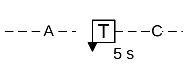
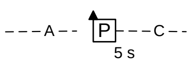
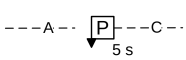


Note 1: Y= X1+X2²

Figure B.8 - Use of the “optional” notation “#”

The logic elements for single signal operation are defined in Table B.3.

Table B.3 - Timer/pulse logic diagrams

Description	Symbol	Logic diagram
		
Inverter		
Timer (delay on rising edge)		
Timer (delay on falling edge)		
Pulse generator (pos. pulse on false – true)		
Pulse generator (pos. pulse on true – false)		

All symbols shall maintain the orientation of the symbol regardless of the relative signal line orientation.

B.4.4 Extended connection line for EFB functions

To obtain better readability there might be need for more inputs or outputs than the symbol itself can accommodate. In these cases a “wall” can be used. The line used can be stretched to desired length.

These connection lines may be represent by one or a combination of multiple EFB’s in the control system.

See Figure B.9, Figure B.10 and Figure B.11.

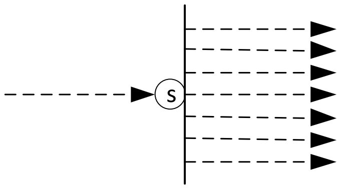


Figure B.9 - Multiple split by extended connection line

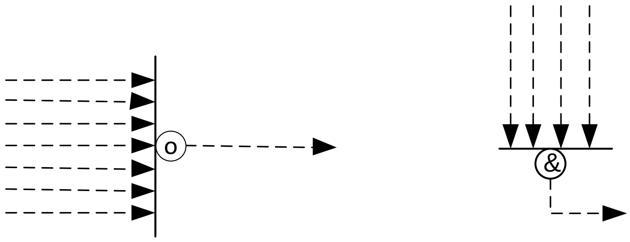


Figure B.10 - Multiple or/and by extended connection line

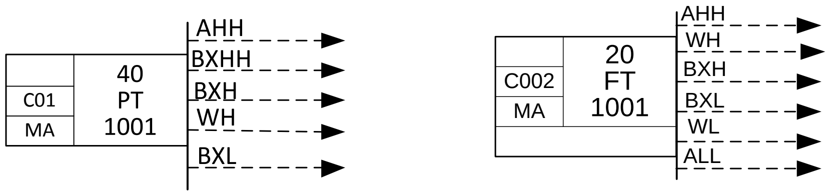


Figure B.11 - Multiple function terminals by extended connection line

B.4.5 Parameter labels

To implement process parameters, numbers and logical operands the symbol shown in Figure B.12 should be used.

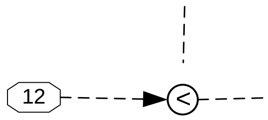


Figure B.12 - Fixed parameter label

B.4.6 Signal line

General signal, e.g. logic software signal within a node or hardwired signal from transmitter to SAS. Can also be used for bus signals and serial lines. The general symbol for signal line is as shown in Figure B.13.

Double arrow = Normally energised

Figure B.13 - Signal line

Normally energised signals are used to obtain fail safe functionality of output signals.

Double arrow may be used to indicate that the signal is normally energized signals. It is a recommended practice to use on digital input signals where you want to indicate that it has a fail safe functionality. It can also be used to indicate normally energized outputs. See also B.4.13.7.

Digital communication link, i.e. bus or serial line. The signal line reflects the logic end points of the signal, and not the actual bus topology. The line in figure B.14 can be used to indicate digital communication. Such communication can contain several information elements between two objects all represented with a single digital communication line.

Figure B.14 - Digital communication link

Lines used for electrical power, hydraulic power and, pneumatic supply shall be identical to symbols defined in the P&ID legend.

Figure B.15 - Electrical power line

Where a signal goes from logic in one node to an elementary logic element in another node it is important to identify where the interface is. A node split symbol for signal lines is defined to identify where the split is. See Figure B.16

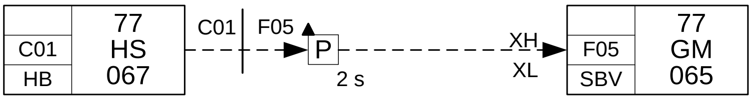


Figure B.16 - Node split symbol for signal lines

B.4.7 Process line

For the process there shall be two types of lines, see Figure B.17 and Figure B.18.

Major process lines are used for main process in main flow direction within current SCD. Minor process line is used for return lines, chemical injection points, cooling/heating medium etc. The same pipe may be drawn with different size on different SCDs dependent on contexts. E.g. on SCD for cooling system the distribution pipe is main, while when used as cooling medium in process-cooler on another SCD the pipe will be minor.

1) Major process line:

Figure B.17 - Major process line

2) Minor process line:

Figure B.18 - Minor process line

It is recommended to use rounded corners for process flow lines to improve readability.

B.4.8 Line connections

Whenever multiple usage of a signal is required, the signal split symbol shall be used, see Figure B.19.

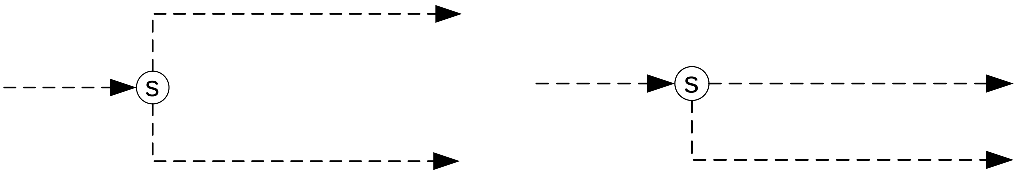


Figure B.19 - Line connections

The signal split can also be represented by a simple ‘dot’. It is recommended that only one type of split presentation is used on the same drawing.

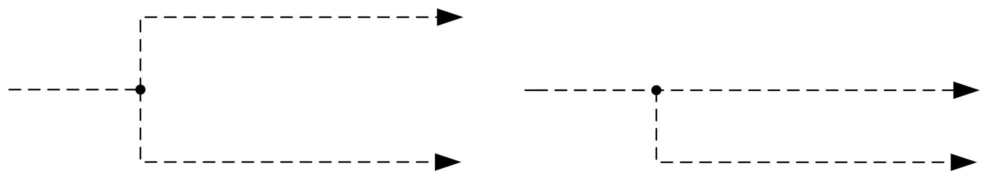


Figure B.20 - Simplified line connections

For process lines the dot shall not be used.

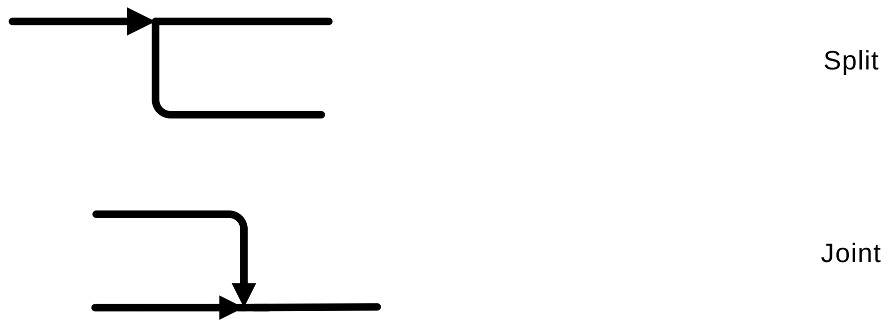


Figure B.21 - Process line connections

It is recommended to use arrows at the connections point where the process flow direction may change (split or joint), see Figure B.21.

B.4.9 Process and signal line crossing/jump

For crossing lines the vertical line shall have a gap, see Figure B.22.

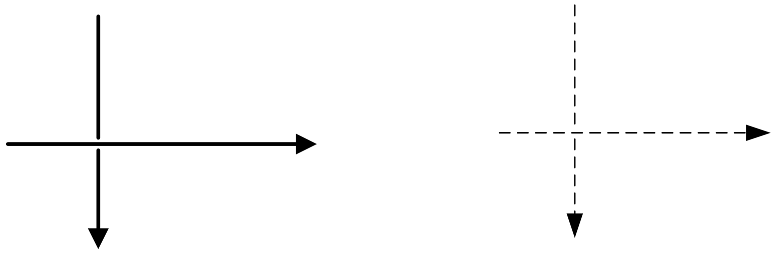


Figure B.22 - Line crossing

B.4.10 Sequential flow chart lines

For the sequential flow chart the flow path shall be indicated using a line shown in Figure B.23.

Figure B.23 - SFC lines

For signals lines into the transitions and out from steps to actions the general signal line shall be used.

For branching the sequence into alternative routes the alternative branch line should be used. Ref figure B.24

Figure B.24 - SFC alternative branch line

For branching the sequence into parallel routes the parallel branch line should be used. Ref figure B.25.

Figure B.25 - SFC parallel branch line

The ends of the parallel routes are indicated synchronised with the use of the same parallel branch line.

B.4.11 Instruments

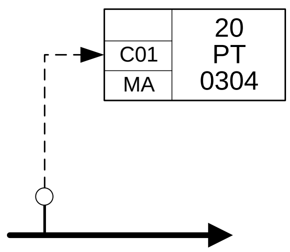


Figure B.26 - Instrument

The instruments shall be drawn with small circles (see Figure B.24) without tag identification on SCD where the instrument tag may be derived from the associated function template. This is a deviation from ISO 3511. The reason for the deviation is that the same information is shown in the function template.

No tag number shall be provided at this point unless where the process variable cannot be derived from the function code shown in the function template. The identification letters dedicated for the measured variable shall in that case be given close to the instrument symbol, see Figure B.25.

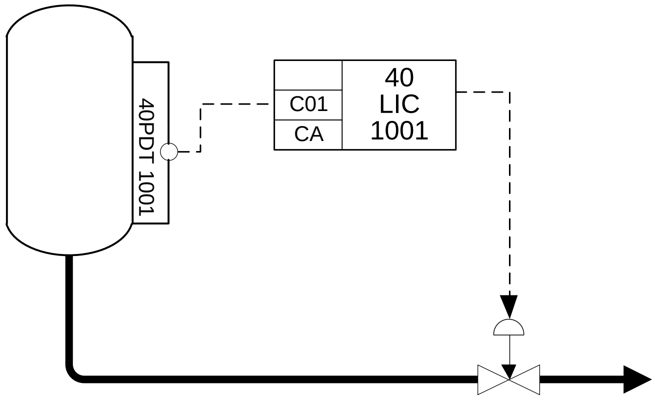


Figure B.27 - Instrument tag location

B.4.12 Mechanical equipment

The symbols for the equipment shall be identical to symbols defined in the P&ID legend. Only the basic symbol shall be used. Auxiliary equipment not required to fulfill the intention of the SCD shall be omitted.

B.4.13 Valves

B.4.13.1 General

In the SCD a generic valve body type shall be used. The variant often shown on P&IDs shall not be used.

B.4.13.2 On/off valves

The on/off valves shall be drawn as a simple valve, see Figure B.28. The actuator shall be drawn with a small circle without tag identification letters. This is a deviation from ISO 3511. The reason for the deviation is that the same information is shown in the function template.

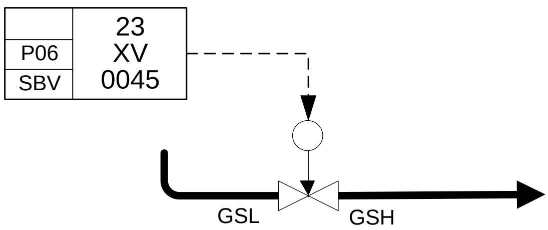


Figure B.28 - On/off valve

B.4.13.3 Modulating control valves

Modulating control valves is identified by a diaphragm looking actuator, as a generic symbol covering both hydraulic, pneumatic and electrical operated valves, see Figure B.29.

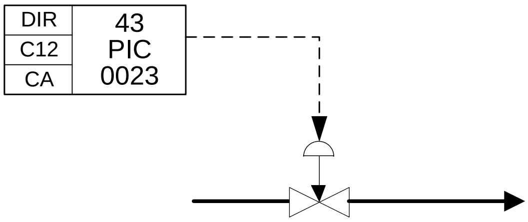


Figure B.29 - Modulating control valve

B.4.13.4 Actuators

For valves and dampers the actuators is divided in two types. On/off and Modulating.

Figure B.30 - Actuators variations

B.4.13.4 Dampers

For SCDs covering HVAC a dedicated damper symbol is used. There are different types of dampers see notation in Figure B.31. Identifications of functionality concerning on/off, modulating or fail safe will be identical to the valve.

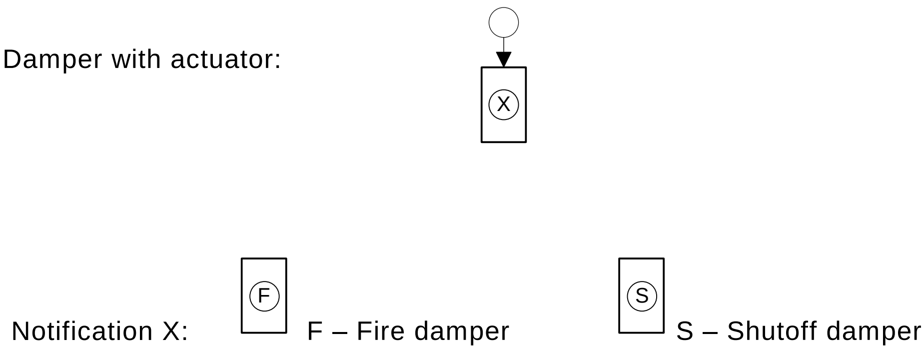


Figure B.31 - HVAC damper variations

B.4.13.5 Limit switches

Limit switch function codes shall be used together with valve / damper. Indication for closed position should be located upstream the valve/damper. Indication for open position should be located downstream the valve. In Figure B.32 a function code defined by ISO 3511/I is used.

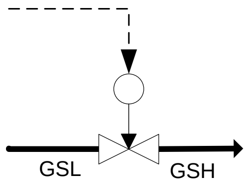


Figure B.32 - Limit switches

B.4.13.6 Fail safe

Fail safe on loss of electrical signal should be shown on the SCD according to the Figure B.33.

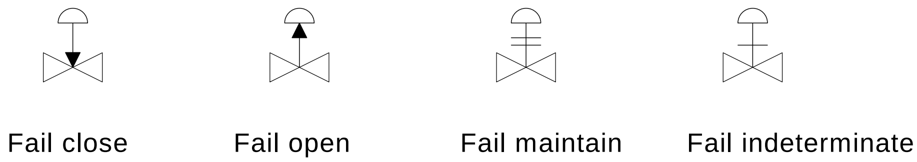


Figure B.33 - Signal failure valve action

B.4.13.7 Normal closed / energized signals

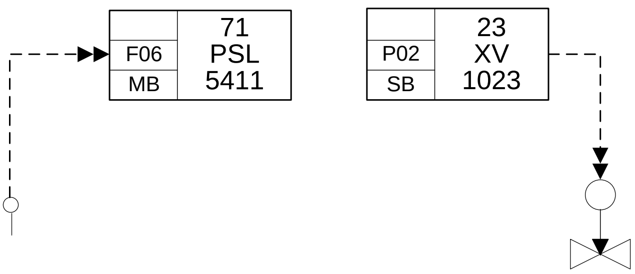


Figure B.34 - Normally energised input and output signals

Double arrow may be used to indicate normally closed inputs circuits and normally energised output.

B.4.13.8 Normal open/normal close

Normal open/normal close should be shown on the SCD. If shown it shall be shown according to Figure B.32. As on P&ID a filled symbol means normally closed valve. On operator HMI it is can be the opposite.

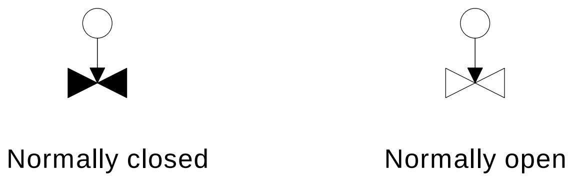
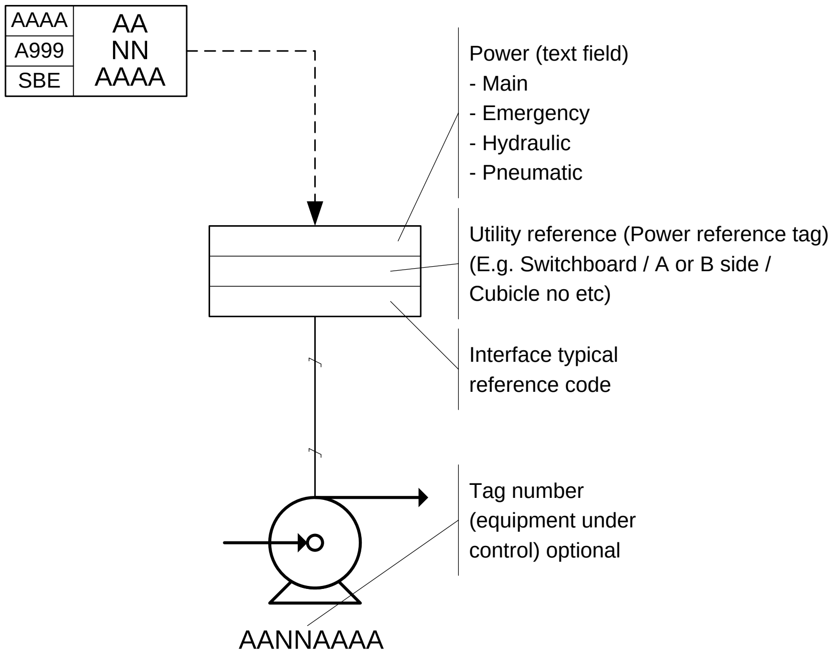


Figure B.35 - Valve normal position

B.4.14 Electrical equipment

For electrical devices, the SCD shall provide references (see Figure B.36) to the electrical equipment which has signal interface to the control system. It is recommended to give the FB a tag number that is identical to the equipment under control. In that way it is easy for the operator to see which equipment he operates. If that is done it is optional to repeat the tag number under the equipment under control. The FB used to stop and start electrical equipment is normally SBE.



NOTE Feedback signals are a part of the interface typical code and should be defined on legend or in typical and are generally not shown on the SCD..

Figure B.36 - Electrical reference symbol

Power field: shall indicate the level of power source for the equipment under control in clear text. Whether it is powered from e.g. main, essential, emergency or UPS. This type of information is vital to the control strategy of the plant.

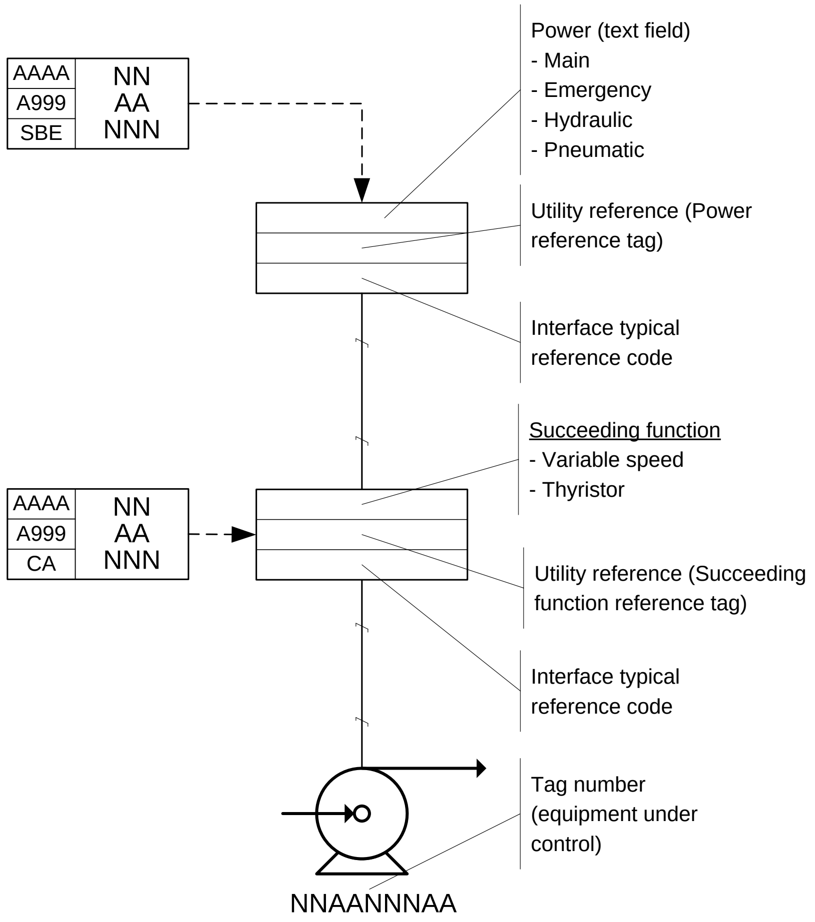
Utility reference tag: shall be the tag reference to the power utility equipment for which the equipment under control is connected/fed from.

Interface typical code: shall be a code identifying the signal interface setup towards the electro equipment, the equipment identified by utility reference tag. In most cases this will be a combination of HW signals and computer link information. A typical should be made corresponding to each code identifying the details in the interface. The typical may be presented on the legend sheets for SCDs or in a separate document.

Tag number: the tag number for the equipment under control should be located adjacent to the equipment or inside. It may be omitted if the tag number is the same as the tag number of the function controlling it.

For variable speed drive electrical equipment generally the electro control consist of two parts. The motor control centre (MCC) and the variable speed unit. It is recommended to then add two electro reference symbols to the diagram, see Figure B.37.

The FB used to control the power feed to the electrical equipment is normally SBE. The control of the variable speed is normally by a CA.



NOTE Feedback signals are a part of the interface typical code and should be defined on legend or in typical and are generally not shown on the SCD..

Figure B.37 - Electrical reference symbol use for variable drive

B.4.15 Sequence symbols

Sequences symbols within this NORSOK standard are based on the principles defined in IEC 60848. The symbols have been expanded with more details for better readability and understanding of the sequence and its integration into the rest of the SCD control logic.

Following symbols (see Figures B.38 to B.42) have been defined for use.

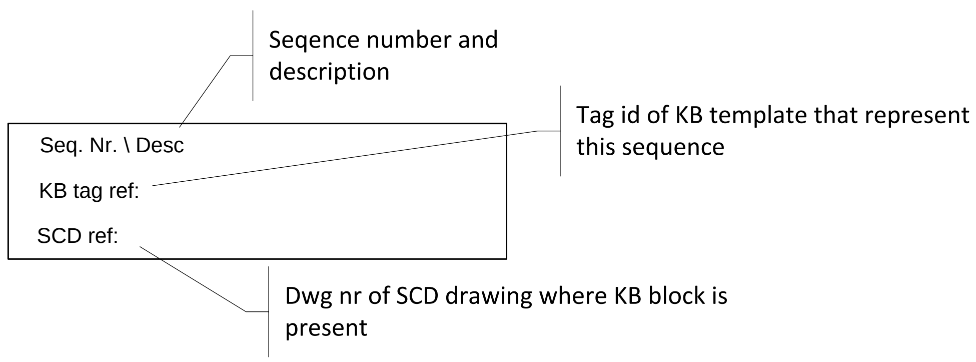


Figure B.38 - SFC sequence start and reference symbol

This start and reference symbol is used to define the start of a sequence and contains references to the KB template which is in use for controlling the sequence.

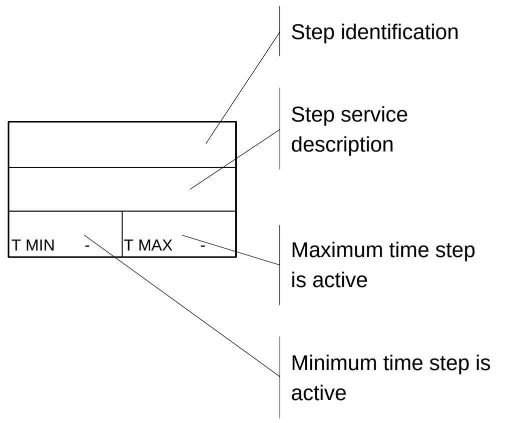


Figure B.39 - SFC step symbol

The step symbols define one step in the sequence and have connected all actions that shall be performed during the step.

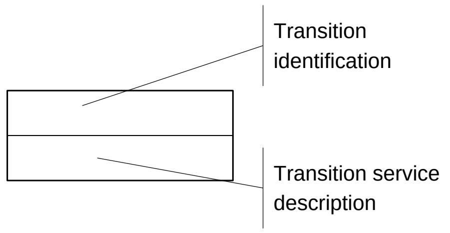


Figure B.40 - SFC transition symbol

The transition symbol defines one transition gateway in the sequence. All conditions that shall be fulfilled for the sequence to continue at this transition must be connected to it.

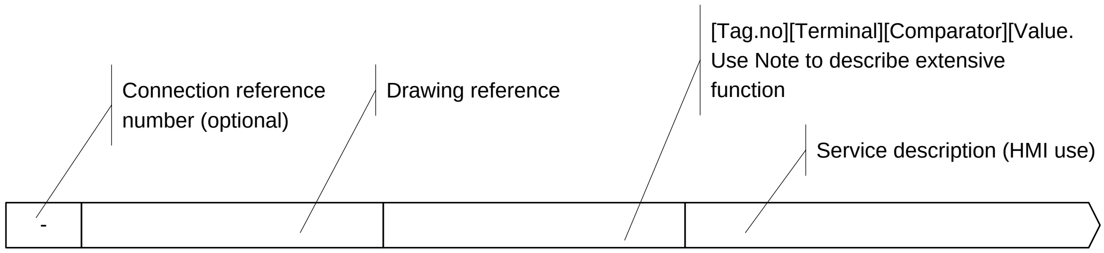


Figure B.41 - SFC transition condition symbol

Logical combinations of transitions can be done using elementary logic symbols in between transitions conditions and the transition header.

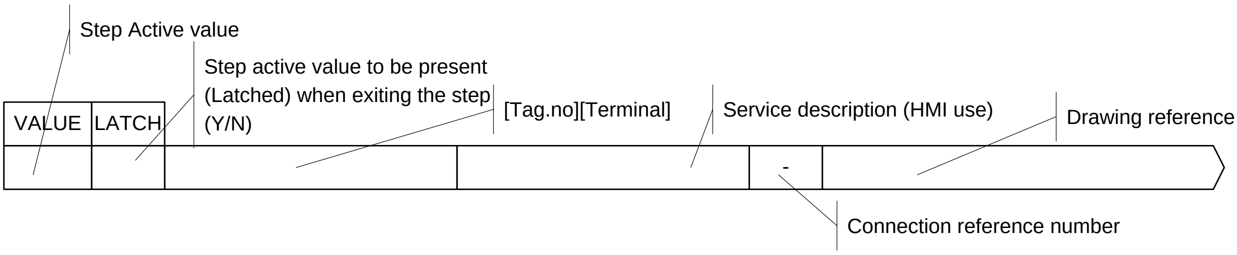


Figure B.42 - SFC step action symbol

Normally the 'Connection reference number' is left blank, because [Tag.no][Terminal] is a unique identifier. The 'Connection reference number' is intended for use whenever the sequences interface logic elements. The reference number will then be included in the sequence flag as shown in clause B.4.16.2

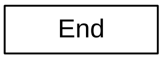


Figure B.43 - SFC Sequence end symbol.

This end symbol is a simple text box symbol that indicates the end of the sequence.

A sequence can have different flow paths.

Single flow sequence paths: The sequence steps follows a single path without branching, see Figure B.44.

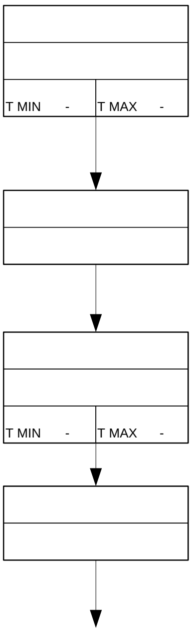


Figure B.44 - Single branch sequence path

Alternate sequence paths: The sequence is branched with dedicated transition condition to each step. This is indicated by an alternate single line branch.

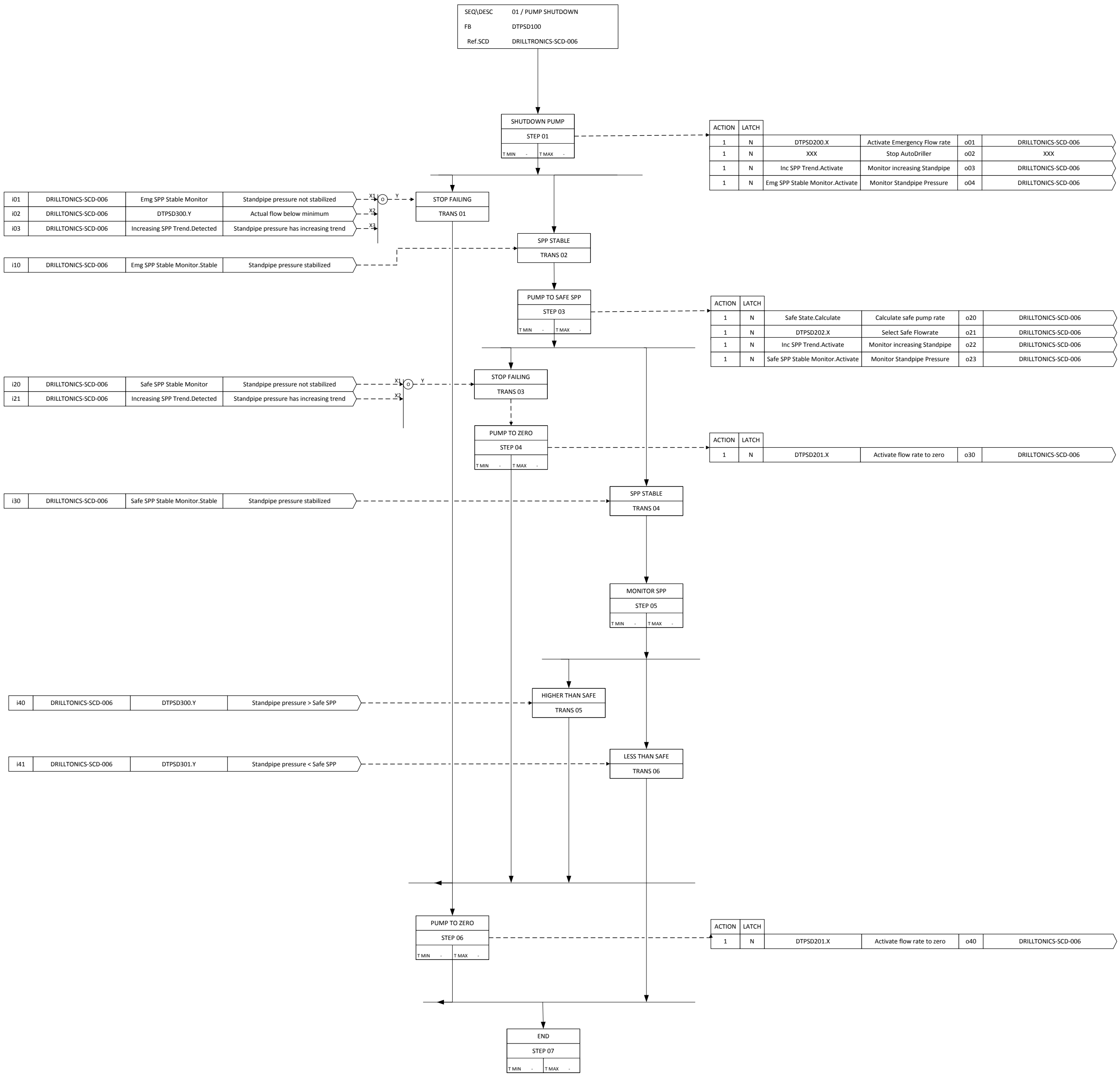


Figure B.45 - Alternate sequence path

Parallel sequence path: The sequence is synchronised and branched after a common transition condition to each step. This is indicated by a double line branch (synchronization symbol). This synchronization symbol may be used elsewhere where the sequence requires synchronization between steps.

For parallel sequence paths, it is required to have a synchronization symbol in the end of the parallel path, to indicate that the sequence will not continue until all parallel paths are completed.

See Figure B.46.

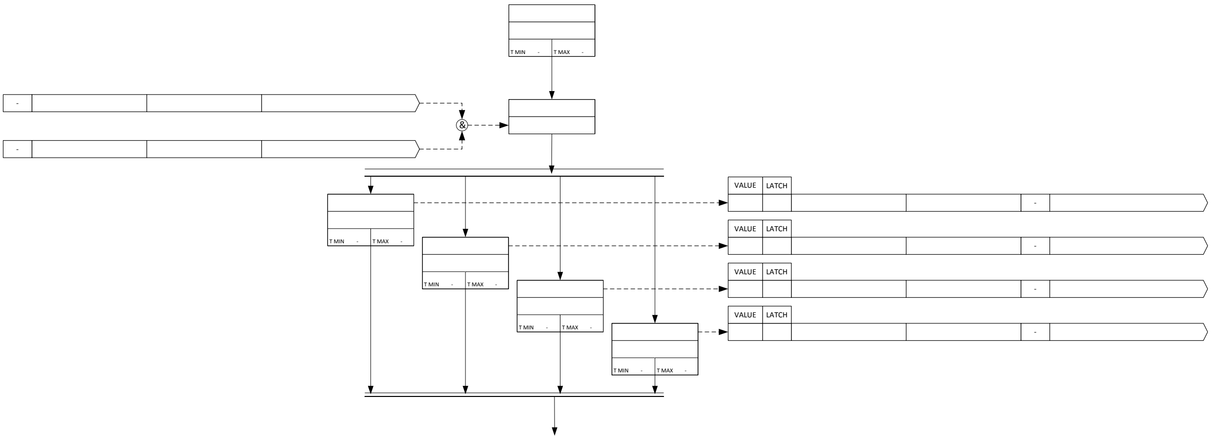


Figure B.46 - Parallel branch sequence path

B.4.16 Reference symbols

B.4.16.1 Page connectors

Page connectors to and from succeeding and preceding SCD sheets shall be included both for process) and signal flow lines. The page connectors represent the connecting links and all transfer of process medium or signals between SCDs shall be supported by the reference symbol.

Drawing reference for process connections

Figure B.47 - Process line page connectors

The reference shall identify the drawing where the line continues/originates. In addition there shall be a descriptive text making the line recognizable from the one sheet to the other.

Figure B.48 - Signal line page connectors

The vertical reference shall be a unique number to identify interconnecting signals. The same number shall be used both in the off page and on page symbol for the same signal. The horizontal reference shall identify the drawing where the line originates/continues.

There should not be arrows in front of the off-page connectors.

B.4.16.2 ESD/HIPPS/F&G reference triangle

References to and from ESD, HIPPS and F&G (see Figure B.49 and Figure B.50)) shall be included on the SCD. They shall be included for information wherever they influence PCS/PSD objects (Reference letters included as examples only)

E = ESD , H = HIPPS, F = F&G

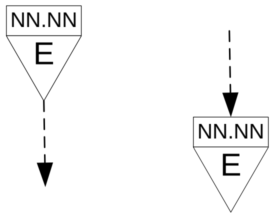


Figure B.49 - SIS reference triangle

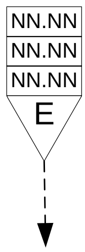


Figure B.50 - Multiple SIS levels reference triangle

Where multiple shutdown references from same system is relevant a ‘stacked’ reference symbol should be used.

B.4.16.2 Sequence reference flag

The sequence flag is used on the SCD to identify connection to/from sequence. The sequence flag shall have a unique reference number to a sequence. The cross reference between sequence number and sequence should be stated on the SCD. The standard sequence flag is used when interconnection is unambiguous - i.e. to a tagged function template. If the sequence interfaces EFB logic the extended symbol containing the unique connection reference number from SFC transition or action symbols shall be used.

Where logic is interfaced by multiple sequences the sequence flag can be expanded to hold multiple sequence reference numbers.

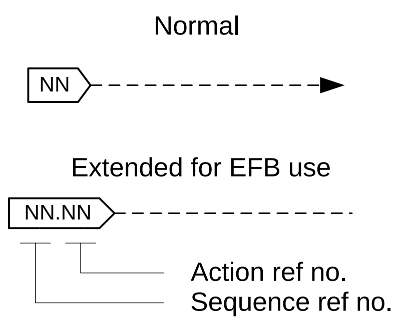


Figure B.51 - Sequence reference flags

B.5 Tagging

All function templates on SCD shall be identified by a tag number.

The specific project standard for tagging shall be used. Such standard will normally be in accordance with generally accepted standards like NS 1438 and ISO 3511 (~ISA 5.1).

It is recommended that the same tag identification shall be used for identical functions on P&ID, SCD and HMI.

All main equipment shown on SCD should be tagged unless connected to a tagged function. For larger equipment, as various processing vessels, a short name/description should be included if not obvious from SCD title.

B.6 Terminal codes

Each function template has a defined set of input and output terminals and terminal codes. For complete overview of terminal codes, see Table A.2.

On the diagram the logical signal flow between the function templates should be identified by making connections between the relevant terminals on the different function template symbols. The connection point on the symbol shall carry the relevant terminal code. Terminals WH, WL and WV shall be indicated on the function template if alarms are defined although they are not connected to downstream logic.

To identify a signal interconnecting two functions, use the terminal codes for identification in addition to function type and function tag number.

The location of the signal connections should be arranged as illustrated in Figure B.52.

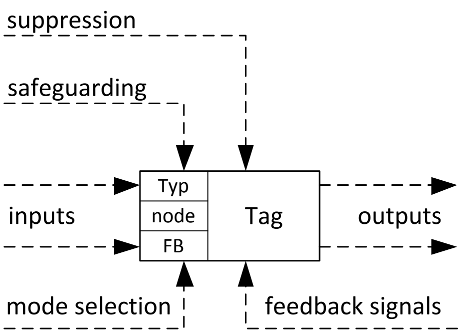


Figure B.52 - Arrangement of terminals on function symbol

Locations:

- the inputs shall be located to the left of the function template;
- the outputs shall be located to the right of the function template(1);
- the feedback signals should be located at the bottom of the function template;
- the control function interlocks, safeguarding and the suppressions should be located of the top of the function template;
- the mode selection should be located at the bottom of the function template.

(1) The sequence of outputs should follow the value of the limit of the threshold, lowest at bottom.

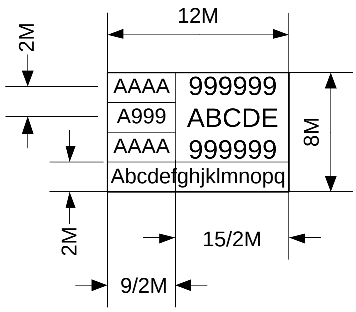
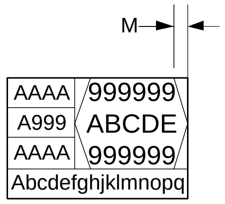
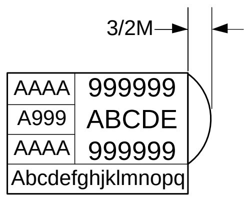
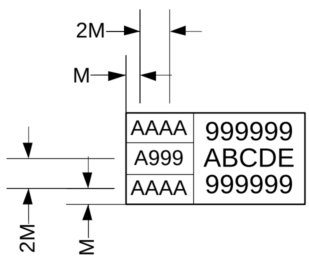
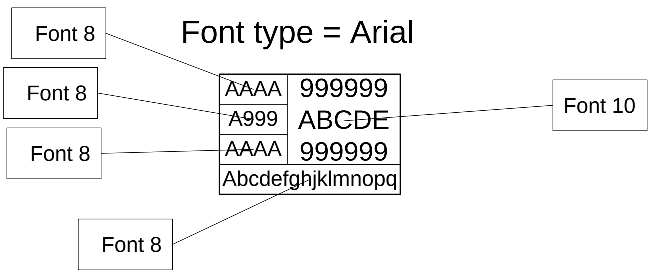
To obtain better readability of the SCD, avoid crossing of lines etc. above principles for top and bottom allocation can be deviated.

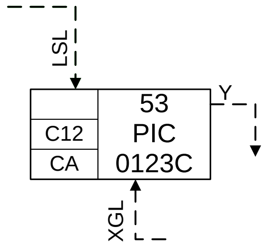
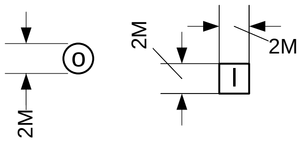
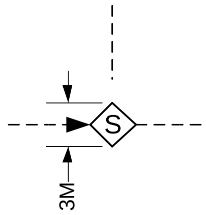
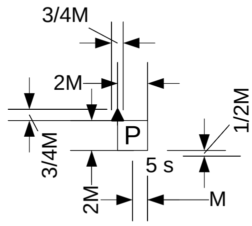
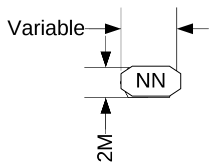
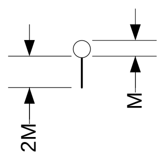
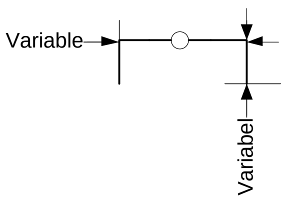
B.7 Symbol and font sizes

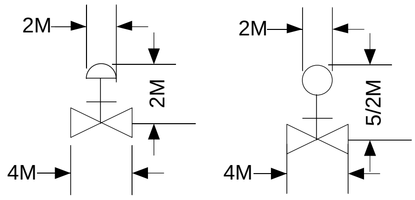
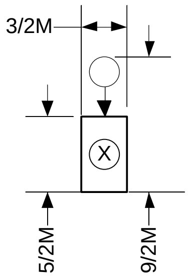
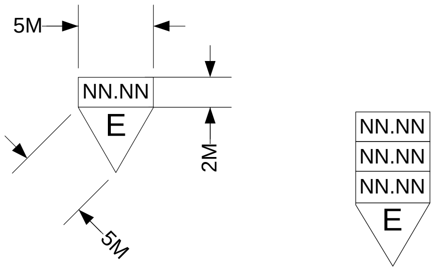
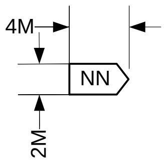
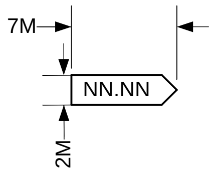
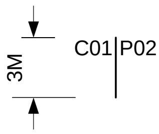
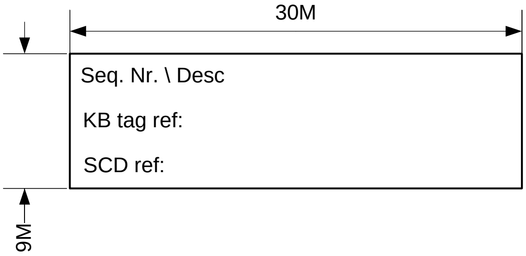
The sizing of the symbols is based on ISO 81714-1 and the unit M is selected to be 2 mm. The grid to be used on SCD diagrams shall be M.

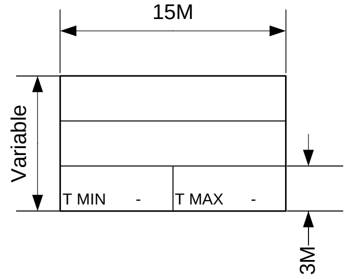
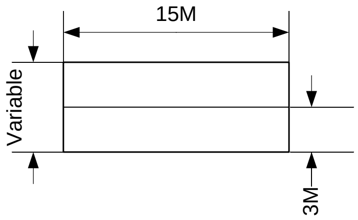
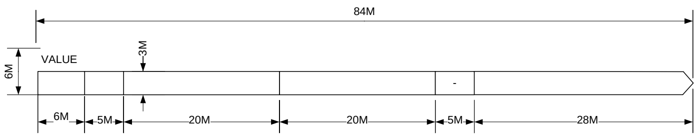
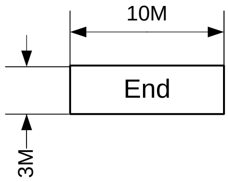
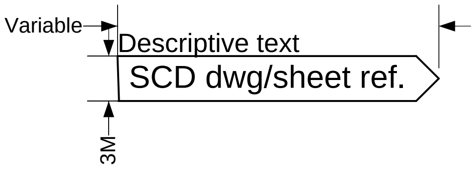
The symbols sizes (see Table B.4) are relative to A1 size drawing.

Table B. 4 - Symbol sizes

Symbol	Comments
	Level 1 symbol Symbol width may be increased if plants use tag names that requires more characters.
	Level 2 symbol
	Level 3 symbol
	Terminal connection points Distance between connection points shall be 2 M. First connection is M distance from corner.
	Font sizes Font 8 = 2 mm height Font 10 = 2,5 mm height distance

Symbol	Comments
	Terminal names to be Font 8. Text for signals entering from top/bottom should be rotated left. Inputs on left and bottom should be right-bottom aligned, inputs on top and outputs left-bottom aligned.
	Elementary function blocks symbols Font Arial 8 = height 2 mm One connection mid on all four sides.
	Hardware signal split symbol Font Arial 8 = height 2 mm One connection mid on all four sides.
	Elementary function blocks symbols Pulse and timer with arrow Font 8 = 2 mm height One connection mid on all four sides.
	Fixed value input symbol Width is variable to fit value Font 8 = 2 mm height One connection mid on left and right side
	Instrument symbol One connection mid-on top of circle Line – instrument stem - 0,35 mm
	Differential pressure instrument symbol One connection mid-on top of circle impulse lines – 0,35 mm

Symbol	Comments
	Valve and actuator symbol Valve connection for process line mid-on left and right side Actuator signal connection mid on top. For on/off valve optional signal connections also mid on left and right side to allow for multiple safeguard connections.
	Damper and actuator symbol Damper connection for duct line mid-on left and right side Actuator signal connection mid on top. For optional signal connections also mid on left and right side to allow for multiple safeguard connections. Damper type identification letter to be in font Arial 8 = height 2 mm
	Safety system reference triangle System identification letter to be in font Arial 10 = height 2,5 mm Shutdown group reference to be in font Arial 8 = height 2 mm The symbol should be variable for multiple references. Connection points tip of triangle and mid on top.
 	Sequence flag Sequence reference number to be in font Arial 8 = height 2 mm. Extended sequence flag Sequence reference number to be in font Arial 8 = height 2 mm. Extended sequence reference flag is used for reference to / from EFB.
	Node split for signal lines Text in symbol to be font Arial 8 = height 2 mm This line has no define connection points. To be placed on a connection line..
	Sequence start and KB reference symbol Text in symbol to be font Arial 8 = height 2 mm

Symbol	Comments
	Sequence flowchart step symbol Text in symbol to be font Arial 12 = height 3 mm T MIN and T MAX to be in font Arial 8 = height 2 mm Connection points to mid-on top and bottom. Height to be variable to enable multiple lines in the middle box. Each line shall be 3M.
	Sequence flowchart transition symbol Text in symbol to be font Arial 12 = height 3 mm Connection points to mid-on top and bottom. Height to be variable to enable multiple lines in the bottom box. Each line shall be 3M.
	Sequence flowchart action reference symbol Text in symbol to be font Arial 12 = height 3 mm VALUE and LATCH to be in font Arial 8 = height 2 mm Connection points to be mid-on main part left and right. Angle of tip to be 90˚.
	Sequence flowchart condition reference symbol Text in symbol to be font Arial 12 = height 3 mm Connection points to mid-on left and right. Angle of tip to be 90˚.
	Sequence end symbol. Text in symbol to be font Arial 10 = height 2,5 mm
	Off page reference symbol for process lines The variable length symbols will be dependant of the length of reference text in each individual project. It is recommended that the project standardize on one length. Using multiple length increases the risk of making the diagrams untidy. Drawing reference font to be Arial 12 = height 3 mm. Descriptive text font to be Arial 10 = height 2,5 mm. It may be multiple lines. Angle of tip to be 90˚.

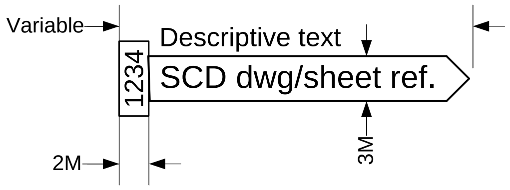
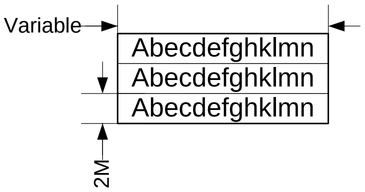
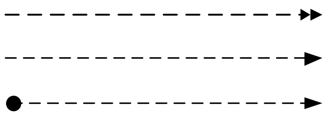
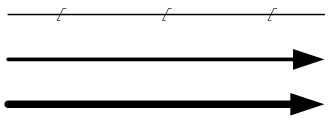
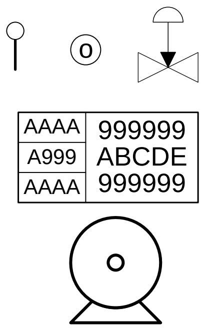
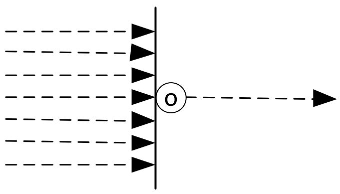
Symbol	Comments
	Off page reference symbol for logic lines The variable length symbols will be dependant of the length of reference text in each individual project. It is recommended that the project standardize on one length. Using multiple length increases the risk of making the diagrams untidy. Drawing reference font to be Arial 12 = height 3 mm. Descriptive text and reference number font to be Arial 10 = height 2,5 mm. It may be multiple lines. Angle of tip to be 90˚.
	Electrical reference symbol The variable length symbols will be dependant of the length of reference text in each individual project. It is recommended that the project standardize on one or two lengths. Using multiple length increases the risk of making the diagrams untidy. Text font to be Arial 10 = height 2,5 mm.

Table B.5 - Line sizes

Symbol	Comments
	Lines shall have following thickness/weights, see ISO 128-20. General signal lines – 0,25 mm Joint point to have M diameter Single Arrow head to be 1/2M width and 3/4M length. Angle of single arrow head tip to be 30˚ Double arrow head to 1/2M width and 1/2M length. Angle of double arrow head tip to be 60˚.
	Lines shall have following thickness/weights, see ISO 128-20. Sequence flow path lines – 0,25 mm Arrow head to be 1/2M width and 3/4M length Angle of arrow head tip to be 30˚.
	Lines shall have following thickness/weights, see ISO 128-20. Sequence alternative branch line – 0,25 mm Length is variable.
	Lines shall have following thickness/weights, see ISO 128-20. Sequence parallel synchronization line – 0,25 mm Double line , distance between lines 0,8

Symbol	Comments
	mm Length is variable.
	Lines shall have following thickness/weights, see ISO 128-20. Data com. line – 0,25 mm Circle on line to have 2/3M diameter
	Lines shall have following thickness/weights, see ISO 128-20. Electrical lines – 0,25 mm Major process line – 1,0 mm(1) Minor process line – 0,5 mm(1) Arrow heads to be M width and 2M length (1) It is recommended to use rounded corners on process lines to differentiate even better from other lines. Rounding should be 2 mm.
	Line thickness in symbols: Logic symbols in general – 0,25 mm Valve body – 0,25 mm Outer frame of main function template symbol – 0,25 mm (internals 0,25 mm) Equipment in general – 0,35 mm Instrument stem – 0,35 mm
	The distance between the connection point to be 2M

B.8 Layers and colors

As a help to make the SCD more readable is it recommended that layers and colours are utilized. The different type of information should be placed on different layers and represented with different colours.

The diagram can then be printed with different layers depending of usage.

If required any project can define multiple additional layers to hold additional information.

Following colours and layers are proposed: (It is anticipated that layer 1-10 is for internal use to support the diagram frame, revision and title block).

Layer 11 – Blue (RGB: 0,0,255) – Process equipment, valves, instruments and lines

Layer 12 – Black (RGB: 0,0,0) – PCS FBs, connections and notes

Layer 13 – Orange (RGB: 255,153,0) – PSD FBs, connections and notes

Layer 14 – Red (RGB: 255,0,0) – ESD/F&G triangles, connections and notes

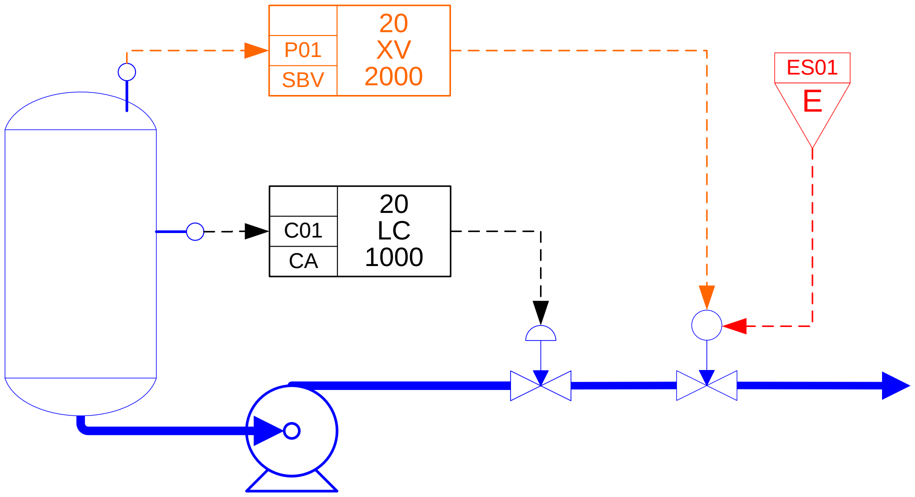


Figure B.53 - Colours

B.9 Legend sheets

B.9.1 General

It is recommended to make a set of legend sheets in each project for the SCDs. They shall be coded as SCD diagrams.

Normally the sheets will have following parts:

- part 1 - symbols and codes;
- part 2 - project/supplier specific function templates and terminal definition codes;
- part 3 - applications typical.

B.9.2 Part 1: Symbols and codes

This part should list the symbols defined in this NORSOK standard. It specifies the valid codes to be used for use in function symbol:

- SAS units;
- non-SAS units;
- mode/typical.

B.9.3 Part 2: System specific function templates and terminal definition codes

This part should list

- project/supplier specific function codes (non-NORSOK functions),
- project/supplier specific function terminal codes (non-NORSOK functions).

Part 2 may require several sheets.

B.9.4 Part 3: Applications typical

This part shall list the typical that should be used throughout the SCDs in the project.

The typical will fulfill two purposes. Firstly it can be used to define applications that can be reused throughout the project and in that way standardise the control and operation of the plant. Example of such standardised applications can be found in the example presented in Annex E.

Secondly it can be used to define simplified representation to be used throughout the SCDs to increase the readability of them.

For examples, see Annex E.

B.10 Drawing frame and title block

The drawing frame shall be in accordance with ISO 5457 and the A1 format defined therein with exception to left margin. The assumption is that the diagrams always will be printed on A3 format paper. To allow for punching of holes on left side in A3 format there shall be a 30 mm margin on the A1 format. The symbol sizes in this annex are defined for A1 format as this is the most referred format for standards and tools.

For title block the most relevant standard format is found in IEC 61802-1, Annex B. If the project have not specified any defined content, IEC 61802-1 could be used.

Annex C
(informative)
Project execution guideline

C.1 Engineering

C.1.1 Objectives

The SCD approach represents an overall methodology in order to achieve the following main objectives during the engineering phase:

- improved quality;
- improved standardization;
- improved safety;
- improved productivity;
- improved process understanding.

C.1.2 Quality

Operation and control requirements are defined by a single document forming the basis for verification activities as well as implementation and testing.

Verification activities include the following:

- verification of control strategies defined by other disciplines, e.g. process, mechanical, HVAC etc.;
- verification of control strategies defined by package suppliers;
- verification of control system implementation;
- validate operation and control strategies with client/operations;
- third-party verifications related authority requirements.

C.1.3 Standardisation

Improved standardisation will be accomplished on a control system level as well as on an application level.

Standardisation on control system level:

- Common functionality in terms of function templates.
- Common documentation, independent of control system supplier.
- Common terminology used for identical control functions, independent of control system supplier.

Standardisation on application level:

- Common control strategies for all systems.
- Common control strategies for packages.

C.1.4 Safety

Process safeguarding functions are shown in connection with process control functions defining the requirements for independent process safeguarding functions in addition to the process control functions

Process related emergency shutdown functions are also shown in connection with the process safeguarding and control functions enabling an enhanced understanding of the plant safety requirements.

C.1.5 Productivity

The previous objectives will obviously result in an improvement of the productivity as follows:

- improved standardisation resulting in simpler implementation;
- improved quality resulting in less changes during design, test and commissioning of the control system.

Efficient communication between all parties will improve the productivity for the control engineers.

The functions are defined in an unambiguous manner making the internal disciplines work more efficient as additional documents and meetings can be reduced.

The fact that the SCD present logic unambiguously, the communication with third parties regarding operation and control will be improved. The SCDs forms the basis for interface discussions. Design changes may be documented by SCD mark-ups, and attached to minutes of meetings etc.

The amount of interchangeable documents and subsequently the number of dependencies between the involved parties can be reduced.

Type of documents:

- common document for design, test, commissioning and operation;
- common document for all disciplines;
- common document for all package suppliers.

The SCD approach will enable the control engineer to develop the operation and control requirements in parallel with the process design and will thus support concurrent engineering.

Field proven solutions may also be copied from previous projects independent of control system supplier.

The SCD development can be split in two main activities:

- basic design;
- application design.

The basic design will normally only be applicable for a first time implementation of the SCD standard or in order to facilitate new operational requirements.

The application design contains the development of the actual SCDs within a specific project.

C.2 Implementation

C.2.1 Objectives

The following main objectives can be defined for the implementation phase:

- unambiguous input to implementation;
- improved standardization;
- improved productivity.

C.2.2 Unambiguous input

Unambiguous definition of functional requirements is of vital importance for the implementation phase. Discussions related interpretation of functional requirements as well as possible re-work is avoided.

The information, which is not relevant for the control system, has compared to a P&ID, been removed making the implementation effort simpler.

A structured design based on standard templates and basic logic functions may be directly translated into application logic providing a simple link between functional requirements and the actual implementation.

The SCD will even be used as input to the making of VDU pictures. For some part of the process the content of one SCD could comply to the content of one lower level VDU picture. But this is fully dependent on HMI strategy laid down in each project.

C.2.3 Standardisation

A well defined and widely recognized standard will provide a basis for development of corresponding supplier standards.

The need to develop project specific typicals (function blocks) will be significantly reduced. Function blocks based on a general standard may thus be used independent of specific project requirements.

Applications may further be re-used from one project to another.

C.2.4 Productivity

The previous objectives will also impact the productivity as follows:

- unambiguous input to the implementation providing a basis for efficient programming as well as reduced probability for modifications;
- improved standardisation resulting in extensive reuse of proven solutions.

A well defined basis for programming will also require less use of system specialists for application programming. The programming effort will mainly consist of translating functional templates and connectivity, rather than software development as such.

The ultimate objective in order to improve the overall productivity is to facilitate automatic configuration of the safety and automation system, based on SCDs, eliminating manual programming.

C.2.5 Documentation

The initial implementation of the SCD standard should be based on a joint effort between the involved parties in order to achieve an optimized use of supplier standard functionality to accomplish the project control strategy.

The implementation model is defined by the basic function design, see 4.4.3.

The high-level supplier documentation should provide a bridge to the SCDs in order to enable non-system experts understanding supplier documentation.

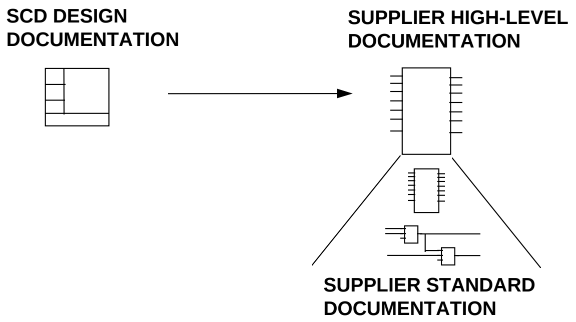


Figure C.1 - SAS supplier interface

Even if a one-to-one mapping of templates should be the ultimate target, a one-to-many strategy should be adopted, if required. System constraints in terms of logic restrictions, CPU load, parameters etc. may call for an optimization. A one-to-many approach implies that one specific template results in variants depending on control options or parameter selections. The number of variants should be kept to an absolute minimum.

The functionality implemented should also be kept within the range of the original template.

C.2.6 Verification

The SCDs should form the basis for the verification activities.

Internal application tests as well as factory acceptance test should be based on SCDs.

C.3 Commissioning

C.3.1 Objectives

The system control diagrams will be used throughout the commissioning phase. The SCDs handed over to commissioning shall reflect as "programmed status". The use of SCDs can be related to the following activities:

- commissioning procedures;
- commissioning runs.

C.3.2 Commissioning procedures

The SCDs forms the basis for the commissioning procedures with respect to the safety and automation system.

The procedures should cover activities not already covered by the SCDs. The SCDs will thus be included as a part of the commissioning documentation as such.

The SCDs will typically provide the following information to be covered by the procedures:

- blocking of interlocks during commissioning;
- suppression of actions.

C.3.3 Commissioning runs

The SCDs shall be kept updated throughout the commissioning phase.

Commissioning of the safety and automation system will mainly be based on the SCDs.

The SCDs will thus be a "live" document subject to yellow-lining, mark-ups, comments etc.

C.4 Operation

C.4.1 General

The development of the system control diagram as such was initiated in order to provide a functional description of the logic contained in the safety and automation system for operational personnel, not familiar with the supplier logic standard.

C.4.2 Objectives

C.4.2.1 General

The main objectives by using SCDs in the operational phase can be related to the following:

- safety analysis;
- production control;
- modifications.

C.4.2.2 Safety analysis

The SCDs defines process safeguarding functions in connection with the process control strategies. Effects of critical process conditions may thus be evaluated by means of the SCDs. "What if " scenarios, as well as post event analysis, may be carried out.

Process effects related to safeguarding systems documented by means of cause and effects may also be evaluated.

Effects resulting from faulty instrumentation or a manual blocking of a safeguarding function will be documented and may be accounted for by means of the SCDs.

The SCDs should form the basis for approval of work permits affecting the safety and automation system.

C.4.3 Production control

The SCD representation is closely allied to the operator interface displayed on the VDUs in the control room. The SCDs will thus provide an unambiguous documentation of the SAS functionality for the operators with an apparent relationship to the actual operator interface.

The daily use of the SCDs in the control centre will be related to "trouble-shooting". The SCDs will enable the operator to resolve operational problems without involving additional system specialists.

Most control systems provide e.g. well defined information on mode of operation for a selected control object. However, if the control object is interlocked by an external cause, the source of the interlock is often not properly documented elsewhere then on the SCD.

By providing the operators with enhanced possibilities to resolve operational problems, the requirements for reduced manning will be met.

C.5 Modifications

The SCDs will also be used in connection with modifications to the safety and automation system. The methodology applicable for modifications during the operational phase will be similar to the engineering methodology for application design, implementation and verification, as follows:

- multidiscipline design;
- input to implementation;
- basis for verification and testing.

Annex D
(Normative)
SCD legend

D.1 Introduction

This annex is a short form list (legend) of the different symbols used to illustrate the control application on the SCD. The symbols will have different content as defined by Annex B. The actual sizes of the symbols are also defined in Table B.4.

In addition process equipment symbols will be used to illustrate the process on the SCD. These are not listed in this legend as this NORSOK standard does not cover these.

D.2 Function template symbols

Control function integration level is indicated by following symbols:

Table D. 1 – Function template symbols

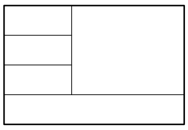
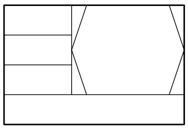
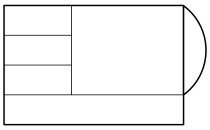
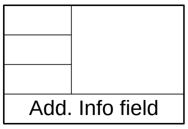
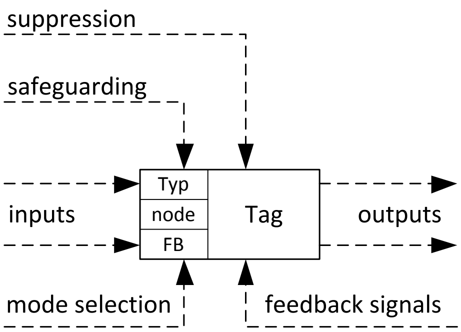
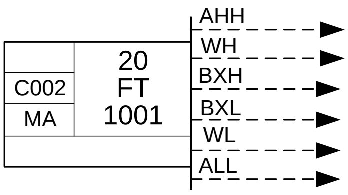
	Level	Definition
	I	Control function and HMI fully integrated in the main control system.
	II	Field device wired to an external control system, symbol only to be used when this external system is not shown separately on the SCD. HMI function integrated in the main control system.
	III	Control function and HMI are in a control system externally to the main control system. Object must be operated in the external system. Interface to the main control system should be shown separately if applicable. Symbol for Level I should then be used.

Table D. 2 – Additional information field

	Additional information field: Identification of the controlled object (e.g. valve, motor, heater) as it appears to the operator (on VDU alarm lists etc.) or other convenient operator info.

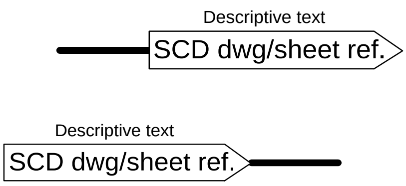
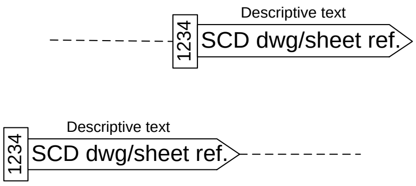
D.3 Function template terminal placement

Table D. 3 – Terminal placement

<table>
<tr><td colspan="2"></td></tr>
<tr><td></td><td>Extension of function template symbols if more terminal points are required.</td></tr>
</table>

D.4 Reference symbols

Table D. 4 – Reference symbols

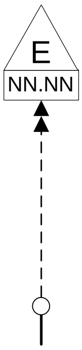
<table>
<tr><th>Symbol</th><th>Comments</th></tr>
<tr><td></td><td>Drawing reference for process connection</td></tr>
<tr><td></td><td>Drawing reference for instrument signals

1234 = Unique signal reference identifying the signal connection</td></tr>
</table>

Symbol	Comments
	Sequence reference flag. Reference to sequence number (e.g. 01). The cross reference between the sequence number and relevant sequence diagram shall be available on SCD.
	Extended sequence reference flag.

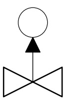
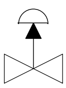
D.5 Function identifier for safety system interface.

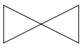
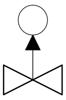
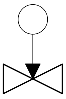
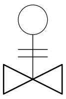
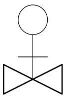
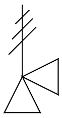
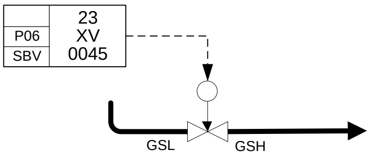
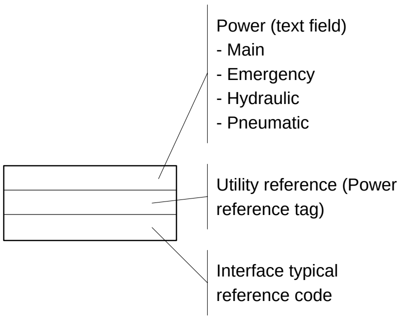
Table D. 5 – Safety system interface

Symbol	Comments
	Signal to global safety function – NN.NN is a reference to a shutdown level. E – Identifies emergency shutdown safety system, see B.4.2. In this example the input is also defined to be failsafe by the double arrowhead on the logic line.
	Signal from global safety function – NN.NN is a reference to a shutdown level. E – Identifies emergency shutdown safety system, see B.4.2.

D.6 Field device symbols

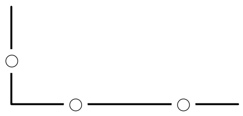
Table D. 6 – Field device symbols

Symbol	Comments
	Block valve
	Control valve
	Valve normally closed

Symbol	Comments
	Valve normally open
	Valve to open on loss of electrical signal (FO)
	Valve to close on loss of electrical signal (FC)
	Valve to be locked on loss of signal (FL)
	Valve will fail indeterminate on loss of signal (FI)
	Transmitter
	Safety relief element
	Low (GSL) and high (GSH) limit switch indicator
	Power (text field) Utility reference (power reference tag) Interface typical (reference code)

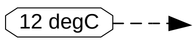
D.7 Instrument signals

Table D. 7 – Instrument signals

Symbol	Comments
	General signal, e.g. logic software signal within a node or hardwired signal from transmitter to SAS. Can also be used for bus signals and serial lines.
	Data communication link, i.e. bus or serial line. The signal line reflects the logic end points of the signal, and not the actual bus topology.

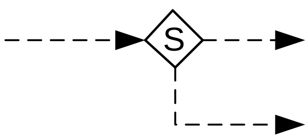
D.8 Constant values

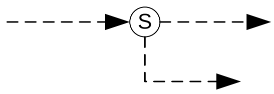
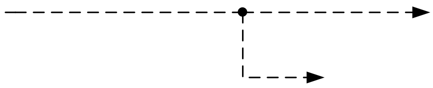
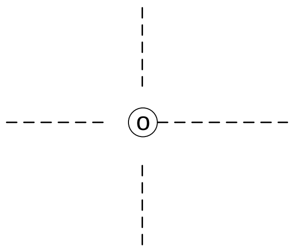
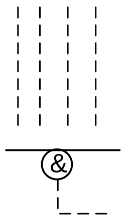
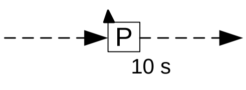
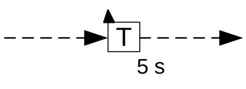
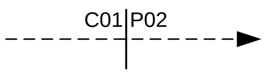
Table D. 8 – Constant values

Symbol	Comments
	Constant values used as parameters to logical/arithmetic elements, e.g. timers, pulses. To be shown as a signal into the actual element. Value of parameter, e.g. 12 degC. Engineering unit to be added when required for control understanding.

D.9 Logic and arithmetic symbols

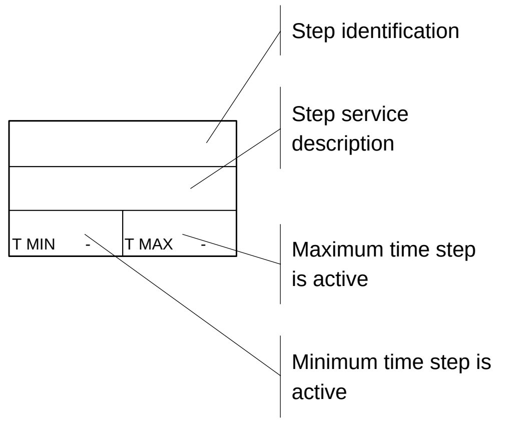
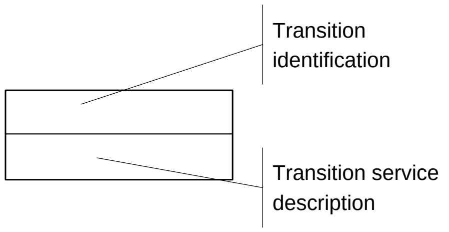
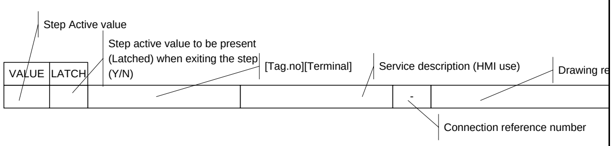
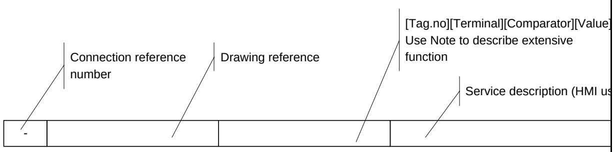
Table D. 9 – Logic and arithmetic symbols

Symbol	Comments
	Hardware split

Symbol	Comments
 	Software split normal simplified
	Software function See Table B.2
	Connection extension line Multiple input to software function
	Inverter
	Pulse, i.e. positive pulse upon transition from 0 to 1 (10 sec = duration of pulse) See Table B.3
	Time delay, i.e. delayed transition from 0 to 1 (5 s = delay time). See Table B.3
	Node split indication, used to identify the node split between EFB’s.

D.10 Sequential function chart symbols

Table D. 10 – Sequential function chart symbols

Symbol	Comments
Seq. Nr. \ Desc KB tag ref: SCD ref:	Sequence start and KB reference symbol
End	Sequence end symbol.
	Step symbol
	Transition symbol
	Step action symbol
	Transition condition symbol
	Sequence flow line

Symbol	Comments
	Sequence parallel synchronization line
	Sequence alternative branch line

Annex E
(informative)
SCD application guidelines

E.1 Purpose

This annex is intended to be a guideline for projects using this NORSOK standard for SCD development. It provides the reader with a number of practical examples of expressing monitoring and control functions on SCDs. The examples are extracted from actual SCDs from several projects. Any project should specify necessary application typical in addition to the typical defined in this annex, based on the same principles. The application typical used for the project should be implemented on the project SCD legend.

This guideline covers both basic functional elements as well as comprehensive application typical. The examples given in this annex are for guideline purposes, and if other project documents or specification dictates or describe other functionality, they will supersedes the examples given in this annex.

E.2 Tagging

All function templates shall be tagged. The same tag identification should be used for identical functions on P&ID, SCD and HMI.

The project standards for tagging should be used. All tagging in this document is for exemplification only.

Symbols for logic and arithmetic functions are not tagged.

E.3 Application typical

E.3.1 General

This chapter will give a selection of a various application typical. Only a few selected inputs and outputs for the function templates will be used in the examples.

E.3.2 Process measurements

E.3.2.1 Analogue measurements

For monitoring and display of analogue process variables, the MA-template is to be used. The template comprises functions for action and warning alarm as well as loop fault annunciation. Additionally the template handles limit-checking for status outputs (events) without any alarm annunciation.

Applicable alarm handling attributes (AHH, WH, WL, ALL) and status/event handling attributes (BXHH, BXH, BXL, BXLL) shall be identified on the SCD. These attributes is be defined in SAS.

Figure E.1 shows MA terminals.

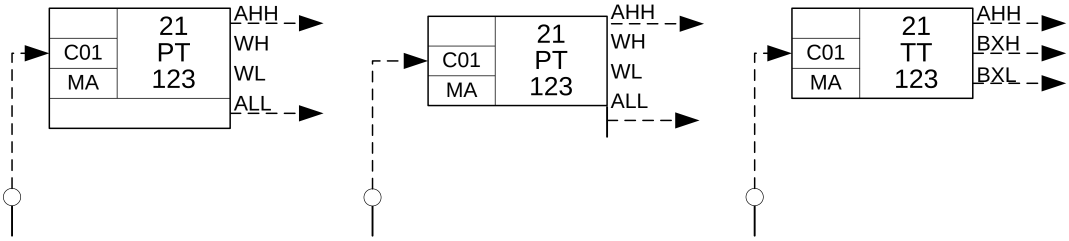


Figure E.1 - MA terminals

E.3.2.2 Totalization

Totalization of flow is handled by a separate function template, the QA template. The template calculates the accumulated flow over a time interval by integrating the measured instantaneous flow. The accumulated flow calculation can be started, stopped or reset either from the OS or by logic input.

The calculated accumulated flow is monitored and compared to HH action and H warning alarms and a HH status (event) output without alarm annunciation. Applicable alarms and events shall be shown on the SCDs.

The analogue value can be connected directly to the x input on the QA template. A MA template should only be used either in series or parallel when indication of the present measured flow on the operator station is necessary.

See Figure E.2.

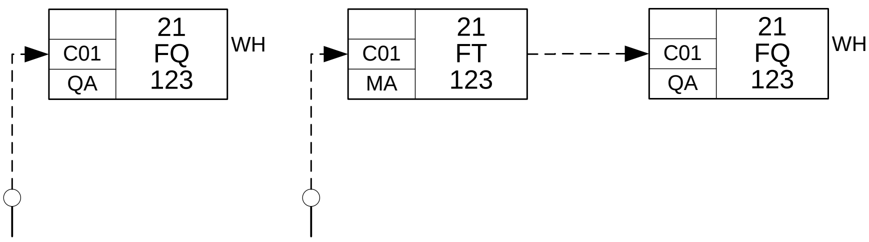


Figure E.2 - Totalization

E.3.2.3 Compensation of measured flow

For accurate volumetric flow calculations, the measured flow is compensated for pressure and temperature. To calculate standardised flow, the measurement also has to be compensated for density. To calculate the compensation a # function should be used, and a formula specified.

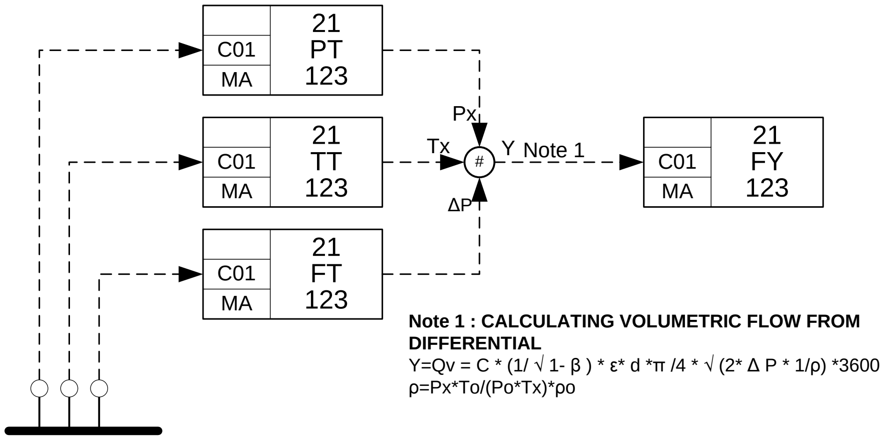


Figure E.3 - Compensation of flow via a formula

E.3.2.4 Example of project specific function - Voting of measured variables

The behaviour of the voting (e.g. malfunction etc.) is not defined within this NORSOK standard. This function should be defined in a project specification as an addendum to this NORSOK standard. In example below (see Figure E.4), the optional EFB is used to illustrate the voting algorithm. As it is just a EFB it will not have any HMI. If a dedicated function with HMI is defined by the project this should be presented as shown in Figure E.5 with the function symbol.

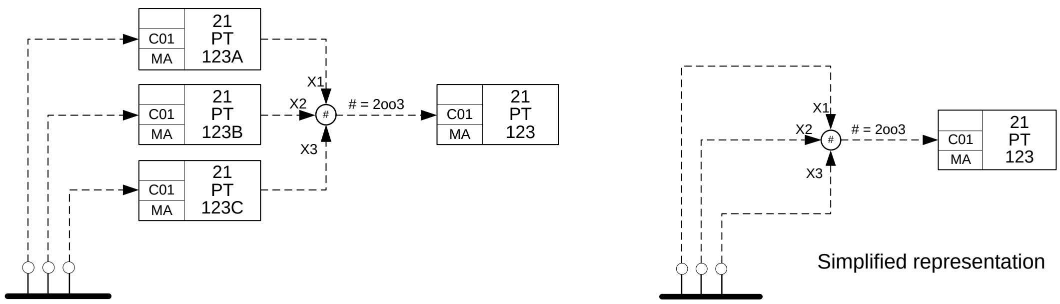


Figure E.4 - Use of optional symbol for voting

Figure E.4 shows an example of “simplified representation”. Such simplified representations should be explained in the SCD legend for the project.

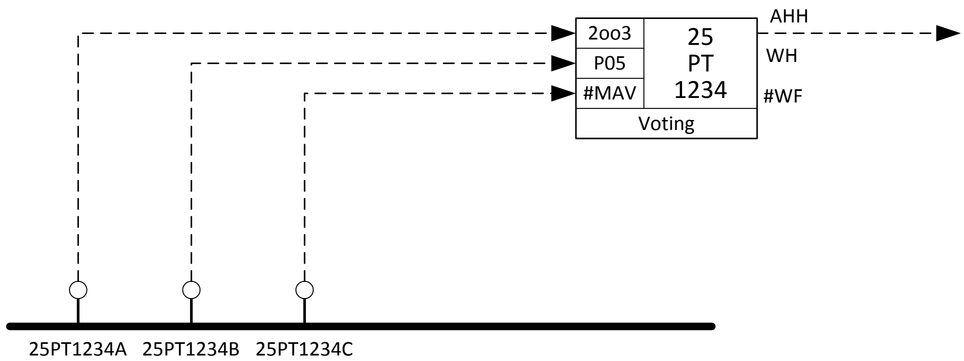


Figure E.5 - Use of project specific function

It is assumed in example above that the same voting function may be used for different types of voting. Therefore the mode field is used for indicating that the function should be set up as voting 2oo3 configuration for this instance.

This example contains a function named #MAV and terminal #WF. The # indicates that neither this function template nor this terminal is defined within this standard. The function do have the terminal AHH and WH (without #) which can be used as they will have exactly the functionality as defined in this standard.

In Figure E.5 it is assumed that the project specific #MAV function allows for the HMI to all connected transmitters and the voting result.

E.3.2.5 Differential pressure measurement

For measuring of differential pressure in the process, it may be indicated on the SCD where the measurement is performed, with simple lines, e.g. across a filter in the process line, as shown in Figure E.6.

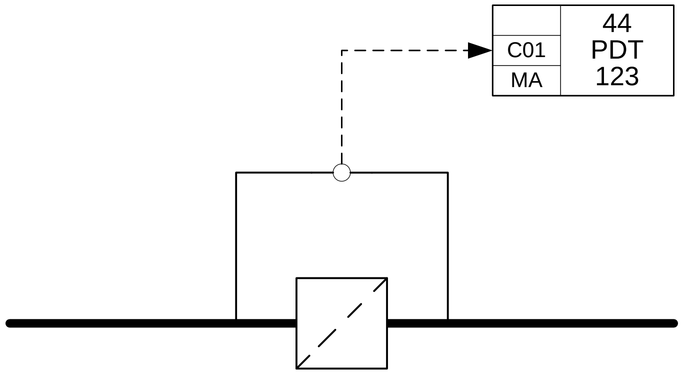


Figure E.6 - Differential pressure measurement

E.3.2.6 Binary measurements

The MB-template is utilised for monitoring and display of binary process variables or digital inputs. The MB-template comprises functions for operator alarming and action initiation, see Figure E.7.

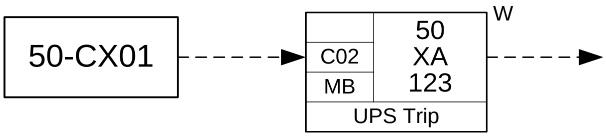


Figure E.7 - MB with action

If only an alarm is given, only the W is shown, see Figure E.8.

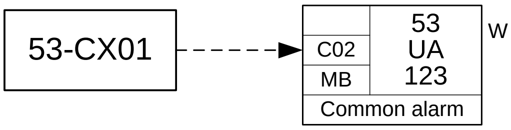


Figure E.8 - MB with alarm only

Digital inputs not initiating any actions or alarms and not requiring separate VDU elements are only used as input to function templates operating the actual controlled object. E.g. for XVs, a GSL limit switch gives input to the position low input (XGL) of the SBV. The feedback signal from the limit switch should not be shown on the SCD, see Figure E.9.

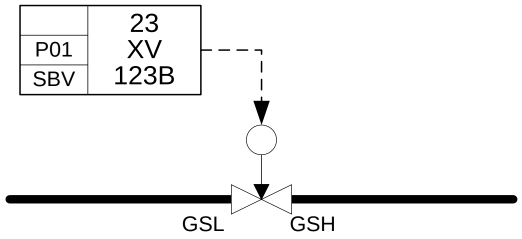


Figure E.9 - Valve feedback presentation

E.3.3 Action and warning alarms

E.3.3.1 General

Action alarms initiate automatic actions in addition to alarm annunciation in CCR. The action is performed independently of the mode (auto/manual) of the interlocked object, see Figure E10.

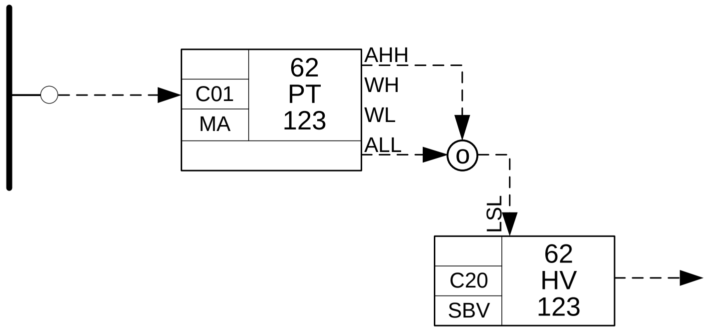


Figure E.10 - Action alarms

Warning alarms warns the operator about an undesired process upset. A warning alarm enables the operator to perform corrective actions, but no automatic action is initiated. The alarm annunciation in CCR requires acknowledgement by the operator, see Figure E.11.

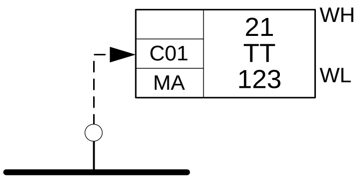


Figure E.11 - Warnings

The general rule is that the only connected terminal names are shown on the SCD. An exception from this rule is made for WH and WL. Warning alarms with no signal outputs (no actions), is presented on the SCD to indicate that these alarms are present on the VDU and in the alarm/event lists.

E.3.3.2 Action blocking

Action alarms may be blocked from initiating the actual action, but still give alarm annunciation. Single action outputs are blocked from the OS or by external logic, see Figure E.12.

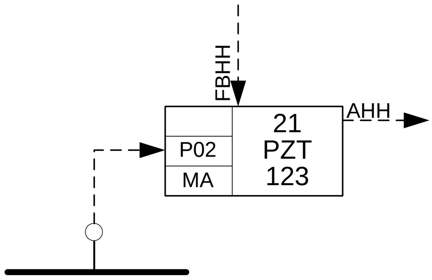


Figure E.12 - Force blocking action alarm high

E.3.3.3 Suppression

Action alarms as well as warning alarms may be suppressed. Suppression from the OS suppresses all interlocking action outputs, alarm and fault annunciation. Single alarms may be suppressed by external logic, see Figure E.13.

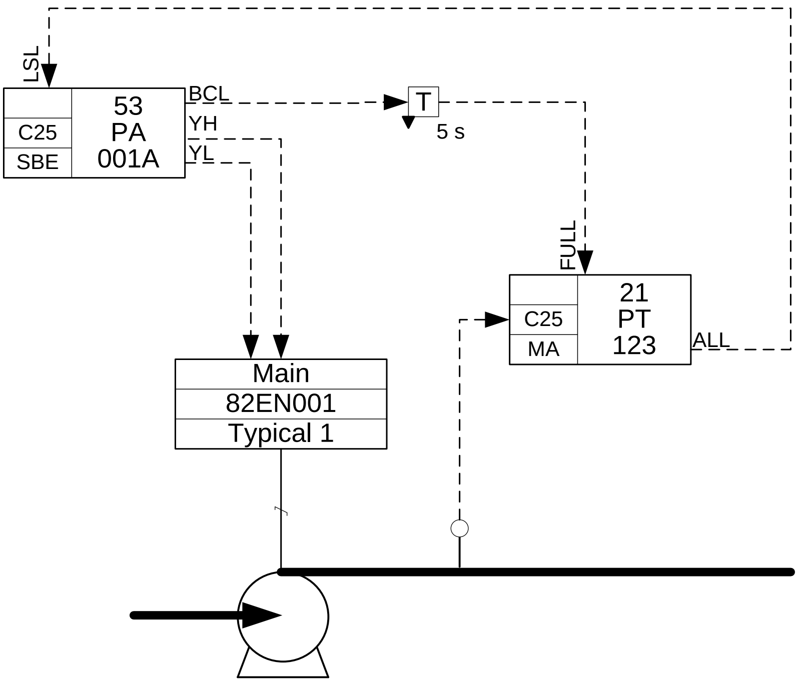


Figure E.13 - Action alarm suppression

E.3.4 Process modulating control

E.3.4.1 Single PID control

The example shows a typical control loop with an analogue pressure measurement to SAS and an analogue signal output to the pressure control valve, see Figure E.14.

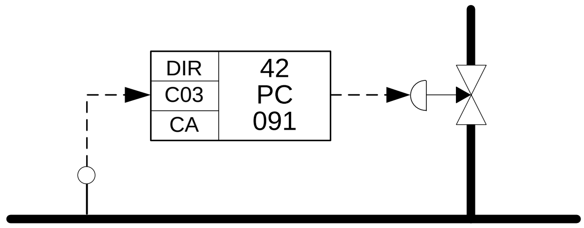


Figure E.14 - PID control

The controller can be operated in either manual, automatic internal or external mode. When operated in automatic mode, the controller can be either direct acting or reverse acting and is identified on the SCD. One way of showing this is by writing either DIR or REV in the top left corner.

If the process measurement has a trip, this is done with an upstream function, see Figure E.15.

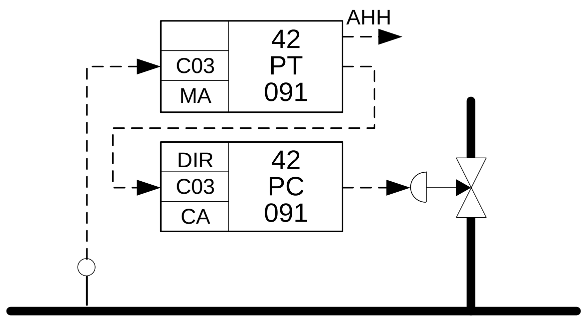


Figure E.15 - PID control and action alarm

E.3.4.2 Cascade control

For controllers in a cascade coupling, the secondary loop controller uses the output of the primary loop controller as its set point. The output range for the primary controller should *be* the same as the input range for secondary controller, see Figure E.16.

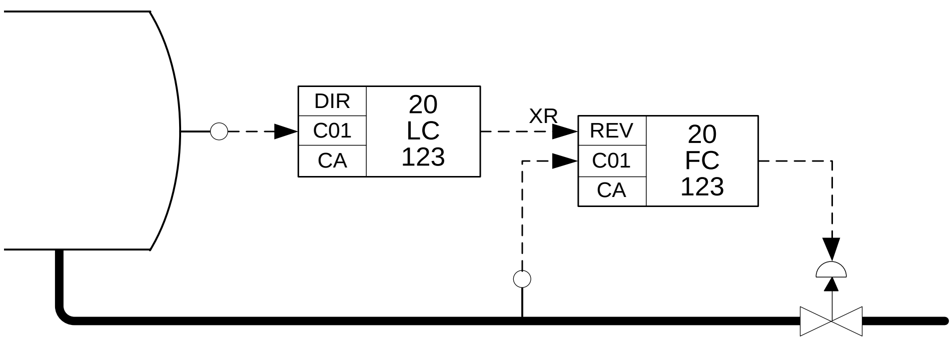


Figure E.16 - Cascade control

E.3.4.3 Split range control

Split range control (see Figure E.17) should be in software. The controller output is calculated in the CA template as for standard closed loop control and connected to two OA templates for controlling the individual valves. The calibration for the valves is done in the OA templates.

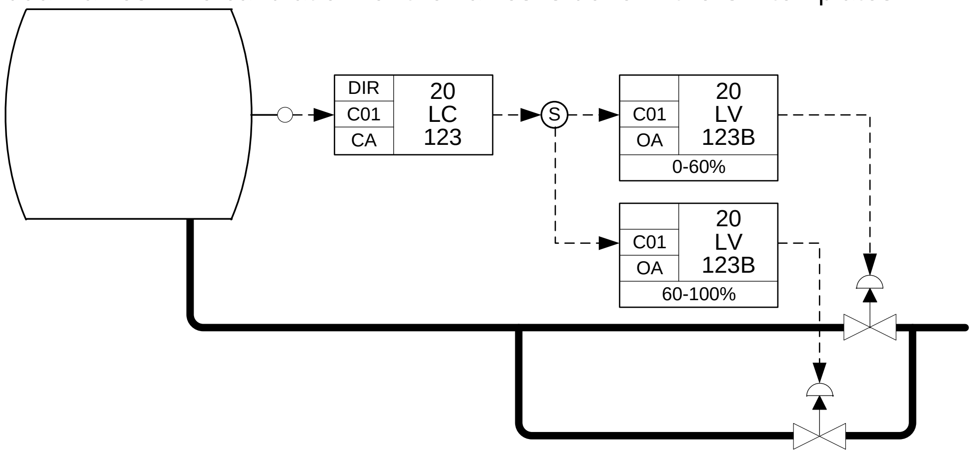


Figure E.17 - Split range control

E.3.4.4 Control of choke valves

Choke valve control (see Figure E.18) are implemented using the CS template. The choke valves are operated by either pulsed or steady output signals. One output for opening and one for closing the valve.

The valve position feedback GT is connected to the XG input on the CS template, but is not shown on the SCD.

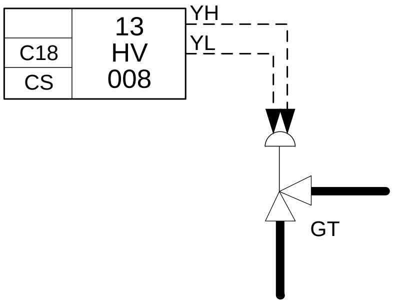


Figure E.18 - Choke valve control

E.3.4.5 Binary control

For binary (on/off) control of flow elements such as valves, pumps and heaters, based on an analogue process measurement, should be done by combining a MA template and a SBV template.

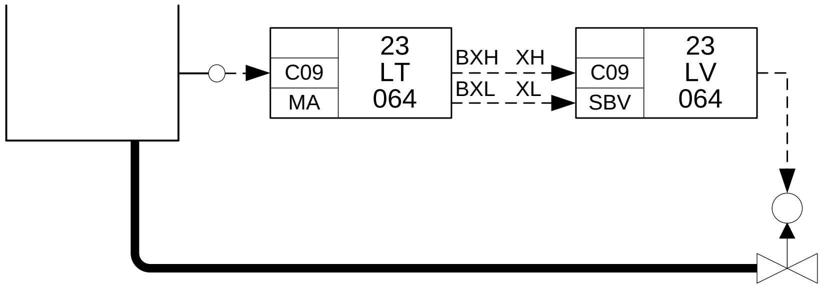


Figure E.19 - Binary control

The example in Figure E.19 shows level control using a MA and a SBV template to switch between open and closed valve position, depending on the level in the tank.

On/off control is also performed with a modulating control valve, switching between two specified values, e.g. between 0 % and 60 % as shown in Figure E.20.

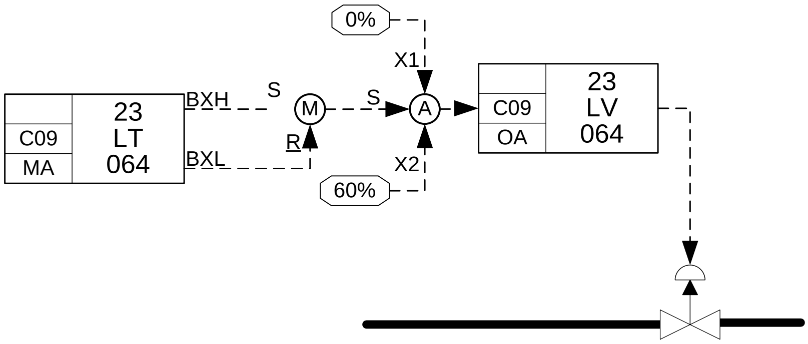


Figure E.20 - Binary control with modulating control valve

The third example shows level control by on/off pump control, implemented with a SBE-template. For this application, the motor control needs two outputs, one to start the motor (YH) and one to stop the motor (YL), see Figure E.21.

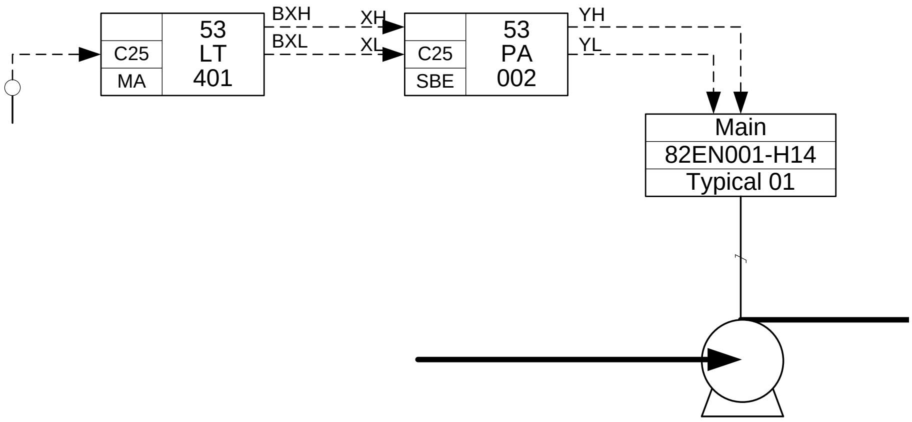


Figure E.21 - Start/Stop control of pump

E.3.4.6 Tracking

The example in figure E.22 shows a valve being controlled either by flow control or by tracking a function based on the speed of other element. The operator can set the CA function in FT by the using the HB function. This will set the FT input and force the CA function in to tracing mode and clamp the output Y to the XT input.

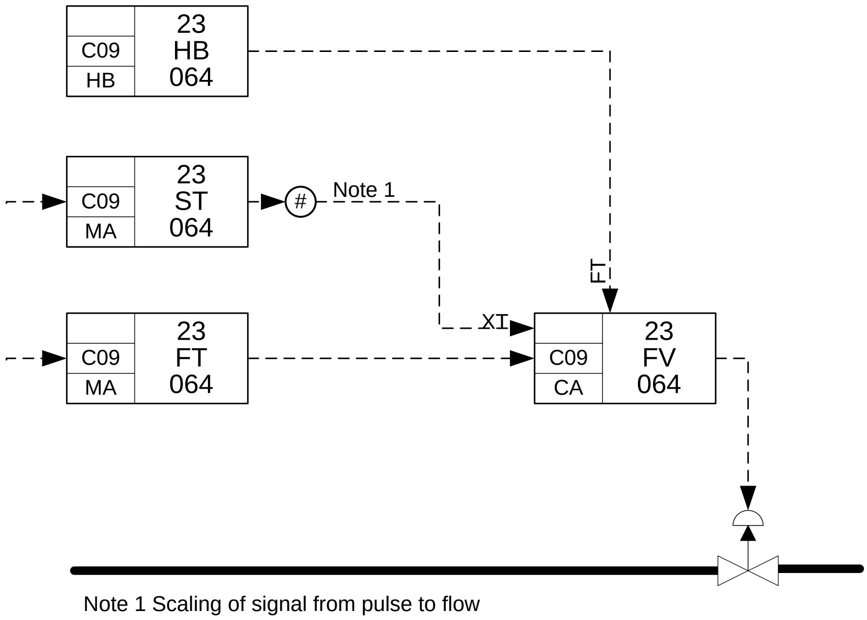


Figure E.22 - Tracking of control valve

E.3.5 Control of on/off valves and dampers

E.3.5.1 General

For control of on/off valves and dampers the function template SBV is used.

The SBV-template will have the following four possible feedback constellations:

- no limit-switch feedback;
- position high limit-switch feedback only;
- position low limit-switch feedback only;
- position high and low switches feedback.

The limit-switch feedbacks to the SBV function template is, as a standard, not drawn on the SCD, but only indicated on the SCD with GSL and GSH below the flow element.

E.3.5.2 On/Off-valves

Figure E.23 shows a manual operated HV-valve with no limit-switch feedback:

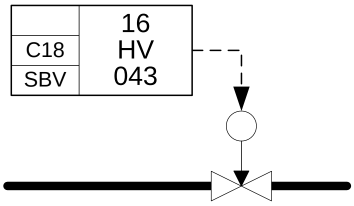


Figure E.23 - On/Off valve

The example in Figure E.24 shows a PCS shutdown action implemented in PCS system, i.e. a shutdown function without SIL demands and not required by ISO 10418 (API RP 14C). Using the LSL input will ensure that the valve will close independent of state and control mode (except blocking) of the SBV template. Using the ALL output will in addition to perform the action, ensure that the operator is alarmed. The LSL input can be blocked by the operator. When the level increases above ALL, it will remain in manual and closed state, but may be operated manually.

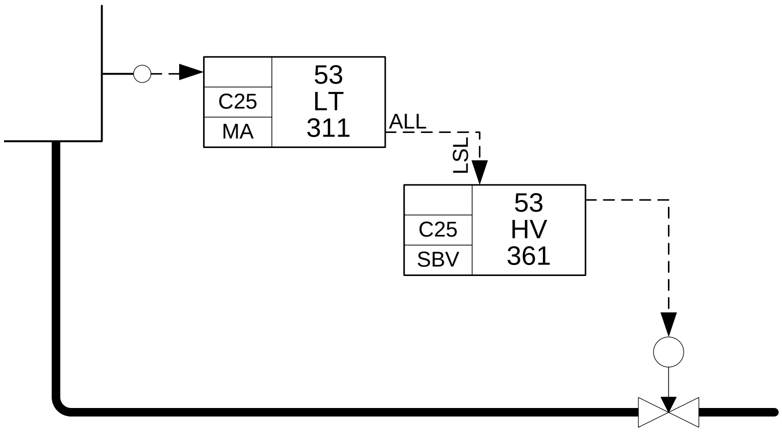


Figure E.24 - Safeguarding of On/Off valve

E.3.5.3 Process shutdown valves

Process shutdown valves are normally operated from PSD, and the PSD level shuts down the SBV valve utilising the LSL input. If the XV valve has limit switches, they are wired back to the system containing the SBV template.

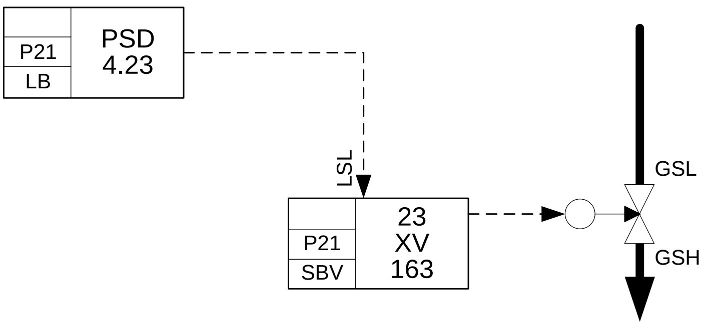


Figure E.25 - Safeguarding of PSD valve

E.3.5.4 Emergency shutdown valves for sectionalisation

EV-valves for sectionalisation are operated with separate solenoids from ESD and PSD. EVs may have both open and closed limit switches for feedback wired to PSD.

After activation from ESD the EVs are reset in the field (except for subsea EV-valves). This reset function is not shown on the SCD, see Figure E.26.

ESD level will normally initiate PSD level. If not, it shall be considered to split the ESD signal and safeguard the SBV template.

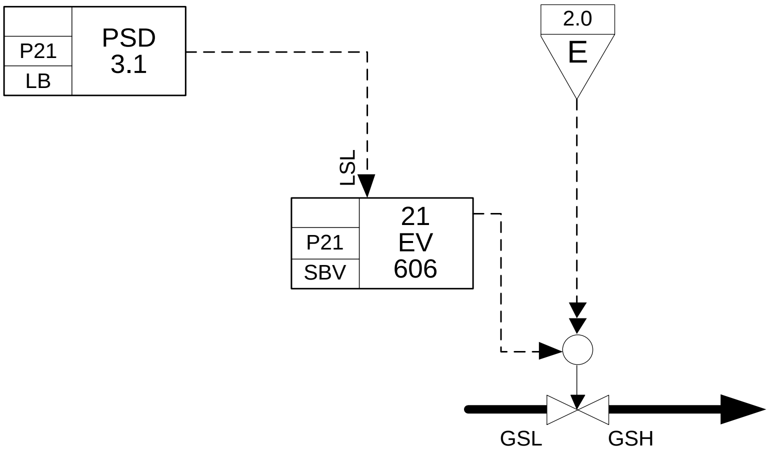


Figure E.26 - Safeguarding of ESD valve

The ESD shutdown group will not be documented on the SCD and is only represented with the triangular E-symbol.

E.3.5.5 Emergency shutdown valves for blowdown

BVs should be safeguarded from ESD only, see Figure E.27. The BVs can have limit switches for both open and closed position feedback wired to ESD.

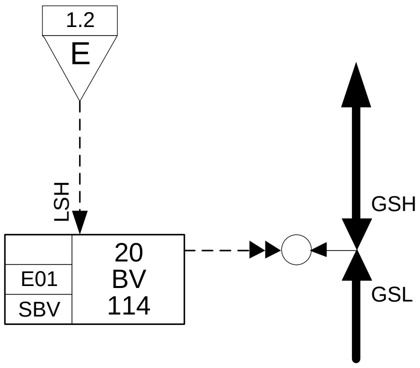


Figure E.27 - Safeguarding blowdown valve with only ESD solenoid

The shutdown group is only represented with the triangular E-symbol. The function template that represents the BV in the ESD node should be explicitly shown on the SCD.

For blowdown functions that are possible to operate from PSD or PCS, e.g. for depressurisation of compressors, a separate solenoid for PSD or PCS is needed, as shown in Figure E.28.

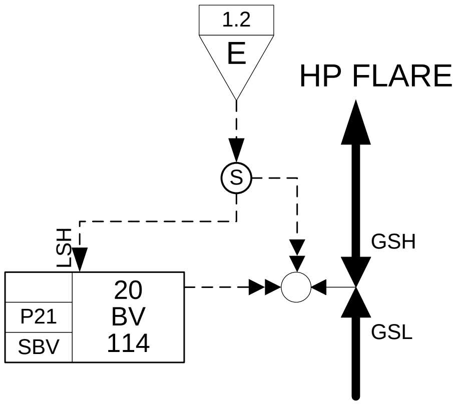


Figure E.28 - Safeguarding blowdown valve with both ESD and PSD solenoid

The function template that represents the BV in the ESD node is not shown on the SCD. The valve should have the limit switches wired back to the node containing the SBV template. To prevent unnecessary alarms from the SBV the blowdown signal can safeguard the SBV template (Safeguarding may alternatively be routed via PSD hierarchy as described in previous clause).

E.3.6 Failure actions for of on/off valves

E.3.6.1 Fail close

For fail close (see Figure E.29) on loss of signal for on/off valves, the valve will close when the electrical signal is lost. The valve is expecting a low signal (0 V DC) for closing of the valve.

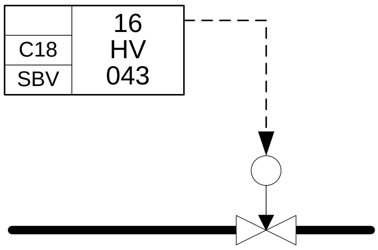


Figure E.29 - Fail close

E.3.6.2 Fail open

For fail open (see Figure E.30) on loss of signal for on/off valves, the valve will open when the electrical signal is lost. The valve is expecting a low signal (0 V DC) for opening of the valve.

Properties for definition of fail-open or fail-close function for the valve should be available within the SBV template.

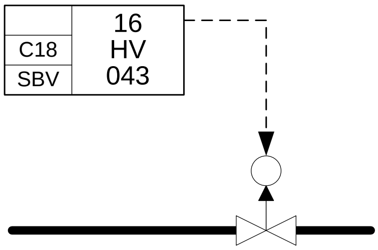


Figure E.30 - Fail open

A double arrow (see Figure E.31) can be used to indicate fail safe/NE signal. In most projects unique identification is not required as this will be a general requirement to the safety system output, but for projects where there is a variety of NDE and NE output the use of double arrow for NE outputs will add clarity.

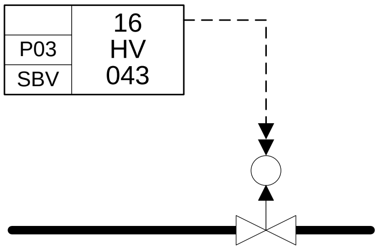


Figure E.31 - Normally energised output signal

E.3.6.3 Fail maintain

For fail maintain on loss of signal for on/off valves, the valve remains in its position when the electrical signal is lost. A fail maintain valve is a double acting valve, consisting of two solenoid valves, one for opening and one for closing of the valve. Both solenoids shall be controlled from one SBV, using the YH and YL output as shown in Figure E.32.

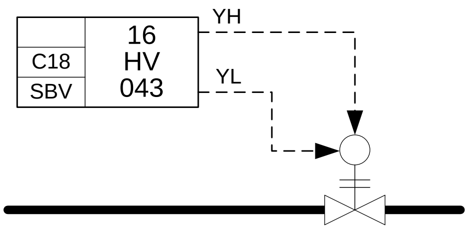


Figure E.32 - Fail maintain

E.3.7 On/off valves and control valve interaction

Control valves located downstream on/off valves should be closed subsequent to closure of the on/off valve. The position confirmed low (BCL) output may be used to shutdown the control valve (using either FSL or LSL depending on project philosophy), see Figure E.33.

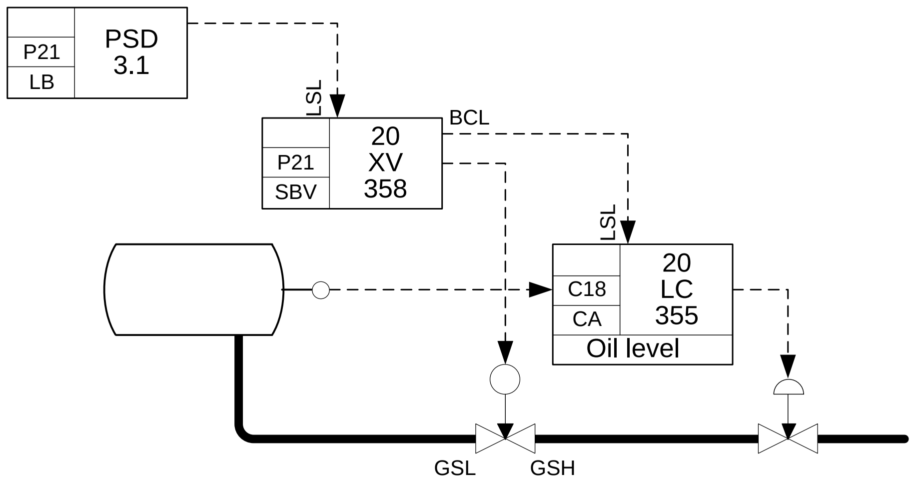


Figure E.33 - On/Off and control valve interaction

E.3.8 Electrical equipment control

E.3.8.1 General

For control of electrical equipment (e.g. motors, pumps, heaters, fans etc.) the function template SBE is used.

The function template can be configured to operate with several options according to the type of application described in Annex A.

E.3.8.2 Low-voltage motors/heaters with on/off control

A motor (or heater) with manual start/stop from the OS and automatic start/stop from external logic with data communication interface to the MCC is shown as given in Figure E.34.

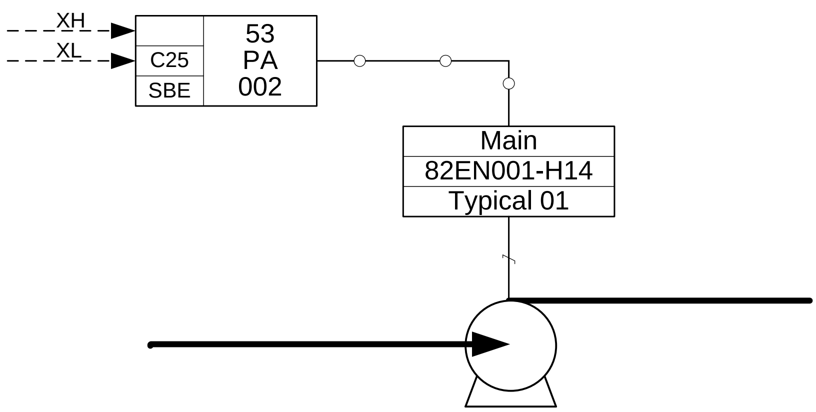


Figure E.34 - Communication interface to motor control center

All motor control is performed from PCS. The signal interface from PCS to the MCC may be via data link, as the example in Figure E.34, or hardwired. The typical signal interface between PCS and MCC for low-voltage motors are a start (YH) and stop (YL) signals in addition to available and running feedback signals. Available and running feedback signals are not shown explicitly on the SCD, but will be a part of the standardized MCC interface for the project, other interface may also be defined by the project. The standard MCC interface should be specified on the project SCD legend.

LV motors may also be controlled by one common hardwired start/stop signal, in addition to available and running feedback signals.

Additionally the motors may have trip signals from separate package logic, PSD, F&G, ESD, or load shedding trip from the electrical system. This is shown explicitly on the SCD.

Heaters are equal to motors.

E.3.8.3 Motors/heaters with manual on/off control and PCS shutdown

In addition to normal control from PCS, motors/heaters may be interlocked by a single PCS trip or by a PCS shutdown group. For single PCS shutdown, see Figure E.35.

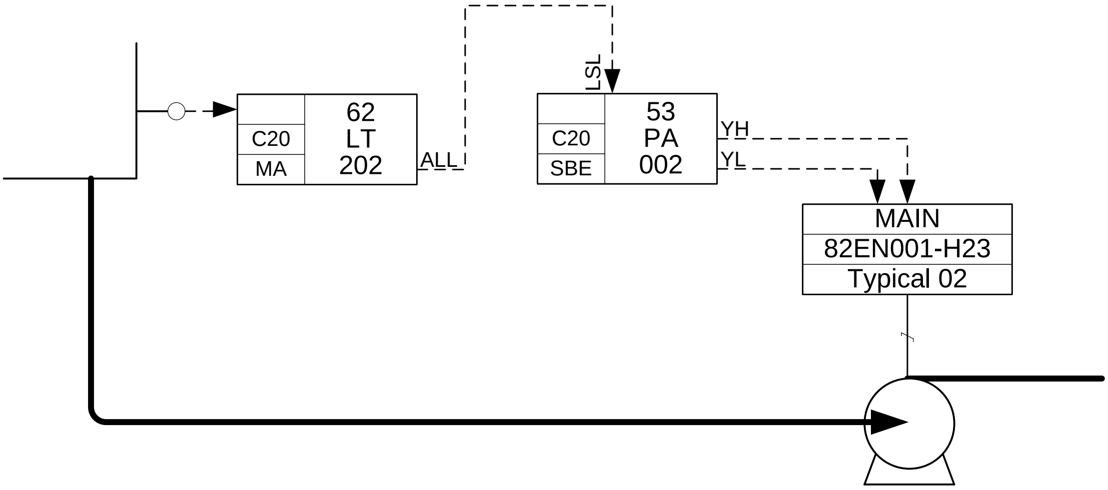


Figure E.35 - Safeguarding of motor

There is normally no use for latching the unit protection of equipment in a USD level (Unit ShutDown). The shutdown will use the LSL input of the FB controlling the equipment when latching is necessary. It is therefore normally no use for a USD level. In some cases it might be desirable to introduce a USD level, for instance when there are needs to block, systemise or visualise the unit protection. This USD level should be implemented with a LB template, see Figure E.36.

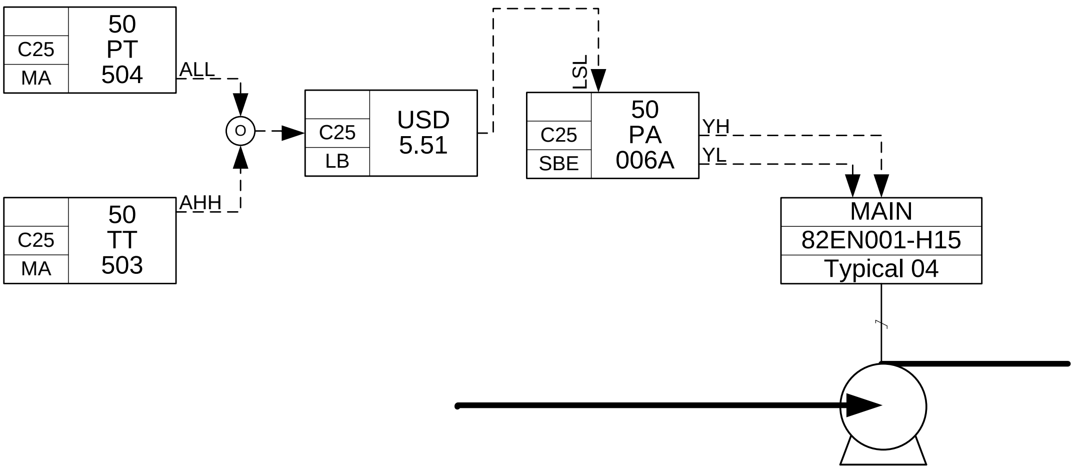


Figure E.36 - Unit shutdown level stop of pump

USD should only be used for non-SIL non-safety functionality.

E.3.8.4 Motor/heater with manual on/off control and PSD interlock

A PSD shutdown is transmitted directly to the MCC and the SCD representation should be as shown in Figure E.37.

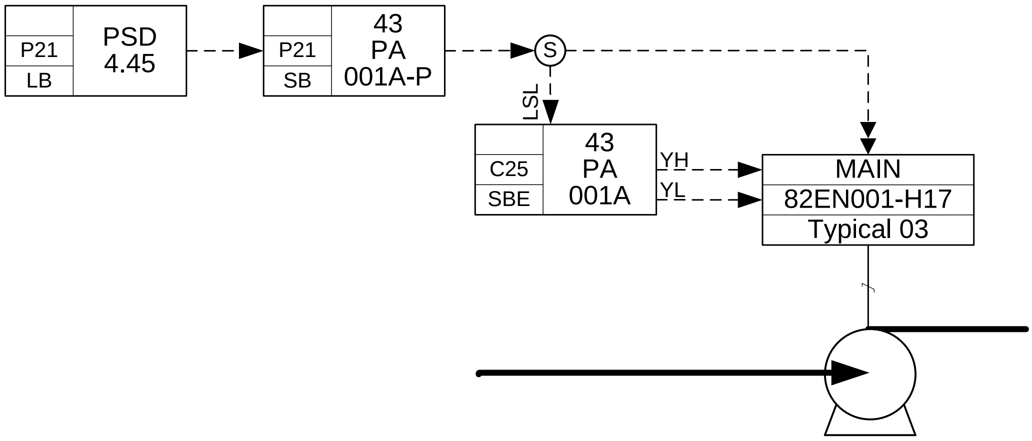


Figure E.37 - Process shutdown level safeguarding of pump

Upon safeguarding activation the hardwired output Y signal from the single shutdown signal function template SB to the trip-relay in the motors circuit breaker is de-energised, thus electrically isolating the motor.

When the motor is tripped from PSD, the output signal Y should be split and used to set the LSL input of the corresponding SBE template. This forces the SBE template in to a lock safeguarding low state, thus setting the SBE in manual and low. This will result in an additional stop signal being transmitted from the SBE and will prevent the SBE from raising a discrepancy alarm.

Connecting to the SBE's LSL terminal via SB, and not directly from LB, allows for single-point override (blocking) of safety function via the SB-template.

E.3.8.5 Motor/heater with automatic on/off control and PSD interlock

Pumps with on/off control based on an analogue process measurement and safeguarding interlock from PSD should typically be shown as in Figure E.38.

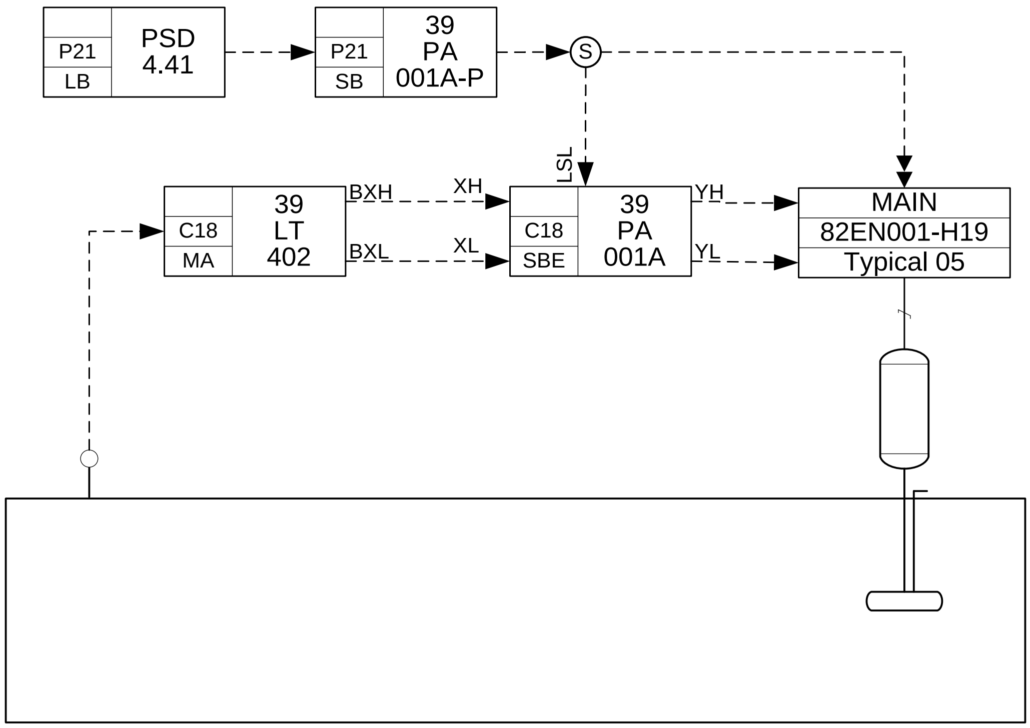


Figure E.38 - Pump with automatic on/off control and PSD interlock

Electrical heaters should be shown similarly, but with an additional note about the local thermistor for TAHH protection, see Figure E.39.

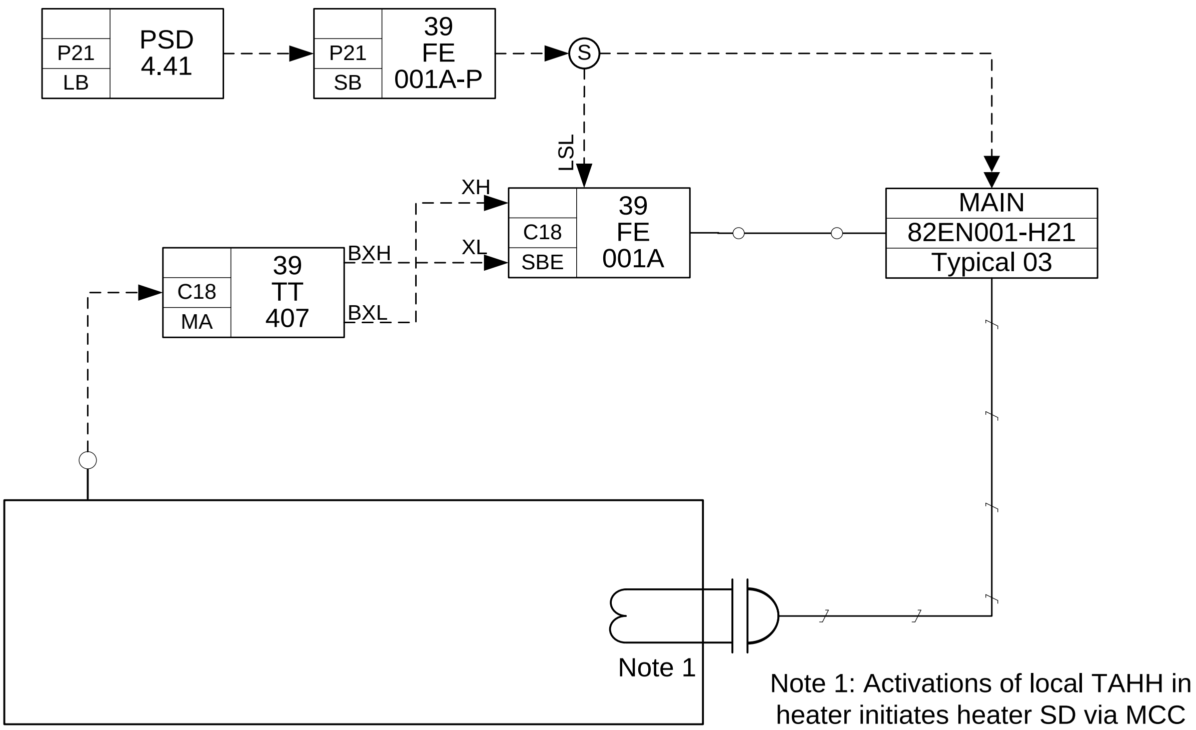


Figure E.39 - Heater with automatic on/off control and PSD interlock

The “Typical 03”nd “Typical 05” on the figures E.39 and E.38 are referring to the communication typical used towards the electrical switchgear. These typicals are identified in the SCD legend with a reference to an additional document for documenting and defining the different communication typicals used on the project.

E.3.8.6 Low voltage motors with modulating control

For variable speed low-voltage motors, a variable speed drive is interfaced from PCS, for the speed control. The CA-template is used to calculate the speed reference input to the variable speed drive. Motor control functions like start/stop and mode selection is handled by the SBE-template.

E.3.8.7 High voltage motors with modulating control

For variable speed high-voltage motors, different types of frequency converters may be used.

The detailed signal interface towards the frequency converter may vary for the different types of converters as well as the specific application. A typical example with data communication interface to the frequency converter in Figure E.40 and one with hardwired are given in Figure E.41.

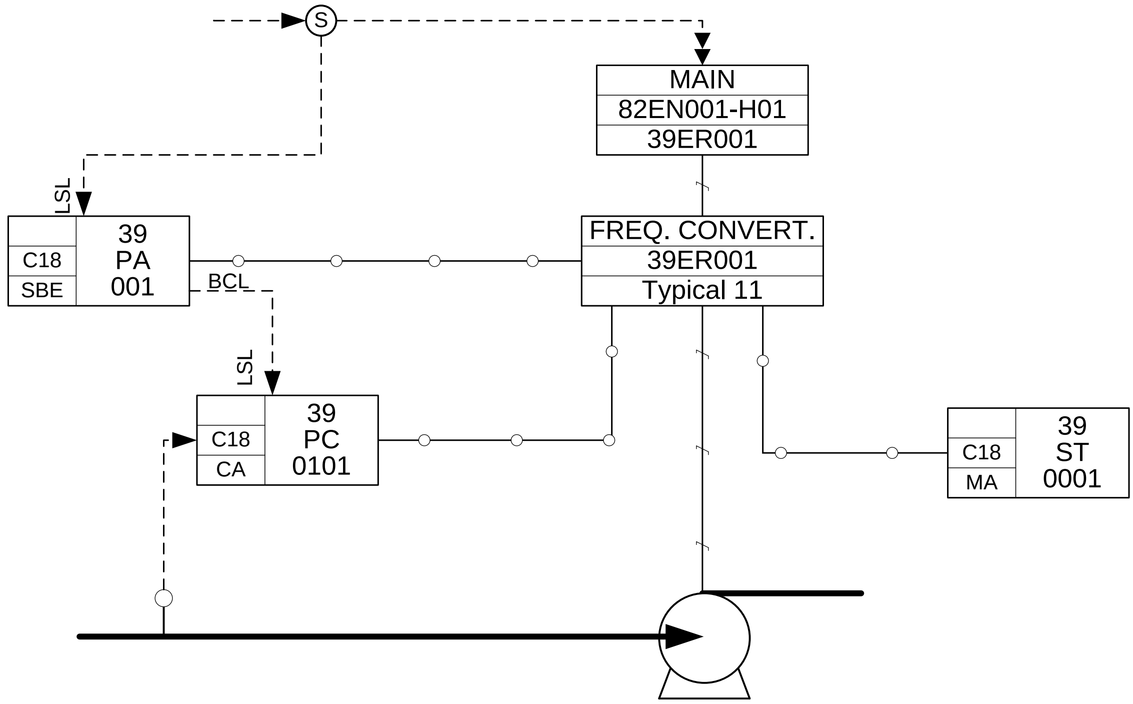


Figure E.40 - Low voltage motors with modulating control via data communication

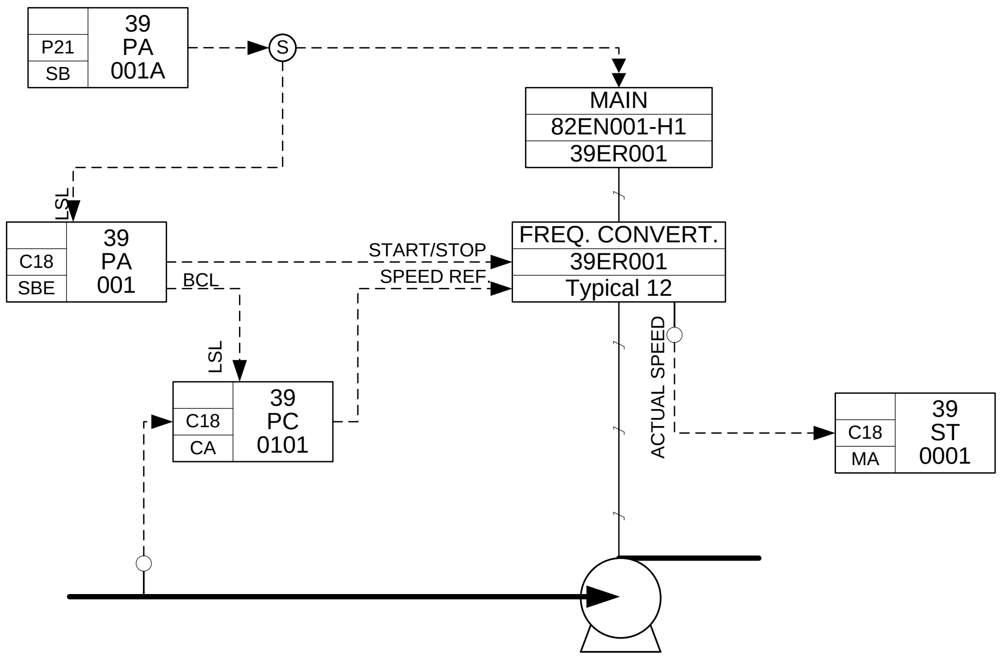


Figure E.41 - Low voltage motors with modulating control via hardwired signals

Running and available are connected to the SBE template, but not drawn on the SCD. Actual speed and speed ref. should be drawn on the SCD.

E.3.8.8 Duty/standby, lead lag

For duty/standby and lead lag control of two or more pumps a SBC template is combined together with the SBE templates. The SBC will coordinate and start/stop the SBE template according to internal algorithms described in annex A. All normal start and stop of the pumps are done by interfacing the SBC template as shown in Figure E.42.

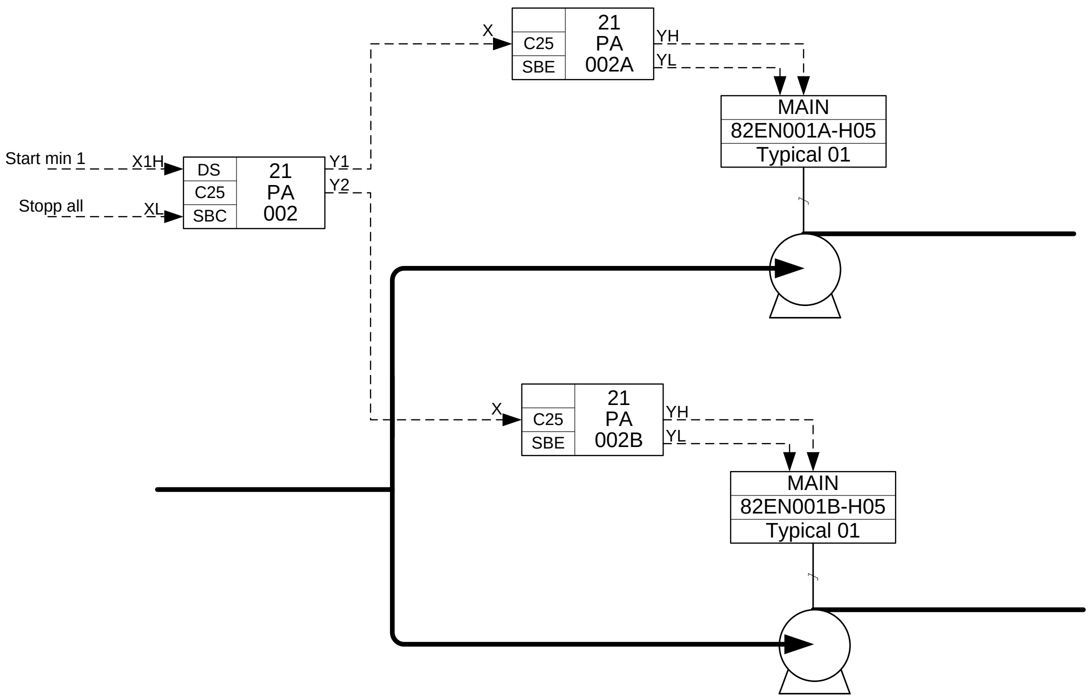


Figure E.42 - Duty/standby or lead/lag

The pumps can either be started manual/individually by the operators or by logic. The SBEs must be set in auto for the SBC to control them.

E.3.8.9 Three pumps in duty/standby configuration

For three objects in duty/standby, the no of elements that are started are defined by using the different terminals on the SBC. In the example in Figure E.43 the logic might start a minimum of 1 or a minimum of 2 pumps dependent on terminal used. See Annex A for more details regarding the SBC template.

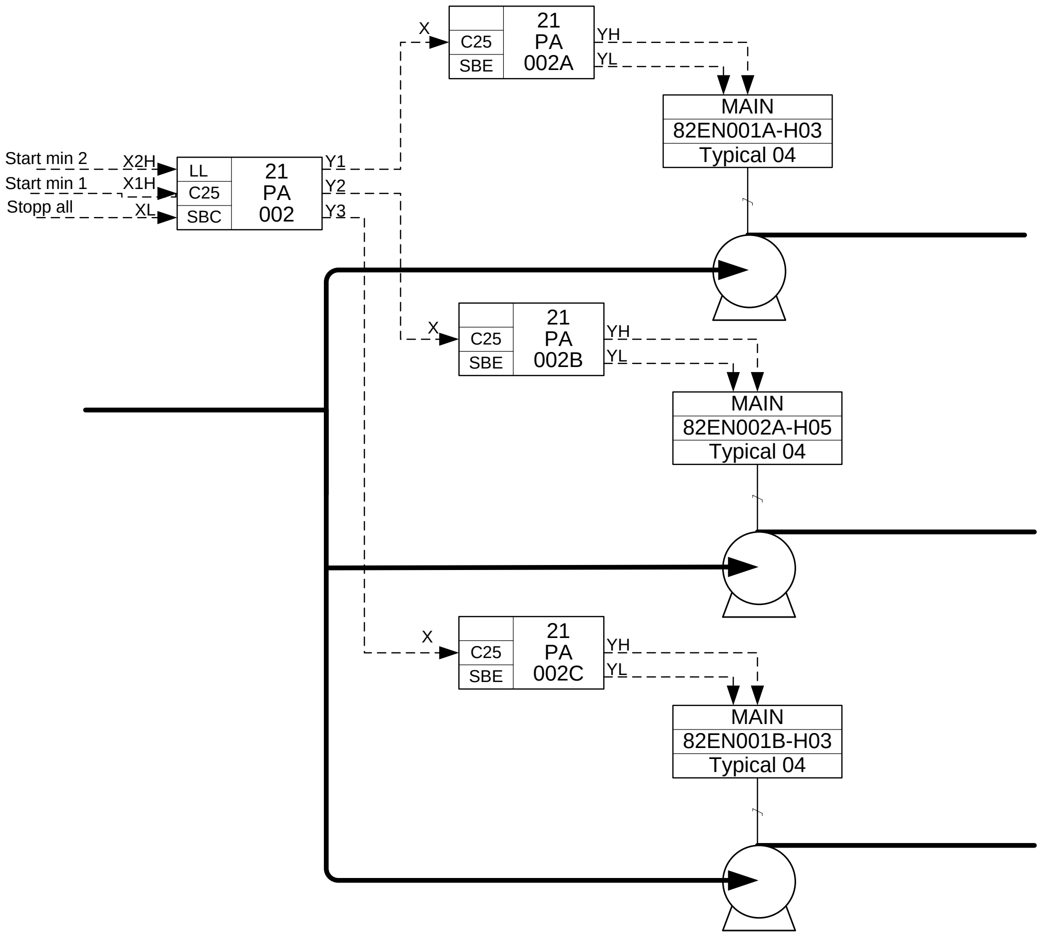


Figure E.43 - Three pumps in duty/standby

E.3.9 HVAC

E.3.9.1 General

HVAC control is normally performed from both the PCS and F&G system, where the PCS is responsible for the normal control (on/off, duty/stand by, temperature control etc) while the F&G performs the safety critical actions (shutdown of fans, heaters, closing dampers etc.).

E.3.9.2 Control of HVAC dampers

See Figure E.44.

It should be possible to operate all fire dampers manually from the OS. When the operator initiates start of a HVAC system it should automatically start the relevant fans and open relevant dampers.

In case of a fire or gas detection in a HVAC systems intake, the relevant fire dampers will be shut down from F&G.

The figures in this clause also show a node split on the logical signals from node C01 to node F05. This is to clarify in which node the 2s pulse should be located. In this case the pulse will reside in node F05.

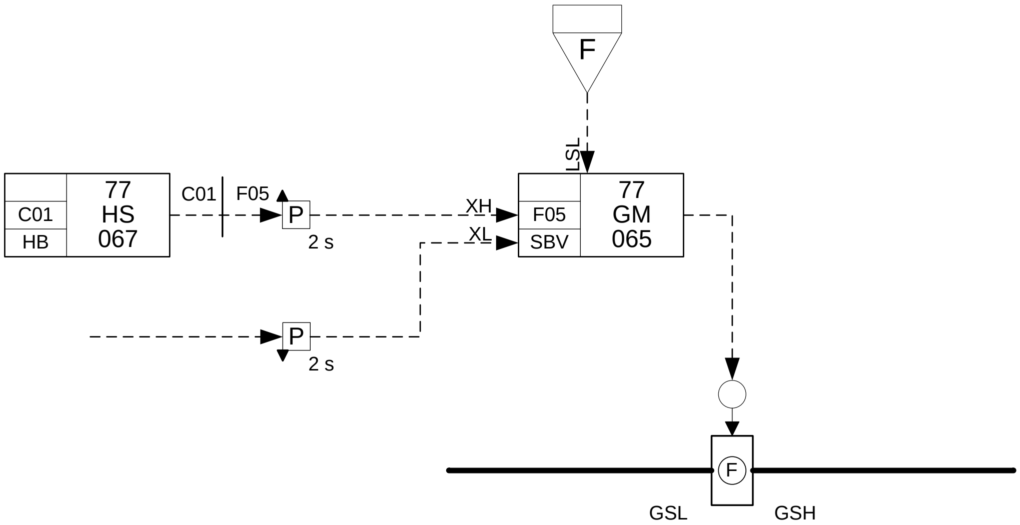


Figure E.44 - Control of HVAC dampers

Fire dampers are generally equipped with closed limit switches wired back to the system containing the SBV controlling the damper. The limit switches are indicated on the SCDs, but not drawn back to the SBV template.

A fire damper can in some cases have a combined functionality. In addition to work as a fire damper, it can also have the functionality as a shutoff damper.

The relevant fire dampers will be closed in case of a fire, but also when the HVAC system is not running. See figure E.45.

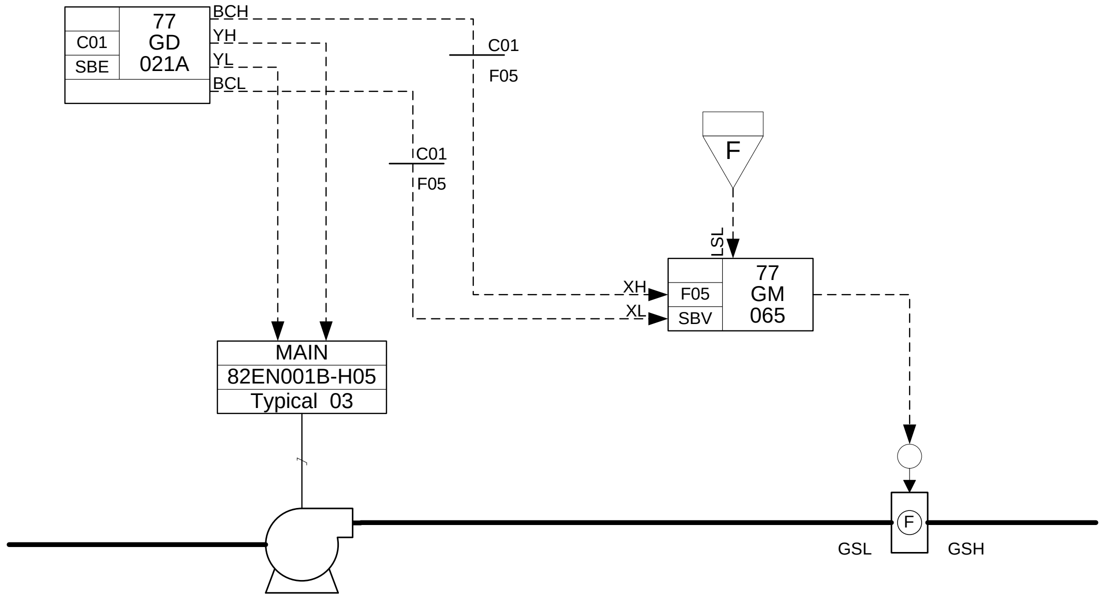


Figure E.45 - HVAC fan and fire damper control on BCL and BCH

E.3.9.3 Control of HVAC fans

See figure E.46. Start of HVAC fans will normally be manually initiated from the OS. Start of a HVAC system should activate the actual supply and extract fans. No fan should be permitted to start unless both inlet and outlet fire/shutoff dampers are confirmed open. In addition to manual stop initiated from the OS, a HVAC fan will be stopped from the logic if either inlet or outlet fire dampers should close. In case of a fire or gas detection in a HVAC systems intake, the relevant fans will be shut down from F&G.

To avoid over- or under pressure, supply and extract fans for the HVAC system should be interlocked. If extract fan stops the supply fan should be stopped, and vice versa.

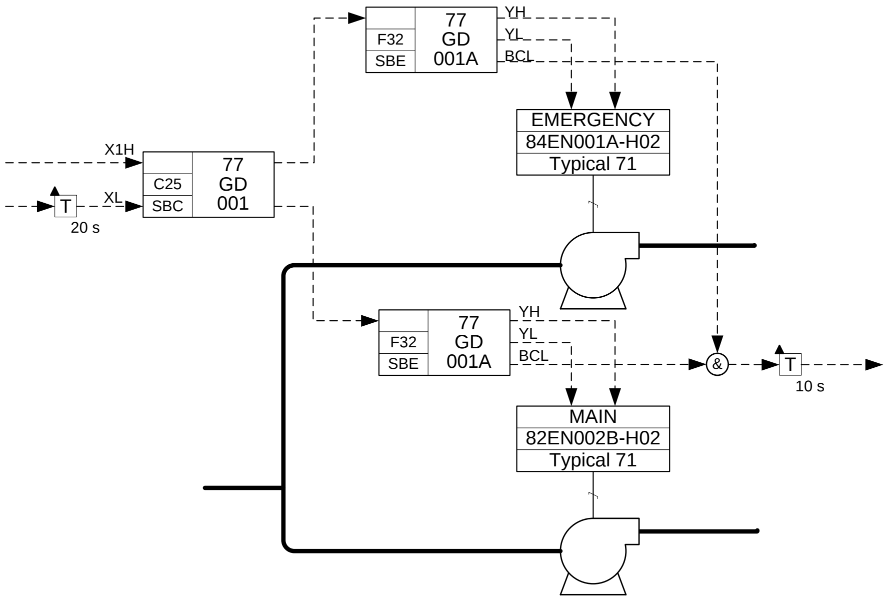


Figure E.46 - Control of multiple fans

E.3.9.4 Control of HVAC heaters

For HVAC heaters with modulating control, thyristor control may be used, see Figure E.48. When the HVAC supply fan is confirmed running, the heater will start. The effect of the heater is controlled by measuring the air outlet temperature. These measurements are used as an input to the controller (TC).

The heater will stop if the HVAC system or fan is stopped or if either inlet- or outlet fire dampers should close. In case of a fire or gas detection, the relevant heater will be shut down from F&G. The running feedback is not drawn on the SCD, but is wired back to the SBE template controlling electrical element.

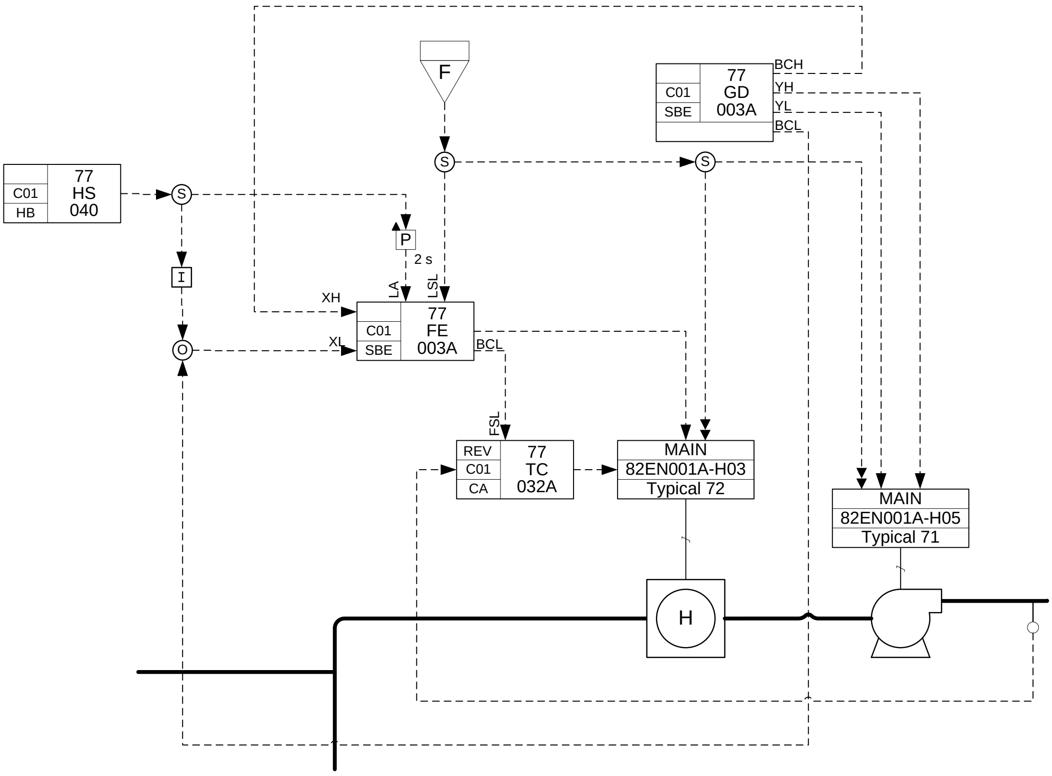


Figure E.47 - HVAC heating and fan control

Depending on the implementation of the thyristor it might also be shown in Figure E.47.

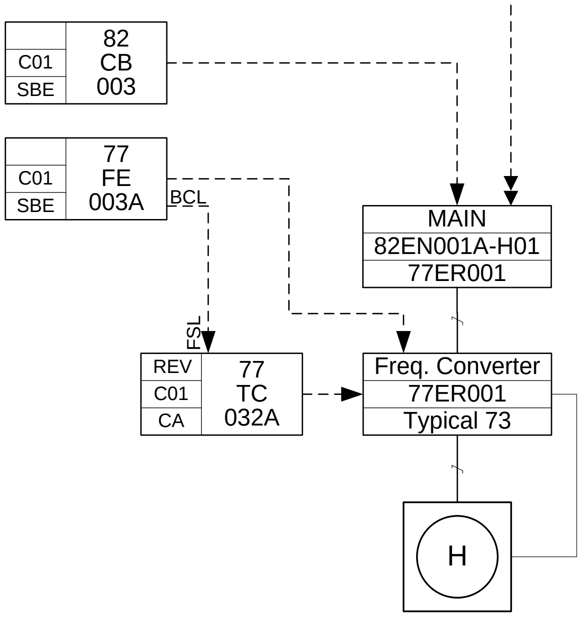


Figure E.48 - Control of thyristor controlled heater

E.3.10 Shutdown

E.3.10.1 PSD shutdown

PSD shutdown levels are implemented with LB blocks. The LB block has two inputs (X and XS) where the X input latches the function block. To prevent all shutdown levels to be latched in a situation where an unwanted process condition is detected by a PSD transmitter this can activate the X input and the higher level can activated the XS input. Thus the initiated shutdown level will be latched, as given in the example below.

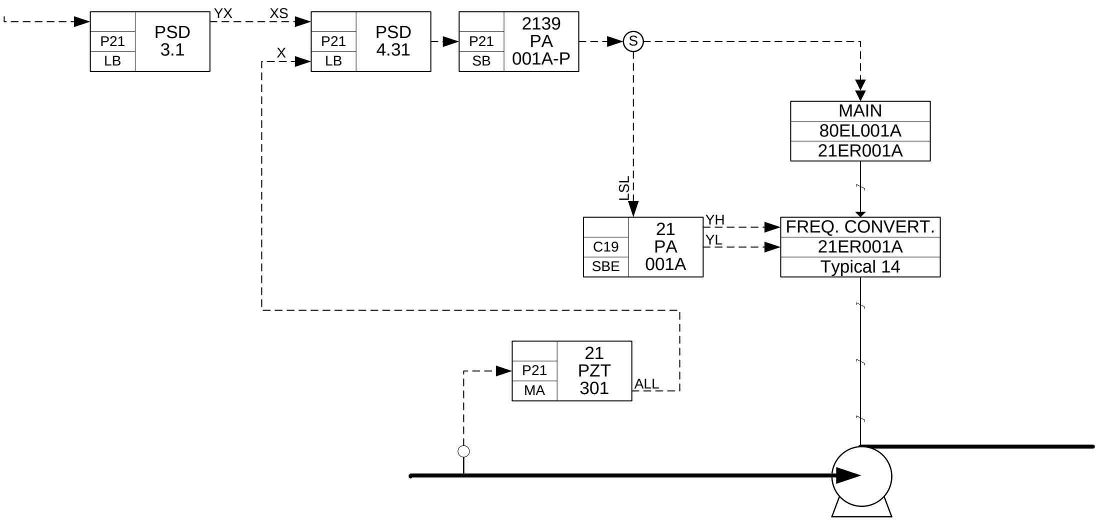


Figure E.49 - Process shutdown group / level

If the PSD 4.31 is shut down from PSD 3.1, PSD 4.31 will reset when PSD 3.1 is reset. If PSD 4.31 is shut down as a result of the 21PZT301.ALL the PSD level has to be reset after 21PZT301.ALL is normalised.

Causes initiating shutdown levels are implemented via a MA or a MB template. With these function templates, the operator can see the status of the signal on the OS and has the possibility to block the signal. In case of a trip, the event initiating the PSD will be shown in the alarm list.

The SB or SBV/SBE template is used on the outputs signals directly from PSD to equipment. If there is a SBV/SBE in the PCS the SB is used in the PSD system. These function templates have blocking possibilities and status indication on the OS.

E.3.10.2 Single PSD shutdown

When a process measurement to the PSD system initiates a shutdown action not part of a shutdown group, the SCD implementation should be as indicated in Figure E.50.

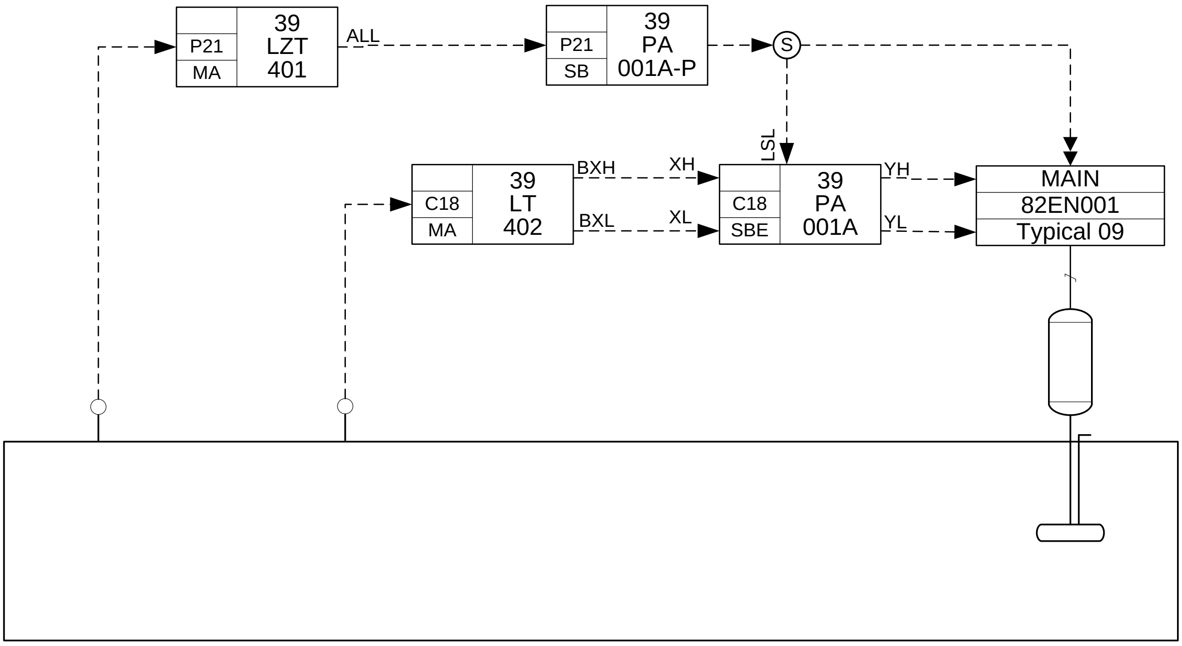


Figure E.50 - Single process shutdown

If the shutdown is latched, a LB template has to be introduced, see Figure E.51.

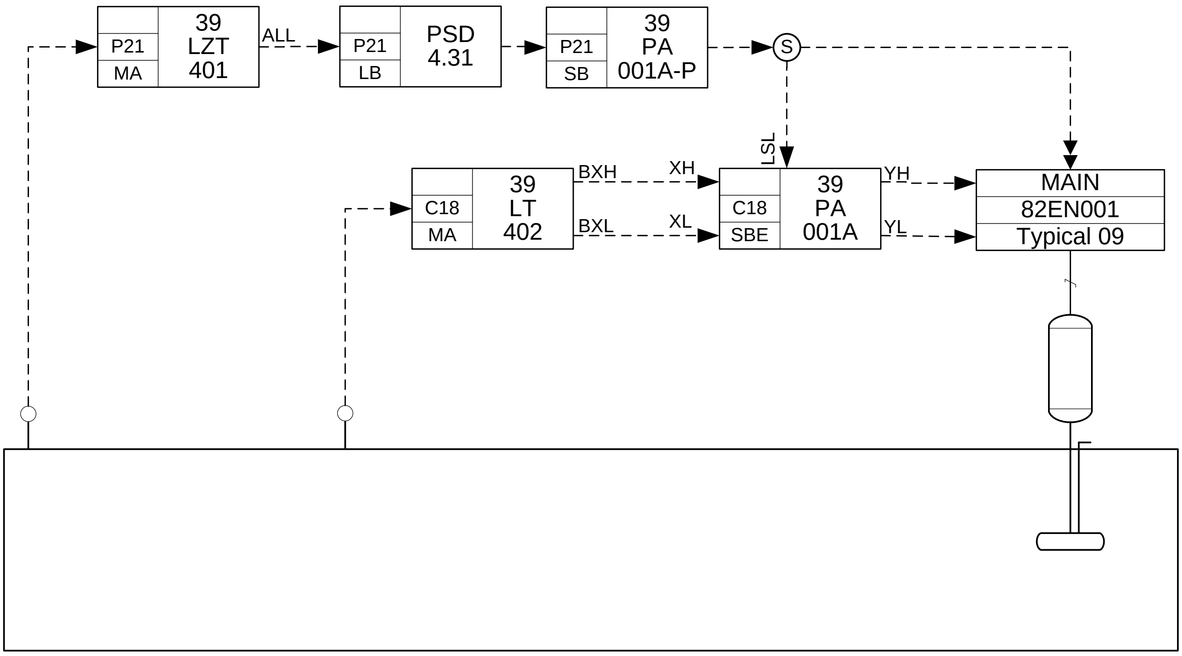


Figure E.51 - Process shutdown level

E.3.10.3 Shutdown from PCS

Shutdowns not part of PSD, ESD, or F&G (e.g. no SIL and not required to be part of a safety system) may be performed from PCS, either by a single shutdown initiator or by a PCS shutdown group. An example of a PCS shutdown is shown in Figure E.52.

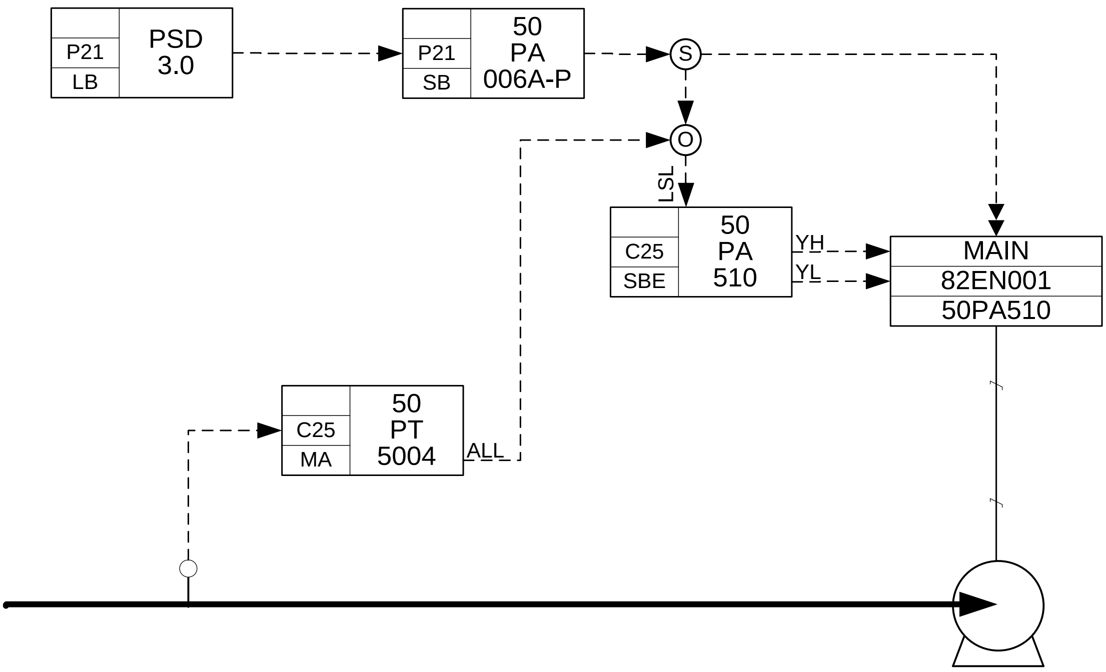


Figure E.52 - Unit shutdown in PCS

E.3.11 Interface to external systems

E.3.11.1 Integration level

To help the operator to orient himself on which system the control function is to be found, different integration levels has been defined within this NORSOK standard and associated with dedicated symbols. See definition in Table B.1.

Functions at integration level I is fully implemented in the main control system (BPCS). See Figure B.3.

For function at integration level II the operator can view the object from the main control system while the field signal is connected to a control system separate to the main control system. The object found in the main control system is identified on the SCD with a specific symbol, see Figure B.4.

Function at integration level III is not available from the main control system. These functions are identified with the symbol shown in Figure B.5. The operator should be able to locate this function in the system external by the tag identifier given in the symbol. This external system may in addition send other information to the main control system, see example in Figure E.53.

These functions will then be represented by integration level I symbols.

E.3.11.2 Typical metering station interface

. Flow computers and metering stations are normally separate systems with integration class 2. The flow computer (FC1) can interface the main control system either via data communication link or hardwired signals. In the example below the flow computer interfaces the central SAS via data communication link, and the data are used for indication only.

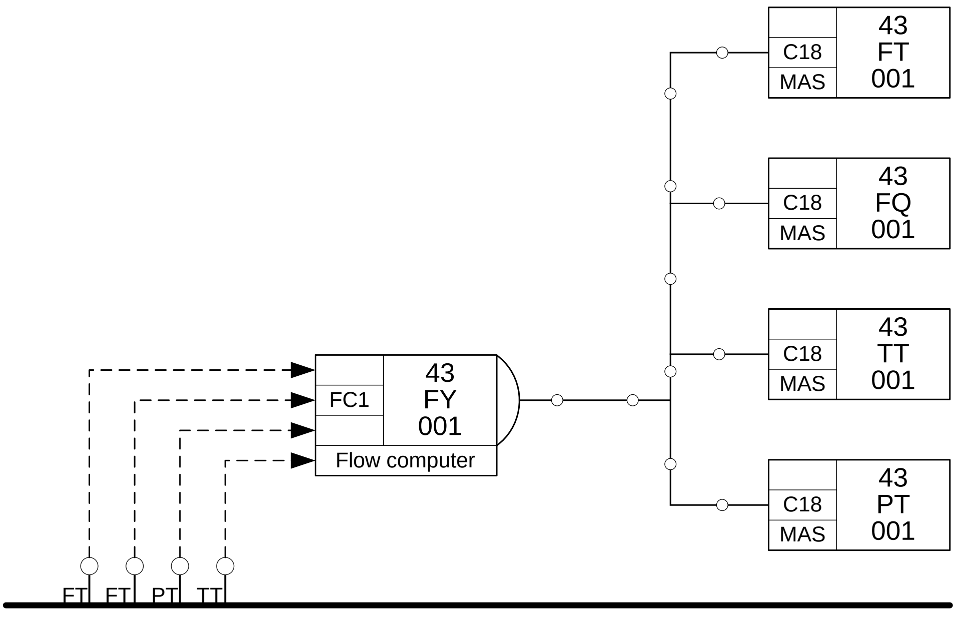


Figure E.53 - Metering interface with flowcomputer shown

The SCDs should show the type of measurements (FT, PT etc.) input to the metering station, the calculation function in the metering computer (FY) and the different values to be indicated on the OS.

See figure E.54. If there is a one to one correspondence between the transmitter in the field and function template, the flow computer can be omitted on the SCD and the diamond symbol used instead.

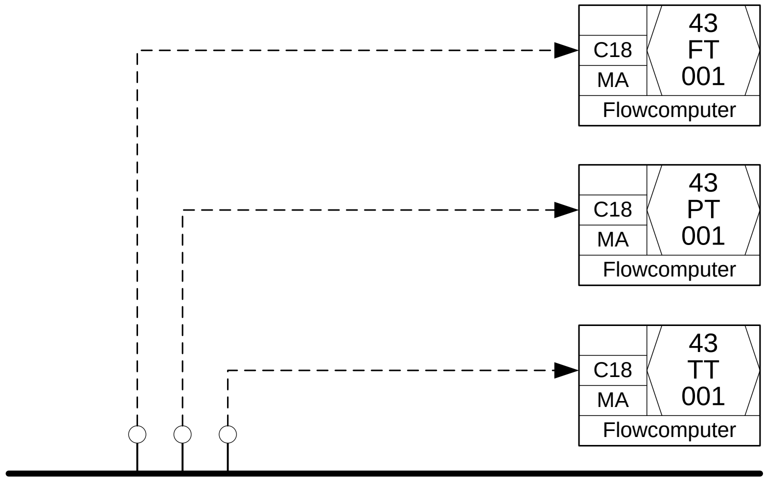


Figure E.54 - Metering interface without showing the flow computer on the SCD

E.3.11.3 Anti-surge control

Anti-surge control may be implemented in the SAS system or in a stand-alone system with interface to SAS. In this example (see Figure E.55) the stand-alone system is identified as FC1 while the SAS PCS node receiving analogue data from this anti-surge controller is identified as C18.

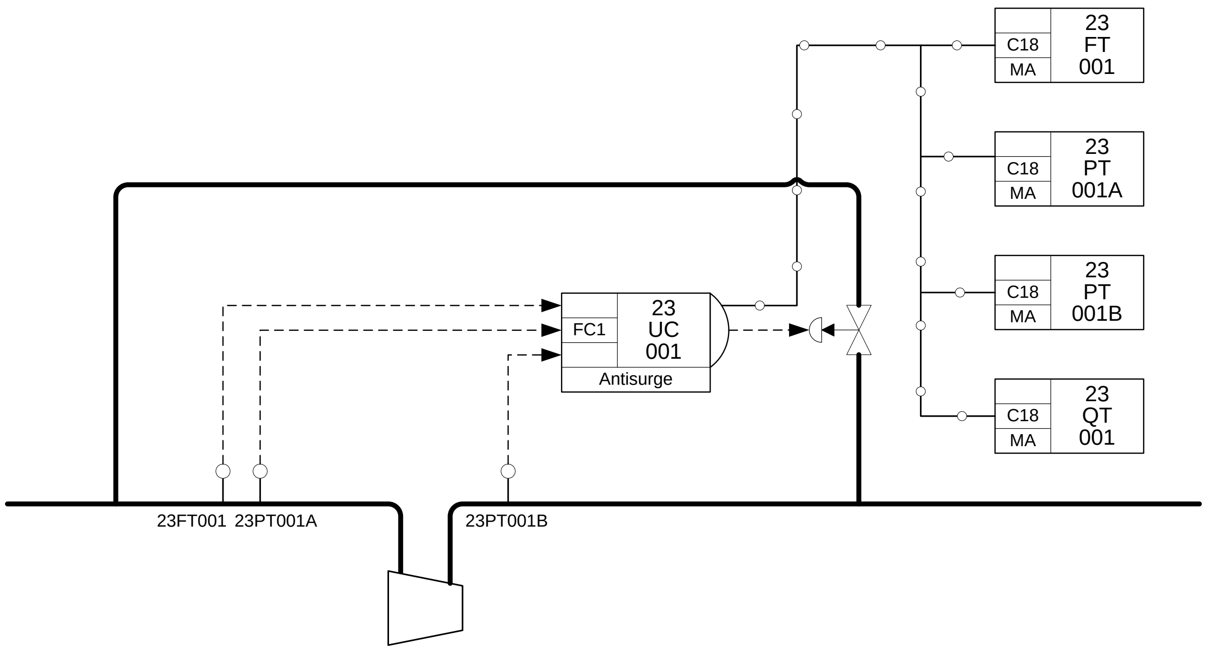


Figure E.55 - Anti-surge interface

E.3.12 Condition monitoring

The hardwired signal interface for the common shutdown (YSHH) signal from the vibration monitoring system should be shown on the SCDs. The measured values from the vibration should be indicated above the interface point of the probe to indicate which probe the signal replicates, see Figure E.56.

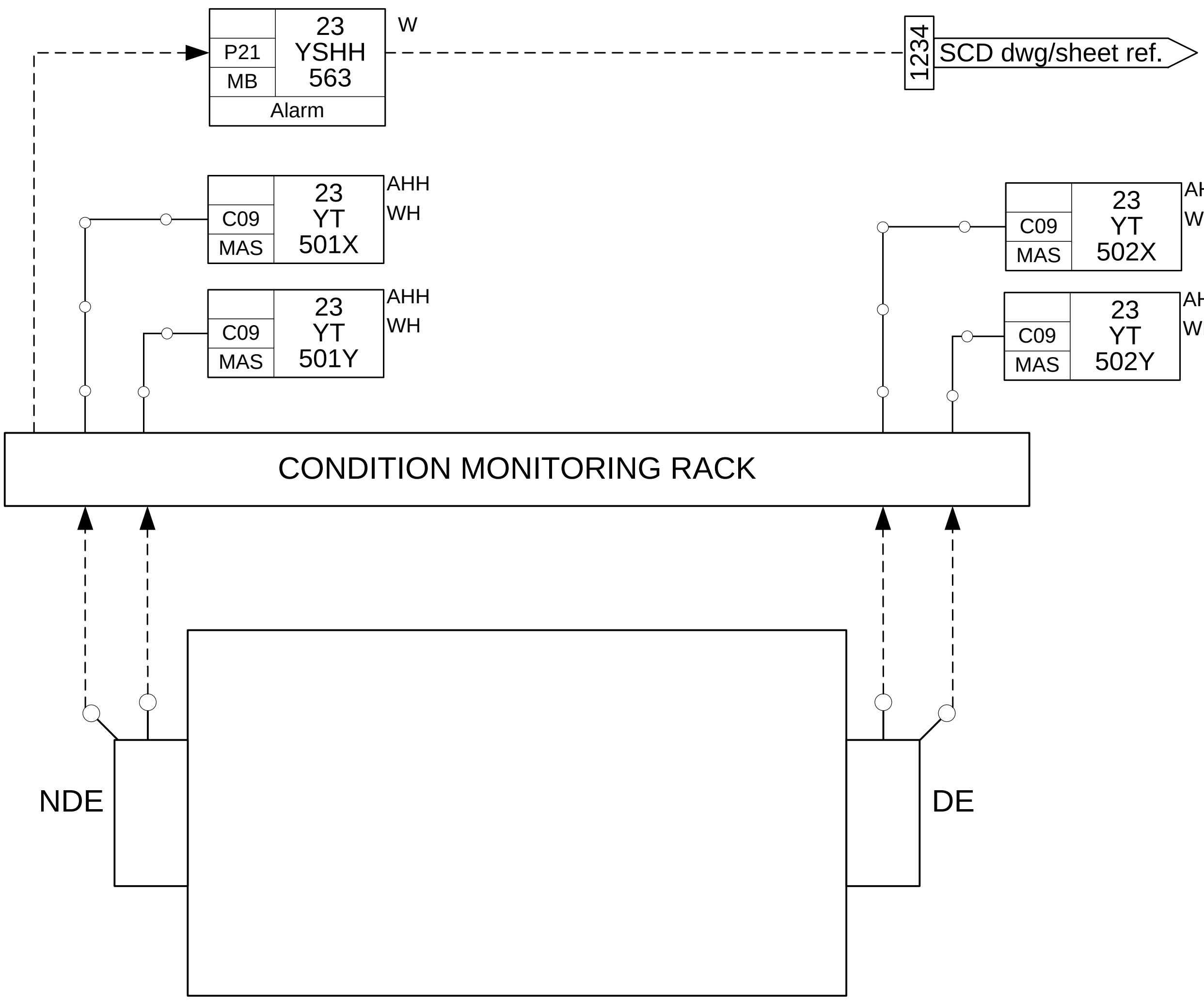


Figure E.56 - Vibration interface

Both analogue values and binary status signals may be transferred via the serial link from the condition monitoring system to the SAS system.

The MAS function is defined to having the alarm limits from the condition monitoring system to the SAS system. These alarm limits should be automatically updated in the SAS system when re-configured in the condition monitoring system.

If alarm limits are not transferred to the SAS system, the limits needs to be configured in both systems, this may cause variations in the two systems and should be avoided.

Note that the local control symbol 3 is replaced by a box representing the same local control system. This is done because this local control system has a complex interface towards SAS. Using the box will therefore, in this case, increase the readability and present more information to the user.

E.3.13 Electrical distribution control

In figure E.57 is an example of the use of SBB function template. This function template is applied for binary control of breakers for both high and low voltage. For these functions it is recommended to define communication typicals which are identified on the SCD as text in the information field in the Function template symbol. These typicals are defined in the SCD legend or in a separate dedicated document. It is recommended to define the communication towards smart starters in this way.

The breaker serving the VSD, 80EH001A-H26, is included in a start sequence. This is identified with sequence flags. The VSD breaker is tripped by PSD shutdown level 03.10. The breaker 80EH001A-H06 is tripped by emergency shutdown level 01.20.

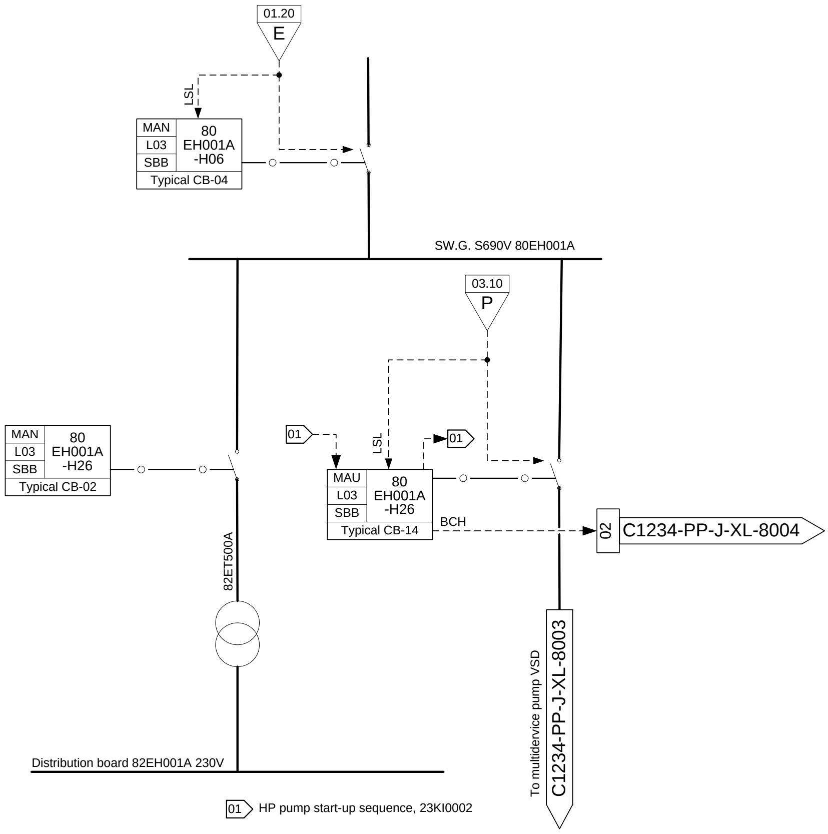


Figure E.57 - Control of breakers

E.3.14 Parallel functions

For parallel functions, two different approaches may be taken, depending on the application.

One approach is to create a detailed SCD for one of the parallel functions and then document the rest of the parallel functions in separate SCDs showing tables of tag numbers for the parallel functions not shown in the detailed SCDs. A typical application where this approach may be used is for subsea production lines and gas lift lines.

An alternative approach is to document each of the parallel functions in detailed dedicated SCDs. This approach may typically be used for parallel process sections like the gas export trains, the glycol regeneration unit, air compressors and oil export pumps.

E.3.15 Sequences

Figure E.58, 59 and 60 shows a simplified example of sequence logic, and the relationship between sequence representation on a process SCD Figure E.58 and a sequence flow diagram SCD Figure E.60. Only reference to the main sequence is made on the process SCD. Step details and connection details are shown on the sequence flow diagram. In this example a pump with minimum flow control is controlled by a sequence. The minimum flow valve is forced to full open position for 5s when the pump is started. After 5 s, the minimum flow controller is set to auto.
Figure E.59 shows the KB sequence header, which is used as an interface for controlling the sequence from HMI and/or other control logic. Located on a dedicated SCD for sequence headers, if several sequences are involved or located together with the rest of the logic if it just a single sequence. In this figure the start sequence 23KI0002 is prevented from start if stop sequence 23KI0003 is running.

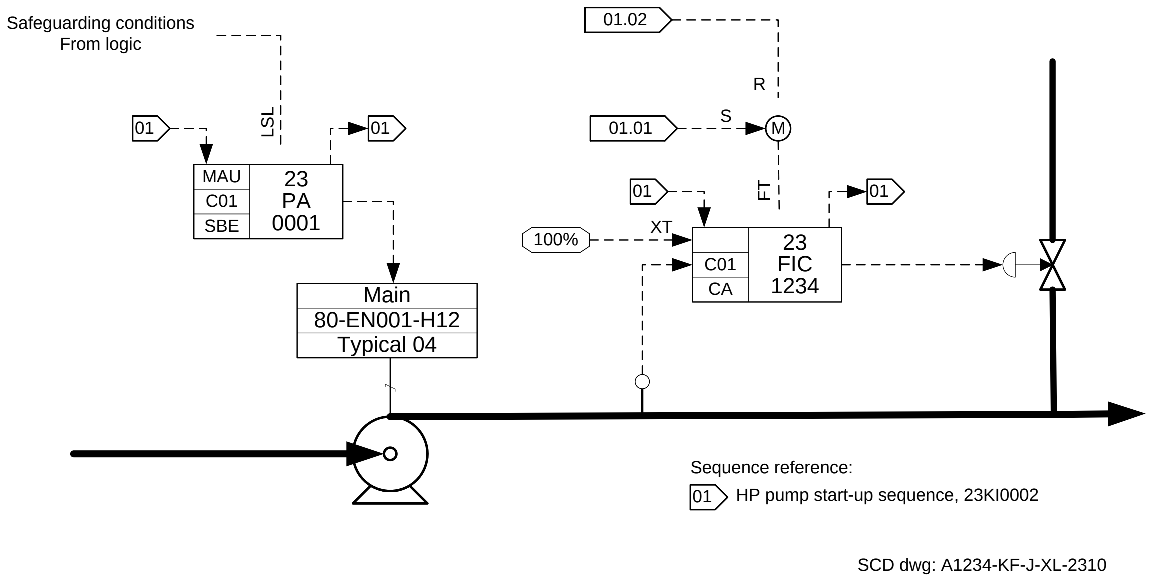


Figure E.58 - Sequence references

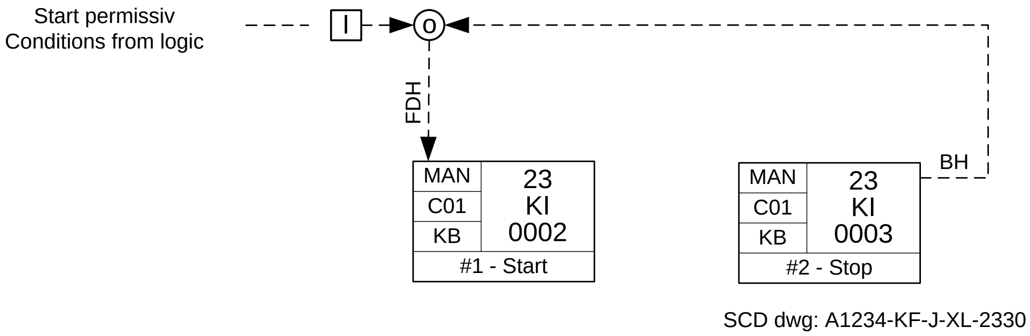


Figure E.59 - Sequence header

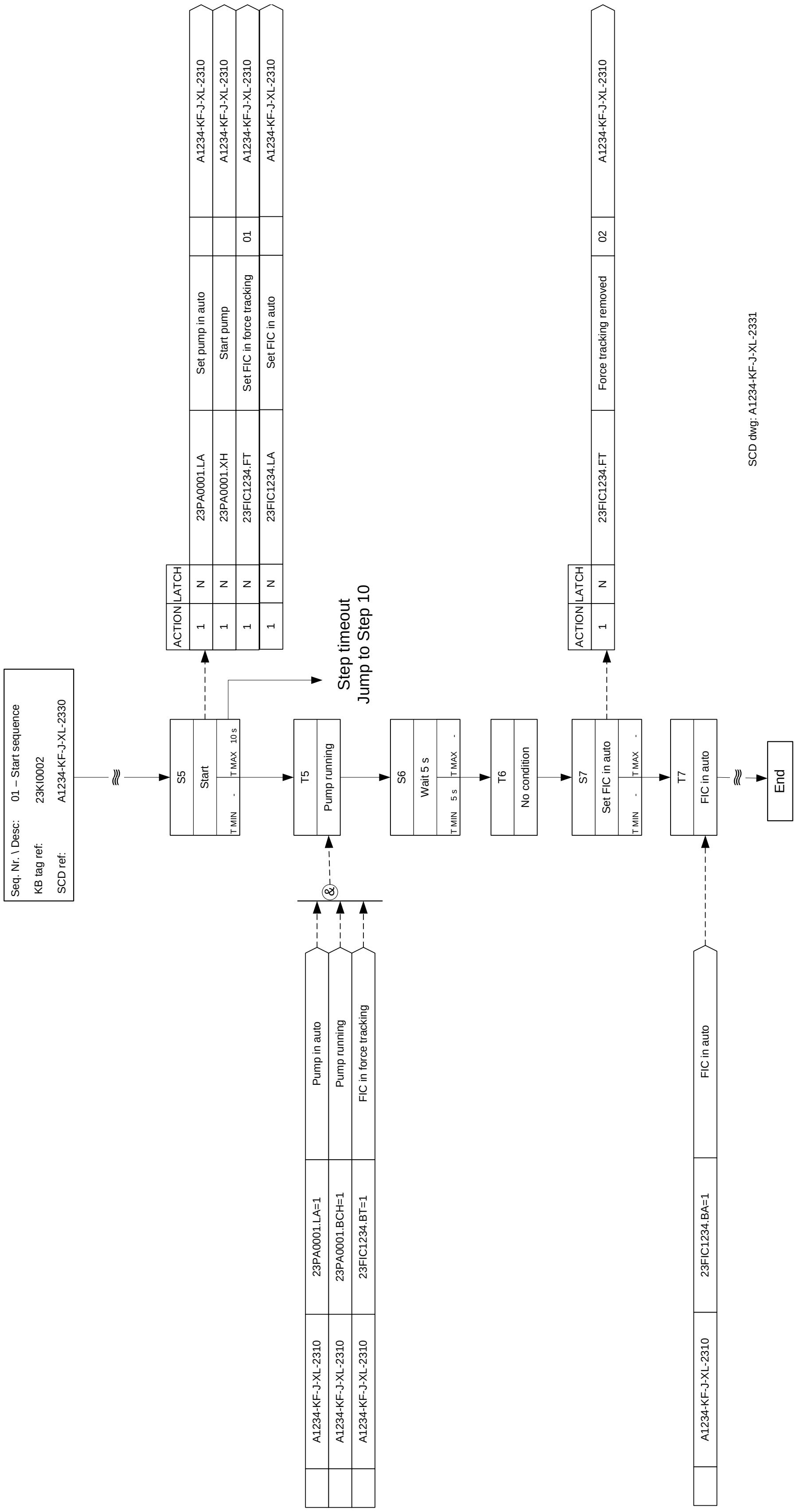


Figure E.60 - Sequence flow chart

E.3.16 Use of 'Black boxes'

In some cases it is necessary to design logic for special functionality. In such cases there is always a risk that the SCD will become filled with a tangle of simple logic elements. This should be avoided. It is an important issue that the readability of the SCD is kept.

In such cases it is recommended that 'black boxes' are used. A black box will then represent a restricted part of the control logic functionality.

An example, setpoint of flow downstream a set of 3 pumps is dependent of how many of the pumps that are running, see Figure E.61.

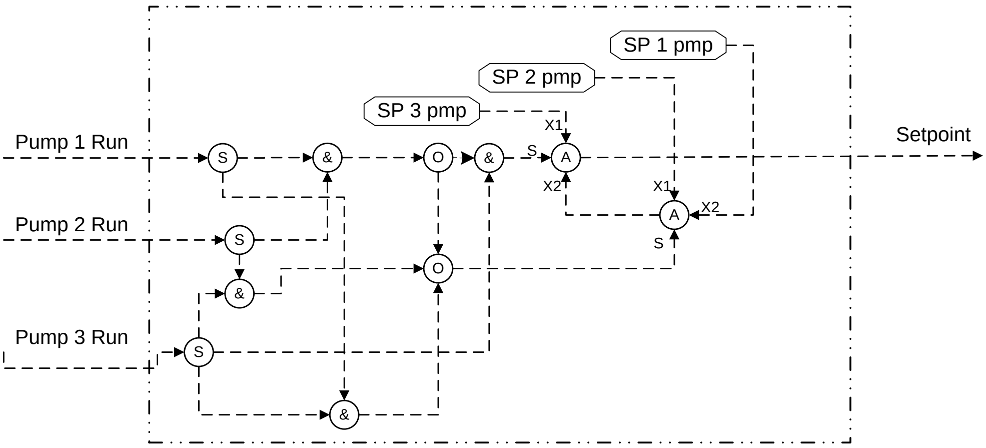


Figure E.61 - Setpoint of flow for 3 pumps

Isolated this set of simple logic functions may be readable but it could be presented as simple black box to improve the overall readability of the SCD, see Figure E.62.

It should be possible to recognise the black box in the implemented configuration in the control system. Therefore the same name is used on input/output terminals in the control system as on the SCD.

The black box should not have any HMI. HMI towards the operator should be external to black box through functions defined by this NORSOK standard.

If the functionality of the black box requires a special HMI, the black box is regarded to be a project specific function block.

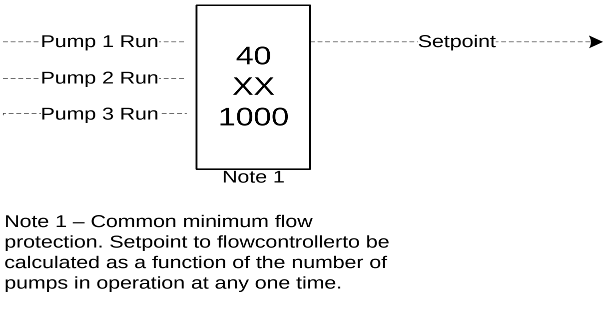


Figure E.62 - Black box representation

A note on the SCD should give the function of the black box or a document reference to where the description of the function is found.

Another aspect of creating complex logic on the SCD is the missing possibilities to prove such logic. It is better to just make one/a set of black box with a functional description.

E.3.17 Use of project specific functions

The templates defined herein covers normally most of the required logic, but in each project it will be required to use project specific function blocks other than the ones defined by this NORSOK standard. Such FBs should be presented in the SCD diagrams along with the standard templates utilising the same symbols.

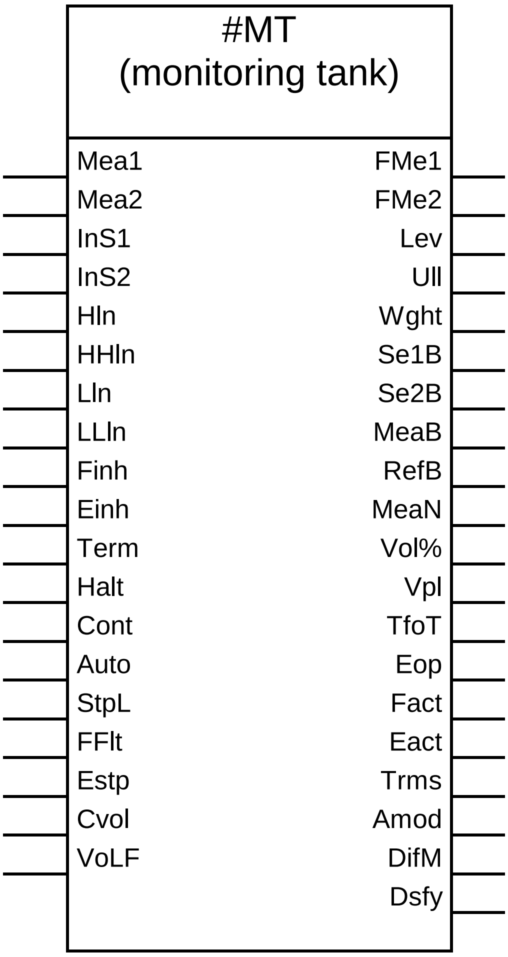
This proprietary FB shall have its own dedicated FB template name and terminal code. These codes have a limited no. of characters. This has to be taken into consideration when creating these codes. The FB name shall start with the symbol # to make it easy to identify that it is a project specific FB.

An example is the monitoring of a non-linear shaped tank, where you may have 2 level sensors:

The supplier has named the Function Block – Tank. FB name selected in the project is MT (Monitoring Tank).

The terminals are coded as shown in Figure E.63.

FB definition:



On SCD:

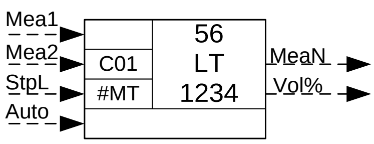


Figure E.63 - Terminal representation for supplier FBs

Annex F
(Normative)
SCD Control function templates behaviour

F.1 Purpose

The purpose of this annex is to define the behaviour of the NORSOK control functions in an unambiguous manner.

F.2 Method for description of behaviour (control function state charts)

F.2.1 Basic idea

A SCD control function (template) basically has the following two types of behaviour.

The flow and processing of *process information* e.g., a measurement and set point into a PID controller and the calculation of the resulting control output.

Processing of *control (logic) information* (discrete events and commands) conveyed by the logic inputs and also commands via operator inputs. The processing of this information determines how the template is to react as a result of these events.

One can say that the results of the *logic information* processing determines how the *process information* is to flow between the control function elements within the template and to some extent how the process information is to be processed.

A natural consequence of recognising these two types of behaviour is that one can use different methods. The basis for the methods used is:

the logic (processing of internal control information) has been visualised based on state charts (explained below), see F.2..2,

the flow process information has been visualised using electrical metaphors (, e.g. signal paths, switches etc.) (explained below), see F.2.3,

The method proposed attempts to clearly distinguish in visualisation between the processing of process information and logic control information through a control function. It attempts to combine the strengths of state charts and logic diagrams (signal or information flow from left to right). In "normal" state chart formalism, the actions performed when entering a state would be described within the state chart. In the formalism developed here, the actions which influence on process information are modelled in terms of electrical symbols. The method has been named "Control Function State Charts". In the following, the method is explained using an example, and starting by explaining the state chart as the basis, and adding the modifications gradually to finally end up with the method for visualising the behaviour of SCD control functions.

F.2.2 State charts

F.2.2.1 General

The logic of a control function is quite complex viewed in the number of inputs/outputs and possible combinations of these. However, an analysis reveals that the much of this behaviour is highly parallel, e.g. Auto/Manual vs. Suppression. This makes the behaviour of the control functions well suited for state charts modelling.

An example of one state chart is given in Figure F.1.

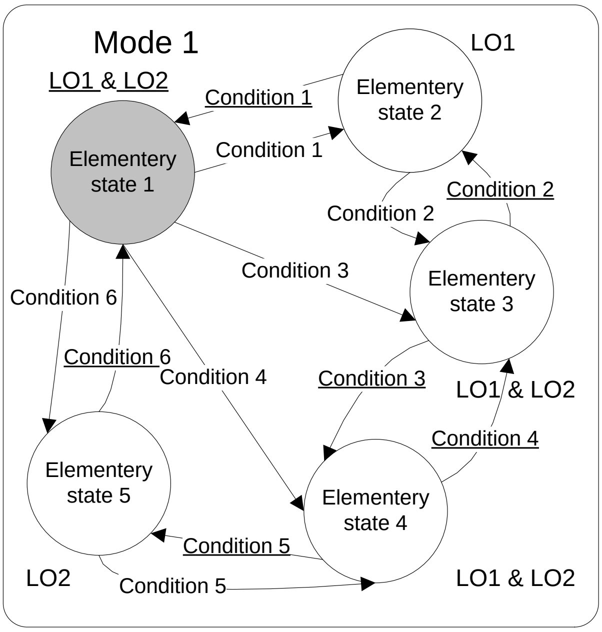


Figure F.1 – Example of state chart

A good reference for further reading on state charts is, see e.g.:Harel, David, State Charts: *A visual Formalism for Complex Systems.* North-Holland, Science of Computer Programming 8 (1987) pp231-274.

F.2.2.2 States

Figure F.1 shows a state chart for Mode 1. The circles indicate elementary states. The elementary states are the bottom level of states. No states are contained within these. The function can only be in one of the elementary states at any time. Between states there are state transitions. Each transition shall have a defined condition which should be fulfilled for the function to enter the new state.

When being in state 1 condition 1 gives a state transition from state 1 to state 2. In the same way, when Condition 1 disappears, the system will return from state 2 back to state 1. While in state 2 condition 2 will bring it to state 3. But while in state 2 it will not react on condition 3.
If being in state 1 and condition 3 occurs it will go to state 3 and, considered condition 2 also is true, remain in state 3 . Upon disappearance of condition 3 it will go to state 4. And so forth. If condition 2 was false when going from state 1 to state 3, the state-machine would immediately go into state 2.

F.3.2.3 Condition for transition

The condition for transition between states is mostly determined by the values (true or false) on the logic input terminals. However, operator input is often also a cause for state transition, e.g. auto manual selection.

One cannot intuitively see the role of the input terminals from the state chart in Figure F.1.

Therefore a modified state chart has been made, where the input terminals used by the state charts are "listed" with arrows on the left side of the state chart, see Figure F.2. In the same figure, the output terminals and OS output terminals whose values are set by the state chart are included on the right side.

Referring to Figure F.2, "Condition 1" means a true value on “Logic input Condition 1”, which is a logic input terminal. “Condition 1” means a false value on the same terminal.

NOTE Sometimes a state from a parallel state chart may enter as a condition for transition in a different state chart. However, this should be the exception rather than the rule in a system with a nature suited for decomposition into parallel behaviour.)

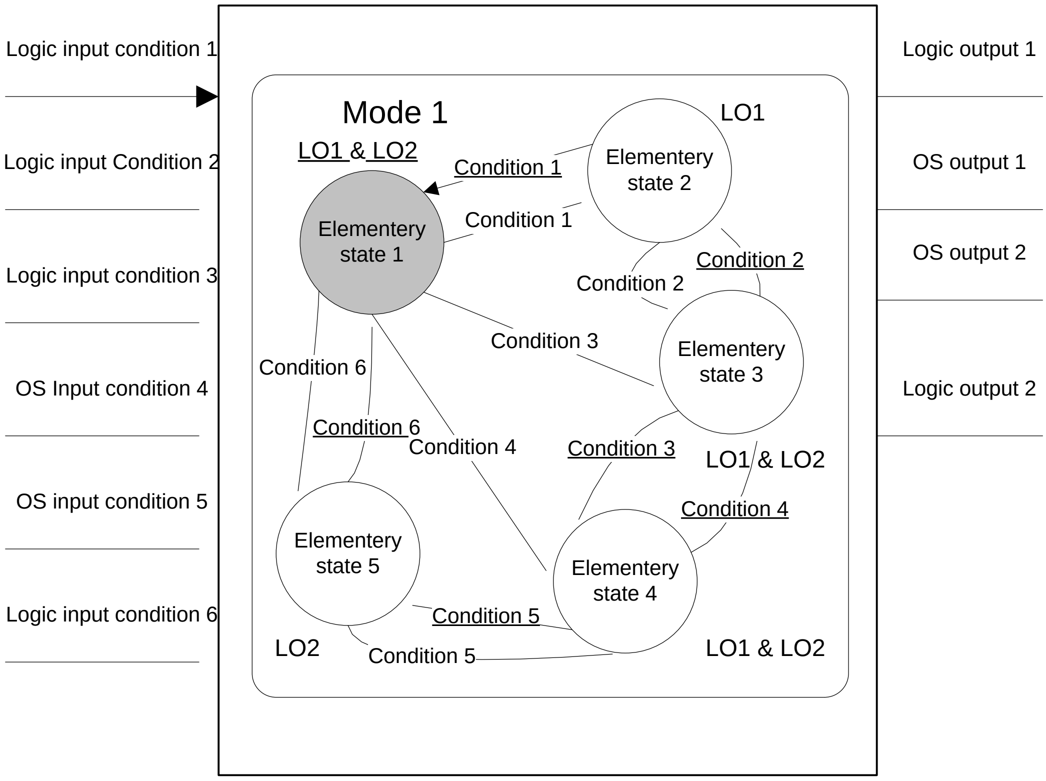


Figure F.2 – Example state chart with terminals

Figure 2 including the logic input terminals and OS input terminals used (left), state-chart and logic output terminals and OS terminals (right) set by the state chart. The condition is build up by combining the inputs.

F.2.2.4 Logic output terminals

The state chart often needs to inform the outer world about its state. This is done by setting a value on a logic output terminal. The state machine in Figure F.2 uses the “Logic output 1” and the “Logic output 2” output terminals as well as information to the OS to tell the outside world about its inner state. The values set out on “Logic output 1” and “Logic output 2” are determined as part of being in a state in the state chart. As one can see from Figure F.2, a LO1 is placed next to the “Elementary state 2” state, indicating that a "true" value will be set out on the “Logic output 1” terminal in this case. For other states “Logic output 1” is set to true, indicated by a LO1 (no underline) next to these states. Both “Logic output 1” and “Logic output 2” are false (LO1 & LO2, underlined) in elementary state 1.

The state is also often reported to the operator station, as indicated by OS output terminals ports in Figure F.2. This may be more complex information than simply a true or false value, therefore the setting of the values of these outputs have not been included in the state chart.

F.2.3 Modelling of the processing of process information

Figure F.2 illustrates how the system reacts to the states of various events and illustrates the additional information that has been added to the state chart in order to give a more complete picture of the handling of logic information. However, the processing of process information remains to be shown. As stated earlier, the consequence of changing states is that process information is processed differently. Figure F.3 shows the state chart again with the flow and processing of process information included. The value of the output Y when being in a certain elementary state is shown using electrical metaphors.

The numbers indicating the position of the switches below the state chart in Figure F.3 are cross-referenced to numbers within the states of the state chart above. For instance, when the system is in "Elementary state 1"(1), the switch will be in position 1 and a control value calculated by the PID controller is set out on the controller output Y. If the system is in "Elementary state 2" state (2), the switch turns position 2 and a “safeguarding high value” is set out on the controller output Y.

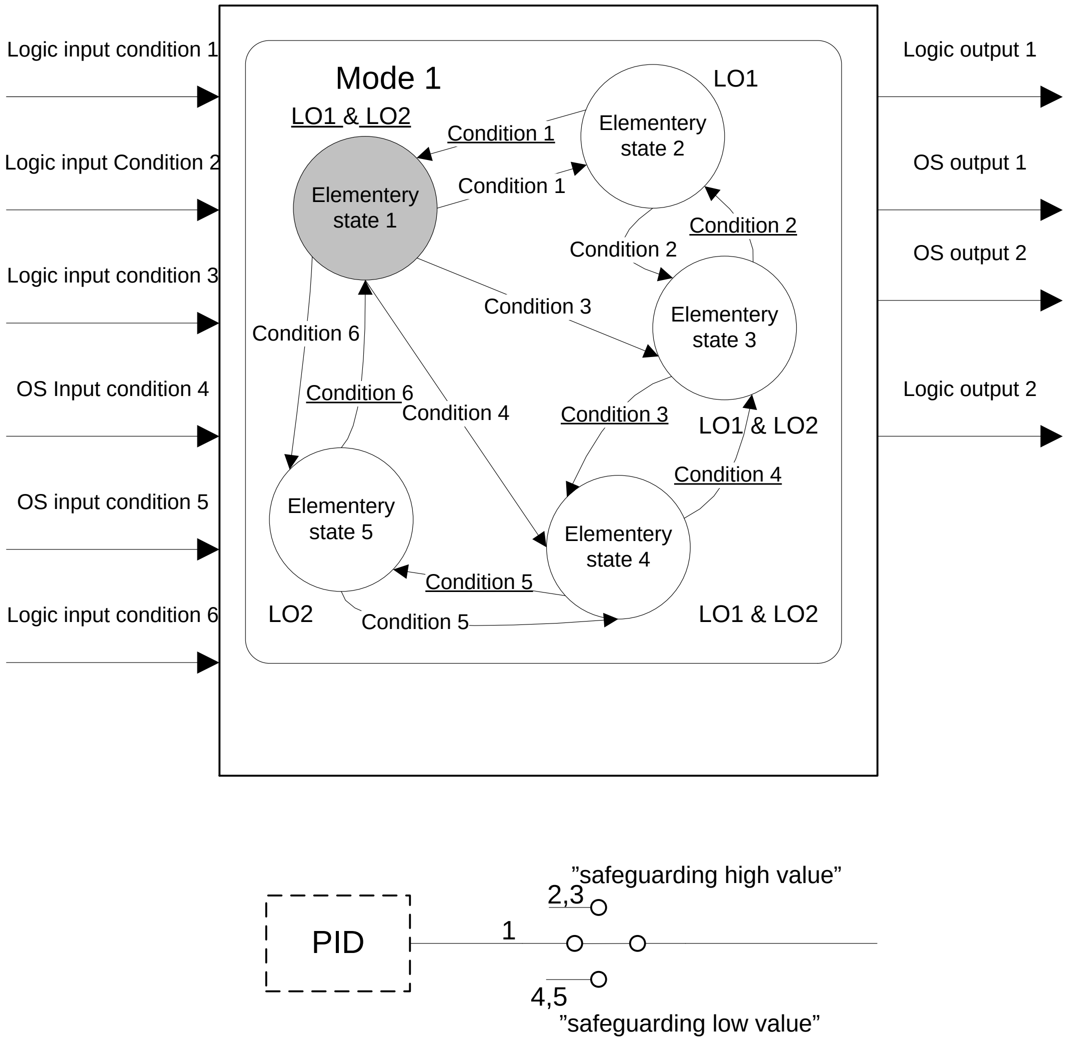


Figure F.3 – Example state chart and electrical metaphors

F.2.4 Parallel state charts

Figure F.3 illustrates the state chart of one single mode and how different values are set out on the output Y. But an SCD control function consists of a number of (parallel) state charts, see e.g. Figure F.19.

Parallel state charts are separated with dotted lines. The actions following the elementary states of a state chart take place between these dotted lines, and the actions of a state are cross-referenced by numbers, as described in F.4.3. As shown in Figure F.19 (or any of the succeeding figures) several of the state charts may influence the same output, e.g. Y.

The order left to right of the state charts indicates the priority of the state charts vs. the output. Given flow from the left to right of process information, the right-most state chart will have the highest priority with regards to setting the value of the output. Safeguarding as an example has the highest priority in setting the output value Y in the CA template, see Figure F.19. If there is No Safeguarding, or Safeguarding is blocked, the position of the switch means that the Safeguarding state chart "leaves the control" over the value set out on Y to a state chart to the left.

F.2.5 Symbols used for modelling control functions using state charts

F.2.5.1 General

An overview of the symbols used when modelling control function behaviour using state charts is given in Figure F.4.

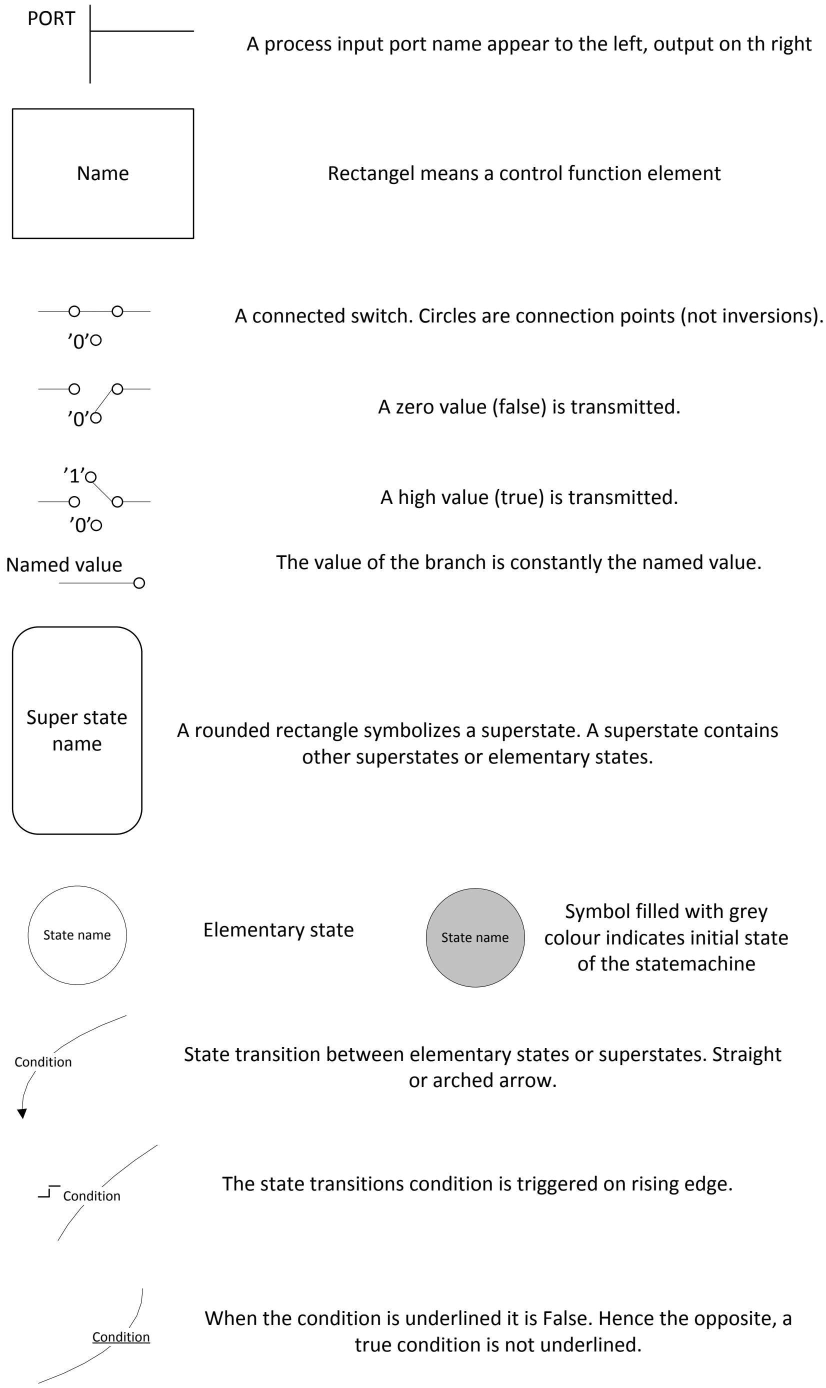


Figure F.4 – Overview of symbols used in state chart

F.2.5.2 How terminals are handled

The names of process input terminal appear outside the border on the left side of the template, and process output terminals to the right. These names are defined in the SCD standard.

Logic input terminals and output terminals have been omitted in the figures defining the template behaviour. For logic input and output terminals, refer to the figures specifying each mode, i.e. Figure F.5 to Figure F.18.

F.3 Description of behaviour in various modes

F.3.1 General

This clause contains descriptions of the NORSOK control function modes, their super states and elementary states and the conditions for changing between states. A change of state is most frequently caused by the input information entered through the logic controller input ports and OS controller input ports. However, a state change may in some cases also occur as a consequence of a state change in a different mode.

Different templates may contain the same modes and mode selection functions (conditions for switching between states). However, the actions performed by a template as a consequence of the state change is highly different, and described in this clause.

This clause describes each individual mode. It starts by describing the Auto Manual Mode. This is a complex mode. It is recommended that readers not familiar with this kind of modelling begins with the succeeding simpler modes, like figure F.6. as this may be easier to understand.

A common set of Mode state charts are used throughout the template behaviour figures. Hence, there are conditions in the state charts that may not occur in the specific template.

F.3.2 Auto-manual mode

F.3.2.1 General

There are four states in Auto Manual Mode, Auto, Manual, Lock Auto and Lock Manual respectively, see Figure F.5. One can give order to switch between Auto and Manual states from the operator station. Lock Auto is entered as the Lock Auto terminal gives a "true" signal. True in this case means on a positive edge, indicated as ↑LA in Figure F.5.

F.3.2.2 The influence of safeguarding mode on auto manual mode

The states Locked Safeguarding High or Low in Safeguarding Mode (see Figure F.13) always cause the Auto Manual Mode to enter Manual. This is indicated as an open arrow in Figure F.5 with Locked Safeguarding High (LSHS) and Low (LSLS) states being the condition for transition. The names of the safeguarding states have been presented by acronyms due to limited space. The acronyms are shown in Table F.1.

Table F.1 – Mode figures acronyms

Acronyms used in Figure F.5 Auto Manual mode	
NOSS	No safeguarding state
LSLS	Locked safeguarding Low state
LSHS	Locked safeguarding High state
BSS	Block safeguarding state

A state transition to Auto or Locked Auto state is only possible if safeguarding is not active, which means that the control function can only be in No Safeguarding or Block Safeguarding. Also, a transition to Locked Manual is only possible in No Safeguarding or Block Safeguarding.

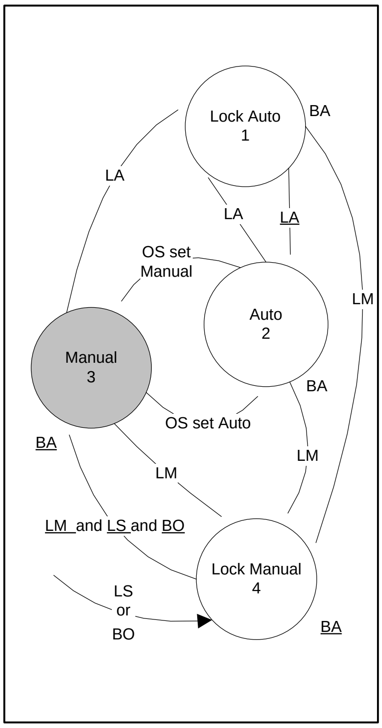


Figure F.5 – States and state transitions of Auto manual mode

F.3.2.3 The influence of outside mode on auto manual mode

If Outside Mode is present in a control function, outside state causes the Auto Manual Mode to enter Manual state. Therefore Outside state is a condition for a transition into the Manual state.

F.3.3 Blocked mode

F.3.3.1 General

This state machine is used to determine blocking of actions. Annunciation of the alarm is still made. Blocking can be selected either from OS or via the logic input terminals, in this case the Force Block terminal, FB.

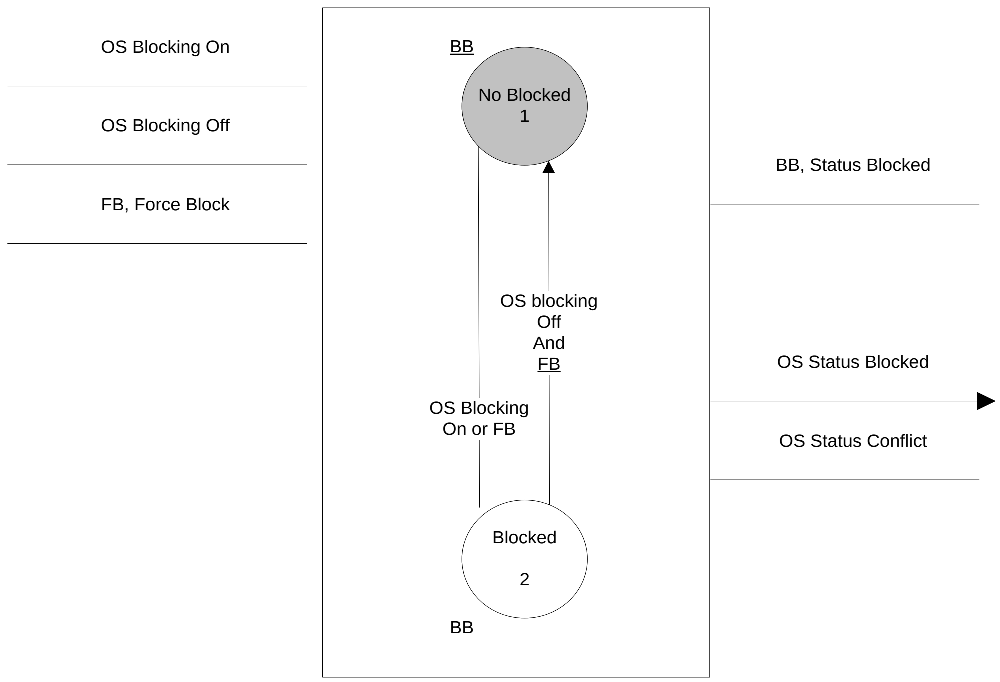


Figure F.6 –Blocked mode

Blocked mode is used to block both HH and LL actions. However, only HH or only LL actions can be blocked by using Blocked HH mode or Blocked LL mode, respectively.

These modes are described in F.3.3.2 to F.3.3.3.

F.3.3.2 Blocked HH mode

Similar to Block mode, only that this mode only blocks actions following HH alarms. The HH actions can be blocked from the OS, or from the logic input terminal FBLL.

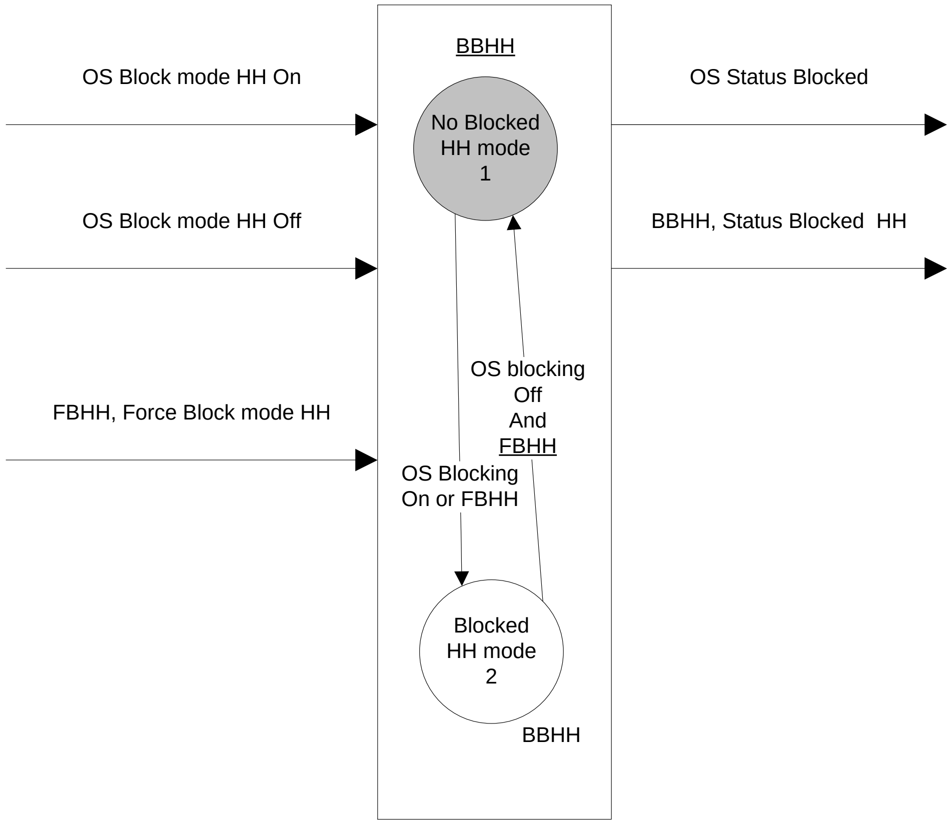


Figure F.7 – Blocked HH mode

F.3.3.3 Blocked LL mode

Similar to Blocked mode, only that this mode only blocks actions following LL alarms. The LL actions can be blocked from the OS, or from the logic input terminal FBLL.

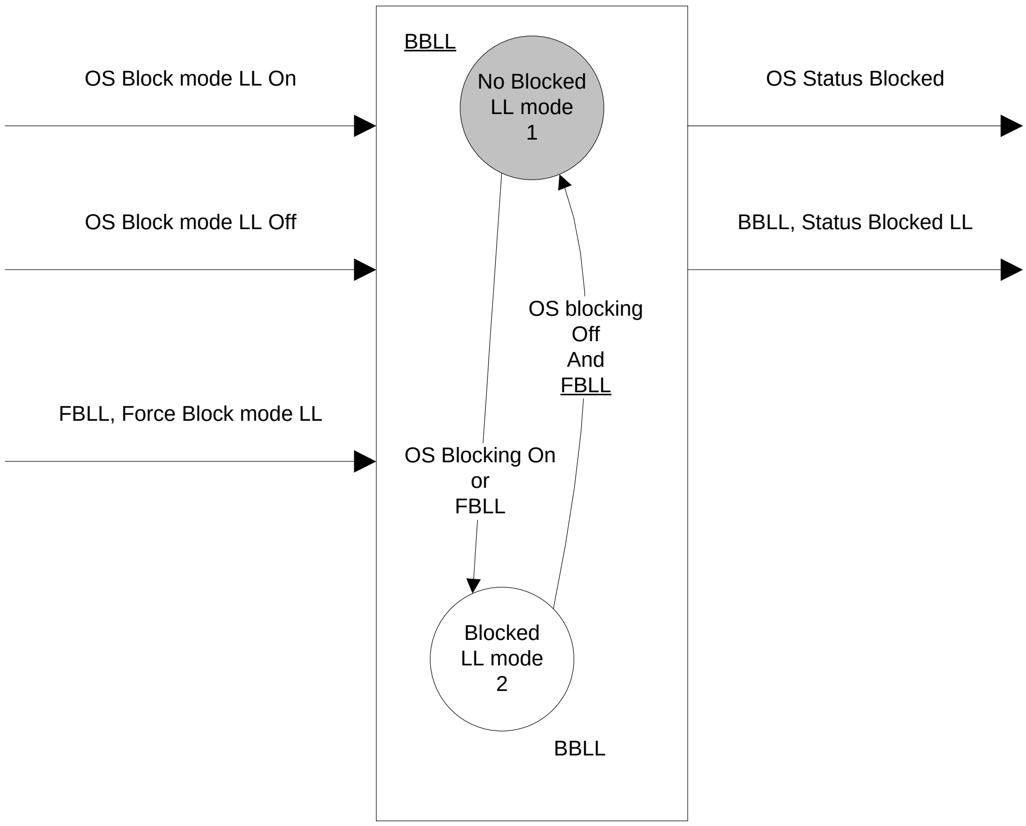


Figure F.8 – Blocked LL mode

F.3.4 Disable transition mode

Disable transition mode is used to prevent the output to go to a high or low state next time this demand is made. If the output is already in low state, and a disable low (FDL) is requested, the output will remain in low state. But when high position is confirmed (BCH) the Disable Transition Low state is entered, and the output will remain in high state even if the input goes low as long as the FDL is true and there is no safeguarding.

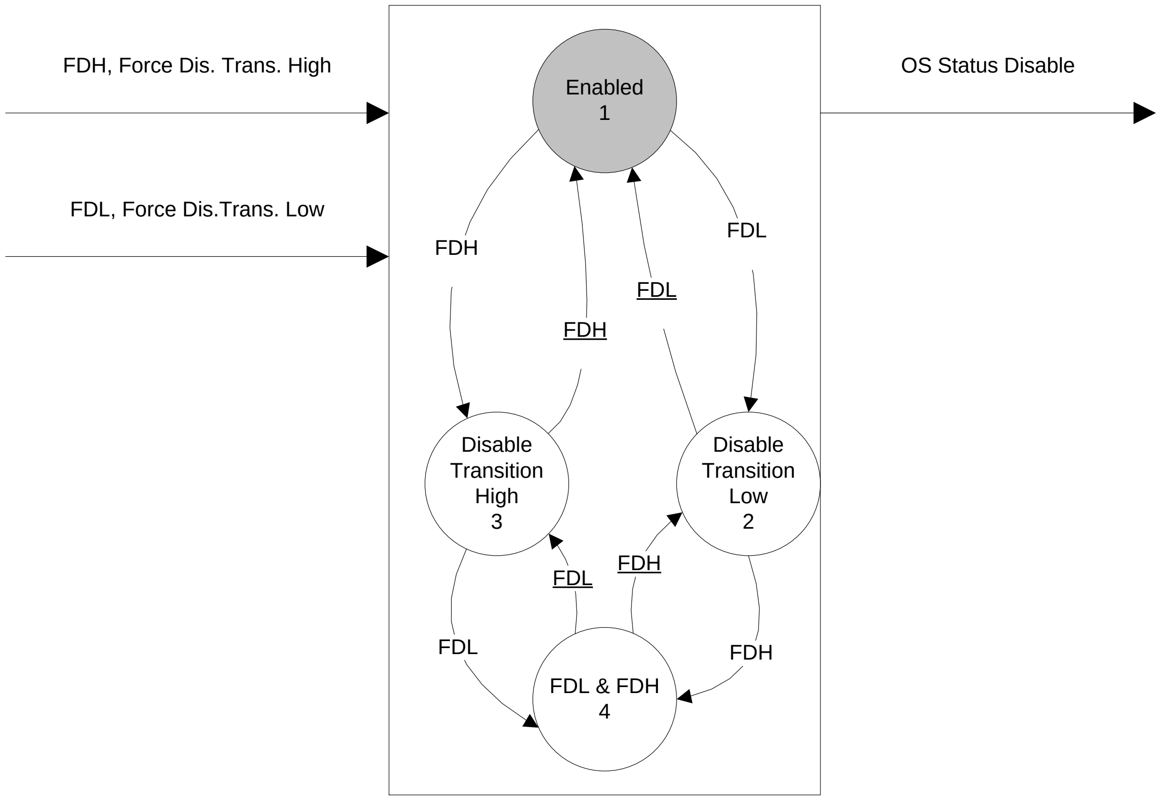


Figure F.9 – Disable transition mode

F.3.5 Internal external mode

Internal External mode controls whether a set point is to be taken from an external terminal or from an internal value set by the operator on the operator station. See e.g. F.4.2.

The locking functionality will prevent the operator from determining if the set point is to be taken internally or from an external terminal.

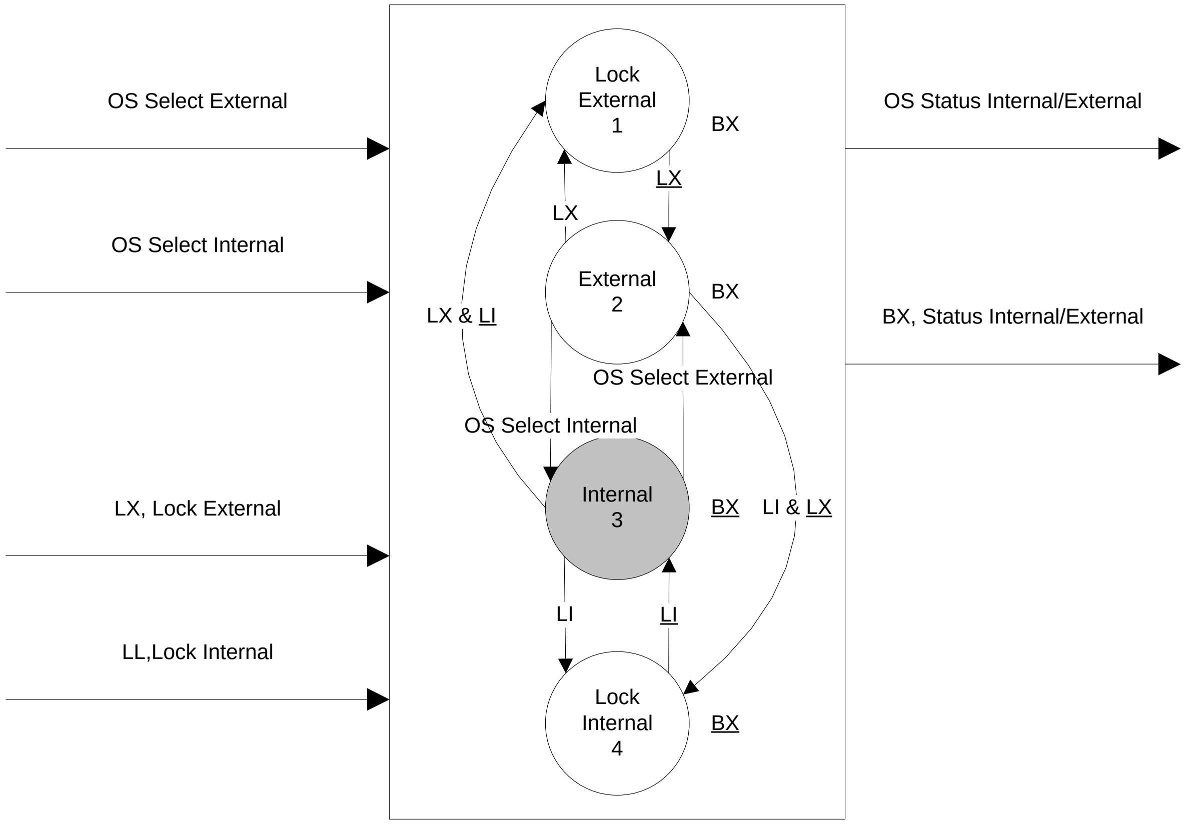


Figure F.10 – Internal External mode

F.3.6 Outside operation mode

When in outside operation state, a valve or engine is controlled (i.e. started/stopped, opened/closed) from a local panel. The central control system can only observe (and if desired display) what happens, but not control the engine or valve. When in No Outside Operation state the valve or engine is controlled by the central control system.

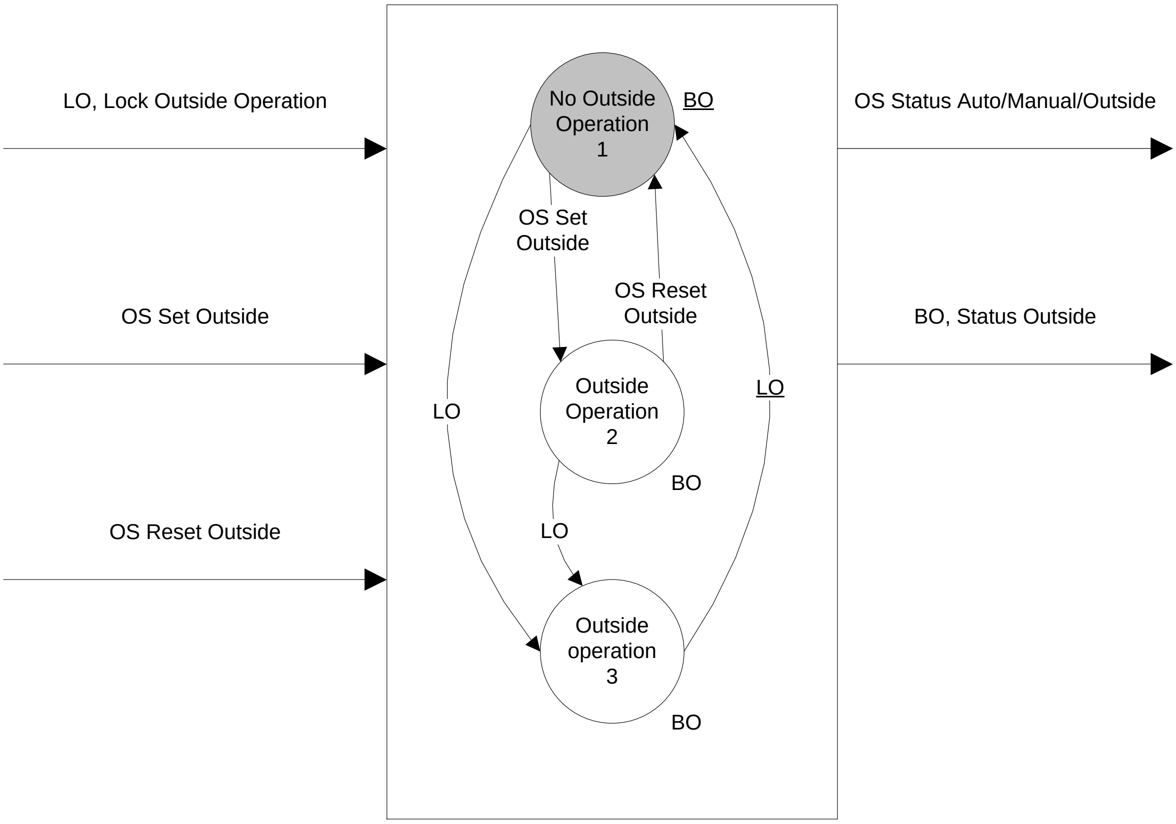


Figure F.11 – Outside operation mode.

F.3.7 Safeguarding mode

Safeguarding mode is controlled by process shut down functionality of the plant, see LB in Figure F.24

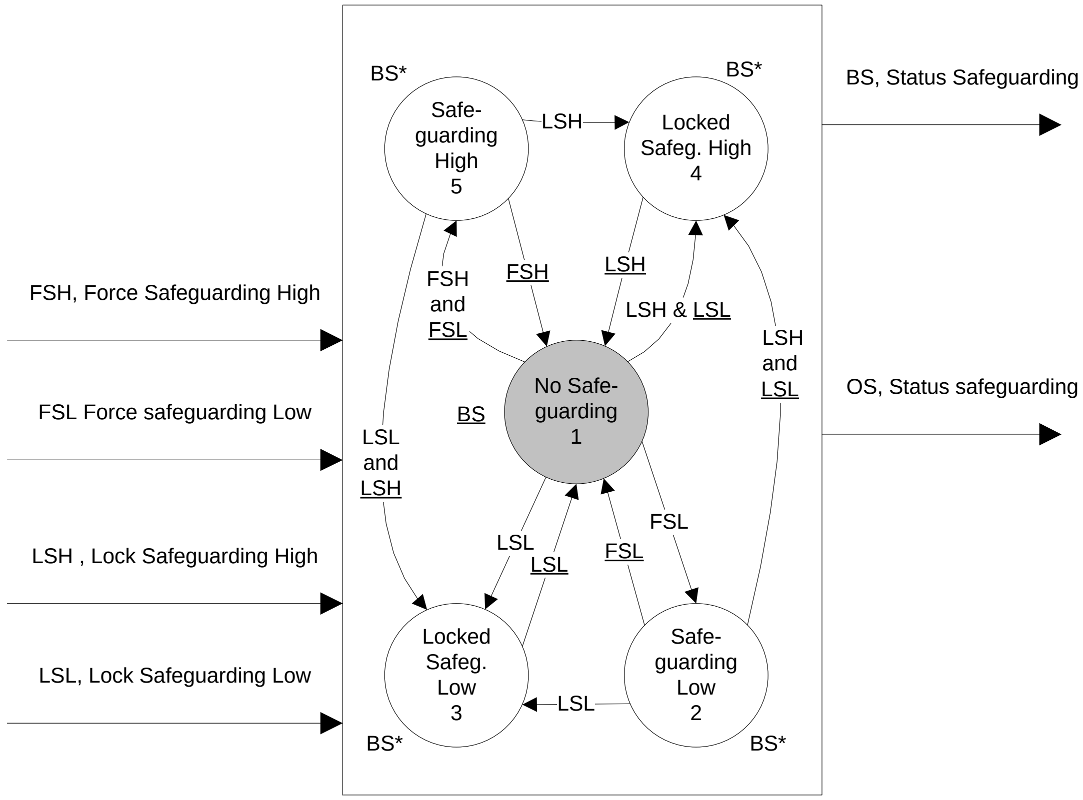


Figure F.12 – Force and Lock safeguarding mode

F.3.8 Suppress alarm mode

F.3.8.1 General

This mode is used to control suppression of annunciation and actions. The mode is controlled both from the logic (FU) and from the operator station (OS).

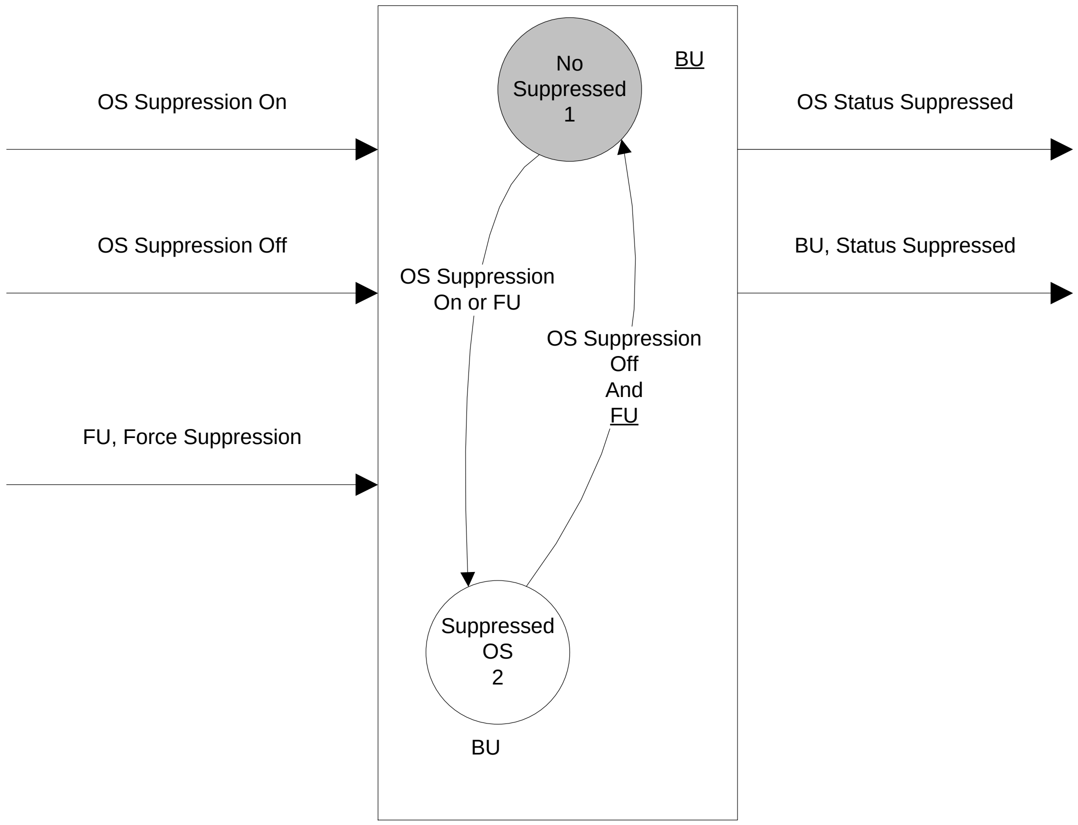


Figure F.13 – Suppress mode

F.3.8.2 Suppress alarm HH mode

This mode controls the suppression of alarms and alarm actions following HH alarms. If in one of the suppression states, the logic output BU is true.

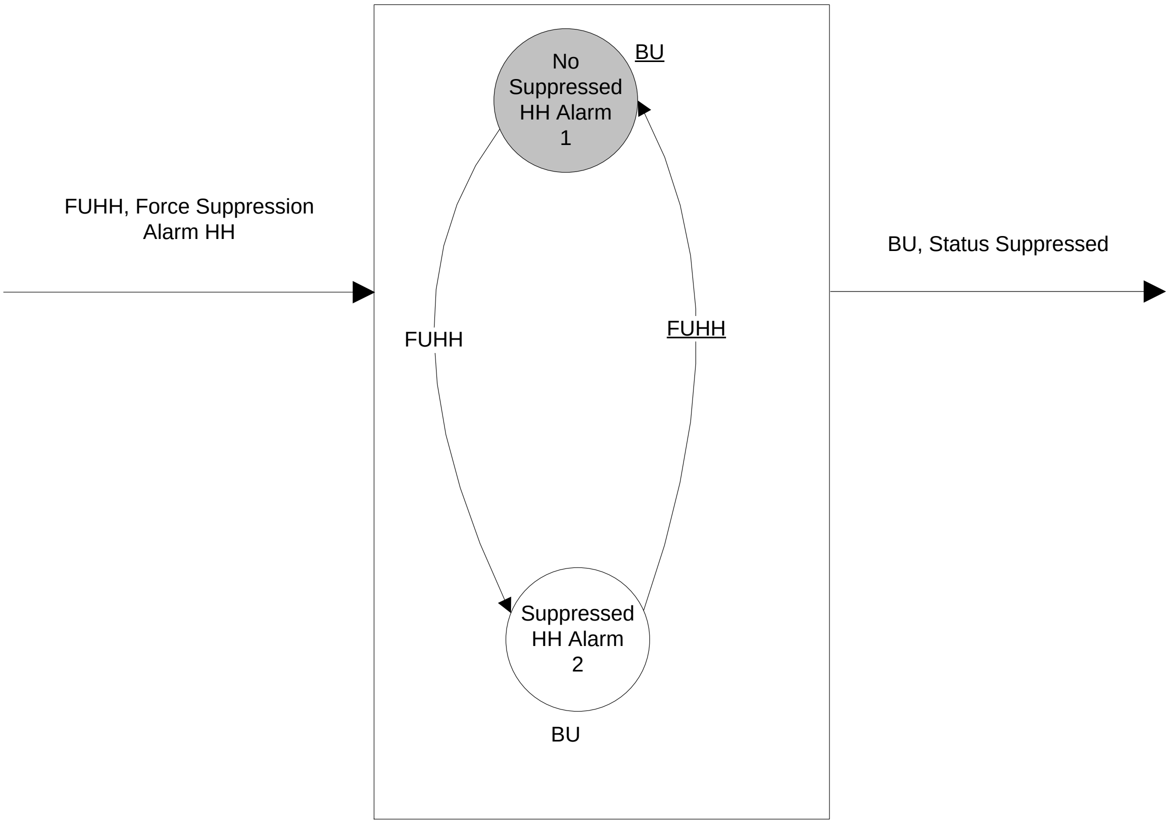


Figure F.14 – Suppress alarm HH mode

F.3.8.3 Suppress alarm LL mode

Similar to suppress alarm HH mode.

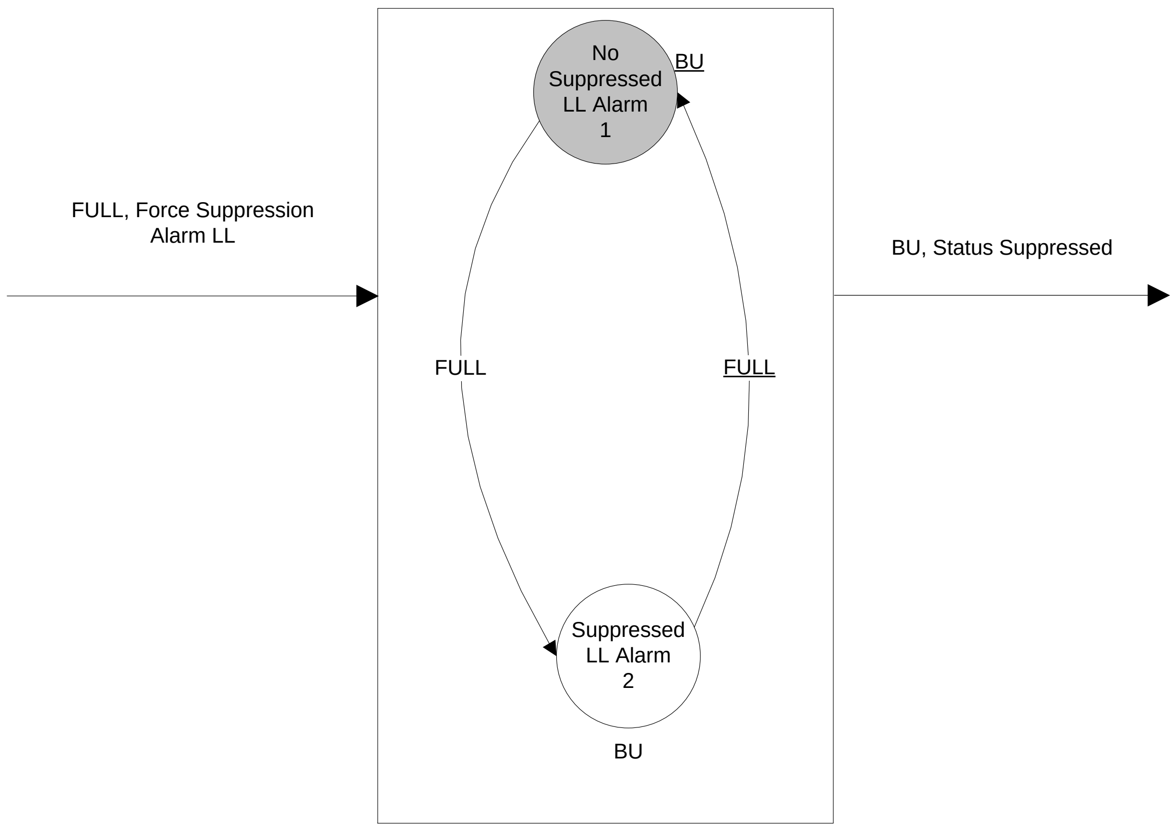


Figure F.15 – Suppress Alarm LL mode

F.3.8.4 Suppress alarm WH mode

This mode is used to control the suppression of the annunciation of a warning high alarm. A warning alarm normally does not have any alarm action, only annunciation.

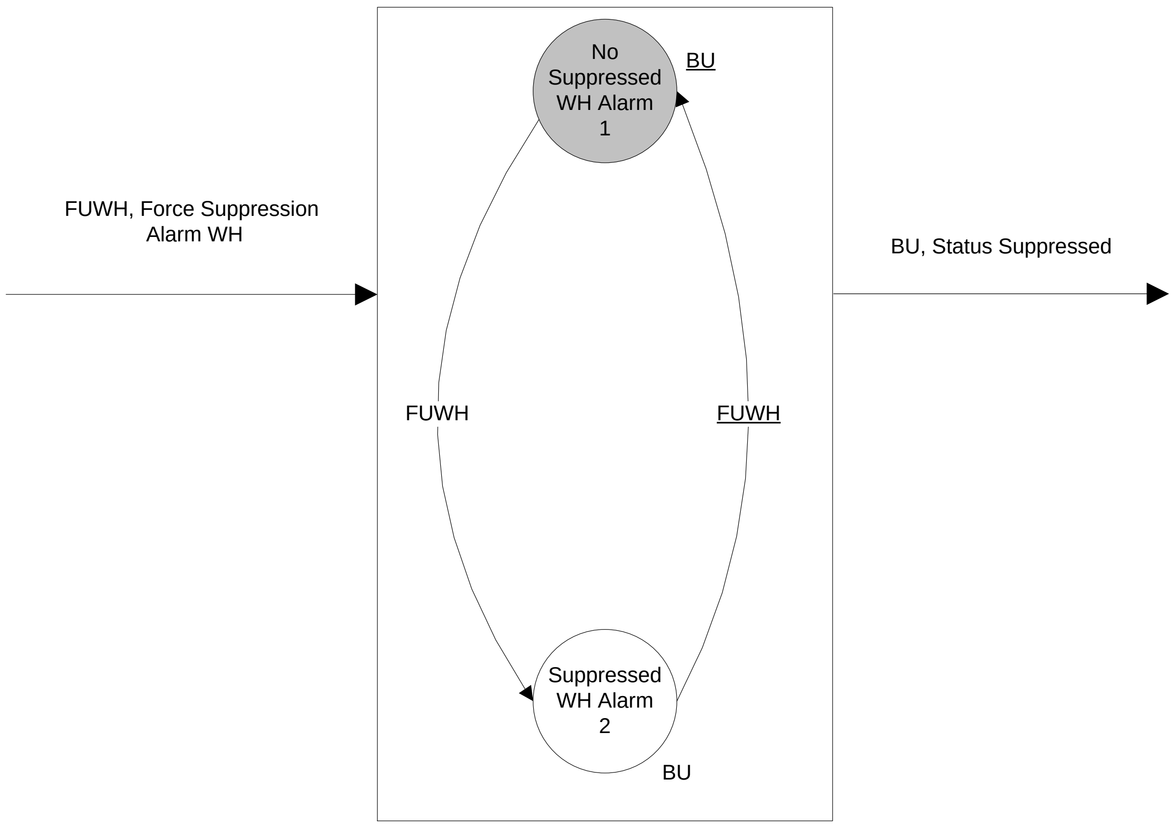


Figure F.16 – Suppress alarm WH mode

F.3.8.5 Suppress alarm WL mode

The suppress alarm WL mode suppresses the annunciation of WL alarms. Warning alarms normally do not have any actions, only annunciation.

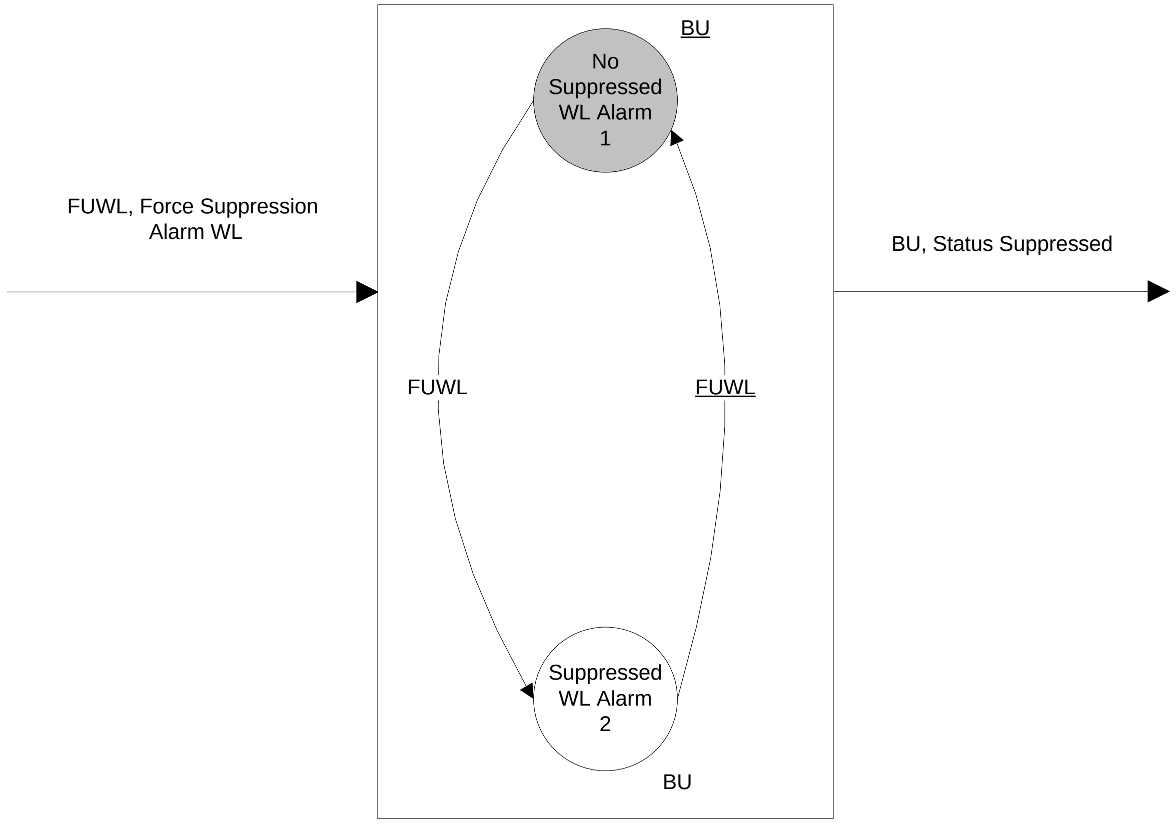


Figure F.17 – Suppress Alarm WL mode

F.3.9 Track mode

Track mode controls whether or not the output of a CA (PID controller) is to follow a track which is given on an input terminal. Track mode is controlled only by the logic.

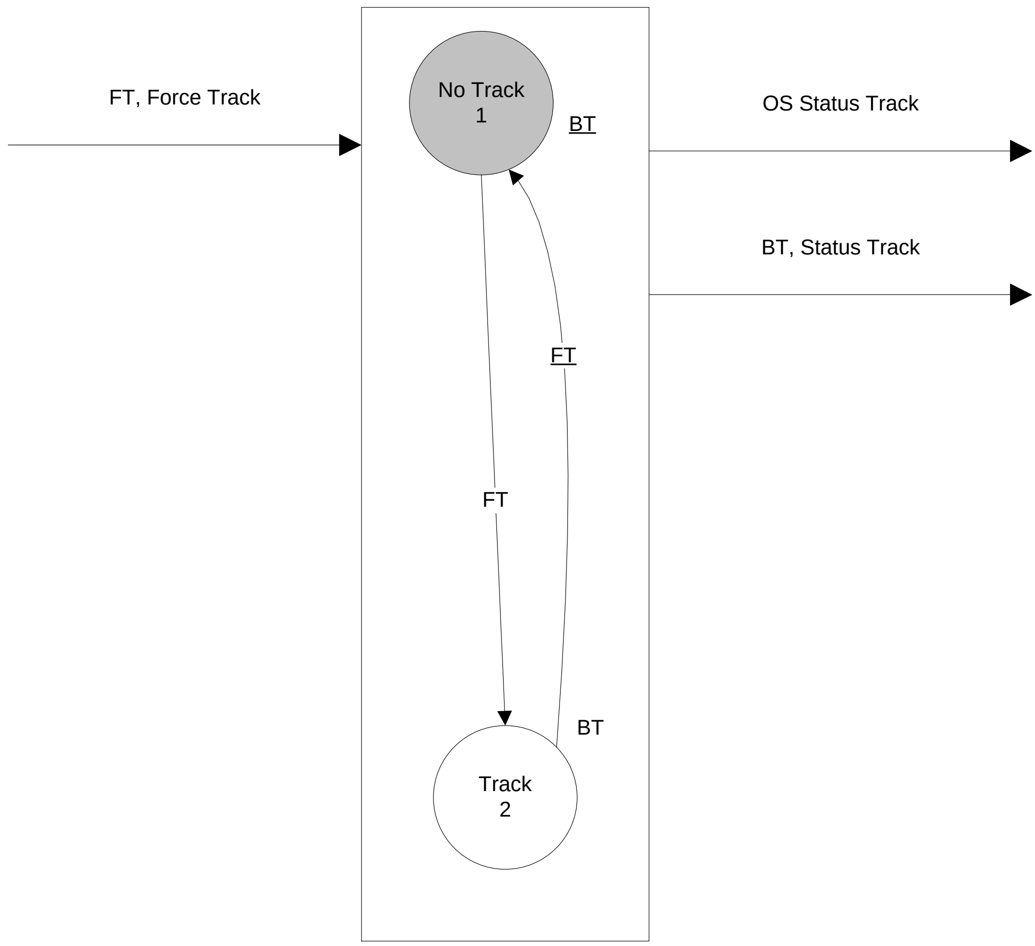


Figure F.18 – Track mode

F.4 Definition of templates control function behaviour

F.4.1 General

This clause will contain description of the behaviour of the NORSOK control functions. The behaviour will be defined using the mode state charts in F.3.

In each template behaviour figure each mode is represented with a full mode state chart. Subset of state charts are not defined even it in some cases the full version is not relevant. The actual terminal present for each template defines the applicable states that can be reached.

F.4.2 CA - PID controller template behaviour

Figure F.23 reflects the behaviour of the CA template (PID controller), and illustrates the template's functionality with regards to the following modes:

Internal/External mode
The setpoint value may be set either internally or externally.
In internal (and auto) mode, the internal setpoint value is set from the OS and used in the PID algorithm.
In external (and auto) mode, the external setpoint value is set from logic and used in the PID algorithm.

Tracking mode
In tracking mode, the output will follow the input terminal XT. The controller must additionally be in auto mode for tracking to be active. The PID algorithm is disregarded in this mode.

Auto/manual mode
In auto mode, the PID algorithm is active and continuously calculates the output value according to the analogue input signal, selected setpoint and PID parameters. In auto mode only (i.e. not additionally in tracking mode), the calculated value is used as the CA template output if no safeguarding actions are active.
In manual mode, the PID algorithm is not active. The output is set manually from OS, and used as the CA template output if no safeguarding actions are active.

Safeguarding mode
In safeguarding mode, the output is set to either minimum operating range (e.g. 0 %) or maximum operating range, e.g. 100 %. Safeguarding mode overrides auto, manual and tracking modes.

Block mode
Block mode will override safeguarding mode.

Suppress mode
The following faults/alarms are suppressed:

- External fault (XF=1)
- Input signal (X) outside range
- Function fault indicating mismatch between output value and valve position.
- Deviation alarm between setpoint and measured process value.

Explanation of the control functions (rectangles) follows:

"Control Function 1": This function is the PID algorithm. The proportional, integral and/or derivate algorithms form the main function of the PID controller.

"Control Function 2": This function serves several tasks as follows:

- Compares the measured value to the setpoint and initiates a deviation alarm (WV) if the deviation exceeds a pre-set limit.
- Generates high and low alarms (WH/WL) based on comparison between a set of alarm limits and the analogue input value.

- Sets confirmed closed status (BCL). The confirmed closed state is set when the Y output is within a pre-set limit, and if the control valve has a closed limit switch, the limit switch must additionally be set.
- Generates failure status (YF) if an external or internal fault is reported.
- Includes a feed forward control function. The feed forward function is SAS vendor dependent, but shall as minimum include a proportional factor that is multiplied with the feed forward signal. The function is disabled if no signal is connected to the XFF input terminal.

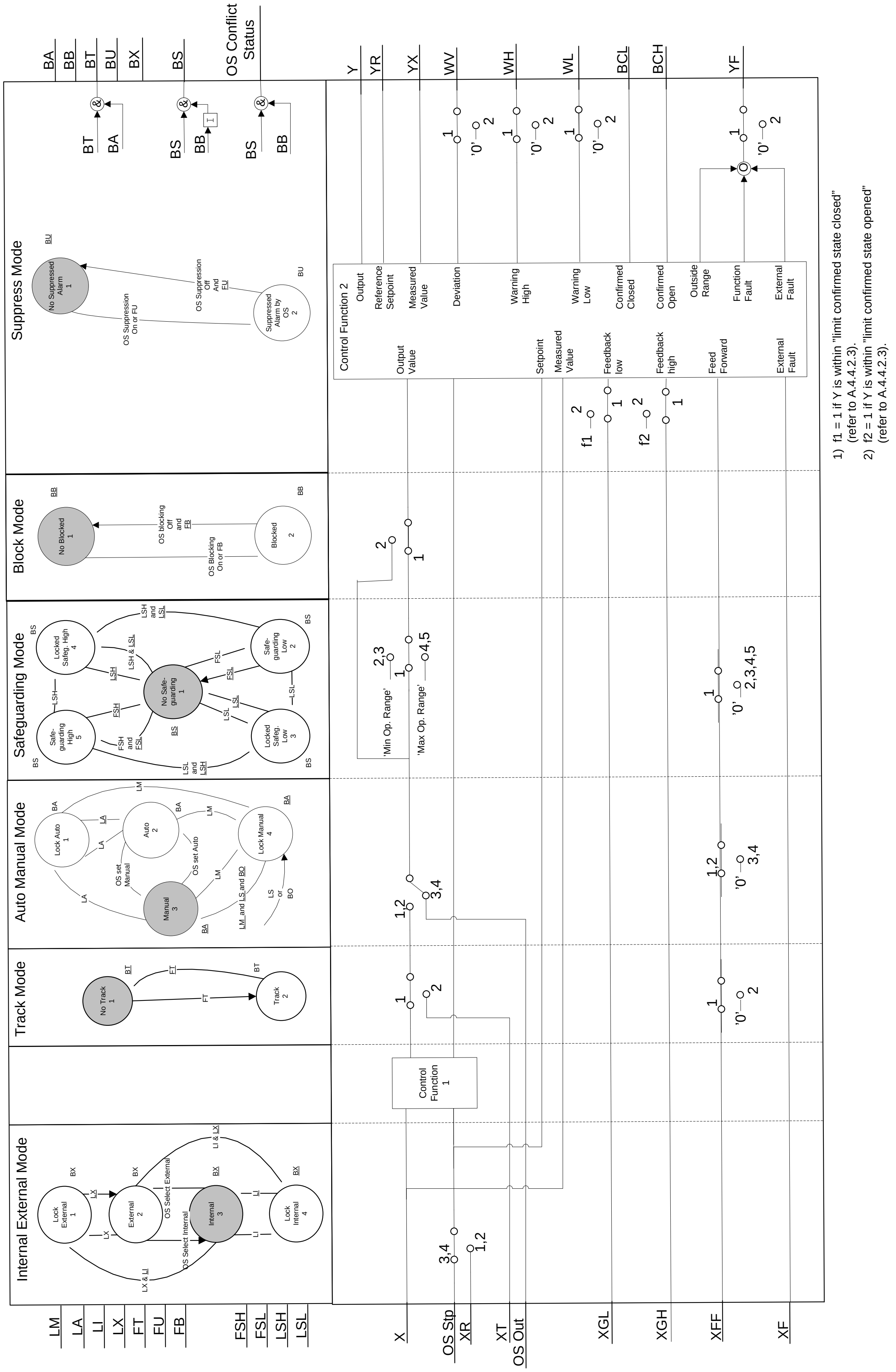


Figure F.19 – Model of CA behaviour

F.4.3 CS - Step control template behaviour

The Step Control Template is used for control and monitoring of position controlled valves. The valves are operated by either pulsed or steady output signals. The output YH will cause the valve to step/move towards the open position. The output YL will cause the valve to step/move towards the closed position.

When commanded to a specific position, either in auto or external, the valve will be commanded using YH/YL until the position reading (XG) is within the commanded setpoint +/- the acceptable deviation (comparison value).

In manual mode, single step commands for opening and closing is given by the operator.

Explanation of the control function rectangle is as follows:

"Control function" : This function serves several tasks. It generates the step signal onto the outputs YH/YL. It monitors the valve position compared to the commanded setpoint and optionally raises an alarm on deviation (WV) after a calculated travel time. It generates failure status YF if an external or internal fault is reported and it compares the actual output to the feedback status from the valve and gives the BCL status out.

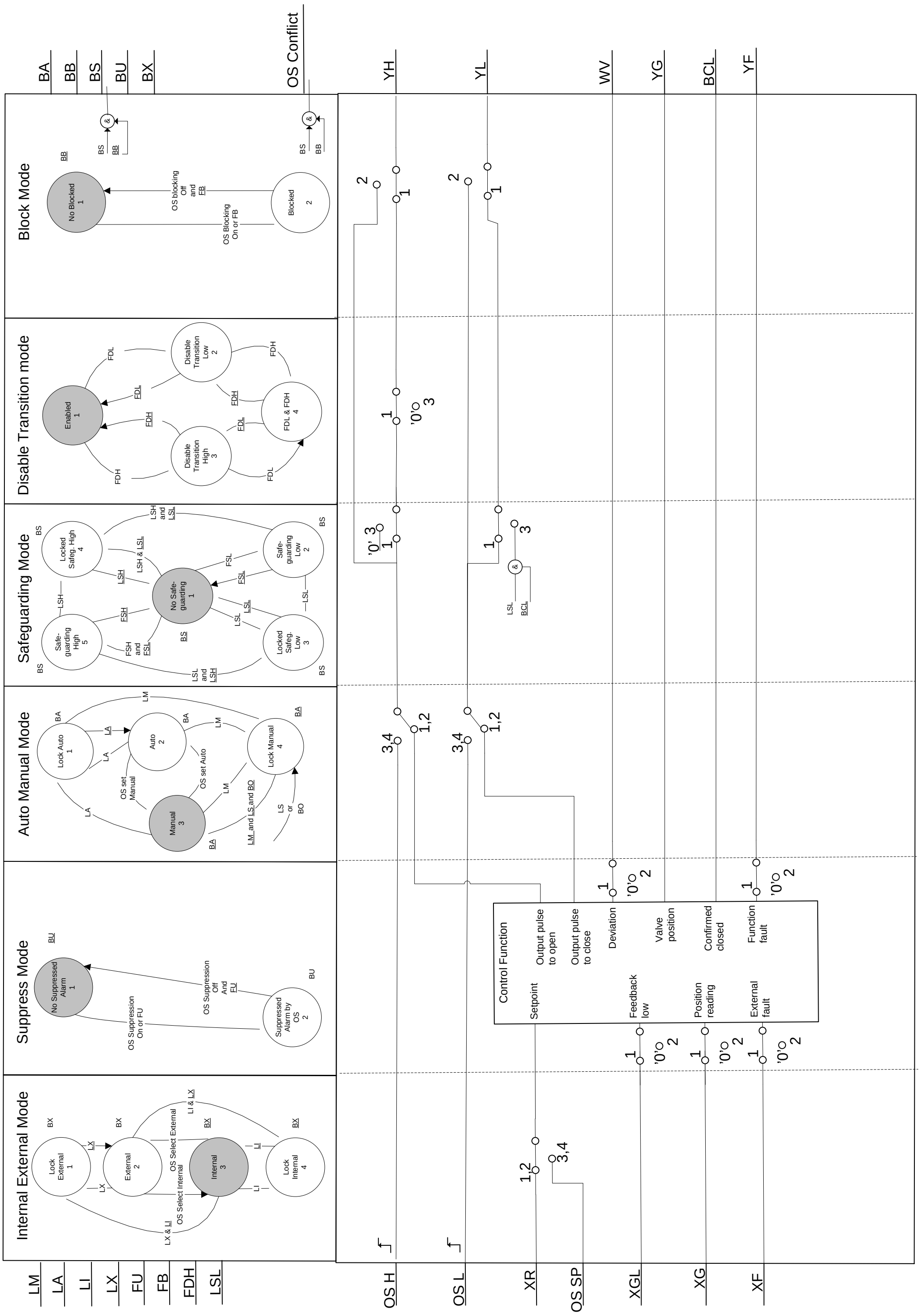


Figure F.20 – Model of CS behaviour

F.4.4 HA - Analogue input command template behaviour

The Analogue input command template is used for entering an analogue value from the HMI.

Explanation of the function rectangle is as follows:

"Ramp" : When switched to auto mode the output (Y) will follow the external set value (X) according to a ramp rate defined by ramp time parameter.

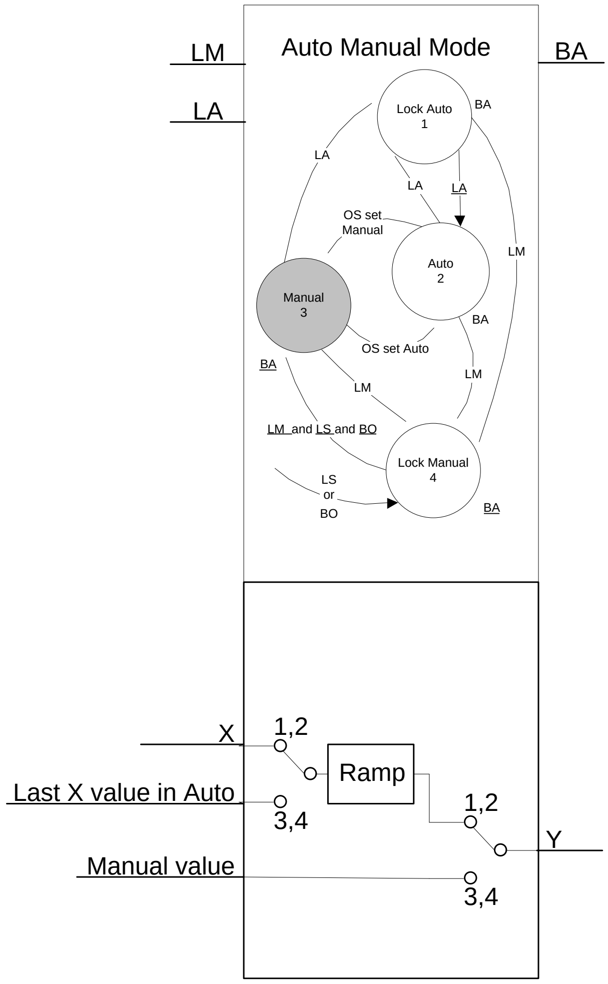


Figure F.21 – Model of HA behaviour

F.4.5 HB - Binary input command template behaviour

The binary input command template is used for entering a binary value from the HMI.

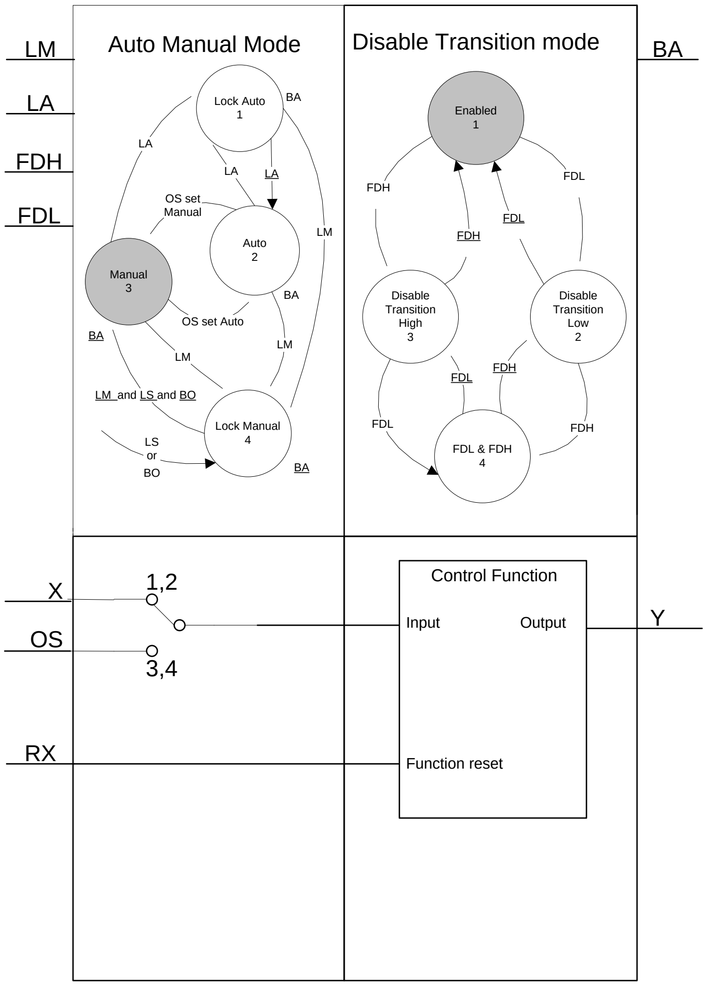


Figure F.22 – Model of HB behaviour

F.4.6 KB - Sequence header template behaviour

The KB function template shall be used for sequences as an interface for controlling the sequence from HMI and/or other control logic. The normal operations are start (continue), hold and terminate.

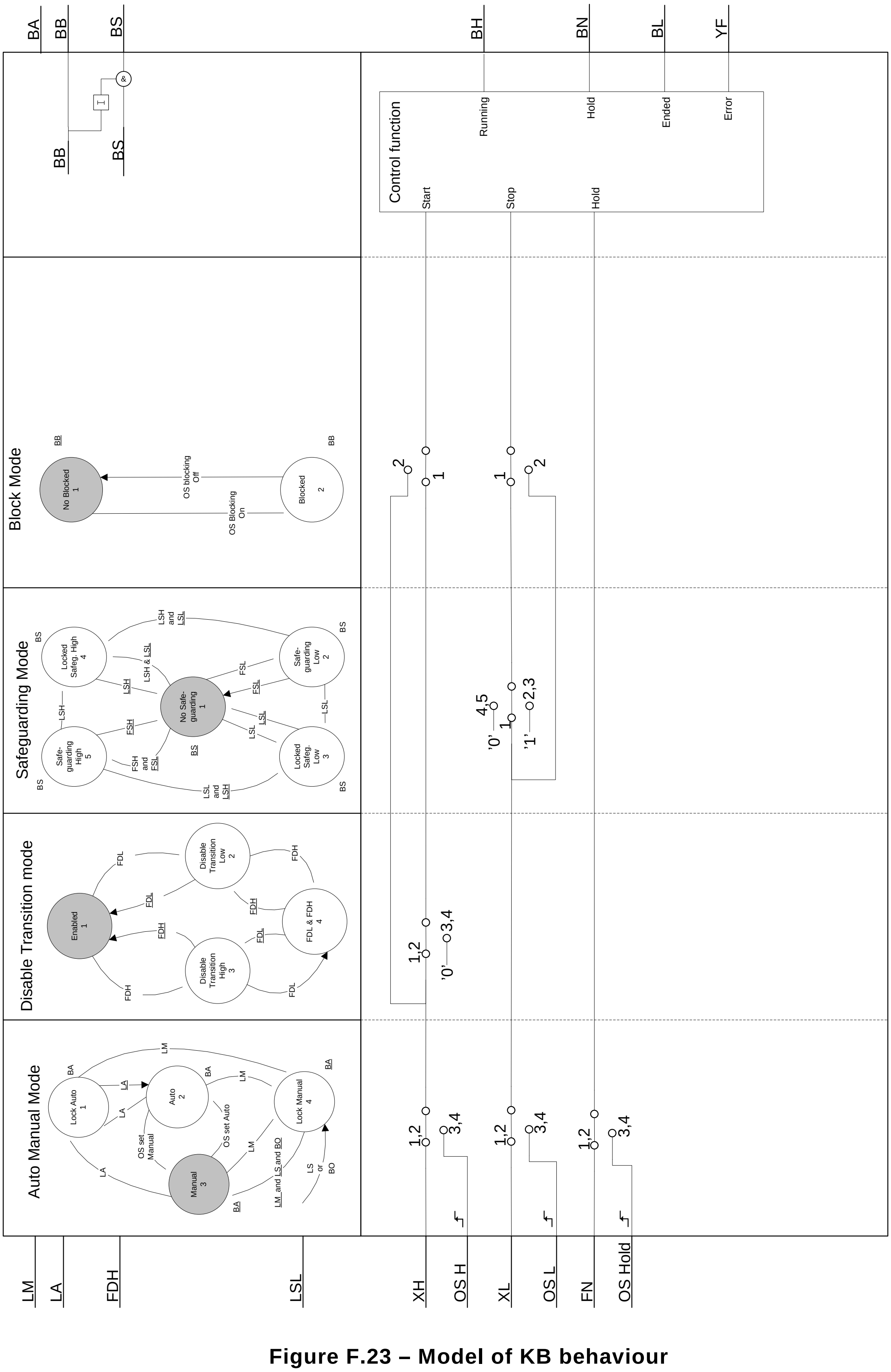


Figure F.23 – Model of KB behaviour

F.4.7 LB - Safeguarding shutdown level template behaviour

The LB template controls the setting and resetting of shutdown level actions.

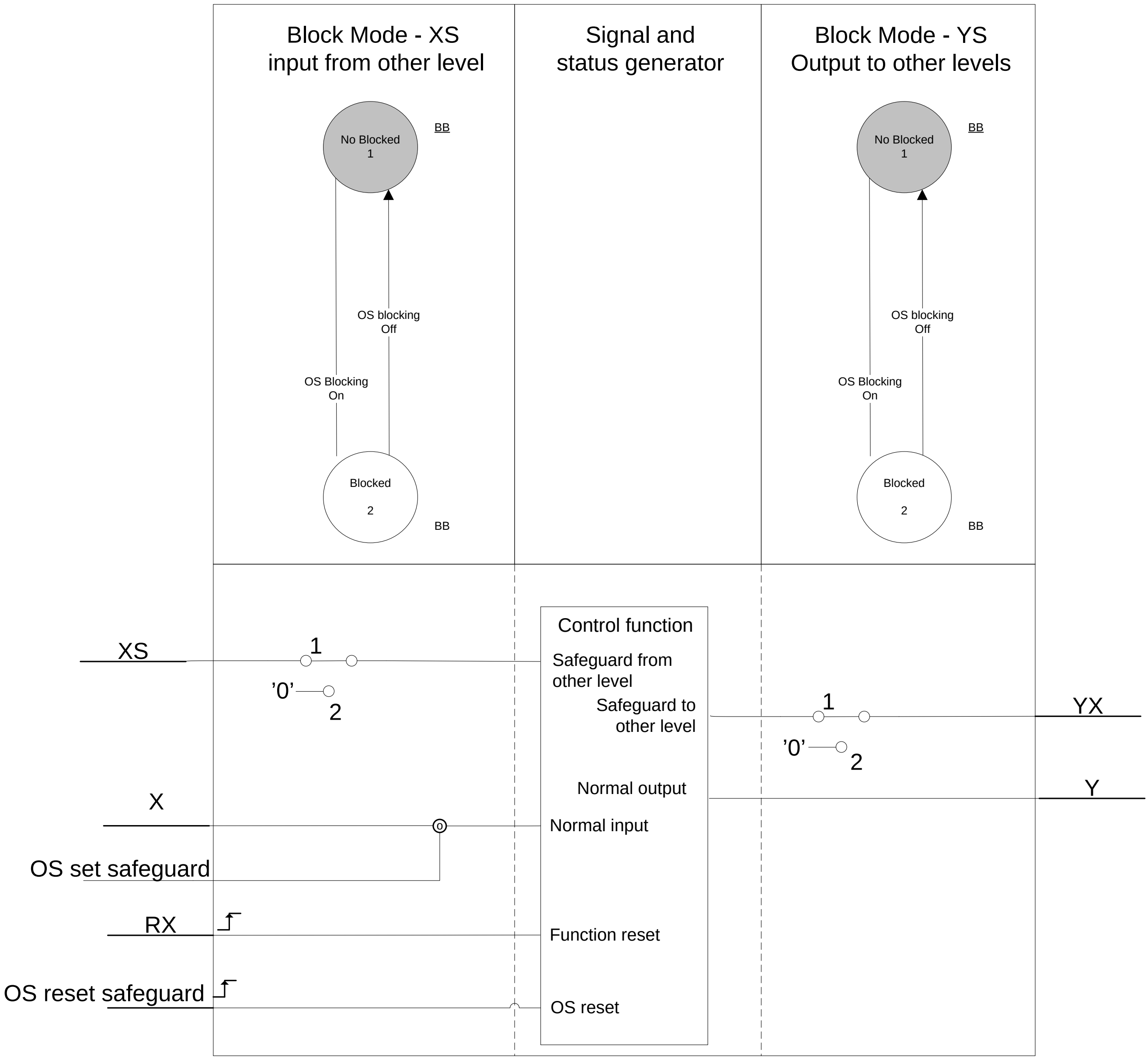


Figure F.24 – Model of LB behaviour

F.4.8 MA - Monitoring of analogue process variable template behaviour

The MA template monitors an analogue variable, X, converts the X value to a defined unit (0 % - 100 %, bara, barg, mm, etc), set alarms and events, and allows the operator to interface the function template.

The control function (rectangle)
compares the analogue input value X (or reconditioned value) with alarm, warning and event limits and generates output states if the limits are either above (AHH, WH, BXHH, BXH) or below (ALL, WL, BXLL, BXL) set limits. AHH and ALL are delayed according to parameter.
The error detected status appears if either the XF flag is set high, the measured X is out of bounds or if an internal error in the FB is detected.

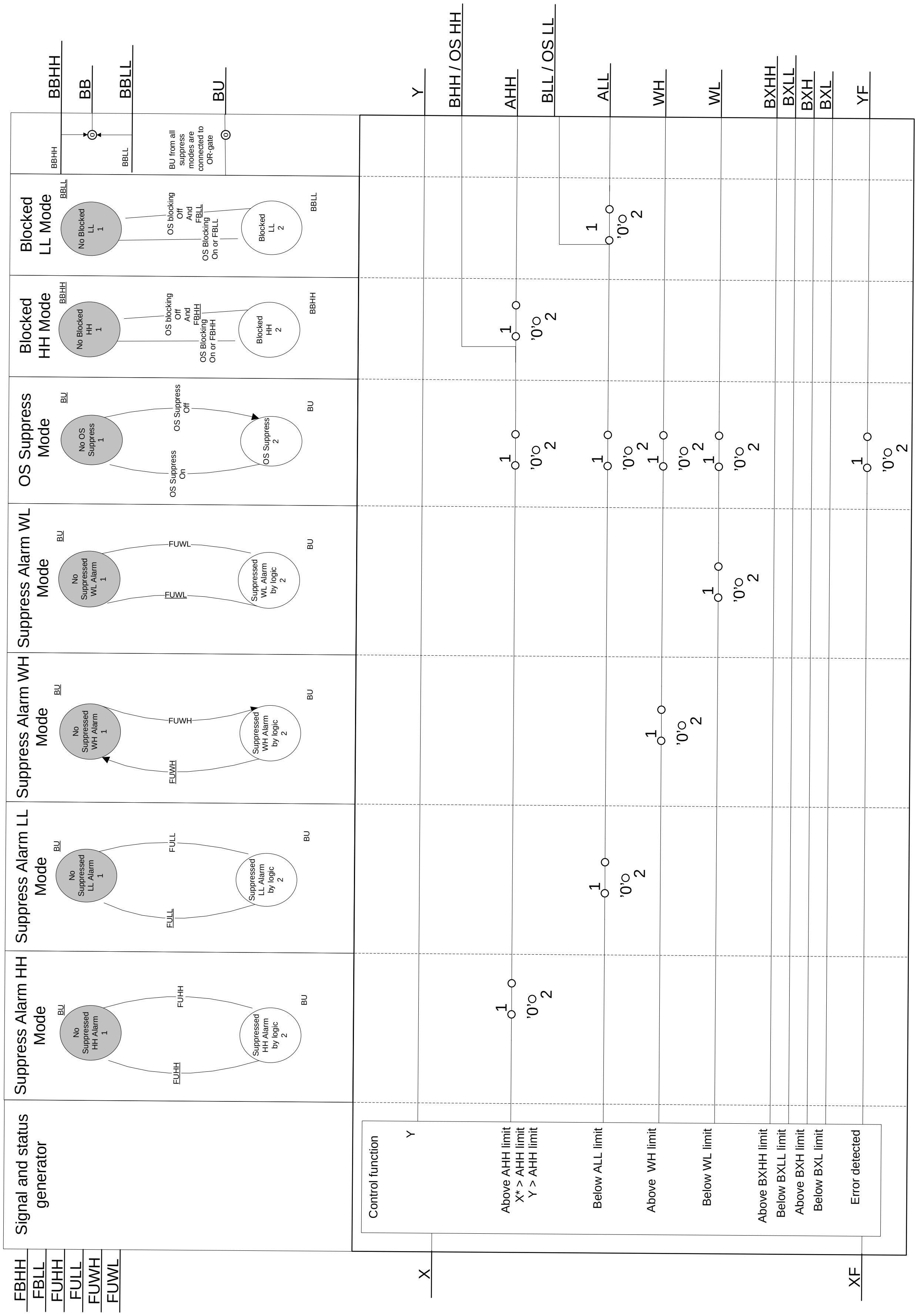


Figure F.25 – Model of MA behaviour

F.4.9 MAS - Analogue measurement acquisition from subsystem template behaviour

The MAS function template shall be used for analogue variables acquired from other control systems, e.g. vibration monitoring, metering, analysers, etc.

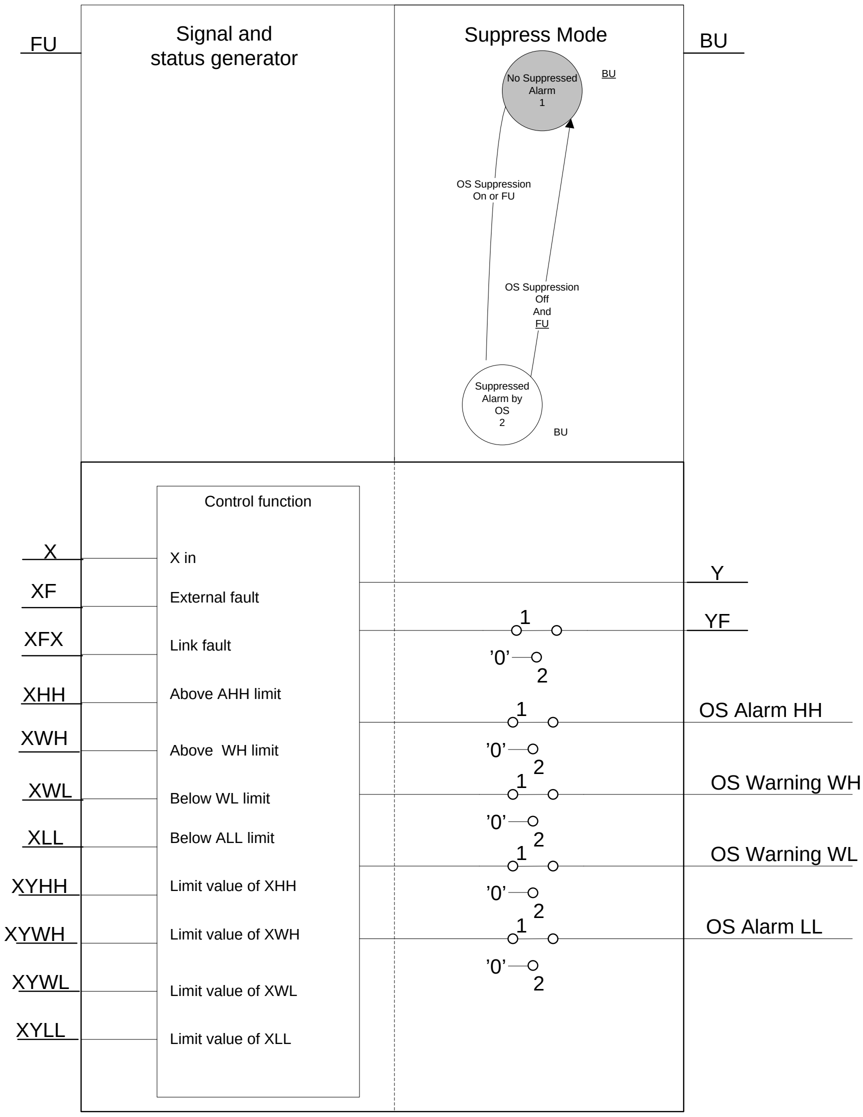


Figure F.26 – Model of MAS behaviour

F.4.10 MB - Monitoring of binary (digital) process variables template behaviour

The MB template monitors a binary variable, X, set a function output, generates alarm (delay according to parameter)/event and allows the operator to interface the function template.

The control function sets the Y output in two different manners based on parameters set for the FB. Either the Y output shall be set equal to X, or Y output shall be set when X goes high and reset when RX is set to 1. The error detected status appears if either the XF flag is set high or if an internal error in the FB is detected.

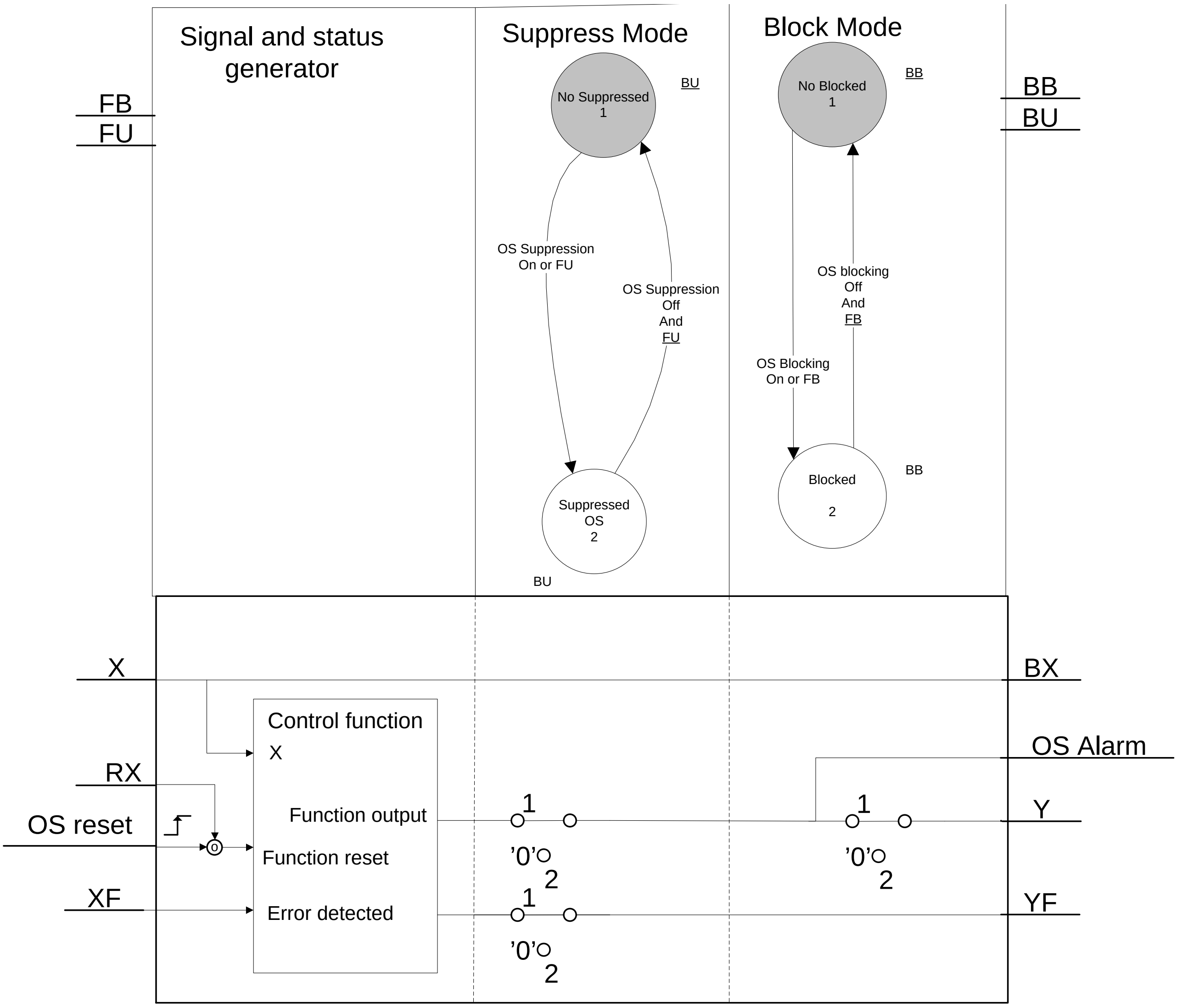


Figure F.27 – Model of MB behaviour

F.4.11 OA - Analogue output template behaviour

Figure F.28 reflects the behaviour of the OA template. The figure illustrates the functionality of the OA with focus on the impact of the different modes. It is also included one control function for treatment of non boolean functionality. The output Y is calculated in the control function.

Explanation of the control function (rectangle) is as follows:

"Control function" : This function calculate the output Y based on the parameters for input, output and operating range. The function also calculates BCH/BCL and deviation fault based on the parameterized feedback configuration. For more details of the functionality, see description in Annex A.

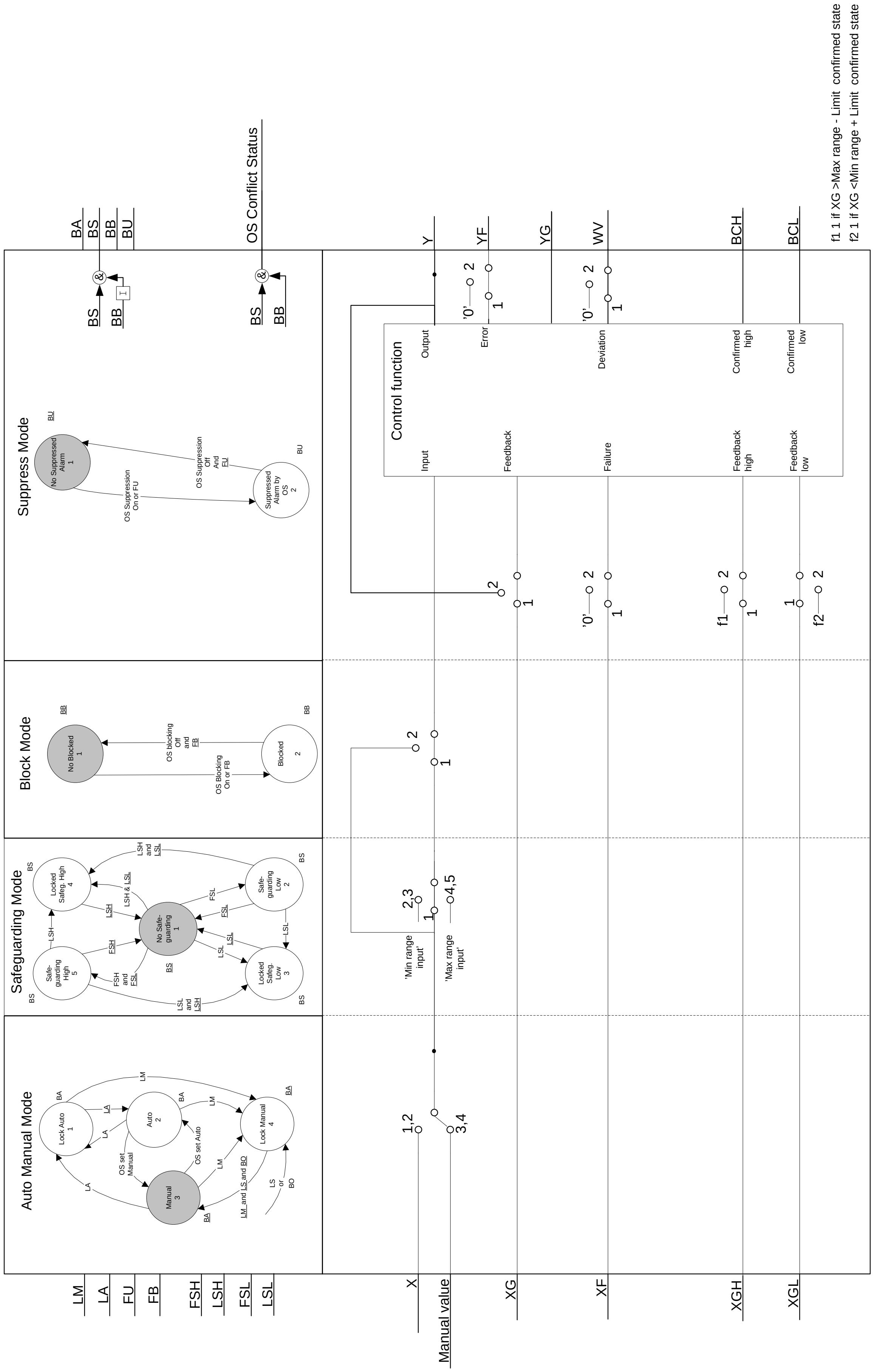


Figure F.28 – Model of OA behaviour

F.4.12 QA - Totalize template behaviour

The totalizer template performs an integration of the input value (Normal Function Input) and sets the value out on the output terminal.

There are various ways to control the totalizing mechanism (totalizer function). The totalizing function shall be enabled from logic external to the template. Once enabled, the Totalizing function can be switched on and off. The integration mechanism can also be reset to start from zero again.

Explanation of the control functions (rectangles) is as follows:

“Totalizing and Limit check”: This function serves several tasks. It performs the main totalizing function. It generates failure status YF if an external or internal fault is reported. It also generates WH/AHH signal based on comparison between a set of alarm limits and the analogue input value.

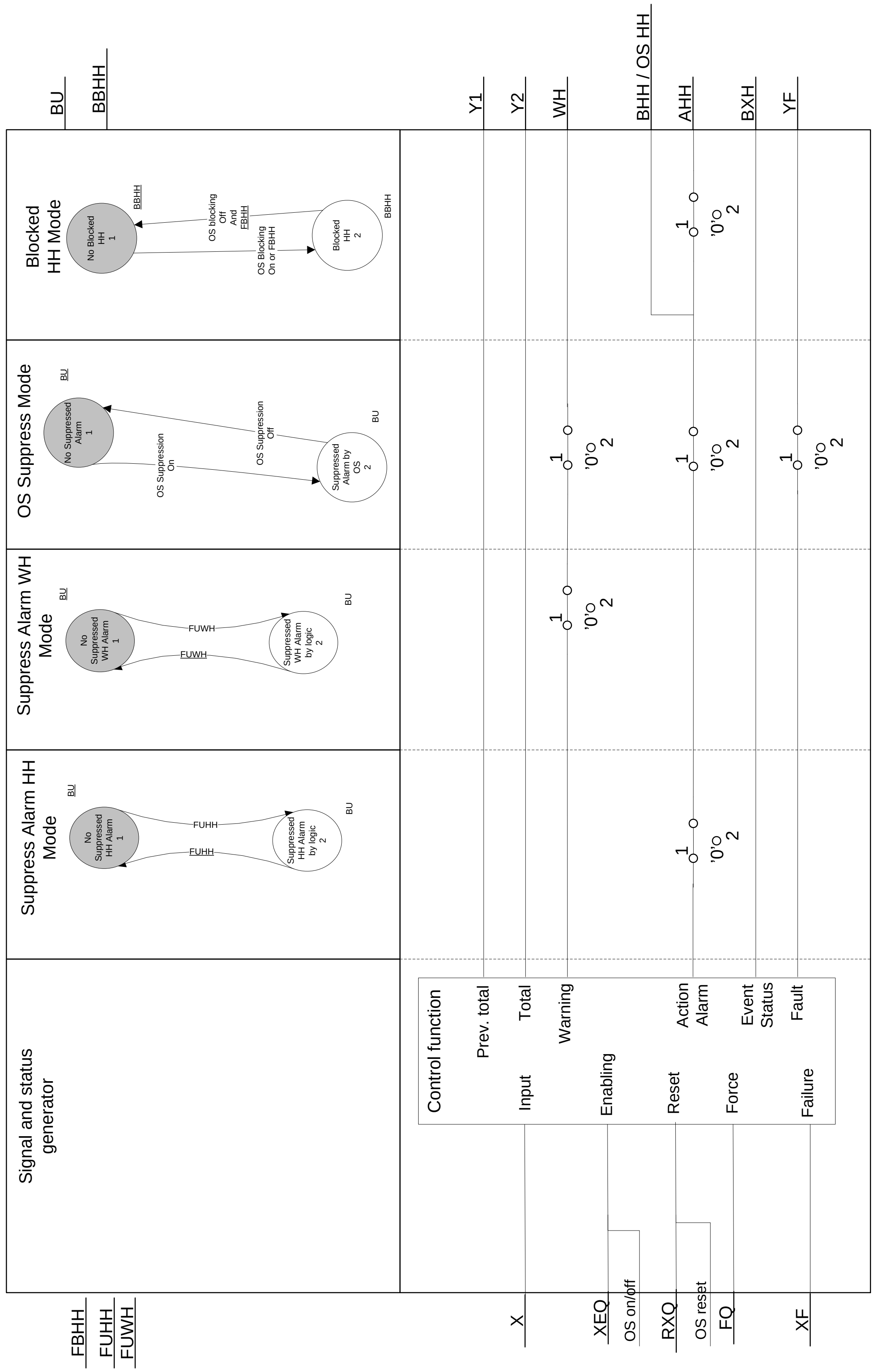


Figure F.29 – Model of QA behaviour

F.4.13 SB - Single binary signal for shutdown template behaviour

Template used for a single signal from a shutdown node (or a process node) not controlling the equipment that shall be shut down. The output signal Y is equal to input signal X unless the signal is blocked by the operator.

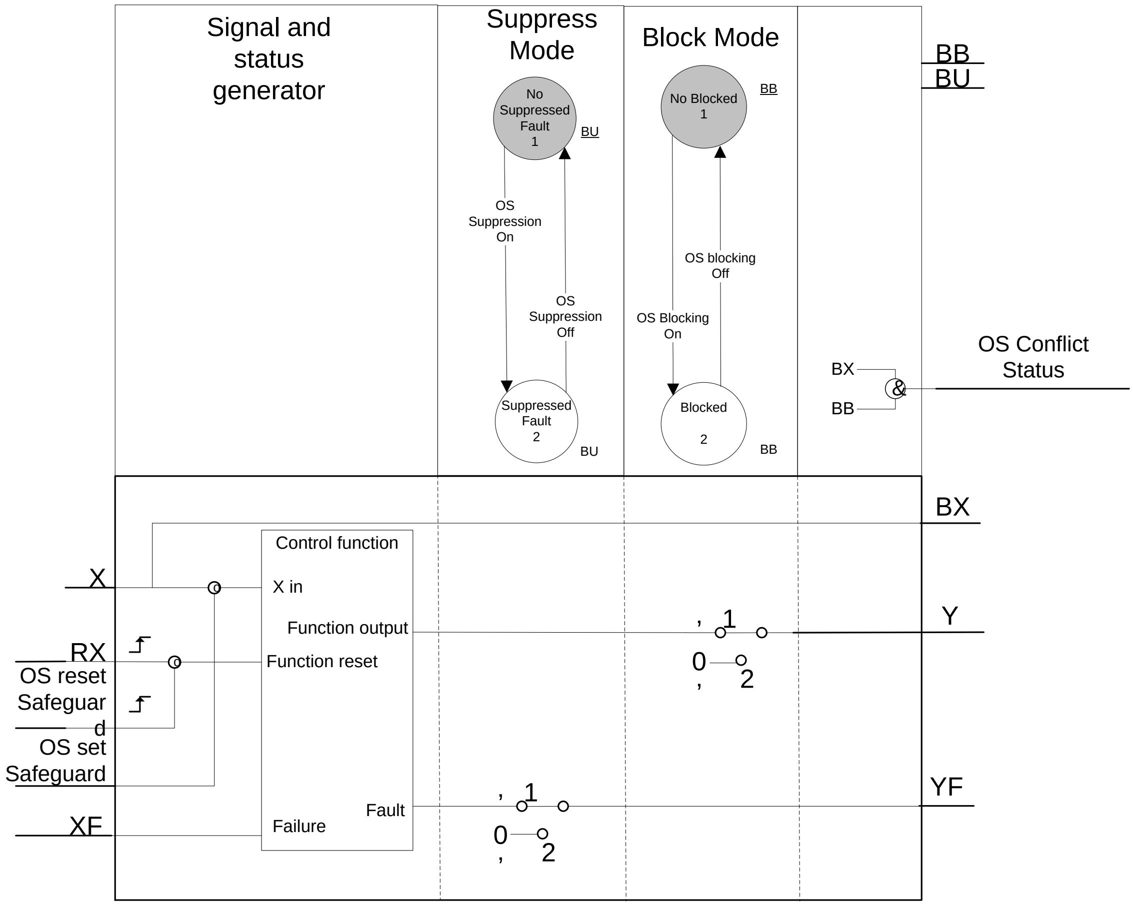


Figure F.30 – Model of SB behaviour

F.4.14 SBB - Breaker control template behaviour

Function Template for binary (on/off) control of electricity to switchboards or consumers.

Explanation of the control functions (rectangles) is as follows:

“Control Function” This function serves several tasks..

- It generates failure status YF if an external or internal fault is reported;
- It sets the output Y according to parameter when faults are detected;
- It sets the output Y based on feedback in outside mode when no external inputs are used (XOH/XOL).

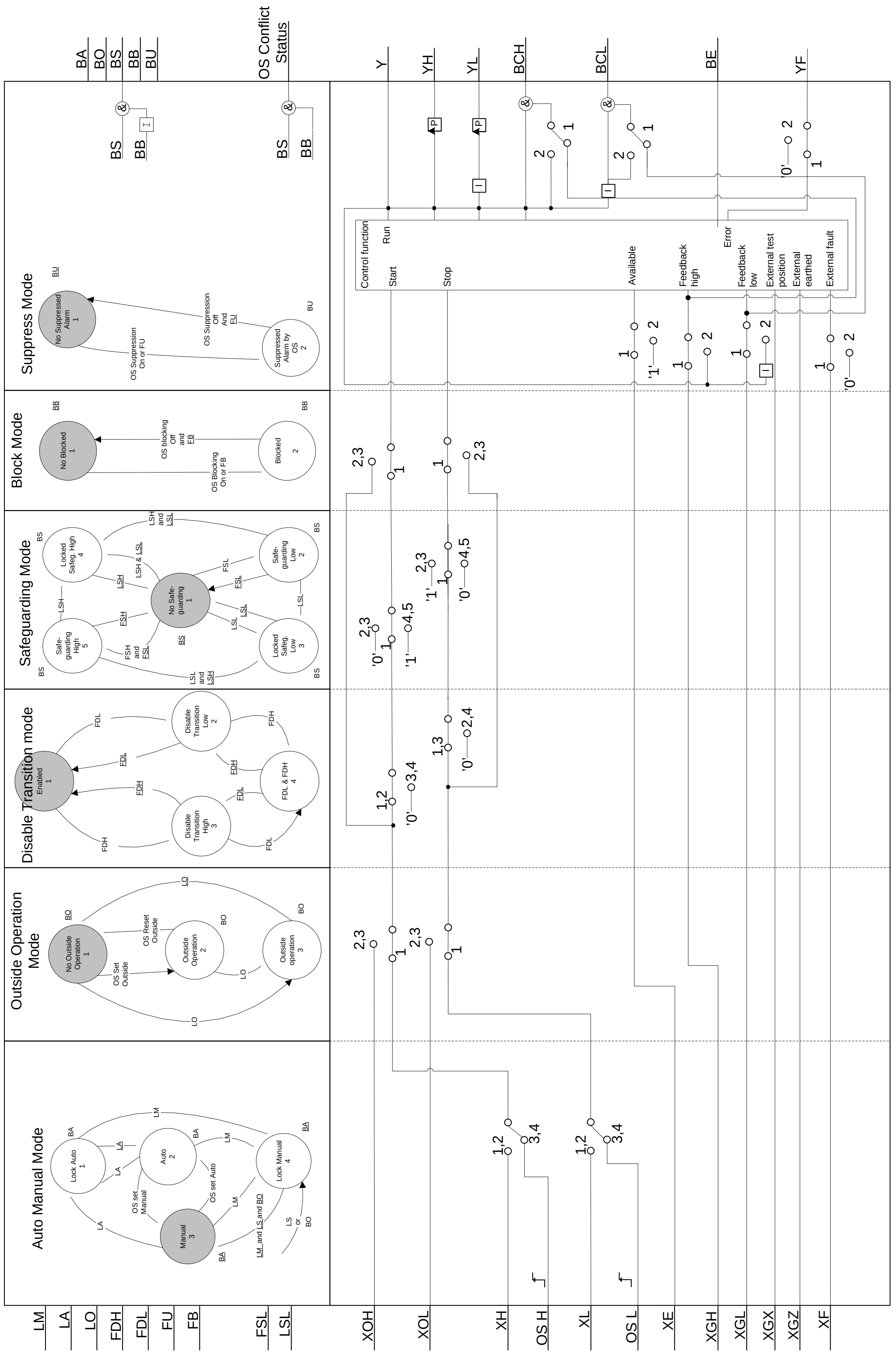


Figure F.31 – Model of SBB behaviour

F.4.15 SBC - Coordinator for SBE template behaviour

General

Figure F.32 reflects the behaviour of the SBC template. The figure illustrates the functionality of the SBC with focus on the impact of Auto/manual and suppress modes. It is also included two control functions for treatment of non-boolean functionality. The connection to the actual SBE functions are made by means of structured interconnection variables (status SBE 1..6 and command SBE 1..6). Dependent of settings of parameters SBE's have to be in auto mode to be taken into account.

SBC in Manual Mode

The operator start and stop the required set of connected SBEs by start/stop commands OS H/OS L. The operator set the requested amount of running SBEs as a number from HMI (Man. Req. OS).

SBC in Auto Mode

For main stop of the coordinator, XL is used. Start command is based either on XH or XnH, dependent of a parameter, described in Annex A. The next main issue is to select the amount of requested SBE units to be running. This selection will be made either based on digital signals XnH/XnL or by a value XQ. The selection of the method for deciding number of required SBE is made based on a parameter as described in Annex A.

Explanation of the control functions (rectangles) is as follows:

"Control function 1" : This function calculate the requested number of running SBE. This is based on current mode (auto/man) and also a parameter to decide which terminals to be used. For more details of the functionality see description in Annex A.

"Control function 2" : This function handles the priority list of the SBE. It selects which SBE shall run based on this list and the required amount of running SBE. This function keeps track of the SBEs that are stopped because of failure, and start standby SBEs accordingly. It gives information about the number of requested SBE (provided by the "Required" control function) and the number of running SBE. If the system can not obtain the requested amount of running SBE, A fault message will be generated. For more details of the functionality, see description in Annex A.

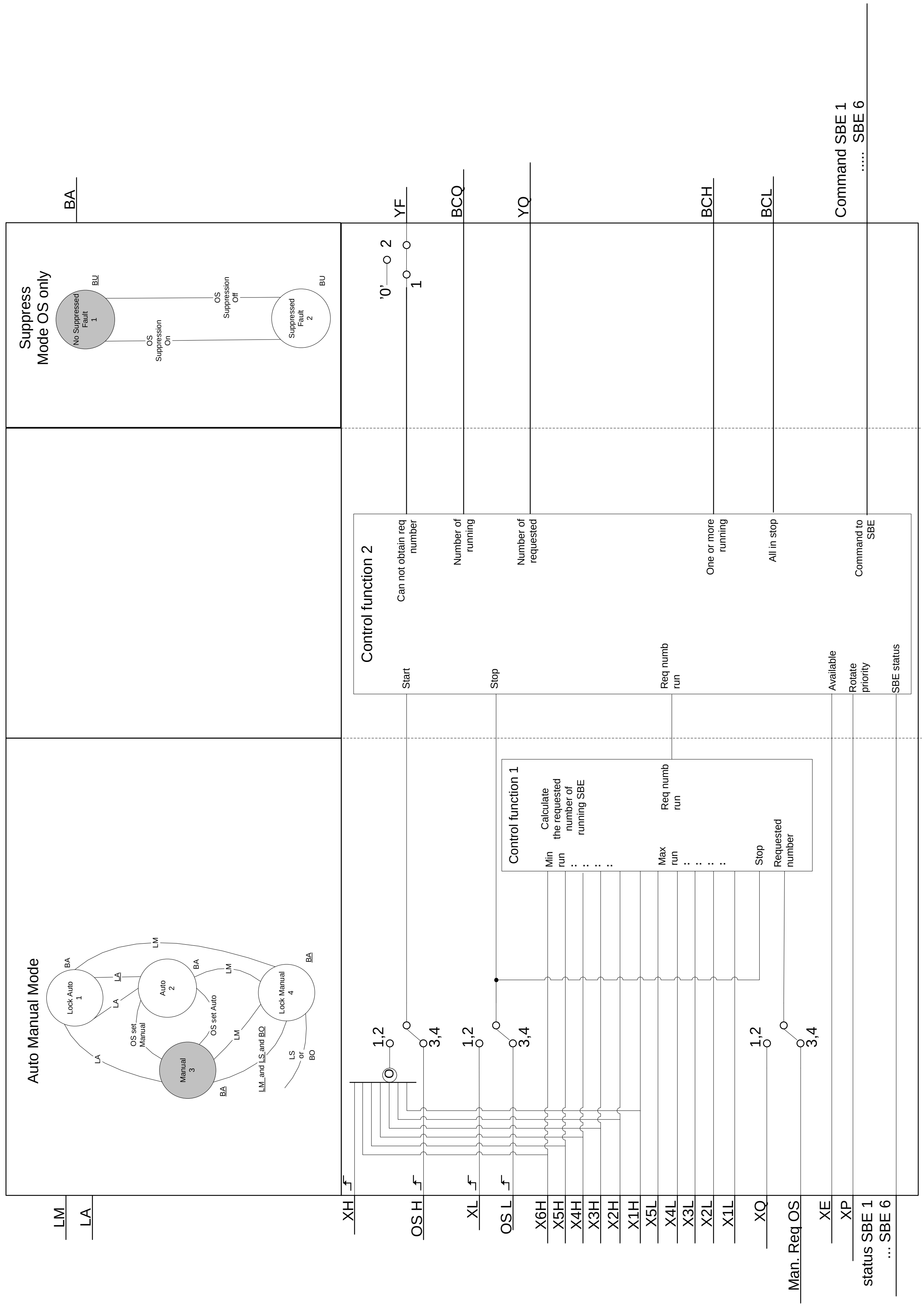


Figure F.32 – Model of SBC behaviour

F.4.16 SBE - Controls of electrical equipment template behaviour

The SBE template describes the control of a unit, e.g. motor, pump, heater, fan etc. There is one output, Y, which gives an open/close (high/low) command to the unit. Figure F.33 reflects the behavior of SBE.

Explanation of the control functions (rectangles) is as follows:

“Control function”: This function serves several tasks. It compares the actual output (Y) with the feedback status from the unit to generate the correct BCL/BCH status. It also generates failure status YF if an external or internal fault is reported.

If block and safeguarding is present at the same time, it will be generated an OS Conflict status.

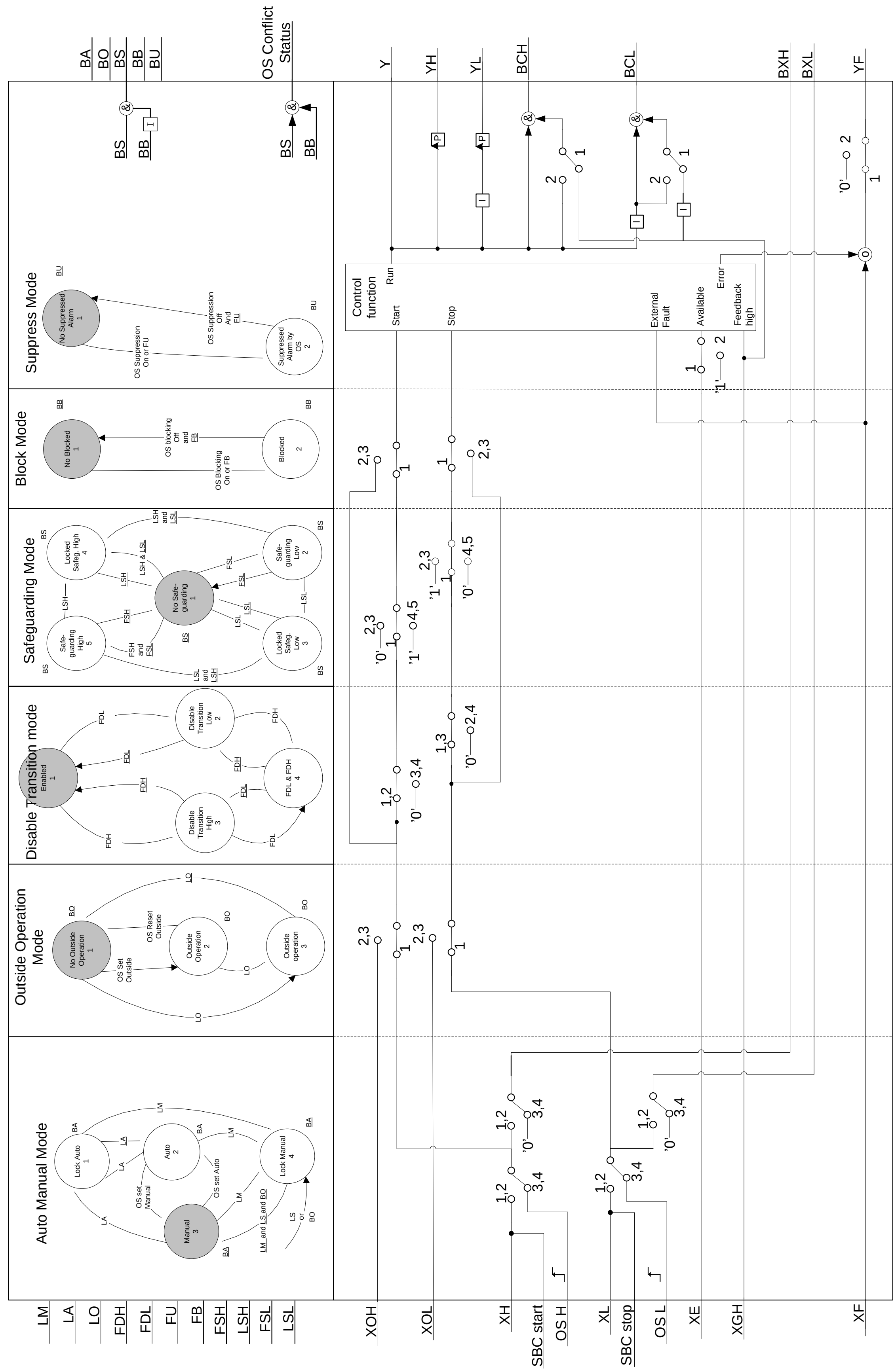


Figure F.33 – Model of SBE behaviour

F.4.17 SBV - Control of pneumatic/hydraulic equipment template behaviour

The SBV template describes the control of valves. There is one output, Y, which conveys an open/close (high/low) command to the valve actuator, or the pulsed output YH and YL can be used.

Explanation of the control functions (rectangles) is as follows:

“Control function”: This function serves several tasks..

- It generates failure status YF if an external or internal fault is reported;
- It sets the output Y according to parameter when faults are detected;
- It sets the output Y based on feedback in outside mode when no external inputs are used (XOH/XOL).

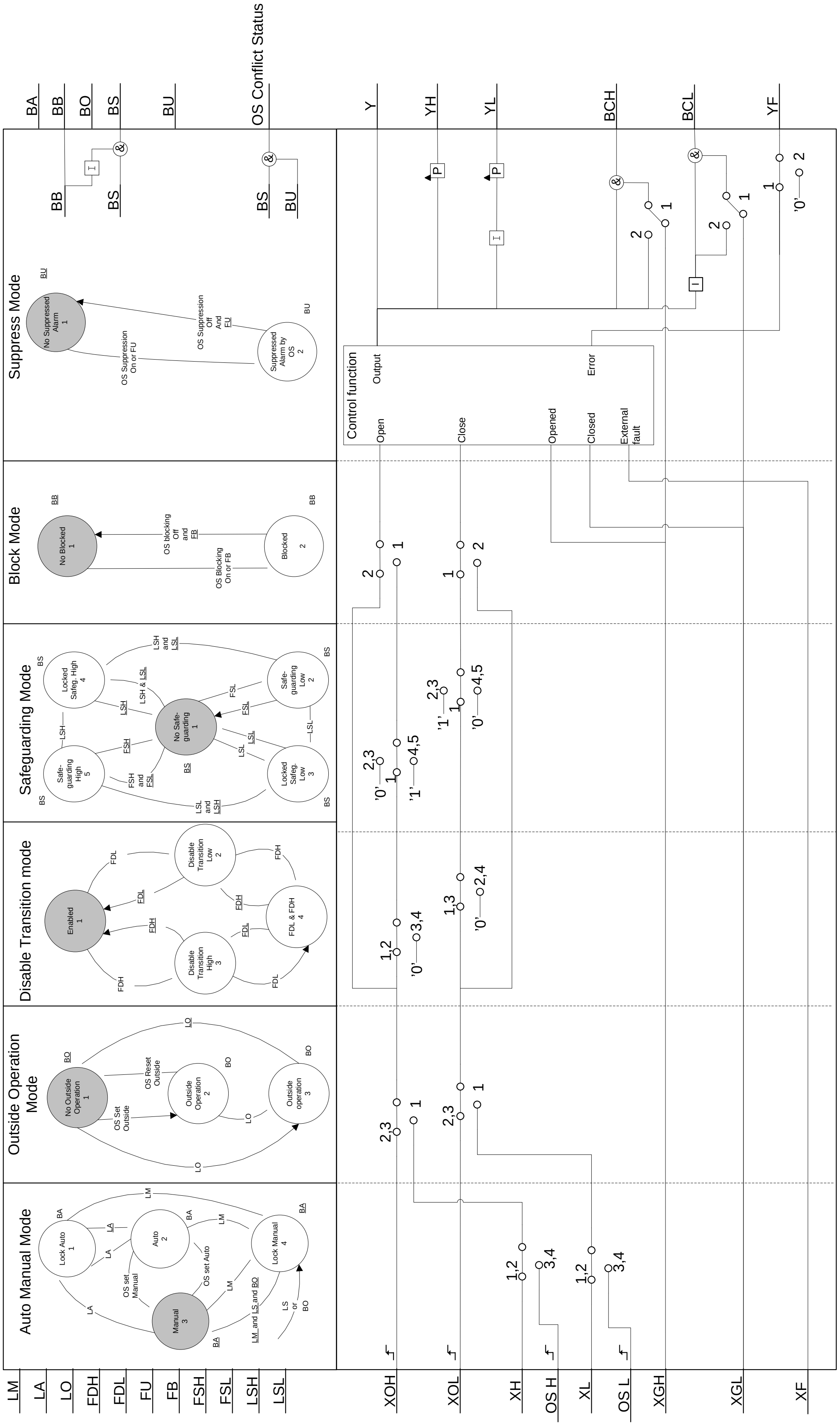


Figure F.34 – Model of SBV behaviour

Annex G
(informative)
SCD readers manual

G.1 What is a system control diagram (SCD)?

A system control diagram (SCD) contains elements both from process/utility flow diagrams and control logic diagrams. It can be looked upon as the result of merging a control system logic diagram with a simplified process/utility flow diagram.

SCDs are not necessarily complete with respect to equipment and process, as this is covered by P&IDs. However, SCDs are complete with respect to all control functions, considering that additional details may apply in the related functional specifications.

SCDs can be used both to specify how control functions shall be implemented, and to document how control functions have been implemented. Within its scope, an SCD can be made identical to the control system software that is implemented in the SAS.

The purpose of merging control information with process/utility flow information is to aid in understanding the control objectives.

SAS suppliers' logic documentation may appear extensive and difficult to non-system specialists. On SCDs this type of information is shown graphically within a process context, making it easier to grasp. Relations between operator functions, automatic control and equipment under control are immediately visualised on a single drawing.

While P&IDs and instrument loop drawings relate to physical equipment, SCDs are function oriented. SCDs identify the process control objects that are accessible to the operator, what the objects do and what the operator can do with the objects.

Standardised logical control system objects are represented on the SCD by a number of software function blocks with surrounding logic, see example in G.5. Function blocks in SAS are tagged, either with the tag of the physical object they represent, or with a non-physical control function tag. On SCDs this tag is shown in exact detail to enable the operators to directly locate the function in the control system. The tags on the SCD can be used to find the function in the control system.

G.2 Areas of use

In the early stages of a project SCDs are used for further developing the initial system control specification expressed on P&IDs and vendor package documentation. SCDs can be easily understood by process engineers, safety engineers, package vendors and other participants. Because of this, SCDs will be used as a basis for interdisciplinary discussions on SAS control logic functionality. Each discipline can use the SCD to verify that the SAS engineer understands their requirements.

During detail engineering SCDs are used for collaborative communication between disciplines and operations. SCDs define the full operator interface, by use of the defined standard function blocks.

At the time of programming the SAS, the SCDs may be used as the detailed program specification. The SAS supplier should support the standard function blocks in this NORSOK standard and hence the logic in SAS will be identical to the logic shown on the SCDs. SCDs can be made to an precise level of detail, such that the SAS programmer does not have to add any control functionality during the programming. Conversely, what control functionality that is programmed will be visible in full detail on the SCDs.

The SCDs may be supplemented by a functional description to describe the background for the selected solutions and provide a description of the complete system under control to help and ease the understanding during programming, testing, commissioning and maintenance. Special details in control logic, vendor package document references and serial line information can be collected in the functional description.

Because of this potential for completeness, SCDs may be used as data input to SAS programming.

The SCDs are SAS supplier independent. If based on the standard function blocks, SCDs can in principle be made without knowledge of the SAS supplier. Re-use of control system solutions becomes possible.

Provided the SCDs are kept updated during commissioning and subsequent modification work, they can act both as educational tools for new personnel and as a tool for evaluating proposed changes and additions to the control system. SCDs can have this function during the whole lifetime of the plant.

G.3 The process part of system control diagrams (SCDs)

The process part of SCD's is simplified. As a main rule it contains about the same information as is visible to the operator on the screens, i.e. the equipment that is necessary for understanding the process.

G.4 The control part of system control diagrams (SCDs)

G.4.1 General

The control part comprises the standardised function blocks, simple logic elements and logic connections. Together these elements express control system functionality such as displaying the state of the process, running control loops, performing shutdowns, control sequences and interfacing with external systems.

G.4.2 Function blocks

Any specific tagged function block is a "function template" brought into use and resident in a given SAS node, i.e. runs in a given machine on the control system network. The operator interface on the screen is independent of which system or node the function block resides in.

A function template defined in this standard has the following standardised components:

- terminals for receiving information (input terminals);
- terminals for calculated information (output terminals);
- available states, alarms and commands for use in operator station;
- set of parameters that select functional options and behaviour;
- description, which determines the total behaviour of the function block. This includes functional description for generating values on output terminals as a function of values on input terminals, parameter values, modes and operator actions on screen; as well as the rules governing the operator screen interface.

Templates have been defined for typical SAS functions, as input of analogue or digital process value, on/off valve control, analogue control loop, electrical motor control, etc.

G.4.3 Simple logic elements

Simple logic elements have input and output terminals that work in the same manner as for function blocks. However, simple logic elements are not tagged on the SCD.

Such elements perform elementary logic functions based on the states of the input terminals, and present the result on the output terminal.

Typical simple logic elements are logical AND, OR, logical inversion, analogue value multiplication, latches (memory elements), etc.

Any specific simple logic element resides in a given SAS node, in the same way as function blocks do.

G.4.4 Logic connections

Logic connections are conceptually similar to electrical connections: A logic connection states that the software has been configured such that the state or value of a source is continuously copied to a destination.

Possible sources are

- the physical field interface for input signals to SAS,
- an output terminal of a function block,
- an output terminal of a simple logic element.

Possible destinations are

- the physical field interface for output signals from SAS,
- an input terminal of a function block,
- an input terminal of a simple logic element.

Logic connections may be made between terminals on single function blocks or between terminals on simple logic elements.

Logic connections may be made within a single SAS node or between different SAS nodes.

SCDs make no distinction between logical connections within a single SAS node and logical connections between different SAS nodes, other than identifying in which node the source and destination reside, respectively.

G.5 Examples

G.5.1 Level control

The CA block, (20LC0355) reads the level measurement from the physical field interface for input signals to SAS, and the controller output goes to the physical field interface for output signals. The SBV block controls the block valve (20XSV0358) through the physical field interface for output signals. The SBV block gets a shutdown signal and output terminal of the LB block. The LB block represents safeguarding function ,PSD 3.1, and it shuts down the SBV block (LSL = Lock Safeguarding Low). The last connection between the SBV block (output source) to the CA block (destination), is the logic that forces the CA block to Lock Safeguarding Low (LSL) when the SBV block is in confirmed closed position (BCL). When the SBV is opened again LSL is removed from the CA block, but as LSL locks the function in manual mode, the operator will have to toggle the CA to auto mode in order to activate the PID algorithm.

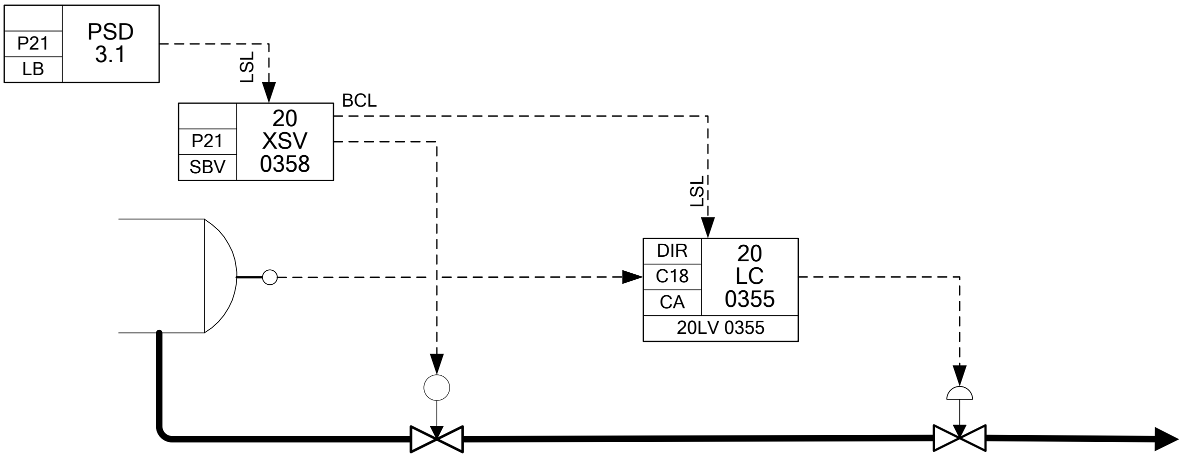


Figure G.1 - Level control

G.5.2 Temperature control

The MA block represents the temperature coming from the physical field interface for input signals to SAS. The high event limit (BXH) on the MA block output terminal is connected to the start terminal (XH) on the SBE block. The low event will send stop to the SBE block. The SBE block is connected to the electrical starter through the physical field interface for output signals from SAS. The LB block is used for shutdown purpose like in the previous example. Note that it is the SB function which performs the actual shutdown to the MCC, while the connection to LSL on SBE is to prevent the SBE from detecting the stop as a function failure.

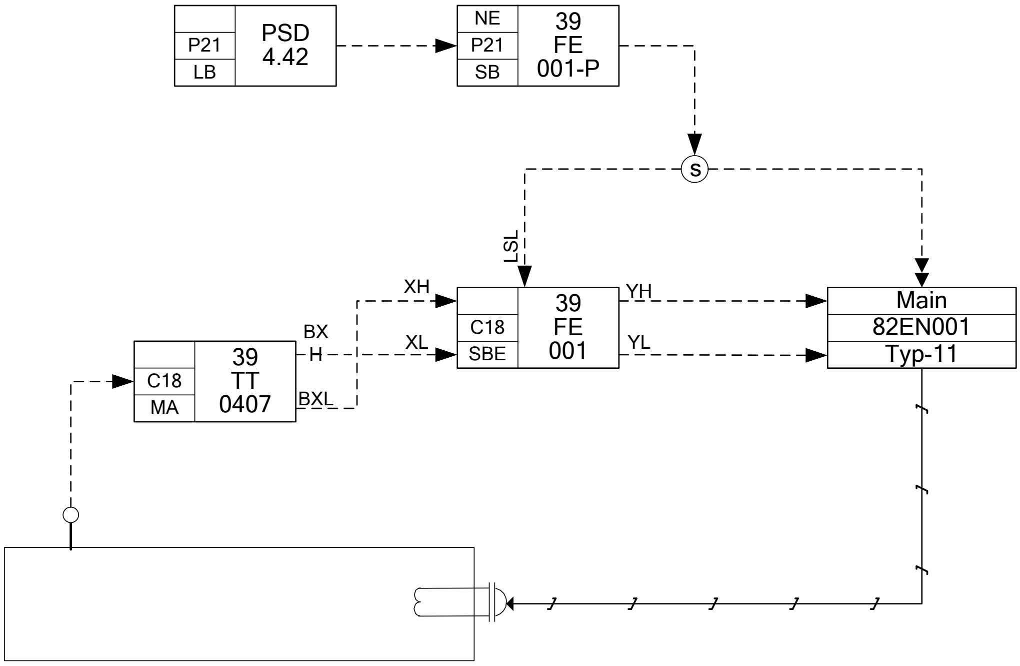


Figure G.2 - Temperature control