Preliminary

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Integrated Platform Management System

Element Processing Specification

Volume -

Preliminary

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[1] **Title:** **Contract**
Description: Contract between Schelde Naval Shipbuilding and IMTECH Marine & Offshore
Ref.: <>
From: Schelde Naval Shipbuilding and IMTECH Marine & Offshore
Issue: <>
Date: <>

[2] **Title:** **Documentation Plan**
Description: Documentation Plan for TNI-AL
Ref.: 190134-DOP
From: R. v. Treuren
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[3] **Title:** **System Specification IAS**
Description: Overall System specification of the Integrated Automation System
Ref.: 190134-4000-SSC
From: E.J. Middeldorp
Issue: V1.0
Date: <>

[4] **Title:** **Functional Specification IPMS**
Description: Functional specification of the (SCADA-PLC based) Integrated Platform Management System function of the IAS.
Ref.: 190134-4380-FSC
From: R.Langeveld
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[5] **Title:** **Technical Specification IPMS HMI**
Description: Technical Specification of the Human Machine Interface of the IPMS
Ref.: 190134-4380-HMI-TSC
From: R. Langeveld
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[6] **Title:** **Technical Specification IPMS ELP**
Description: Technical Specification of the Element Processing of the IPMS
Ref.: 190134-4380-ELP-TSC
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[7] **Title:** **Functional Specification PMS**
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[8] **Title:** **Functional Specification PCS**
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Ref.: 190134-2520-FSC
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[9] **Title:** **Network Architecture CSN and PDN**
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From: G. Tiekstra
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Ref.: 190134-4380-IOL
From: E.J. Middeldorp
Issue: V1.0
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Description: States the defined items and their characteristics, such as dimensions, weight, and allocation on board
Ref.: 190134-4000-ISL
From: E.J. Middeldorp
Issue: V1.0
Date: <>

[12] **Title:** **IPMS User Manual**
Description: An operator guide that describes the entire user scoped IPMS functions.
Ref.: 190134-4380-UM
From: R. Langeveld
Issue: V1.0
Date: <>

Abbreviations

AAE	Analogue Application-element
AI	Analogue Input
ALP	Alarm presentation
IPMS	Alarm, Monitoring & Control System
AO	Analogue Output
CAP	Component Assist Presentation
CBA	Circuit-breaker element (application)
CBE	Circuit-breaker element
CIP	Component Information Presentation
CTR	Control Element
DAE	Digital Application Element
DINC	Discrete Input - Normally Close
DINO	Discrete Input - Normally Open
DO	Discrete Output
ELP	Element Processing
EU	Engineering Unit
HA	High Alarm
HAV	High Alarm Value
HHA	Highhigh alarm
HHAV	Highhigh alarm value
HY	Common Hysteresis
HYHA	Hysteresis on High Alarm
HYLA	Hysteresis on Low Alarm
IMO	Imtech Marine & Offshore
IO	Input/Output
LA	Low Alarm
LAN	Local Area Network
LAV	Low Alarm Value
LPU	Local Processing Unit
MCE	Motor starter single speed-element
MCD	Motor starter double speed-element
MCS	Motor starter standby-element
MIP	Mimic Presentation
MMI	Man Machine Interface
OORH	Out Of Range High
OORL	Out Of Range Low
PCM	Platform Control and Monitoring
PLC	Programmable Logic Controller
RFU	Ready For Use
RFC	Ready For Closing
RFO	Ready For Opening
RHE	Running Hour Element
SAE	Serial Application Element
SEE	Switching Events Element
SF	Scale factor
SG	Specific gravity
SSE	Sensor-element
SSL	Tank level element

SWB	Switch element bit
SWE	Switch-element
SWF	Switch with no delay element
SWN	Switch with NBCD Functionality
TA	Time delay for alarm
TAU	Filter constant
TCTRL	Control duration
TDLY	Delay time before activation
THA	Delay time alarm high active
TLA	Delay time alarm low active
TOORH	Time delay Out Of Range High
TOORL	Time delay Out Of Range Low
TTRANS	Allowable transition duration
TTRO	Time needed for run-out
V20	Scaled sensor value @ 20 mA
V4	Scaled sensor value @ 4 mA
VCE	Valve-element
VCH	Hydraulic valve element
XHA	Too high alarm
XHAV	Too high alarm value

Updates

Underneath are the updates indicated of those parts, which have been changed related to the previous release.

Issue:	Date:	Change:	Reason:
0.1	1 March 2005	-	Preliminary release
0.2	April 2006	Added VCP element section 25	

1. Introduction

1.1 Purpose of this document

This document covers the technical specification of the Element Processing function as defined within the Function Specification of the Integrated Platform Management System (IPMS), ref. [4].

1.2 Relationship to other documents

This document is part of the documentation for the Integrated Automation System. The relation to other documents is illustrated by **Error! Reference source not found.**

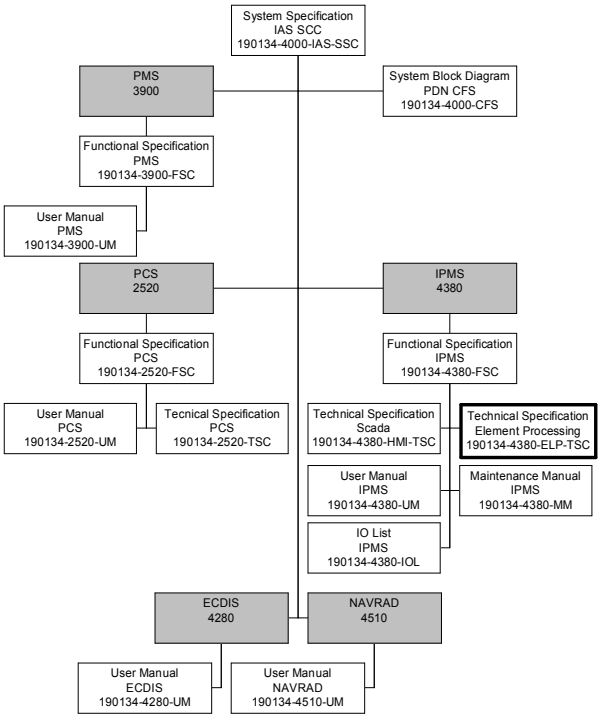

Figure 1-1 Overview of the documentation

2. Data interfacing, a brief overview

2.1 General

Though not strictly necessary to understand this document, the reader should be familiar with platform information monitoring. The next sections will introduce you to some of the interface aspects.

2.1.1 ELP Monitoring

Consider a sensor somewhere on the platform that senses a physical value. The sensor transfers the physical value into an analogue electrical value. Usually the sensor transfers the physical value into an electrical current but other quantities may be used also. In most cases, the sensor output will be wired to an analogue input module that is able to convert the electrical value into a numerical value. ELP is involved with all generic monitoring figures such as:

- Scaling the raw numerical value into an engineering range;
- Determining the sensor status regarding alarm thresholds that may apply to this sensor;
- Adapting information needed by the HMI like:
  - Visualization of the sensor value;
  - Setting/resetting of alarm statuses;
- Picking up HMI commands, alarm events, and changed parameter settings.

This data interface is illustrated in Figure 2-1.

2.2 ELP Control

Equipment that can be controlled from a remote location will be wired to a PLC output module. The actual status of this equipment is monitored by the PLC also. In this case ELP comprises of:

- Interfacing commands given from remote, either manually or automatically.
- Validation of commands regarding element control mode;
- Driving the relevant output modules

This data interface is illustrated in Figure 2-1.

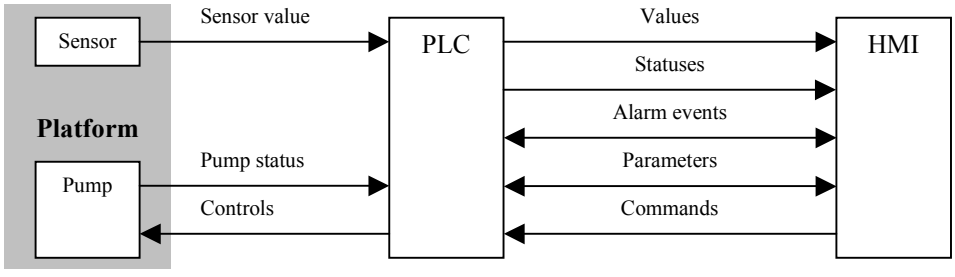

Figure 2-1 Data interfacing

3. Functional Design of Element Processing

3.1 Ship's platform

The ELP function is based on a number of generic software modules, one for each platform element type. Platform element types can be distinguished by classifying each platform component among one of the element types currently defined. Classification can be realized based on the electrical interface and functional behaviour of each component. Once classified, calling its applicable software module along with relevant component id's and settings can process each platform object.

Classification information along with specific settings for each platform object is stored within a, so-called, element list. The element list, in fact, is an off-line database, which resides within the software development environment of each project.

The Element list comprises the next information for each platform component:

- General information:
  Element type (basic element), name (id), description and main mimic number.

- Alarm information:
  Settings regarding alarm configuration, installation group and relevant platform evaluations.

- Parameters:
  Default parameter values. Most of the parameters apply to the alarm process.

- IO mapping.
  Processor module ID. This defines the processor module that will process the software regarding the platform component. Rack ID, Module ID and IO-Channels involved with the platform component.

By means of a data generator tool the Element list data is transformed to a set of files relevant for:

- HMI/SCADA system;
- Element Processing functions in the PLC's.

Error! Reference source not found. summarizes the element types currently defined along with their acronym:

Element type acronym	Element type description
AAE	Analogue Application Element
CBA	Circuit Breaker Element for Applications
CBE	Circuit Breaker Element
CTR	Control-element
DAE	Digital Application Element
MCD	Motor Control element with Double speed function
MCE	Motor Control Element
MCS	Motor Control element with Standby function
RHE	Running Hours counter Element
SAE	Serial Application Element. Dual logical alarm inputs
SEE	Switching Event Element
SPE	Setpoint element
SSE	Sensor Element with alarm low/high support

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Element type acronym	Element type description
SS1	Sensor Element with alarm high / highhigh / too high support
SS2	Application Element with alarm high / highhigh / too high support
SSL	Sensor element with tank content measurement support
SWB	Switch-element Basic functions only
SWE	Switch-element with alarm function
SWN	Switch element used for NBCD related objects
VCE	Valve Control Element
VCH	Valve Control Element for hydraulically controlled valves
VCP	Valve Control Element for proportionally controlled valves

Table 3-1 List of element types

The next sections will describe all functions relevant for each element type.

4. Analogue Application Element (AAE)

4.1 Function

The analogue application-element handles a derived or calculated (i.e. not related to a physical input) value. The element is able to generate high and low alarms whenever the analogue input exceeds one of the alarm thresholds. Along with these alarms the element supports hysteresis and time delay functions as well. Spurious alarms which might be caused by a certain platform state can be inhibited as it supports an alarm inhibit input also.

4.2 Interface

The element interface is shown by Figure 4-1.

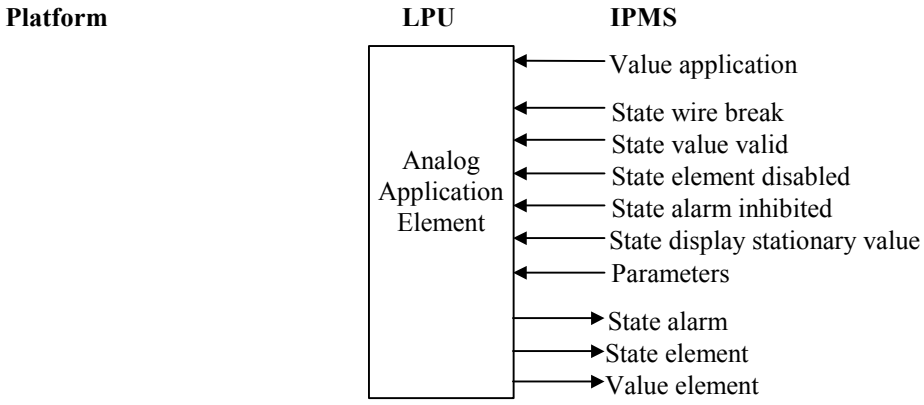


Figure 4-1 Analogue application-element interface

The next sections describe the interfaces.

4.2.1 Platform interface

This element has no interface related to physical IO.

4.2.2 IPMS interface

The IPMS interface is shown in Table 4-1.

Name	Value
Input	
Value application	Value (not scaled)
State value valid	[Valid | Invalid]
State wire break	[Wire break | No Wire break]
State element disabled	[Disabled | Enabled]
State alarm inhibit	[Inhibited | Not inhibited]
State display stationary value	[Display stationary value | Display element value]
Parameters	[HAV + LAV + HYHA + HYLA + THA + TLA+ SF + STA]
Output	
State alarm	[None | HA | LA | Wire break| Inhibited]
State element	[Value OK| Disabled | HA | LA | Unavailable| Wire break]
Value element	Scaled value in EU

Table 4-1 Application-element IPMS interface

4.3 Parameters

The parameters of the element are shown in Table 4-2.

Parameter	Description	Unit	Value	Adjustable
HAV	High alarm value	EU		Yes
LAV	Low alarm value	EU		Yes
HYHA	Hysteresis on HA alarms	EU		Yes
HYLA	Hysteresis on LA alarms	EU		Yes
THA	Time delay high alarm	s		Yes
TLA	Time delay low alarm	s		Yes
SF	Scale factor	-		Yes
STA	Stationary value	EU		No

Table 4-2 Analogue application-element parameters

4.4 Processing

The element processing comprises the next functions:

- Application Value conversion;
- Value selection;
- Alarm evaluation;
- Alarm/element state determination.

The processing is shown in Figure 4-2.

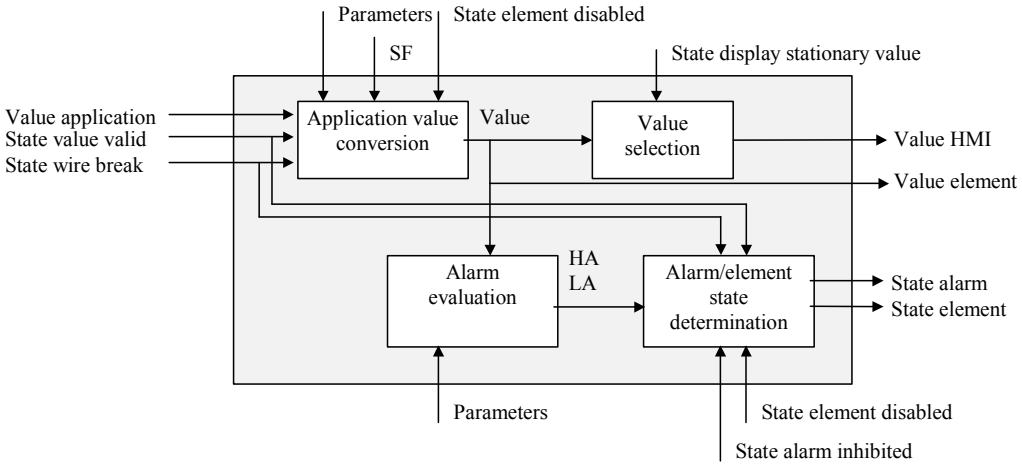


Figure 4-2 Analogue application-element processing

The next sections describe these functions.

4.4.1 Application value conversion

IF (State element disabled = disabled) OR
(Value application valid = invalid) OR
(State wire break = wire break) THEN
Value Element = Unavailable;
ELSE
Value = Value application / SF;
END

4.4.2 Value selection

IF (State display stationary value = display stationary value) THEN
Value HMI = Stationary value;
ELSE
Value HMI = Value Element;
END

4.4.3 Alarm evaluation

The alarm evaluation determines if there is an alarm condition active. The next alarm conditions are available:

- HA;
- LA.

HA

IF ((Value element > HAV) during (t > THa)) THEN
HA = 1;
END
IF (Value element <= (HAV - HYHA) THEN)
HA = 0;
END

LA

IF ((Value element < LAV) during (t > TLa)) THEN
LA = 1;
END
IF (Value element >= (LAV + HYLA)) THEN
LA = 0;
END

4.4.4 Alarm/element state determination

The alarm/element state determination is shown in Table 4-3.

State element disabled	State Value Valid	State Alarm inhibited	Wire break	HA	LA	State alarm	State element
Disabled	x	x	x	x	x	None	Disabled
Enabled	Invalid	x	x	x	x	None	Unavailable
Enabled	Valid	Inhibited	x	x	x	Inhibited	Value OK
Enabled	Valid	Not inhibited	1	x	x	Wire break	Wire break
Enabled	Valid	Not inhibited	0	1	0	HA	HA
Enabled	Valid	Not inhibited	0	0	1	LA	LA

Enabled	Valid	Not inhibited	0	0	0	None	Value OK

Table 4-3 Analogue application-element alarm/element state determination

4.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word represent the element status.
The next sections describe command - and status word arrangements.

4.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 4-4 Analogue application element Command word HMI

4.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	-
0010	0-3	-
0011	0-3	-
0100	0-3	Value OK
0101	0-3	-
0110	0-3	-
0111	0-3	-
1000	0-3	Not Valid
1001	0-3	Reserved
1010	0-3	Reserved
1011	0-3	Alarm wire break
1100	0-3	Alarm low
1101	0-3	Alarm high
1110	0-3	-
1111	0-3	-
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	-
	5	-
	6	-
	7	-
	8	Alarm inhibited
	9	-
	10	-
	11	-
	12	-
	13	-
	14	-
	15	-

Table 4-5 Analogue Application Element Status word

5. Circuit Breaker element for Applications (CBA)

5.1 Function

The function of the circuit breaker element for applications is to forward both the breaker status (including relevant alarms) and breaker commands from/to an external application like a Power Management System. As this application must have full control over the circuit breaker, the element processing only adapts the signals it needs to achieve a proper HMI interface.

5.2 Interface

The circuit breaker element interface is shown in Figure 5-1.

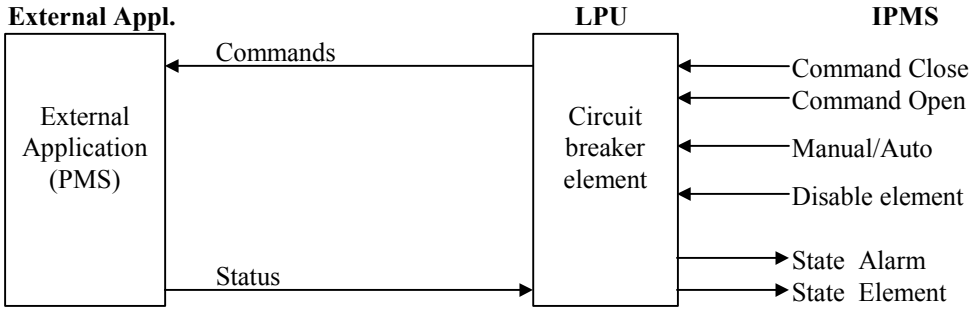


Figure 5-1 Circuit-breaker element interface

The next sections describe these interfaces in detail.

5.2.1 External Application Interface

Table 5-1 lists all signals incorporated by this interface.

Name	Value
Input	
Status	[Element disabled | Closed | Open | Transition | Not RFO | Not RFC | Failure | Local | Remote | Manual | Auto | Unknown | Fault | Tripped | Failed to open | Failed to close]
Output	
Commands	[Open | Close | Manual | Auto | Disable element | Enable element]

Table 5-1 Circuit breaker-element platform interface

5.2.2 IPMS interface

The IPMS interface of the element is shown in Table 5-2.

Name	Value
Input	
Command open	[Not activated | Activated]
Command close	[Not activated | Activated]
Manual / Auto	[Manual | Auto]
Disable element	[Disabled | Enabled]
Output	
State alarm	[None | Unknown | Fault | Tripped | Open failure | Close failure]
State element	[Disabled | Closed | Open | Transition | Not RFO | Not RFC | Close failure | Open failure | Undetermined | Fault]

Table 5-2 Circuit breaker-element IPMS interface

5.3 Parameters

This element has no parameters.

5.4 Processing

The element processing comprises the next functions:

- Platform control;
- Alarm / element state determination.

The processing is shown by Figure 5-2.

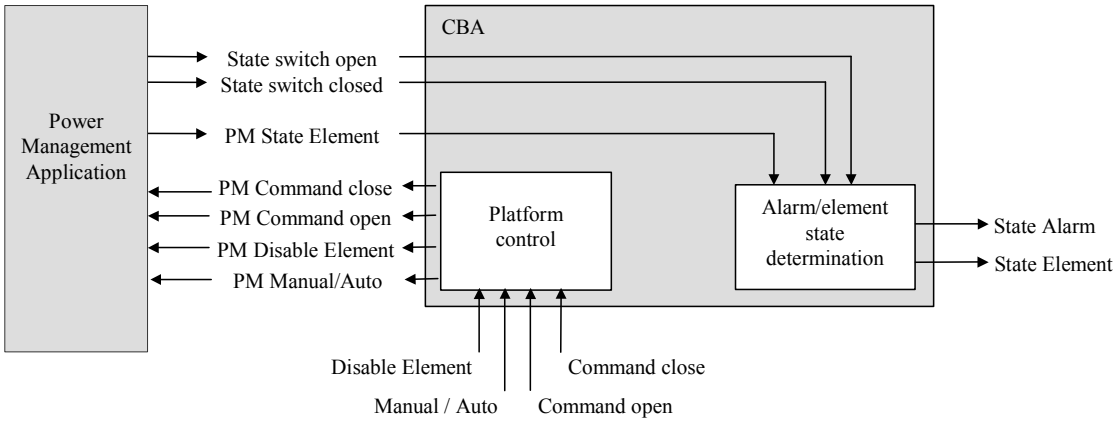


Figure 5-2 Circuit breaker-element processing

The next sections describe the functionality.

5.4.1 Platform control

IF (Disable element = Disabled) THEN
PM Command Close = None;
PM Command Open = None;
END

PM Command close = Command close
PM Command open = Command open
PM Disable Element = Disable Element
PM Manual/Auto = Manual/Auto

5.4.2 Alarm/element state determination

The alarm/element state determination is shown in Table 5-3.

Element Disabled	State switch Closed	State switch Open	State element (from PM)	State alarm	State element
Disabled	x	x	x	None	Disabled
Enabled	x	x	Closed	None	Closed
Enabled	x	x	Open	None	Open
Enabled	x	x	Not RFO	None	Not RFO
Enabled	x	x	Not RFC	None	Not RFC
Enabled	x	x	Transition	None	Transition
Enabled	x	x	Tripped	Tripped	Tripped
Enabled	x	x	Fault	Fault	Fault
Enabled	x	x	Unknown	Unknown	Unknown
Enabled	x	x	Failed To Close	Open failure	Failed To Close
Enabled	x	x	Failed To Open	Close failure	Failed To Open

Table 5-3 Circuit breaker-element alarm/element state determination

5.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word represent the element status.
The next sections describe command - and status word arrangements.

5.5.1 Command word

Bit	Description
0	Close
1	Open
2	-
3	-
4	-
5	Manual
6	Auto
7	-
8	Disable element
9	Enable element
10	-
11	-
12	Reserved
13	-
14	-
15	-

Table 5-4 Circuit breaker element Command word HMI

5.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	Closed
0010	0-3	Open
0011	0-3	-
0100	0-3	-
0101	0-3	Transition
0110	0-3	-
0111	0-3	-
1000	0-3	-
1001	0-3	Not Ready for closing
1010	0-3	Not Ready for opening
1011	0-3	Tripped
1100	0-3	Failed to close
1101	0-3	Failed to open
1110	0-3	Unknown
1111	0-3	Fault
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	Last command was: Close
	5	Last command was: Open
	6	-
	7	-
	8	Alarm Inhibited
	9	True = Manual / False = Auto
	10	True = Local / False = Remote
	11	-
	12	-
	13	-
	14	-
	15	-

Table 5-5 Circuit breaker element Status word

6. Circuit Breaker Element (CBE)

6.1 Function

The function of the circuit breaker element is support monitoring and control functions relevant for a circuit breaker such as commands, statuses and alarms. This element supports alarm inhibition. To use this feature, an external logical expression must define all platform states that might cause a spurious CBE alarm.

6.2 Interface

The element interfacing is shown by Figure 6-1.

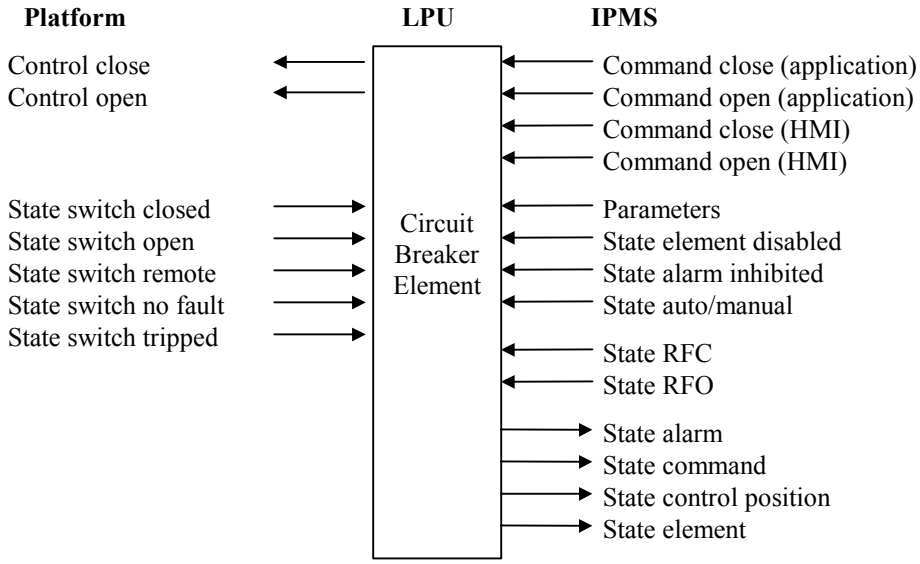


Figure 6-1 Circuit breaker element interface

The next sections specify the interfaces.

6.2.1 Platform interface

The element platform interface is shown in Table 6-1.

Name	Value	I/O specification
Input		
State switch closed	[Closed | Not closed]	DINO
State switch open	[Open | Not open]	DINO
State switch remote	[Local | Remote]	DINO
State switch tripped	[Tripped | Not Tripped]	DINO
State switch no fault	[Fault | No fault]	DINO
Output		
Control close	[Not activated | Activated]	DO
Control open	[Not activated | Activated]	DO

Table 6-1 Circuit breaker element platform interface

6.2.2 IPMS interface

The IPMS interface is shown within Table 6-2

Name	Value
Input	
Command close (application)	[Not activated | Activated]
Command open (application)	[Not activated | Activated]
Command close (HMI)	[Not activated | Activated]
Command open (HMI)	[Not activated | Activated]
Parameters	[Ttrans + Tctrl]
State element disabled	[Disabled | Enabled]
State alarm inhibited	[Inhibited | Not inhibited]
State auto/manual	[Manual | Auto]
State RFC	[Ready for Closing | Not Ready for Closing]
State RFO	[Ready for Opening | Not Ready for Opening]
Output	
State alarm	[None | Close failure | Open failure | Unknown]
State command	[None | Command close | Command open]
State control position	[None | Local | Manual | Auto]
State element	[Disabled | Closed | Open | Transition | Not RFC | Not RFO | Open failure | Close failure | Unknown | Tripped | Fault]

Table 6-2 Circuit breaker element IPMS interface

6.3 Parameters

The element parameters are shown by Table 6-3

Parameter	Description	Unit	Value	Adjustable
Ttrans	Time delay allowed for transition	s		Yes
Tctrl	Control Pulse duration (0=continuously controlled)	s		Yes

Table 6-3 Circuit breaker element parameters

If Tctrl = 0, then the relevant output is driven continuously (I.e. not by a pulse)
If Ttrans = 0, then no time-out alarm will be generated.

6.4 Processing

The element processing comprises the next functions:

- Alarm/element state determination;
- Control mode determination;
- Platform control.

The processing is shown by Figure 6-2.

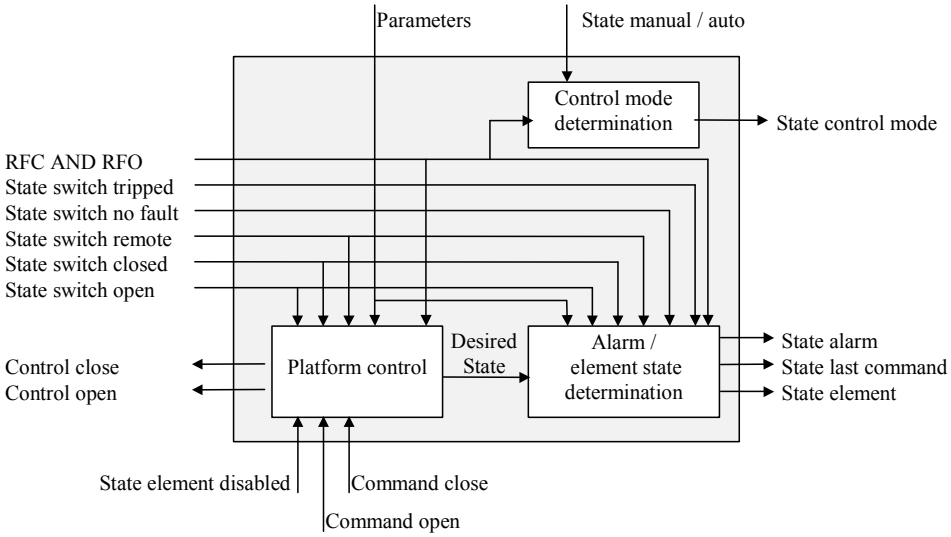


Figure 6-2 Circuit breaker element processing

These functions are described by the next paragraphs.

6.4.1 Platform control

```
IF      (State element disabled = Disabled) THEN
        Control close = Deactivated;
        Control open = Deactivated;
        Desired State = none;
ELSE
        IF      (Command close = Activated) THEN
                Control open = Deactivated;
                Desired State = Closed;
                IF      (Tctrl = 0) THEN
                        Control close = Activated continuously;
                END
                IF      (TCtrl > 0) THEN
                        Control close = Activated during t = TCtrl;
                END
        END
        IF      (Command open = Activated) THEN
                Control close = Deactivated;
                Desired State = Open;
                IF      (TCtrl = 0) THEN
                        Control open = Activated continuously;
                END
                IF      (TCtrl > 0) THEN
                        Control open = Activated during t = TCtrl;
                END
        END
END
```

Whenever the element is (re-) initialised (LPU state toggles from offline to online) or when the element control mode is switched from 'local' to 'remote' or when the element is enabled then the desired state must be forced to match the actual state of the breaker. In all other cases the desired state must keep up with the command input state.

```
IF      ((Initialising                                  ) OR
        (State switch remote = Open -> Closed           ) OR
        (State element disabled = Disabled -> Enabled   )) THEN
        IF      ( State switch closed = Activated ) THEN
                Desired state = closed;
        ELSE
                IF      ( State switch open = Activated ) THEN
                        Desired state = open;
                ELSE
                        Desired state = none;
                END
        END
ELSE
        IF Command Close =activated THEN Desired State = Closed
        IF Command Open = activated THEN Desired State = Open
END
```

6.4.2 Control mode determination

The control mode determination is shown by Table 6-4.

State element disabled	State switch remote	State manual /auto	Control mode
Disabled	x	x	None
Enabled	Local	x	Local
Enabled	Remote	Manual	Manual
Enabled	Remote	Auto	Auto

Table 6-4 Circuit breaker element control position determination

6.4.3 Element Control

The element is controlled as specified by Table 6-5.

State element disabled	Command	Control mode	Element control
Disabled	x	x	None
Enabled	None	x	None
Enabled	Command close (Appl)	Auto	Close
Enabled	Command open (Appl)	Auto	Open
Enabled	Command close (Appl)	Manual	None
Enabled	Command open (Appl)	Manual	None
Enabled	Command close (HMI)	Auto	None
Enabled	Command open (HMI)	Auto	None
Enabled	Command close (HMI)	Manual	Close
Enabled	Command open (HMI)	Manual	Open

Table 6-5 Circuit breaker element control

6.5 Alarm/element state determination

The alarm/element state determination is shown by Table 6-6.

State element Disabled	State Tripped	State No fault	RFU = RFO AND RFC	State switch Remote	Desired State	State switch Closed	State switch Open	Ttrans	Timer *)	State alarm	State element
Disabled	x	x	x	x	x	x	x	x	x	None	Disabled
Enabled	Tripped	x	x	x	x	x	x	x	x	Tripped	Tripped
Enabled	Not tripped	Fault	x	x	x	x	x	x	x	Fault	Fault
Enabled	Not tripped	No fault	x	x	x	Closed	Open	x	x	Unknown	Unknown
Enabled	Not tripped	No fault	Not RFC	x	x	x	x	x	x	None	Not RFC
Enabled	Not tripped	No fault	Not RFO	x	x	x	x	x	x	None	Not RFO
Enabled	Not tripped	No fault	RFU	Local	x	Closed	Not open	x	x	None	Closed
Enabled	Not tripped	No fault	RFU	Local	x	Not closed	Open	x	x	None	Open
Enabled	Not tripped	No fault	RFU	Local	x	Not closed	Not open	x	x	None	Transition
Enabled	Not tripped	No fault	RFU	Rem	Closed	Closed	Not open	x	x	None	Closed
Enabled	Not tripped	No fault	RFU	Rem	Closed	Not closed	x	>0	t<Ttrans	None	Transition
Enabled	Not tripped	No fault	RFU	Rem	Closed	Not closed	x	=0	x	None	Transition
Enabled	Not tripped	No fault	RFU	Rem	Closed	Not closed	x	>0	t>=Ttrans	Close failure	Failed to Close
Enabled	Not tripped	No fault	RFU	Rem	Open	Not closed	Open	x	x	None	Open
Enabled	Not tripped	No fault	RFU	Rem	Open	x	Not open	>0	t<Ttrans	None	Transition
Enabled	Not tripped	No fault	RFU	Rem	Open	x	Not open	>0	t>=Ttrans	Open failure	Failed to open

Table 6-6 Circuit breaker element alarm/element state determination

*) The timer is reset on the rising edge of the command close or command open signal.

6.6 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word represent the element status.
The next sections describe command - and status word arrangements.

6.6.1 Command word HMI

Bit	Description
0	Close
1	Open
2	-
3	-
4	-
5	Manual
6	Auto
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 6-7 Circuit breaker element Command word HMI

6.6.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	Closed
0010	0-3	Opened
0011	0-3	-
0100	0-3	-
0101	0-3	Transition
0110	0-3	-
0111	0-3	-
1000	0-3	-
1001	0-3	Not Ready for Closing
1010	0-3	Not Ready for Opening
1011	0-3	Tripped
1100	0-3	Failed to close
1101	0-3	Failed to open
1110	0-3	Unknown
1111	0-3	Fault
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	Last command was: Close
	5	Last command was: Open
	6	-
	7	-
	8	-
	9	True = Hand / False = Auto
	10	True = Local / False = Remote
	11	-
	12	-
	13	-
	14	-
	15	-

Table 6-8 Circuit breaker element Status word

7. Control element (CTR)

7.1 Function

The control-element supports a button or checkbox object within the HMI. Buttons and checkboxes might be used by HMI mimics to achieve remote operator access relevant to control/configure a platform process. Whenever the state of a button or checkbox is toggled, a HMI command is send to the LPU involved with that process. If the IPMS accepts the command then this has to be designated by an element status change. To acknowledge the operator command the HMI uses the control element status for animation purposes regarding the button/checkbox symbol.

7.2 Interface

The element interface is shown by Figure 7-1.

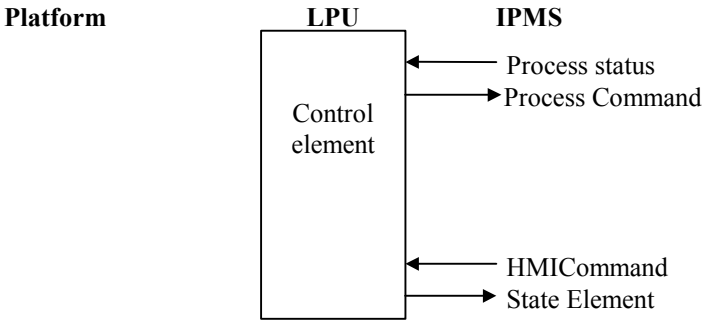


Figure 7-1 Control-element interface

The next sections will specify the interface.

7.2.1 Platform interface

The platform is not involved with the CTR interface.

7.2.2 IPMS interface

The IPMS interface considering the CTR is shown by Table 7-1.

Name	Value
Input	
HMICommand	[Not activated | Activated]
Process Status	[No fault | Fault], [RFU | Not RFU], [In transition | Not in transition]
Output	
Process Command	[Not Activated | Activated]
State Element	[Not RFU | Not Applicable | Normal | Active | Transition | Fault]

Table 7-1 Control-element IPMS interface

7.3 Parameters

Parameter	Description	Unit	Value	Adjustable
TCtrl	Control timer	s		Yes

Table 7-2 Control element parameters

7.4 Processing

The element processing comprises the next functions:

- Element state determination;
- Platform control.

The processing is shown in Figure 7-2.

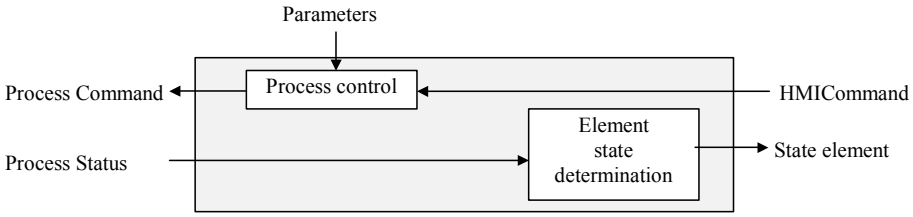


Figure 7-2 Control-element processing

The next sections describe the process functions.

7.4.1 Platform control

IF (HMICommand = Activated) THEN
State Command = Activated for t = TCtrl.
END

7.4.2 Element state determination

The element state determination is shown in Table 7-3.

No fault	NRFU	Transition	Process Status	State element
Fault	x	x	x	Fault
No Fault	NRFU	x	x	Not RFU
No Fault	RFU	In transition	x	In transition
No Fault	RFU	Not in transition	Normal	Normal
No Fault	RFU	Not in transition	Active	Active

Table 7-3 Control-element state determination

7.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections describe command - and status word arrangements.

7.5.1 Command word HMI

Bit	Description
0	Control button activated
1	-
2	-
3	-

Bit	Description
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 7-4 Control element Command word HMI

7.5.2 Status word

SM	Bit	Description
0000	0-3	-
0001	0-3	-
0010	0-3	Normal
0011	0-3	Active
0100	0-3	-
0101	0-3	Transition
0110	0-3	-
0111	0-3	-
1000	0-3	-
1001	0-3	Not Applicable
1010	0-3	Not Ready for Use
1011	0-3	-
1100	0-3	-
1101	0-3	-
1110	0-3	-
1111	0-3	Alarm
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	-
	5	-
	6	-
	7	-
	8	Reserved
	9	1
	10	0
	11	-
	12	-
	13	-
	14	-
	15	-

Table 7-5 Control element Status word

8. Digital Application Element (DAE)

8.1 Function

The discrete application-element is able to designate15 different statuses either derived from a process or from the platform. Although alarm statuses may be indicated by the matching HMI symbol, the DAE itself is not capable of generating an alarm.

8.2 Interface

The DAE interface is shown by Figure 8-1.

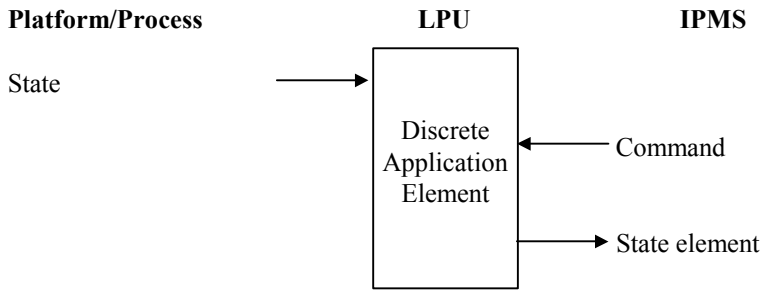


Figure 8-1 Discrete application-element interface

The interfaces are described by the next paragraphs.

8.2.1 Platform interface

The platform interface is shown by Table 8-1.

Name	Value
Input	
State	[‘State 1’ to ‘State 15’]

Table 8-1 Application-element IPMS interface

8.2.2 IPMS interface

The IPMS interface is shown by Table 8-2.

Name	Value
Input	
Command	[Disable | Enable]
Output	
State element	[Disabled | ‘State 1’to ‘State 15’]

Table 8-2 Application-element IPMS interface

8.3 Parameters

No parameters apply to this element.

8.4 Processing

The element processing comprises the next functions:

- Element state determination.

The processing is visualized by Figure 8-2.

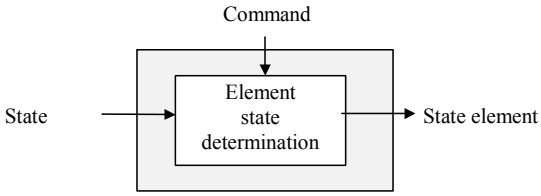


Figure 8-2 Analogue application-element processing

The functions are described in the next paragraphs.

8.4.1 Element state determination

The alarm/element state determination is visualized by Table 8-3.

Command: Enabled/ Disabled	State	State element
Disabled	x	Disabled
Enabled	'State1'	'State1'
Enabled	'State2'	'State2'
Enabled	'State3'	'State3'
Enabled	'State4'	'State4'
Enabled	'State5'	'State5'
Enabled	'State6'	'State6'
Enabled	'State7'	'State7'
Enabled	'State8'	'State8'
Enabled	'State9'	'State9'
Enabled	'State10'	'State10'
Enabled	'State11'	'State11'
Enabled	'State12'	'State12'
Enabled	'State13'	'State13'
Enabled	'State14'	'State14'
Enabled	'State 15'	'State 15'

Table 8-3 Analogue Application Element state determination

8.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections describe command - and status word arrangements.

8.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	-
11	-
12	Reserved
13	-
14	-
15	-

Table 8-4 Digital Application Element Command word HMI

8.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	‘text 0’ is displayed
0010	0-3	‘text 1’ is displayed
0011	0-3	‘text 2’ is displayed
0100	0-3	‘text 3’ is displayed
0101	0-3	‘text 4’ is displayed
0110	0-3	‘text 5’ is displayed
0111	0-3	‘text 6’ is displayed
1000	0-3	‘text 7’ is displayed
1001	0-3	‘text 8’ is displayed
1010	0-3	‘text 9’ is displayed
1011	0-3	‘text 10’ is displayed
1100	0-3	‘text 11’ is displayed
1101	0-3	‘text 12’ is displayed
1110	0-3	‘text 13’ is displayed
1111	0-3	‘text 14’ is displayed
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	-
	5	-
	6	-
	7	-
	8	Reserved
	9	-
	10	-
	11	-
	12	-
	13	-
	14	-
	15	-

Table 8-5 Digital Application Element Status word

9. Motor Control Element (MCE)

9.1 Function

The Motor Control Element interfaces a motor starter unit on the platform. Though the MCE supports a wide range of platform components it usually processes the monitoring and control functions of a single speed motor.

9.2 Interface

The element interfacing is visualized by Figure 9-1.

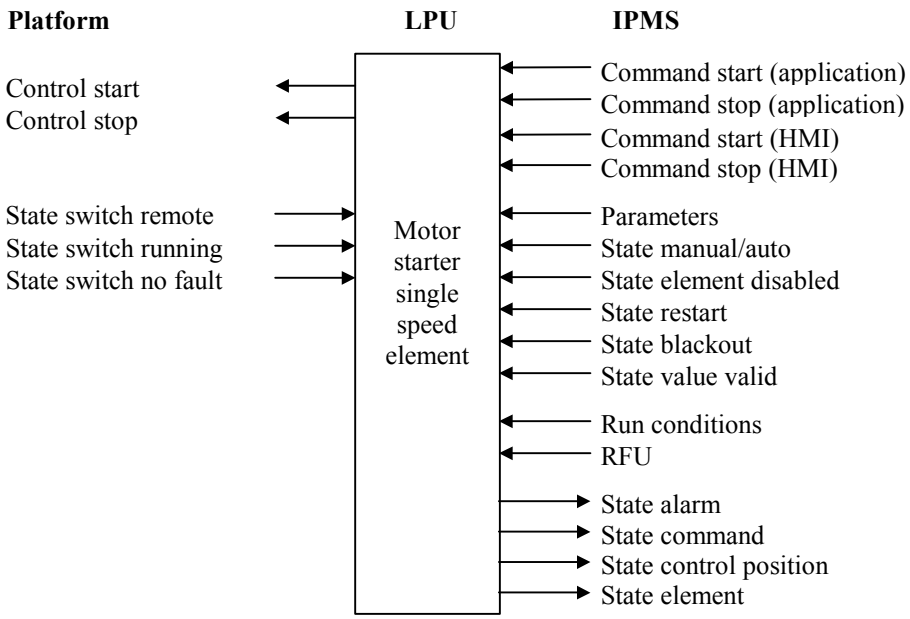


Figure 9-1 Motor starter-element interface

The interfaces are described in the next paragraphs.

9.2.1 Platform interface

The platform interface of the element is shown in Table 9-1.

Name	Value	I/O specification
Input		
State switch remote	[Local | Remote]	DINO
State switch running	[Running | Not Running]	DINO
State switch no fault	[No fault | Fault]	DINC
Output		
Control start	[Not activated | Activated]	DO
Control stop	[Not activated | Activated]	DO

Table 9-1 Motor starter-element platform interface

9.2.2 IPMS interface

The IPMS interface of the element is shown in Table 9-2.

Name	Value
Input	
Command start (application)	[Not activated | Activated]
Command stop (application)	[Not activated | Activated]
Command start (HMI)	[Not activated | Activated]
Command stop (HMI)	[Not activated | Activated]
Parameters	[Ttrans + Tctrl]
State manual/auto	[Manual | Auto]
State element disabled	[Disabled | Enabled]
State blackout	[Activated | Not activated]
State restart	[Activated | Not activated]
State value valid	[Valid | Not valid]
Run conditions	[OK | NOK]
RFU	[RFU | Not RFU]
Output	
State alarm	[None | Fault | Unknown | Failed to start | Failed to stop]
State command	[None | Command start | Command stop]
State control position	[None | Local | Manual | Auto]
State element	[Disabled | Stopped | Running | Transition | Not valid | Not RFU | Run failure | Stop failure | Unknown | Motor fault]

Table 9-2 Motor Control Element IPMS interface

9.3 Parameters

The element parameters are listed by Table 9-3.

Parameter	Description	Unit	Value	Adjustable
Ttrans	Time allowed for stopped/running transition	s		Yes
Tctrl	Pulse length used for control	s		Yes

Table 9-3 Motor Control Element parameters

If Tctrl = 0, then the relevant output is driven continuously (I.e. not by a pulse)
If Ttrans = 0, then no time-out alarm will be generated.

9.4 Processing

The element comprises the next functions:

- Alarm & element state determination;
- Control mode determination;
- Platform control.

These functions along with their interconnection are visualized by Figure 9-2.

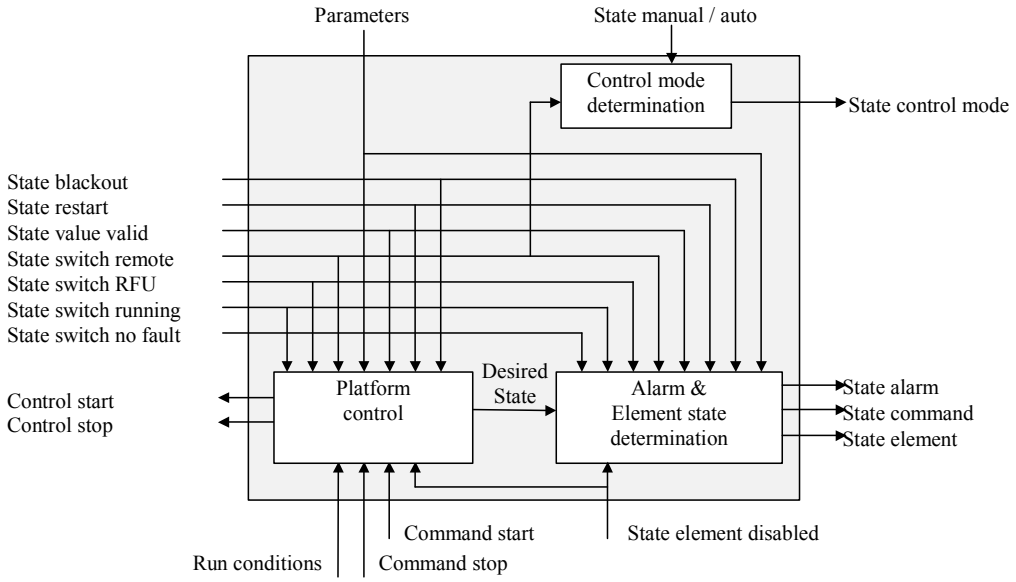


Figure 9-2 Motor Control Element processing

The next sections specify these functions.

9.4.1 Platform control

The element is controlled as defined by Table 9-4

State element disabled	Command (any)	Running Conditions	State switch RFU	Control mode	Platform control
Disabled	x	x	x	x	None
Enabled	None	x	x	x	None
Enabled	x	x	x	Local	None
Enabled	x	NOK	x	Auto	Stop
Enabled	x	NOK	x	Manual	Stop
Enabled	Command stop (Appl)	OK	x	Auto	Stop
Enabled	Command start (Appl)	OK	OK	Auto	Start
Enabled	Command start (Appl)	OK	NOK	Auto	None
Enabled	Any command (Appl)	OK	x	Manual	None
Enabled	Any command (HMI)	OK	x	Auto	None
Enabled	Command stop (HMI)	OK	x	Manual	Stop
Enabled	Command start (HMI)	OK	OK	Manual	Start
Enabled	Command start (HMI)	OK	NOK	Manual	Start

Table 9-4 Motor Control Element platform control

Whenever the element is (re-) initialised (LPU state toggles from offline to online) or when the element control mode is switched from ‘local’ to ‘remote’ or when the element is enabled then the desired state must be forced to match the actual state of the motor. In all other cases the desired state must keep up with the command input state.

```
IF      (( Initialising                                 ) OR
    ( State switch remote      = Local -> Remote        ) OR
    (State element disabled    = Disabled -> Enabled)) THEN
     IF  (State switch running = running) AND (State switch RFU=RFU ) THEN
         Desired State = Running;
     END
     IF  ( State switch running = Not running ) AND ( State switch RFU=RFU) THEN
         Desired State = Stop;
     END
ELSE
         IF Command Start THEN Desired State = Running
         IF Command Stop THEN Desired State = Stop
END
```

9.4.1.1 Embedded control functions

Run Conditions

For safety reasons the motor might have to be forced to stop despite its desired 'Run' state. Element processing supports this by providing a 'Run conditions' input. As soon as the run conditions are not met anymore this input must be deactivated to stop the motor provided that the element is controlled by the LPU (I.e the control mode is not local). However since the desired state is still 'Run' a run failure alarm will be generated after t = Ttrans if Ttrans > 0.

This function is not to be confused with the 'State switch RFU' input. Although the 'Ready For Use' input needs to be in state RFU before it is possible to start the motor it won't stop once it is running whenever this input toggles to state 'Not Ready For Use' (NRFU).

Power Management support

The element supports the next blackout functions:

```
IF (State Blackout = Activated) THEN
         Failed to run alarm is suppressed
         Desired State line up sequence is disabled
         IF (State Restart = Activated) AND (Desired State = Run) THEN
                  Motor is restarted
         END
END
```

9.4.2 Control mode determination

The control mode is determined by the Remote/Local switch and the Manual/Auto switch as shown in Table 9-5.

State switch remote	State switch Manual/Auto	Control mode
Local	x	Local
Remote	Manual	Manual
Remote	Auto	Auto

Table 9-5 Motor Control Element control mode determination

9.4.3 Alarm/element state determination

The alarm/element state determination is shown in Table 9-6.

State element disabled	State value Valid	State switch No fault	State switch remote	State switch RFU	Desired State	State switch running	Ttrans	Transition timer	State alarm	State element
Disabled	x	x	x	x	x	x	x	x	None	Disabled
Enabled	Not valid	x	x	x	x	x	x	x	None	Invalid
Enabled	Valid	Fault	x	x	x	x	x	x	Fault	Fault
Enabled	Valid	Fault	x	x	x	Running	x	x	Unknown	Unknown
Enabled	Valid	No fault	Local	x	x	Not running	x	x	None	Stopped
Enabled	Valid	No fault	Local	x	x	Running	x	x	None	Running
Enabled	Valid	No fault	Rem.	Not RFU	x	x	x	x	None	Not RFU
Enabled	Valid	No fault	Rem.	RFU	None	Not running	x	x	None	Stopped
Enabled	Valid	No fault	Rem.	RFU	None	Running	x	x	None	Running
Enabled	Valid	No fault	Rem.	RFU	Stop	Running	>0	< Ttrans	None	Transition
Enabled	Valid	No fault	Rem.	RFU	Stop	Running	>0	>= Ttrans	Stop failure	Stop failure
Enabled	Valid	No fault	Rem.	RFU	Stop	Not running	>0	x	None	Stopped
Enabled	Valid	No fault	Rem.	RFU	Stop	Running	=0	x	None	Running
Enabled	Valid	No fault	Rem.	RFU	Run	Not running	>0	< Ttrans	None	Transition
Enabled	Valid	No fault	Rem.	RFU	Run	Not running	>0	>= Ttrans	Start failure	Run failure
Enabled	Valid	No fault	Rem.	RFU	Run	Running	>0	x	None	Running
Enabled	Valid	No fault	Rem.	RFU	Run	Not Running	=0	x	None	Stopped

Table 9-6 Motor Control Element alarm/element state determination

*) The timer is reset on a positive edge of the command stop or command start signal.

9.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections describe command - and status word arrangements.

9.5.1 Command word HMI

Bit	Description
0	Stop
1	Start
2	-

3	-
4	-
5	Manual
6	Auto
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 9-7 Motor control element Command word HMI

9.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	Stopped
0010	0-3	Running
0011	0-3	-
0100	0-3	-
0101	0-3	Transition
0110	0-3	-
0111	0-3	-
1000	0-3	Not valid
1001	0-3	-
1010	0-3	Not Ready for use
1011	0-3	-
1100	0-3	Run failure
1101	0-3	Stop failure
1110	0-3	Unknown
1111	0-3	Motor fault
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	Last command was: stop
	5	Last command was: start
	6	-
	7	-
	8	Alarm inhibited
	9	True = Hand / False = Auto
	10	True = Local / False = Remote
	11	-
	12	-
	13	-
	14	-
	15	-

Table 9-8 Motor control element Status word

10. Dual speed Motor Control element (MCD)

10.1 Function

The dual speed motor control element interfaces a motor starter unit that supports a dual speed motor. I.e. the motor either runs at low/high speed or in two different directions.

10.2 Interface

The element interface is visualized by Figure 10-1.

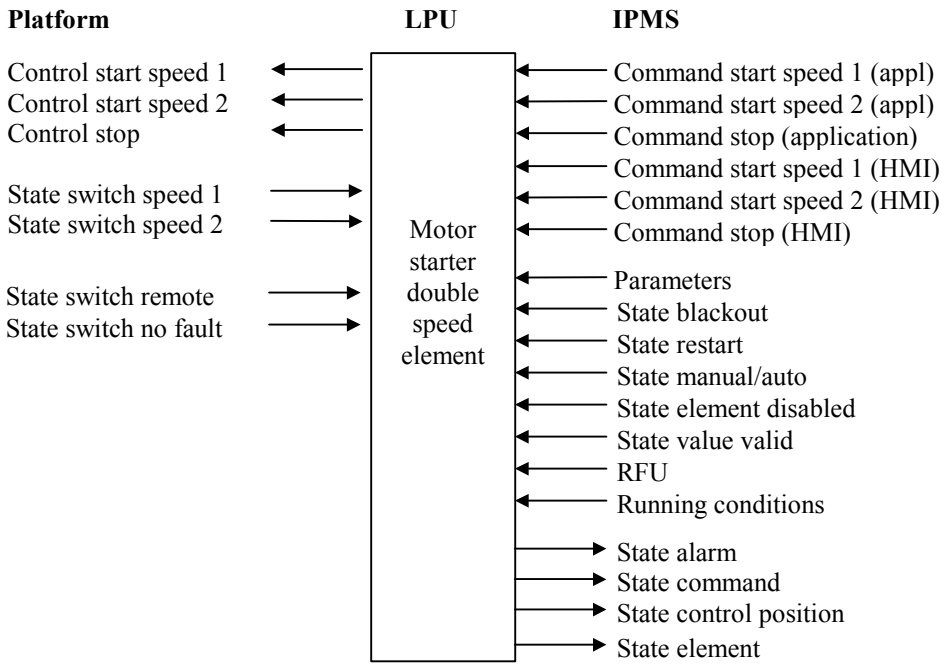


Figure 10-1 Motor starter dual speed-element interface

The next sections specify the interface.

10.2.1 Platform interface

The involved platform IO is listed by Table 10-1.

Name	Value	I/O specification
Input		
State switch speed 1	[Running speed 1 | Not running speed 1]	DINO
State switch speed 2	[Running speed 2 | Not running speed 2]	DINO
State switch remote	[Local | Remote]	DINO
State switch no fault	[Fault | No fault]	DINC
Output		
Control start speed 1	[Not activated | Activated]	DO
Control start speed 2	[Not activated | Activated]	DO
Control stop	[Not activated | Activated]	DO

Table 10-1 Motor starter dual speed-element platform interface

10.2.2 IPMS interface

The involved IPMS links are listed by Table 10-2.

Name	Value
Input	
Command start speed 1 (appl)	[Not activated | Activated]
Command start speed 2 (appl)	[Not activated | Activated]
Command stop (appl)	[Not activated | Activated]
Command start speed 1 (HMI)	[Not activated | Activated]
Command start speed 2 (HMI)	[Not activated | Activated]
Command stop (HMI)	[Not activated | Activated]
Parameters	[Ttrans + Tctrl + Tro]
State blackout	[Activated | Not activated]
State restart	[Activated | Not activated]
State manual / auto	[Manual | Auto]
State element disabled	[Disabled | Enabled]
State value valid	[Valid | Not valid]
RFU	[RFU | Not RFU]
Running conditions	[Activated | Not activated]
Output	
State alarm	[None | Fault | Unknown | Failed to run at 'Speed 2' while running at 'Speed 1' | Failed to run at 'Speed 1' while running at 'Speed 2' | Failed to stop while running at 'Speed 2'| Stopped – Failed to run at 'Speed 2' | Stopped – Failed to run at 'Speed 1' | Failed to stop while running at 'Speed 1']
State command	[None | Command start speed 1 | Command start speed 2 | Command stop]
State control position	[None | Local | Manual | Auto]
State element	[Disabled | Stopped | Running speed 1 | Running speed 2 | Transition | Not valid | Not RFU | Failed to run at 'Speed 2' while running at 'Speed 1' | Failed to run at 'Speed 1' while running at 'Speed 2' | Failed to stop while running at 'Speed 2'| Stopped – Failed to run at 'Speed 2' | Stopped – Failed to run at 'Speed 1' | Failed to stop while running at 'Speed 1'| Unknown | Motor fault]

Table 10-2 Motor starter dual speed-element IPMS interface

10.3 Parameters

The element parameters are summarized by Table 10-3.

Parameter	Description	Unit	Value	Adjustable
Ttrans	Time delay on transition	s		Yes
Tctrl	Pulse control length	s		Yes
Tro	Run out time	s		Yes

Table 10-3 Motor starter dual speed-element parameters

If Tctrl = 0, then the relevant output is driven continuously (I.e. not by a pulse)
If Ttrans = 0, then no time-out alarm will be generated.

10.4 Processing

The element processing comprises the next functions:

- Alarm & element state determination;
- Control mode determination;
- Platform control.

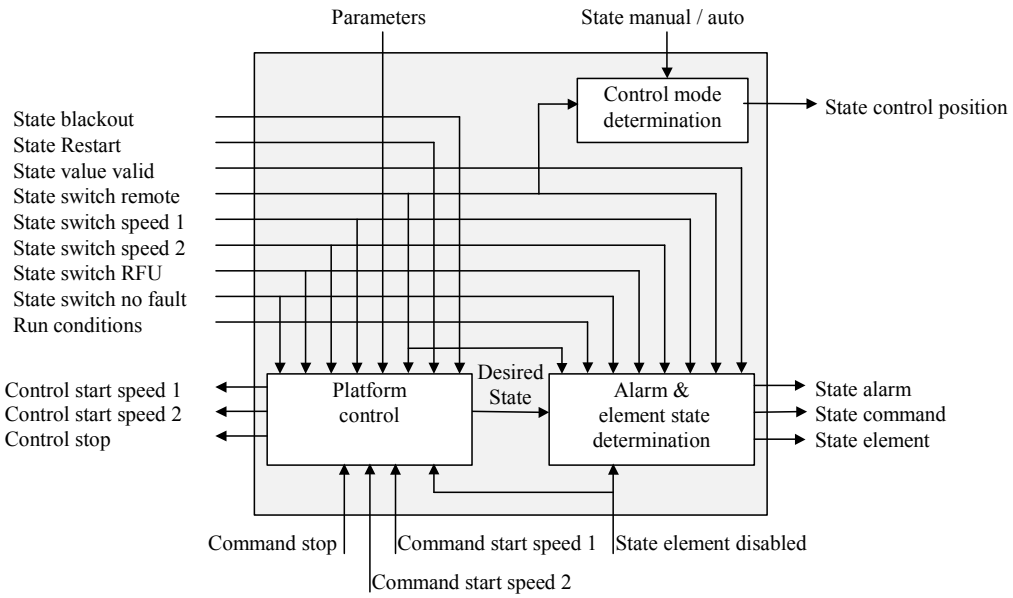


Figure 10-2 Motor starter dual speed-element processing

The functions are described in the next paragraphs.

10.4.1 Platform control

The element is controlled according to Table 10-4

State element disabled	Command	Running Conditions	State switch RFU	Control mode	Platform control
Disabled	x	x	x	x	None
Enabled	None	x	x	x	None
Enabled	x	x	x	Local	None
Enabled	x	NOK	x	Auto	Stop
Enabled	x	NOK	x	Manual	Stop
Enabled	Command stop (Appl)	x	x	Auto	Stop
Enabled	Command start speed 1 (Appl)	OK	OK	Auto	Start speed 1
Enabled	Command start speed 1 (Appl)	OK	NOK	Auto	None
Enabled	Command start speed 2 (Appl)	OK	OK	Auto	Start speed 2
Enabled	Command start speed 2 (Appl)	OK	NOK	Auto	None
Enabled	Any command from the appl.	OK	x	Manual	None
Enabled	Any command from the HMI	OK	x	Auto	None
Enabled	Command stop (HMI)	x	x	Manual	Stop
Enabled	Command start speed 1 (HMI)	OK	OK	Manual	Start speed 1
Enabled	Command start speed 1 (HMI)	OK	NOK	Manual	None
Enabled	Command start speed 2 (HMI)	OK	OK	Manual	Start speed 2
Enabled	Command start speed 2 (HMI)	OK	NOK	Manual	None

Table 10-4 Motor starter dual speed-element platform control

10.4.1.1 Embedded control functions

Running Conditions

For safety reasons the motor might need to stop despite its desired ‘Running Speed 1’ or ‘Running Speed 2’ state. Element processing supports this by providing a ‘Run conditions’ input. As soon as the run conditions are not met anymore the input will be deactivated causing the motor to stop provided that the element is controlled by the LPU (I.e the control mode is not local). However since the desired state is still ‘Running Speed 1’ or “Running Speed 2’ a run failure alarm will be generated after t = Ttrans if Ttrans > 0.

This function is not to be confused with the ‘State switch RFU’ input. Although the ‘Ready For Use’ input needs to be in state RFU before it is possible to start the motor it won’t stop once it is running whenever this input toggles to state ‘Not Ready For Use’ (NRFU).

Power Management support

The element supports the next blackout functions:

```
IF (State Blackout = Activated) THEN
        Failed to run alarms are suppressed
        Line up sequence concerning the ‘Desired State’ is disabled
        IF (State Restart = Activated) THEN
                IF  (Desired State = Running Speed 1) THEN
                        Motor is restarted at Speed 1
                ELSEIF (Desired State = Running Speed 2) THEN
                        Motor is restarted at Speed 2
                END
        END
END
```

Whenever the element is (re-) initialised (LPU state toggles from offline to online) or when the element control mode is switched from ‘local’ to ‘remote’ or when the element is enabled then the desired state must be forced to match the actual state of the motor. In all other cases the desired state must keep up with the command input state.

```
IF      ((Initialising) OR (State switch remote = Local -> Remote) OR
        (State element disabled = Disabled -> Enabled)) THEN
    IF (State switch speed 1 = Open) And (State switch speed 2 = Closed) And (State switch RFU=Open) THEN
        Desired state = Running speed 2;
    END
    IF (State switch speed 1 = Closed) And (State switch speed 2 = Open) And (State switch RFU=Open) THEN
        Desired state = Running speed 1;
    END
    IF (State switch speed 1 = Open) And (State switch speed 2 = Open) And (State switch RFU=Open) THEN
        Desired state = Stop;
    END
END
```

10.4.2 Control mode determination

The control mode is determined by the Remote/Local switch and the Manual/Auto switch as shown in Table 10-5.

State switch Remote	State Manual / Auto	Control mode
Local	x	Local
Remote	Manual	Manual
Remote	Auto	Auto

Table 10-5 Motor starter dual speed-element control mode determination

10.4.3 Value/element state determination

State element disabled	State value valid	State switch no fault	State switch remote	State switch RFU	Desired State	State switch speed 2	State switch speed 1	Ttrans	Transition timer *)	State alarm	State element
Disabled	x	x	x	x	x	x	x	x	x	None	Disabled
Enabled	Not valid	x	x	x	x	x	x	x	x	None	Not valid
Enabled	Valid	Fault	x	x	x	x	x	x	x	Fault	Fault
Enabled	Valid	Fault	x	x	x	Speed 2	x	x	x	Unknown	Unknown
Enabled	Valid	Fault	x	x	x	x	Speed 1	x	x	Unknown	Unknown
Enabled	Valid	No fault	x	x	x	Speed 2	Speed 1	x	x	Unknown	Unknown
Enabled	Valid	No fault	Loc	x	x	Speed 2	Not Speed 1	x	x	None	Speed 2
Enabled	Valid	No fault	Loc	x	x	Not Speed 2	Speed 1	x	x	None	Speed 1
Enabled	Valid	No fault	Loc	x	x	Not Speed 2	Not Speed 1	x	x	None	Stopped
Enabled	Valid	No fault	Rem	Not RFU	x	X	X	x	x	None	Not RFU
Enabled	Valid	No fault	Rem	RFU	None	Not Speed 2	Not Speed 1	x	x	None	Stopped
Enabled	Valid	No fault	Rem	RFU	None	Speed 2	Not Speed 1	x	x	None	Speed 2
Enabled	Valid	No fault	Rem	RFU	None	Not Speed 2	Speed 1	x	x	None	Speed 1
Enabled	Valid	No fault	Rem	RFU	Stop	Not Speed 2	Not Speed 1	x	x	None	Stopped
Enabled	Valid	No fault	Rem	RFU	Stop	Speed 2	Not	>0	t<Ttrans	None	Transition

State element disabled	State value valid	State switch no fault	State switch remote	State switch RFU	Desired State	State switch speed 2	State switch speed 1	Ttrans	Transition timer *)	State alarm	State element
							Speed 1				
Enabled	Valid	No fault	Rem	RFU	Stop	Speed 2	Not Speed 1	>0	t=>Ttrans	Speed 2 – Failed to stop	Speed 2 – Failed to stop
Enabled	Valid	No fault	Rem	RFU	Stop	Speed 2	Not Speed 1	=0	x	None	Speed 2
Enabled	Valid	No fault	Rem	RFU	Stop	Not Speed 2	Speed 1	>0	t<Ttrans	None	Transition
Enabled	Valid	No fault	Rem	RFU	Stop	Not Speed 2	Speed 1	>0	t>=Ttrans	Speed 1 – Failed to stop	Speed 1 – Failed to stop
Enabled	Valid	No fault	Rem	RFU	Speed 2	Not Speed 2	X	>0	t<Ttrans	None	Transition
Enabled	Valid	No fault	Rem	RFU	Speed 2	Not Speed 2	X	>0	t>=Ttrans	Speed 2 failure	Speed 2 failure
Enabled	Valid	No fault	Rem	RFU	Speed 2	Speed 2	Not Speed 1	>0	x	None	Speed 2
Enabled	Valid	No fault	Rem	RFU	Speed 1	X	Not Speed 1	>0	t<Ttrans	None	Transition
Enabled	Valid	No fault	Rem	RFU	Speed 1	X	Not Speed 1	>0	t>=Ttrans	Speed 1 failure	Speed 1 failure
Enabled	Valid	No fault	Rem	RFU	Speed 1	Not Speed 2	Speed 1	>0	x	None	Speed 1

Table 10-6 Motor starter dual speed-element alarm/element state determination

*) The timer is reset on a positive edge of the command stop, start speed 2 or start speed 1 signal.

10.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections describe command - and status word arrangements.

10.5.1 Command word HMI

Bit	Description
0	Stop
1	Speed 1
2	Speed 2
3	-
4	-
5	Manual
6	Auto
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 10-7 Motor starter dual speed-element Command word HMI

10.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	Stopped
0010	0-3	Running Speed 1
0011	0-3	Running Speed 2
0100	0-3	-
0101	0-3	Transition
0110	0-3	Not Valid
0111	0-3	Speed 2 – Failed to speed 1
1000	0-3	Speed 1 – Failed to speed 2
1001	0-3	Speed 1 – Failed to stop
1010	0-3	Not Ready for use
1011	0-3	Stopped – Failed to speed 1
1100	0-3	Stopped – Failed to speed 2
1101	0-3	Speed 2 – Failed to stop
1110	0-3	Undetermined
1111	0-3	Motor fault
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	Last command was: stop
	5	Last command was: Speed 1
	6	Last command was: Speed 2
	7	-
	8	-
	9	True = Hand / False = Auto
	10	True = Local / False = Remote
	11	-
	12	-
	13	-
	14	-
	15	-

Table 10-8 Motor starter dual speed-element Status word

11. Motor Control Standby-element (MCS)

11.1 Function

The motor starter standby-element manages the control and monitoring functions relevant to of a motor starter with standby functionality. I.e. the motor is started automatically if certain conditions are met provided that the element state is 'Standby'.

11.2 Interface

The element interface is shown by Figure 11-1.

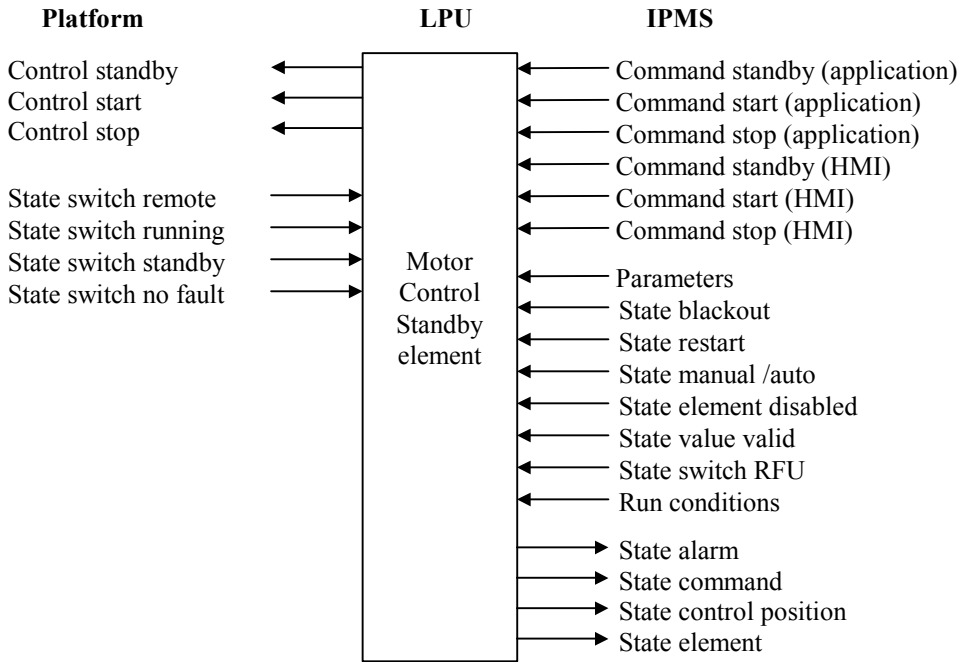


Figure 11-1 Motor Control Standby-element interface

The interfaces are described in the next paragraphs.

11.2.1 Platform interface

The element platform interface is shown by Table 11-1.

Name	Value	I/O specification
Input		
State switch remote	[Local | Remote]	DINO
State switch running	[Running | Not Running]	DINO
State switch standby	[Standby | Not Standby]	DINO
State switch no fault	[Fault | No fault]	DINC
Output		
Control standby	[Not activated | Activated]	DO
Control start	[Not activated | Activated]	DO
Control stop	[Not activated | Activated]	DO

Table 11-1 Motor Control Standby-element platform interface

11.2.2 IPMS interface

The IPMS interface is listed by Table 11-2.

Name	Value
Input	
Command standby (appl)	[Not activated | Activated]
Command start (appl)	[Not activated | Activated]
Command stop (appl)	[Not activated | Activated]
Command standby (HMI)	[Not activated | Activated]
Command start (HMI)	[Not activated | Activated]
Command stop (HMI)	[Not activated | Activated]
State blackout	[Activated | Not activated]
State restart	[Activated | Not activated]
State value valid	[Valid | Not valid]
Parameters	[Ttrans + Tctrl]
State manual /auto	[Manual | Auto]
State element disabled	[Disabled | Enabled]
State switch RFU	[RFU | Not RFU]
Run conditions	[OK| NOK]
Output	
State alarm	[None | Fault | Running – Failed to Standby | Standby – Failed to Start | Standby – Failed to stop | Stopped – Failed to Standby | Stopped – Failed to Start | Running – Failed to Stop | Unknown]
State command	[None | Command standby | Command start | Command stop]
State control position	[None | Local | Manual | Auto]
State element	[Disabled | Stopped | Running | Standby | Transition | Not valid | Not RFU | Running – Failed to Standby | Standby – Failed to Start | Standby – Failed to stop | Stopped – Failed to Standby | Stopped – Failed to Start | Running – Failed to Stop | Unknown | Fault]

Table 11-2 Motor Control Standby-element IPMS interface

11.3 Parameters

The element parameters are summarized by Table 11-3.

Parameter	Description	Unit	Value	Adjustable
Ttrans	Time delay on transition	s		Yes
Tctrl	Control pulse length	s		Yes

Table 11-3 Motor Control Standby-element parameters

If Tctrl = 0, then the relevant output is driven continuously (I.e. not by a pulse)
If Ttrans = 0, then no time-out alarm will be generated.

11.4 Processing

The element processing comprises the next functions:

- Alarm & element state determination;
- Control mode determination;
- Platform control.

The element processing functions along with their internal links are visualized by Figure 11-2.

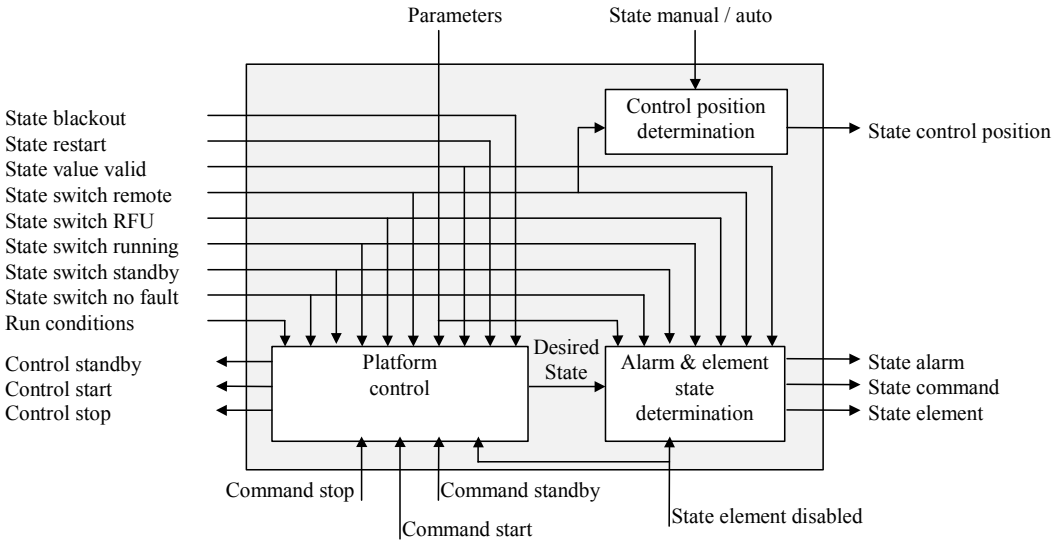


Figure 11-2 Motor Control Standby-element processing

The next sections specify these functions.

11.4.1 Platform control

The element is controlled as shown in Table 11-4.

State element disabled	Command	Run Conditions	State Switch RFU	Control mode	Platform control
Disabled	x	x	x	x	None
Enabled	None	x	x	x	None
Enabled	x	x	x	Local	None
Enabled	x	NOK	x	Auto	Stop
Enabled	x	NOK	x	Manual	Stop
Enabled	Command Stop (Appl)	x	x	Auto	Stop
Enabled	Command Start (Appl)	OK	RFU	Auto	Start
Enabled	Command Start (Appl)	OK	NRFU	Auto	None
Enabled	Command Standby (Appl)	x	RFU	Auto	Standby
Enabled	Any command from the appl.	x	X	Manual	None
Enabled	Any command from the HMI	x	X	Auto	None
Enabled	Command Stop (HMI)	x	X	Manual	Stop
Enabled	Command Start (HMI)	OK	RFU	Manual	Start
Enabled	Command Start (HMI)	OK	NRFU	Manual	None
Enabled	Command Standby (HMI)	x	RFU	Manual	Standby

Table 11-4 Motor Control Standby-element platform control

11.4.1.1 Embedded control functions

Run Conditions

For safety reasons the motor might have to be forced to stop despite its desired run or standby state. Element processing supports this by providing a 'Running conditions' input. As soon as the running conditions are not met anymore the input will be deactivated causing the motor to stop provided that the element is controlled by the LPU (I.e the control mode is not local). However since the desired state is still 'Run' or 'Standby' a 'run failure' or 'failed to standby' alarm will be generated after t = Ttrans if Ttrans > 0.

This function is not to be confused with the 'State switch RFU' input. Although the 'Ready For Use' input needs to be in state RFU before it is possible to start the motor it won't stop once it is running whenever this input toggles to state 'Not Ready For Use' (NRFU).

Power Management support

The element support the next blackout functions:

```
IF (State Blackout = Activated) THEN
        Failed to run alarms are suppressed
        Line up sequence concerning the 'Desired State' is disabled
        IF (State Restart = Activated) THEN
                IF  (Desired State = Start) THEN
                        Motor is restarted
                ELSEIF (Desired State = Standby) THEN
                        Motor is set to standby
                END
        END
END
```

Whenever the element is (re-) initialised (LPU state toggles from offline to online) or when the element control mode is switched from 'local' to 'remote' or when the element is enabled then the desired state must be forced to match the actual state of the motor. In all other cases the desired state must keep up with the command input state.

```
IF      ((Initialising) OR (State switch remote = Local -> Remote) OR
        (State element disabled = Disabled -> Enabled)) THEN
    IF (State switch standby = Closed) AND (State switch running = Open) AND (State switch RFU=Open) THEN
        Desired State = Standby;
    END
    IF (State switch standby = Open) AND (State switch running = Closed) AND (State switch RFU=Open) THEN
        Desired State = Start;
    END
    IF (State switch standby = Open) AND (State switch running = Open) AND (State switch RFU=Open) THEN
        Desired State = Stop;
    END
END
```

11.4.2 Control mode determination

The control mode is determined by the Remote/Local switch and the Manual/Auto switch as shown in Table 11-5.

State switch Remote	State switch manual / auto	Control mode
Local	x	Local
Remote	Manual	Manual
Remote	Auto	Auto

Table 11-5 Motor Control Standby-element control position determination

11.4.3 Alarm/element state determination

The alarm/element state determination is shown in Table 11-6.

State element disabled	State value valid	State switch no fault	State switch remote	State switch RFU	Desired State	State switch running	State switch standby	Trans	Transition timer *)	State alarm	State element
Disabled	x	x	x	x	x	x	x	x	x	None	Disabled
Enabled	Not valid	x	x	x	x	x	x	x	x	None	Invalid
Enabled	Valid	Fault	x	x	x	x	x	x	x	Fault	Fault
Enabled	Valid	Fault	x	x	x	Running	x	x	x	Unknown	Unknown
Enabled	Valid	Fault	x	x	x	x	Standby	x	x	Unknown	Unknown
Enabled	Valid	No fault	x	x	x	Running	Standby	x	x	Unknown	Unknown
Enabled	Valid	No fault	Local	x	x	Not running	Not Standby	x	x	Not Standby	Stopped
Enabled	Valid	No fault	Local	x	x	Running	Not Standby	x	x	None	Running
Enabled	Valid	No fault	Local	x	x	Not running	Standby	x	x	None	Standby
Enabled	Valid	No fault	Rem	Not RFU	x	x	x	x	x	None	Not RFU
Enabled	Valid	No fault	Rem	RFU	None	Not running	Not Standby	x	x	Not Standby	Stopped
Enabled	Valid	No fault	Rem	RFU	None	Not running	Standby	x	x	None	Standby
Enabled	Valid	No fault	Rem	RFU	None	Running	Not Standby	x	x	None	Running
Enabled	Valid	No	Rem	RFU	Stop	Not	Not	>0	x	Not Standby	Stopped

State element disabled	State value valid	State switch no fault	State switch remote	State switch RFU	Desired State	State switch running	State switch standby	Ttrans	Transition timer *)	State alarm	State element
		fault				running	Standby				
Enabled	Valid	No fault	Rem	RFU	Stop	Running	Not Standby	>0	<Ttrans	None	Transition
Enabled	Valid	No fault	Rem	RFU	Stop	Running	Not Standby	>0	>=Ttrans	Running – Failed to stop	Stop failure
Enabled	Valid	No fault	Rem	RFU	Stop	Running	Not Standby	=0	>=Ttrans	None	Running
Enabled	Valid	No fault	Rem	RFU	Stop	Not running	Standby	>0	<Ttrans	None	Transition
Enabled	Valid	No fault	Rem	RFU	Stop	Not running	Standby	>0	>=Ttrans	Standby – Failed to stop	Standby – Failed to Stop
Enabled	Valid	No fault	Rem	RFU	Start	Running	Not Standby	>0	x	None	Running
Enabled	Valid	No fault	Rem	RFU	Start	Not running	x	>0	<Ttrans	Not Standby	Transition
Enabled	Valid	No fault	Rem	RFU	Start	Not running	x	>0	>=Ttrans	Start failure	Start failure
Enabled	Valid	No fault	Rem	RFU	Stand by	Not running	Standby	>0	x	None	Standby
Enabled	Valid	No fault	Rem	RFU	Stand by	x	Not Standby	>0	<Ttrans	Not Standby	Transition
Enabled	Valid	No fault	Rem	RFU	Stand by	x	Not Standby	>0	>=Ttrans	Standby failure	Standby failure

Table 11-6 Motor Control Standby-element alarm/element state determination

*) The timer is reset on a positive edge of the command stop, Command start or command standby signal.
For specific standby-elements the alarm state “Auto start” can be suppressed. These elements should be defined at system configuration.

11.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections describe command - and status word arrangements.

11.5.1 Command word HMI

Bit	Description
0	Stop
1	Start
2	Standby
3	-
4	-
5	Manual
6	Auto
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-

Bit	Description
14	-
15	Parameter update request

Table 11-7 Motor Control Standby-element Command word HMI

11.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	Stopped
0010	0-3	Running
0011	0-3	Standby
0100	0-3	-
0101	0-3	Transition
0110	0-3	Not valid
0111	0-3	Running – Failed to Standby
1000	0-3	Standby – Failed to Start
1001	0-3	Standby – Failed to Stop
1010	0-3	Not Ready for use
1011	0-3	Stopped – Failed to Standby
1100	0-3	Stopped – Failed to Start
1101	0-3	Running – Failed to Stop
1110	0-3	Unknown
1111	0-3	Motor fault
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	Last command was: stop
	5	Last command was: start
	6	Last command was: standby
	7	-
	8	Alarm inhibited
	9	True = Hand / False = Auto
	10	True = Local / False = Remote
	11	-
	12	-
	13	-
	14	-
	15	-

Table 11-8 Motor Control Standby-element Status word

12. Running hours-element (RHE)

12.1 Function

The RHE element is used to count up the hours whenever a platform component is in operation. If the relevant platform component is in operation, the value will accumulate. The operator can reset the counter provided that he is authorized to. This might be of use in case the platform component is replaced or overhauled. In case the accumulated value is lost the last known value may be put in. This is realized by setting the offset parameter. Again the operator must have sufficient privileges to do so.

12.2 Interface

The interface of the element is shown in Figure 12-1.

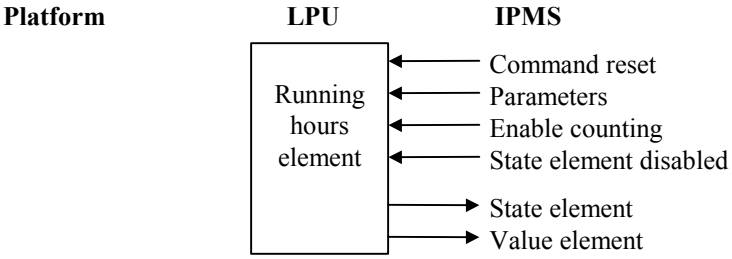


Figure 12-1 Running hours-element interface

The interfaces are described in the next paragraphs.

12.2.1 Platform interface

A platform interface doesn't apply to the RHE.

12.2.2 IPMS interface

The IPMS interface is shown by Table 12-1.

Name	Value
Input	
Command reset	[Not activated | Activated]
Parameters	[OFFSET]
Enable counting	[Not enabled | Enabled]
State element disabled	[Disabled | Enabled]
Output	
State element	[Disabled | Stopped | Counting]
Value element	Value in hours

Table 12-1 Running hours-element IPMS interface

12.3 Parameters

The element parameters are shown in Table 12-2.

Parameter	Description	Unit	Value	Adjustable
OFFSET	Offset on running hours value	Hours		Yes

Table 12-2 Running hours-element parameters

12.4 Processing

The element processing comprises the next functions:

- Element state determination;
- Running hours determination.

The processing is shown in Figure 12-2.

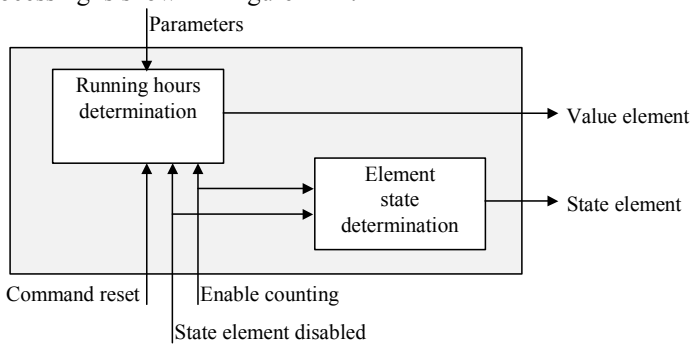


Figure 12-2 Running hours-element processing

The next sections specify these functions.

12.4.1 Element state determination and Running hours determination

The element state determination is shown in Table 12-3.

State element disabled	Enable counting	Command reset	State element	Value element
Disabled	x	x	Disabled	Unavailable
Enabled	Not enabled	Not Activated	Stopped	OFFSET + Accumulated value (stopped)
Enabled	x	Activated	-	OFFSET
Enabled	Enabled	Not activated	Counting	OFFSET + Accumulated value (counting)

Table 12-3 Running hour-element element state determination

12.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections describe command - and status word arrangements.

12.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	Reset counter
11	-
12	-
13	-
14	-
15	Parameter update request

Table 12-4 Running hours element Command word HMI

12.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	-
0010	0-3	-
0011	0-3	Stopped
0100	0-3	Counting
0101	0-3	-
0110	0-3	-
0111	0-3	-
1000	0-3	Reserved
1001	0-3	Reserved
1010	0-3	Reserved
1011	0-3	Reserved
1100	0-3	Reserved
1101	0-3	Reserved
1110	0-3	Reserved
1111	0-3	Reserved
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	-
	5	-
	6	-
	7	-
	8	Reserved
	9	-
	10	-
	11	-
	12	-
	13	-
	14	-
	15	-

Table 12-5 Running hours element Status word

13. Serial Application Element (SAE)

13.1 Function

Like the AAE type element (See section 4) the SAE is able to manage all functions necessary to interface an analogue value that is derived from another application. However, unlike the AAE element the SAE type does no alarm detection by itself. This is especially useful in case an external system (with a native controller inside) not only provides the analogue value but its relevant alarm statuses as well. The SAE is able to interface both the analogue value and the alarm statuses and will forward all these to the HMI in a proper way.

13.2 Interface

The element interface is visualized by Figure 13-1.

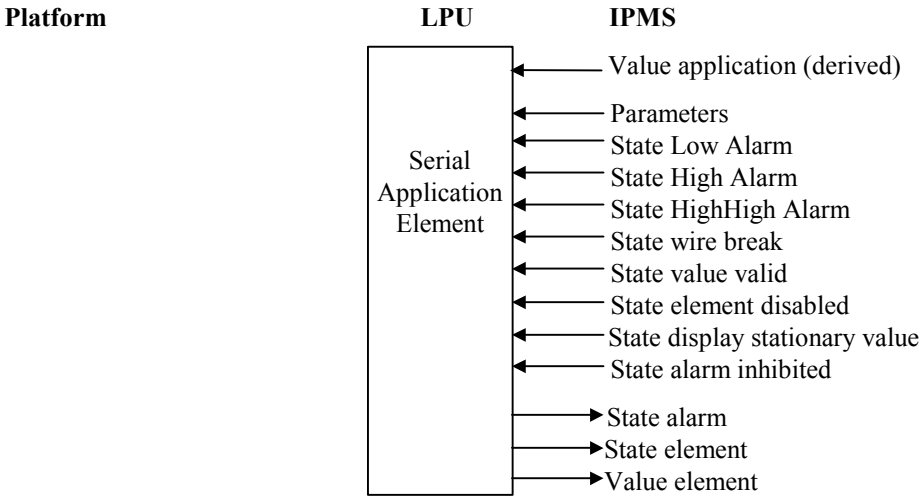


Figure 13-1 Serial Application Element interface

The next sections specify the interfaces.

13.2.1 Platform interface

A platform interface does not apply to this element.

13.2.2 IPMS interface

The IPMS interface is shown by Table 13-1

Name	Value
Input	
Value application	Value from external application (raw)
State element disabled	[Disabled | Enabled]
State display stationary value	[Display stationary value | Display value element]
State alarm inhibited	[Inhibited | Not inhibited]
Parameters	[SF + STA]
State value valid	[Valid | Invalid]
State wire break	[Wire break | No wire break]
State low alarm	[Low Alarm | No Alarm]
State high alarm	[High Alarm | No Alarm]
State highhigh alarm	[Highhigh Alarm | No Alarm]
Output	
State alarm	[None | HHA | HA | LA | Wire break]
State element	[Disabled | None | Not valid | Wire break | LA | HA| HHA]
Value element	Scaled value in EU

Table 13-1 Serial Application Element IPMS interface

13.3 Parameters

The element parameters are shown in Table 13-2

Parameter	Description	Unit	Value	Adjustable
SF	Scale factor	-		Yes
STA	Stationary Value			No

Table 13-2 Serial Application Element parameters

13.4 Processing

The element processing comprises the next functions:

- Application Value conversion
- Value selection
- Alarm/element state determination.

These functions along with their interconnections are visualized by Figure 13-2

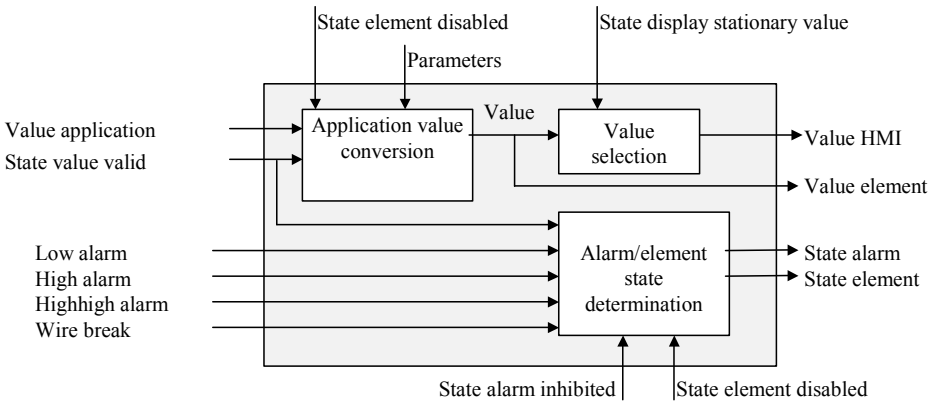


Figure 13-2 Serial Application Element processing

The next sections specify these functions.

13.4.1 Application value conversion

IF (State element disabled = disabled) OR (Value application valid = invalid) THEN
Value = Unavailable;
ELSE
Value = Value application / SF;
END

13.4.2 Value selection

IF (State display stationary value = display stationary value) THEN
Value HMI = Stationary value;
ELSE
Value HMI = Value Element;
END

13.4.3 Alarm/element state determination

The alarm/element state determination is shown in Table 13-3

State element Disabled	State value Valid	State alarm inhibited	Wire Break	HHA	HA	LA	State alarm	State element
Disabled	x	x	x	x	x	x	None	Disabled
Enabled	Invalid	x	x	x	x	x	None	Invalid
Enabled	Valid	Inhibited	x	x	x	1	Inhibited	Value OK
Enabled	Valid	Inhibited	x	x	1	x	Inhibited	Value OK
Enabled	Valid	x	x	1	x	x	HHA	HHA
Enabled	Valid	x	1	x	x	x	Wire break	Wire break
Enabled	Valid	Not inhibited	0	0	0	1	LA	LA
Enabled	Valid	Not inhibited	0	0	1	0	HA	HA
Enabled	Valid	Not inhibited	0	0	0	0	None	Value OK

Table 13-3 Serial Application Element alarm/element state determination

13.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections describe command - and status word arrangements.

13.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 13-4 Serial Application Element Command word HMI

13.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	-
0010	0-3	-
0011	0-3	-
0100	0-3	Normal
0101	0-3	-
0110	0-3	-
0111	0-3	-
1000	0-3	Not valid
1001	0-3	Reserved
1010	0-3	Reserved
1011	0-3	Alarm wire break
1100	0-3	Alarm low
1101	0-3	Alarm high
1110	0-3	Reserved
1111	0-3	Reserved
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	-
	5	-
	6	-
	7	-
	8	Alarm inhibited
	9	-
	10	-
	11	-
	12	-
	13	-
	14	-
	15	-

Table 13-5 Serial Application Element Status word

14. Switch Event Element (SEE)

14.1 Function

The Switch Event Element is used to count the number of switch events of a platform component. If a relevant change of state of the component is detected a positive edge applied on the event input will increment the count by one. The operator can reset the counter provided that he is authorized to. This might be of use in case the relevant component has been replaced of overhauled. In case the accumulated value is lost the last known value may be put in by setting an offset parameter. Again the operator needs sufficient privileges to able to.

14.2 Interface

The interface of the element is shown in Figure 14-1.

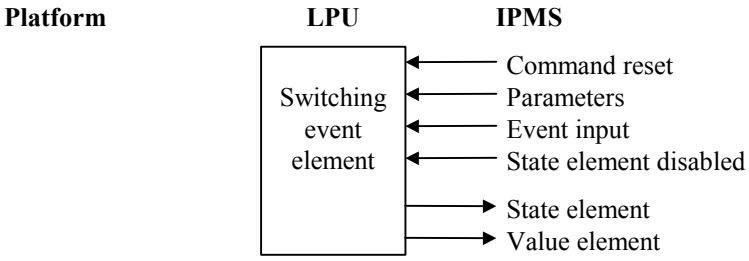


Figure 14-1 Switch Event Element interface

The interfaces are described in the next paragraphs.

14.2.1 Platform interface

This element has no platform interface.

14.2.2 IPMS interface

The IPMS interface of the element is shown in Table 14-1.

Name	Value
Input	
Command reset	[Not activated | Activated]
Parameters	[OFFSET]
Event input	[Not activated | Activated]
State element disabled	[Disabled | Enabled]
Output	
State element	[Disabled | Counting | Normal]
Value element	Number of events

Table 14-1 Switch Event Element IPMS interface

14.3 Parameters

The parameters of the element are shown in Table 14-2.

Parameter	Description	Unit	Value	Adjustable
OFFSET	Offset on switching event counter	Events	0	Yes

Table 14-2 Switch Event Element parameters

14.4 Processing

The element processing comprises the next functions:

- Element state determination;
- Switch events determination.

The processing is shown in Figure 12-2.

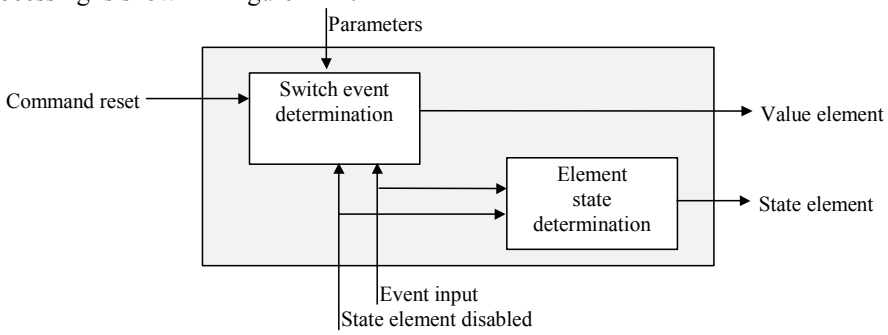


Figure 14-2 Switch Event Element processing

The next sections specify these functions

14.4.1 Switch Events determination

IF (Event Input = Activated) THEN
    Value element = Value element + 1
ELSEIF
    (Command reset = Activated) OR (Value element > 2147483647) THEN
    Value element = 0;
ELSE
    Value element is unchanged
END

14.4.2 Element state determination

The element state determination is shown in Table 14-3

State element disabled	Event input	State element
Disabled	x	Disabled
Enabled	x	Normal

Table 14-3 Switch Event Element state determination

14.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections describe command - and status word arrangements.

14.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	Reset counter
11	-
12	-
13	-
14	-
15	Parameter update request

Table 14-4 Command word HMI

14.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	-
0010	0-3	-
0011	0-3	-
0100	0-3	Normal
0101	0-3	-
0110	0-3	-
0111	0-3	-
1000	0-3	Reserved
1001	0-3	Reserved
1010	0-3	Reserved
1011	0-3	Reserved
1100	0-3	Reserved
1101	0-3	Reserved
1110	0-3	Reserved
1111	0-3	Reserved
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	-
	5	-
	6	-
	7	-
	8	Reserved
	9	-
	10	-
	11	-
	12	-
	13	-
	14	-
	15	-

Table 14-5 Status word

15. Setpoint Element (SPE)

15.1 Function

The setpoint element supports numerical input from remote. By using this element a remote operator is able to readjust setpoint values regarding a certain process.

15.2 Interface

The element interface is shown in Figure 15-1.

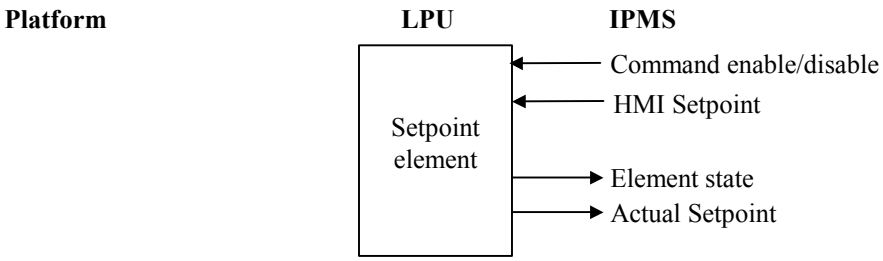


Figure 15-1 Setpoint Element interface

The next sections specify the setpoint element interface signals.

15.2.1 Platform interface

A platform interface doesn't apply to this element

15.2.2 IPMS interface

The IPMS interface is shown in Table 15-1.

Name	Value
Input	
Command enable/disable	[Disable | Enable]
HMI Setpoint	New setpoint value
Output	
Element state	[Disabled | Normal]
Actual Setpoint	Value in EU (to HMI and application)

Table 15-1 Setpoint Element IPMS interface

15.3 Parameters

This element has no parameters.

15.4 Processing

The element processing comprises the next functions:

- Storage of setpoint value;
- Enable/disable element

These functions are shown by Figure 15-2.

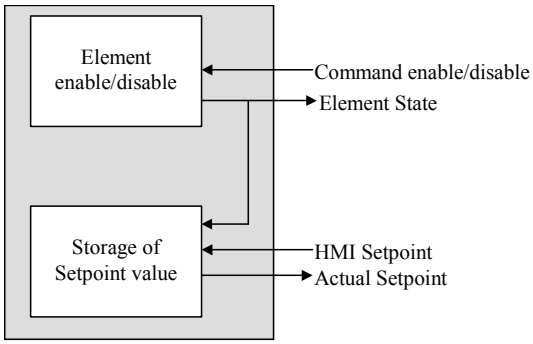


Figure 15-2 Setpoint element processing

The next sections specify these functions.

15.4.1 Element enable/disable

IF (Command enable/disable = disable) THEN
Element state = Disabled
ELSE IF (Command enable/disable = enable) THEN
Element state = Enabled
END

15.4.2 Storage of setpoint value

IF (Element state = disabled) THEN
Actual Setpoint = Unavailable;
ELSE
Actual Setpoint = HMI Setpoint
END

15.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections describe command - and status word arrangements.

15.5.1 Command word HMI

Bit	Description
0	-
1	-
2	Reserved
3	Reserved
4	Reserved
5	-
6	-
7	-
8	Disable element
9	Enable element
10	-
11	-
12	Reserved
13	-
14	-
15	-

Table 15-2 Setpoint Element Command word HMI

15.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	-
0010	0-3	-
0011	0-3	-
0100	0-3	Normal
0101	0-3	-
0110	0-3	-
0111	0-3	-
1000	0-3	Reserved
1001	0-3	Reserved
1010	0-3	Reserved
1011	0-3	Reserved
1100	0-3	Reserved
1101	0-3	Reserved
1110	0-3	Reserved
1111	0-3	Reserved
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	-
	5	-
	6	-
	7	-
	8	Reserved
	9	-
	10	-
	11	-
	12	-
	13	-
	14	-
	15	-

Table 15-3 Setpoint Element Status word

16. Sensor element (SSE)

16.1 Function

The sensor element interfaces an analogue value that is derived from a physical analogue input. The element function includes scaling by using a linear conversion algorithm and the upper and lower limits of its specified range. An 'out of range low' or 'out of range high' alarm will be generated in case the input value is outside its normal range. Furthermore a high or low alarm will be generated in case the input value exceeds an alarm threshold value being set for the element although it is within its working range. The element supports hysteresis and time delay functions for both the high and low alarms.

Besides this, both the high and low alarms can be inhibited in case the sensor value exceeds its limits due to a normal platform state. In that case the alarm is considered to be spurious.

16.2 Interface

The element interface is shown in Figure 16-1

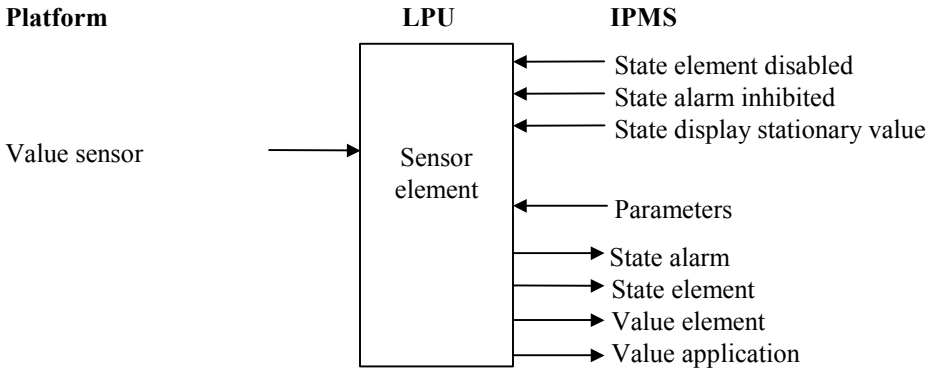


Figure 16-1 Sensor Element interface

The interfaces are specified by the next sections.

16.2.1 Platform interface

The platform interface is shown in Table 16-1

Name	Value	I/O specification
Input Value sensor	 0 - 20 mA	 AI 4 - 20 mA

Table 16-1 Sensor Element platform interface

16.2.2 IPMS interface

The IPMS interface is shown in Table 16-2

Name	Value
Input	
State element disabled	[Disabled | Enabled]
State inhibited	[Not inhibited | Inhibited]
State display stationary value	[Display stationary value | Display sensor value (scaled)]
Parameters	[HA + LA + HYHA + HYLA + THA + TLA + TOORH + TOORL + V20+ V4 + STA]
Output	
State alarm	[None | HA | LA | OORL | OORH]
State element	[Disabled | Value OK | HA | LA | OORL | OORH]
Value element	Value in EU (to HMI)
Value application	Value in EU (to application)

Table 16-2 Sensor Element IPMS interface

16.3 Parameters

The parameters that apply are shown in Table 16-3

Parameter	Description	Unit	Value	Adjustable
HA	High alarm value	EU		Yes
LA	Low alarm value	EU		Yes
HYHA	Hysteresis on HA alarms	EU		Yes
HYLA	Hysteresis on LA alarms	EU		Yes
THA	Time delay high alarm	s		Yes
TLA	Time delay low alarm	s		Yes
TOORL	Time delay OORL alarm	s		No
TOORH	Time delay OORH alarm	s		No
V20	Value on 20 mA	EU		Yes
V4	Value on 4 mA	EU		Yes
STA	Stationary Value	EU		No

Table 16-3 Sensor Element parameters

16.4 Processing

The element processing comprises the next functions:

- Alarm evaluation;
- Alarm / Element state determination;
- Sensor value conversion.

The processing is shown in Figure 16-2

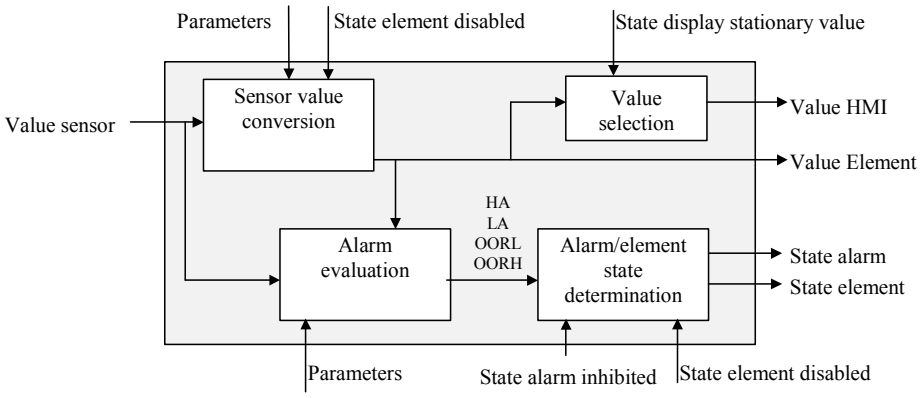


Figure 16-2 Sensor Element processing

The functions are described in the next paragraphs.

16.4.1 Sensor value conversion

IF (State element disabled = disabled) THEN
Value element = Unavailable;
ELSE
Value element = (V20 -V4)/16 * (Value sensor - 4) + V4;
Value application = (V20 -V4)/16 * (Value sensor - 4) + V4;
END

16.4.2 Value selection

IF (State display stationary value = display stationary value) THEN
Value HMI = Stationary value;
ELSE
Value HMI = Value Element;
END

16.4.3 Alarm evaluation

The alarm evaluation determines if there is an alarm condition active. The next alarm conditions are available:

- HA;
- LA;
- OORH;
- OORL.

HA

IF (Value element > HAV during t > THA) AND (OORH≠1) THEN
HA = 1;
END
IF (Value element <= (HAV - HYHA) during (t > THA)) THEN
HA = 0;
END

LA
IF (Value element < LAV during t > TLA) AND (OORL≠1) THEN
LA = 1;
END
IF (Value element >= (LAV + HYLA) during (t > TLA)) THEN
LA = 0;
END

OORH
IF (Value sensor > V20 during (t > TOORH)) THEN
OORH = 1;
END
IF (Value sensor < V20 limit during (t > TOORH)) THEN
OORH = 0;
END

OORL
IF (Value sensor < V4 limit during (t > TOORL)) THEN
OORL = 1;
END
IF (Value sensor > v4 limit during (t > TOORL)) THEN
OORL = 0;
END

16.4.4 Alarm / element state determination

The alarm/element state determination is shown in Table 16-4

State element disabled	State Inhibited	OORH	OORL	HA	LA	State alarm	State element
Disabled	x	x	x	x	x	None	Disabled
Enabled	Inhibited	x	x	x	x	Inhibited	Value OK
Enabled	Not inhibited	0	0	0	1	LA	LA
Enabled	Not inhibited	0	0	1	0	HA	HA
Enabled	Not inhibited	0	1	x	x	OORL	OORL
Enabled	Not inhibited	1	0	x	x	OORH	OORH
Enabled	Not inhibited	0	0	0	0	None	Value OK

Table 16-4 Sensor Element alarm/element state determination

16.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections specify command - and status word arrangements.

16.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 16-5 Sensor Element Command word HMI

16.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	-
0010	0-3	-
0011	0-3	-
0100	0-3	Normal
0101	0-3	-
0110	0-3	-
0111	0-3	-
1000	0-3	Reserved
1001	0-3	Reserved
1010	0-3	Reserved
1011	0-3	
1100	0-3	Alarm low
1101	0-3	Alarm high
1110	0-3	Alarm Out of range low
1111	0-3	Alarm Out of range high
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	-
	5	-
	6	-
	7	-
	8	Alarm inhibited
	9	-
	10	-
	11	-
	12	-
	13	-
	14	-
	15	-

Table 16-6 Sensor Element Status word

17. Tank Level element (SSL)

17.1 Function

The tank level element functions are dedicated to tank content measurements. The tank level can be derived from a pressure sensor that is installed inside, and near the bottom of, a tank. For accurate tank content determination, the SSL element needs adjustment of relevant parameters such as specific gravity constant (applicable to the medium inside the tank) and tank sensor location relative to the tank bottom.

Besides this, the relationship between tank level and tank content must be specified for each tank. A maximum of 16 breakpoints is supported to configure the tank curve.

Furthermore the SSL element features

- A first order filter to filter out tank level changes due to the ship's swell;
- Air pressure compensation;
- Max. 5 tank curves to compensate for several ship-trim angles.

An 'out of range low' or 'out of range high' alarm will be generated in case the input value is outside its normal range. Moreover a high or low alarm will be generated in case the input value exceeds an alarm threshold value being set for the element although it is in its working range. The element supports hysteresis and time delay functions for each 'high' or 'low' alarm.

Both the high and low alarms can be inhibited in case the sensor value exceeds its limits for a known situation.

17.2 Interface

The element interface is shown by Figure 17-1.

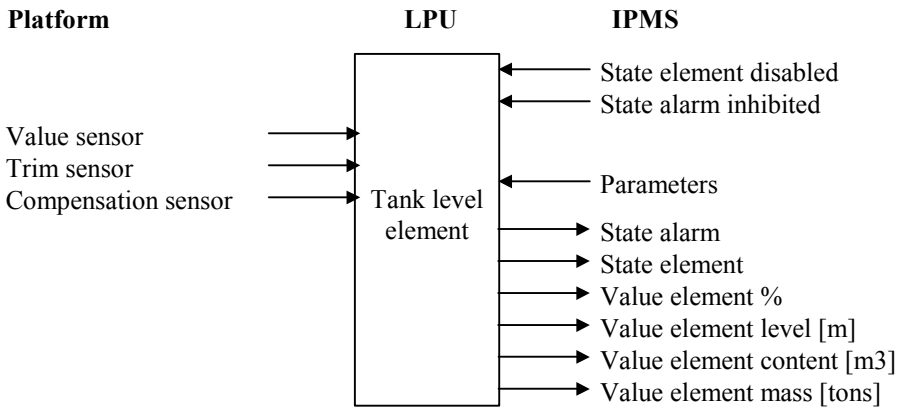


Figure 17-1 Tank level element interface

The interfaces are described in the next paragraphs.

17.2.1 Platform interface

The platform interface is summarized by Table 17-1.

Name	Value	I/O specification
Input		
Value sensor	0 - 20 mA	AI 4 - 20 mA
Trim value	0 - 20 mA	AI 4 - 20 mA
Compensation sensor	0 - 20 mA	AI 4 - 20 mA

Table 17-1 Tank level element platform interface

17.2.2 IPMS interface

The IPMS interface is summarized by Table 17-2.

Name	Value
Input	
Parameters	[SG + Tau + HA + LA + HYHA + HYLA + THA + TLA + TOORL + TOORH + V20+ V4 + SenOff + TnkCntMax + X1...X16 + TRIM1...TRIM5]
State element disabled	[Disabled | Enabled]
State inhibited	[Not inhibited | Inhibited]
Output	
State alarm	[None | Inhibited | WB | HA | LA | OORL | OORH]
State element	[Disabled | None | WB | HA | LA | OORL | OORH]
Value element %	Value in %
Value element level	Value in m
Value element m3	Value in m3
Value element mass	Value in tons

Table 17-2 Tank level element IPMS interface

17.3 Parameters

The parameters that apply to this element are shown by Table 17-3.

Parameter	Description	Unit	Value	Adjustable
SG	Specific Gravity of tank medium	Kg/m^3		Yes
Tau	Filter Constant	s		Yes
HAV	High alarm value	m		Yes
HYHA	Hysteresis on HA alarms	m		Yes
HYLA	Hysteresis on LA alarms	m		Yes
LAV	Low alarm value	m		Yes
THA	Time delay high alarm	s		Yes
TLA	Time delay low alarm	s		Yes
TOORL	Time delay OORL alarm	s		No
TOORH	Time delay OORH alarm	s		No
V4	Value on 4 mA	m		Yes
V20	Value on 20 mA	m		Yes
SenOff	Distance below tank sensor relative to tank bottom	m		No
TnkCntMax	Max. content of tank	m3		No
X1...X16	Breakpoints “tank level vs. tank content” curve	m		No
Y1...Y5	Breakpoints “trim” vs. “tank content” curve	m		No

Table 17-3 Tank level element parameters

17.4 Processing

The element processing comprises the next functions:

- Sensor value conversion;
- Tank level determination;
- Tank contents determination.
- Alarm evaluation;
- Alarm/element state determination;

These functions along with their interconnections are visualized by Figure 17-2.

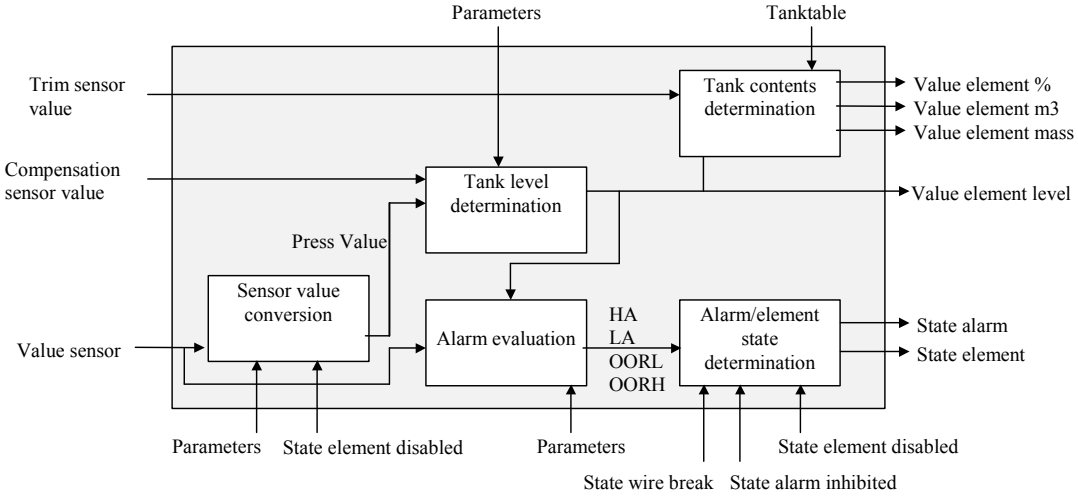


Figure 17-2 Tank level element processing

The next sections specify these functions.

17.4.1 Sensor value conversion

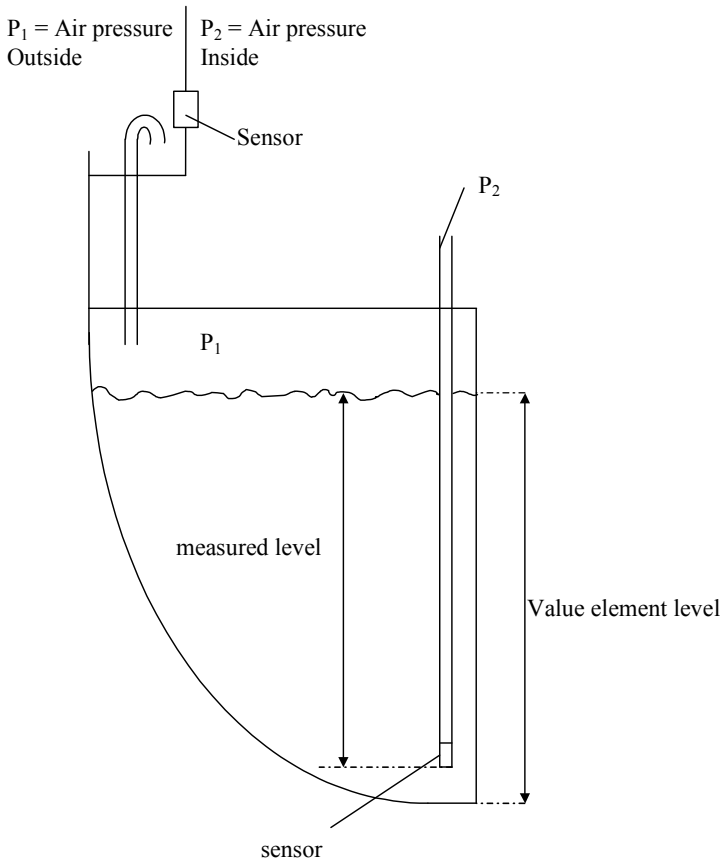
IF (State element disabled = disabled) THEN
  Press Value = Unavailable;
ELSE
  Press Value = (Value sensor / 100) * (V20 – V4) + V4;
END

17.4.2 Tank level determination

The tank level will be derived from the pressure measured at the bottom of the tank, the compensation sensor value, the gravity constant (ρ) and the specific gravity for the medium (SG).

$$\text{Measured level} = \frac{\text{PressVal} + \text{Compensation factor}}{\text{SG} * \rho}$$

Where:
compensation factor = P_2 - P_1
When the air pressure compensation sensor is not OK or not installed, then $P_2 = P_1$ And Compensation factor = 0.



A first order filter algorithm will filter the measured level. (Time constant defined by parameter 'Tau'):

$$\text{Measured level} = \text{Measured level}(t) - \text{Measured level}(t - dt) * \frac{\text{Tcycle}}{\text{Tau}} + \text{Measured level}(t - dt)$$

Besides this the measured level might need an extra offset as the sensor position is probably slightly above the bottom of the tank. In that case an offset parameter can be used to compensate for the actual tank level.

Value element level = Measured level + Offset

17.4.3 Tank content determination

The determination of the tank content is derived from the tank level by interpolation of a given curve. This curve is unique for each tank. The tank curve has to be provided by the customer. A maximum of 16 breakpoints will be derived from that curve. To compensate for trim several curves must be supplied for each trim. A maximum of 5 breakpoints can be derived to compensate tank level determination for a deviation of trim.

Value element m3 = Interpolation (X1..16, Value element level), Interpolation (Y1..5, Trim value);

Value element % = 100.0 * Value element m3 / TnkCntMax

Value element mass (in tons) = Value element m3 * SG / 1000

17.4.4 Alarm evaluation

The alarm evaluation determines if there is an alarm condition active. The next alarm conditions are available:

- HA;
- LA;
- OORH;
- OORL.

HA

IF (Value element level > HAV during t > THA) AND (OORH = 0) THEN
    HA = 1;
END
IF (Value element level <= (HAV - HYHA) during (t > THA)) THEN
    HA = 0;
END

LA

IF (Value element level < LAV during t > TLA) AND (OORL = 0) THEN
    LA = 1;
END
IF (Value element level >= (LAV + HYLA) during (t > TLA)) THEN
    LA = 0;
END

OORH

IF (Value sensor > OORH during (t > TOORH)) THEN
    OORH = 1;
END
IF (Value sensor < OORH during (t > TOORH)) THEN
    OORH = 0;
END

OORL

IF (Value sensor < OORL limit during (t > TOORL)) THEN
    OORL = 1;
END
IF (Value sensor > OORL limit during (t > TOORL)) THEN
    OORL = 0;
END

17.4.5 Alarm/element state determination

The alarm/element state determination is shown in Table 17-4.

State element disabled	State alarm Inhibited	OORH	OORL	HA	LA	State alarm	State element
Disabled	x	x	x	x	x	None	Disabled
Enabled	Inhibited	1	0	x	x	Inhibited	Value OK
Enabled	Not inhibited	0	0	1	0	HA	HA
Enabled	Not inhibited	0	0	0	1	LA	LA
Enabled	Not inhibited	0	0	0	0	None	Value OK
Enabled	Not inhibited	1	0	x	x	OORH	OORH
Enabled	Not inhibited	0	1	x	x	OORL	OORL

Table 17-4 Tank level element alarm/element state determination

17.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections specify command - and status word arrangements.

17.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 17-5 Tank level element Command word HMI

17.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	-
0010	0-3	-
0011	0-3	-
0100	0-3	Normal
0101	0-3	-
0110	0-3	-
0111	0-3	-
1000	0-3	Reserved
1001	0-3	Reserved
1010	0-3	Reserved
1011	0-3	
1100	0-3	Alarm low
1101	0-3	Alarm high
1110	0-3	Alarm Out of range low
1111	0-3	Alarm Out of range high
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	-
	5	-
	6	-
	7	-
	8	Alarm inhibited
	9	-
	10	-
	11	-
	12	-
	13	-
	14	-
	15	-

Table 17-6 Tank level element Status word

18. Sensor element (SS1)

18.1 Function

Like the SSE (See section 16) this element is mend to interface an analogue value derived from a physical analogue input. The element function includes a linear scaling algorithm based on the upper and lower limits of its specified normal range. An 'out of range low' or 'out of range high' alarm will be generated in case the input value is outside its normal range.

Unlike the SSE, three different alarm high threshold levels are defined for this element. That is the element is able to generate 'high', 'highhigh' and 'extra high' alarms. The element supports hysteresis and time delay functions for each alarm.

The 'high' alarm can be inhibited in case the sensor value exceeds this limit for a known platform situation. The other alarm levels though are not inhibited by this element.

18.2 Interface

The interface of the element is shown in Figure 18-1

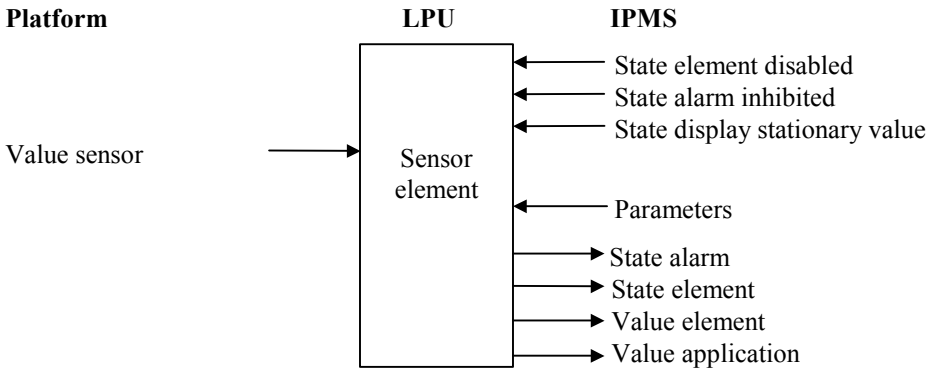


Figure 18-1 Sensor element interface

The next sections specify the sensor element interface.

18.2.1 Platform interface

The platform interface is shown in Table 18-1

Name	Value	I/O specification
Input Value sensor	0 - 20 mA	AI 4 - 20 mA

Table 18-1 Sensor-element platform interface

18.2.2 IPMS interface

The IPMS interface is summarized by Table 18-2

Name	Value
Input	
State element disabled	[Disabled | Enabled]
State alarm inhibited	[Not inhibited | Inhibited]
State display stationary value	[Display stationary value | Display sensor value (scaled)]
Parameters	[HAV + HHAV + XHAV + HY + TA+ V20+ V4 + STA]
Output	
State alarm	[None | HA | HHA | XHA | OORL | OORH]
State element	[Disabled | Value OK | HA | HHA | XHA | OORL | OORH]
Value element	Value in EU (to HMI)
Value application	Value in EU (to application)

Table 18-2 Sensor-element IPMS interface

18.3 Parameters

The parameters that apply to this element are listed by Table 18-3

Parameter	Description	Unit	Value	Adjustable
HAV	High alarm value	EU		Yes
HHAV	Highhigh alarm value	EU		Yes
XHAV	Extra high alarm value	EU		Yes
HY	Hysteresis applicable to all high alarms	EU		Yes
TA	Time delay applicable to all high alarms	s		Yes
TOORL	Time delay OORL alarm	s		No
TOORH	Time delay OORH alarm	s		No
V20	Value on 20 mA	EU		Yes
V4	Value on 4 mA	EU		Yes
STA	Stationary Value	EU		No

Table 18-3 Sensor-element parameters

18.4 Processing

The element processing comprises:

- Alarm evaluation;
- Alarm / Element state determination;
- Sensor value conversion;
- Value selection.

The processing is shown in Figure 18-2

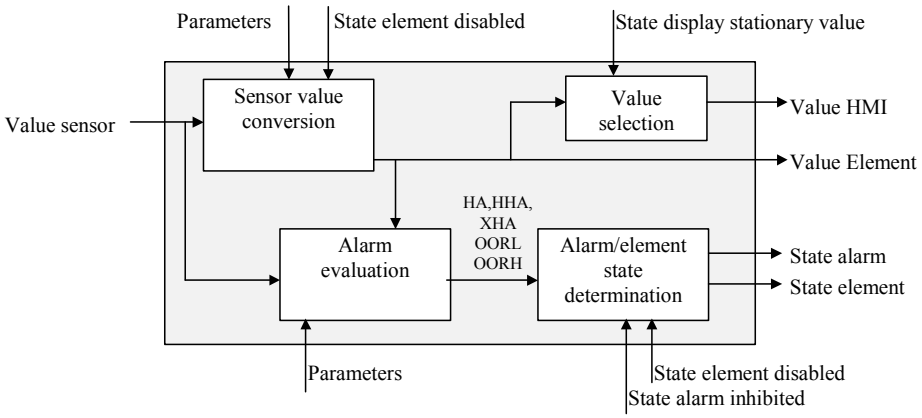


Figure 18-2 Sensor-element processing

The functions are described in the next paragraphs.

18.4.1 Sensor value conversion

IF (State element disabled = disabled) THEN
Value element = Unavailable;
ELSE
Value element = (V20 -V4)/16 * (Value sensor - 4) + V4;
Value application = (V20 -V4)/16 * (Value sensor - 4) + V4;
END

18.4.2 Value selection

IF (State display stationary value = display stationary value) THEN
Value HMI = Stationary value;
ELSE
Value HMI = Value Element;
END

18.4.3 Alarm evaluation

The alarms are generated by the alarm evaluation function. The next alarms apply to this element:

- HA;
- HHA;
- XHA;
- OORH;
- OORL.

HA

IF (Value element > HAV during t > TA) AND (OORH≠1) THEN
HA = 1;
END
IF (Value element <= (HAV - HY) during (t > TA)) THEN
HA = 0;
END

HHA
IF (Value element > HHAV during t > TA) AND (OORH≠1) THEN
HHA = 1;
END
IF (Value element <= (HHAV - HY) during (t > TA)) THEN
HHA = 0;
END

XHA
IF (Value element > XHAV during t > TA) AND (OORH≠1) THEN
XHA = 1;
END
IF (Value element <= (XHAV - HY) during (t > TA)) THEN
XHA = 0;
END

OORH
IF (Value sensor > OORH) limit during (t > TOORH)) THEN
OORH = 1;
END
IF (Value sensor < OORH limit during (t > TOORH)) THEN
OORH = 0;
END

OORL
IF (Value sensor < OORL limit during (t > TOORL)) THEN
OORL = 1;
END
IF (Value sensor > OORL limit during (t > TOORL)) THEN
OORL = 0;
END

18.4.4 Alarm / element state determination

The alarm/element state determination is shown in Table 18-4

State element disabled	State Inhibited	OORH	OORL	HA	HHA	XHA	State alarm	State element
Disabled	x	x	x	x	x	x	None	Disabled
Enabled	Inhibited	x	x	x	x	x	Inhibited	Value OK
Enabled	Not inhibited	0	0	0	0	1	XHA	XHA
Enabled	Not inhibited	0	0	0	1	0	HHA	HHA
Enabled	Not inhibited	0	0	1	0	0	HA	HA
Enabled	Not inhibited	0	1	x	x	x	OORL	OORL
Enabled	Not inhibited	1	0	x	x	x	OORH	OORH
Enabled	Not inhibited	0	0	0	0	0	None	Value OK

Table 18-4 Sensor element alarm/element state determination

18.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections specify command - and status word arrangements.

18.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 18-5 Sensor element Command word HMI

18.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	-
0010	0-3	-
0011	0-3	-
0100	0-3	Normal
0101	0-3	-
0110	0-3	-
0111	0-3	-
1000	0-3	Reserved
1001	0-3	Reserved
1010	0-3	Alarm high
1011	0-3	
1100	0-3	Alarm highhigh
1101	0-3	Alarm extra high
1110	0-3	Alarm Out of range low
1111	0-3	Alarm Out of range high
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	-
	5	-
	6	-
	7	-
	8	Alarm inhibited
	9	-
	10	-
	11	-
	12	-
	13	-

SM	Bit	Description
	14	-
	15	-

Table 18-6 Sensor element Status word

19. Sensor element (SS2)

19.1 Function

Like the AAE (See section 4) this element is mend to interface a derived or calculated (i.e. not related to a physical input) value. Unlike the AAE, three different alarm high threshold levels are defined for this element. That is, the element is able to generate 'high', 'highhigh' and 'extra high' alarms. Along with these alarms the element supports hysteresis and time delay functions as well.

The 'high' alarm can be inhibited in case the sensor value exceeds this limit for a known platform situation. The other alarm levels though are not inhibited by this element.

19.2 Interface

The interface of the element is shown in Figure 19-1

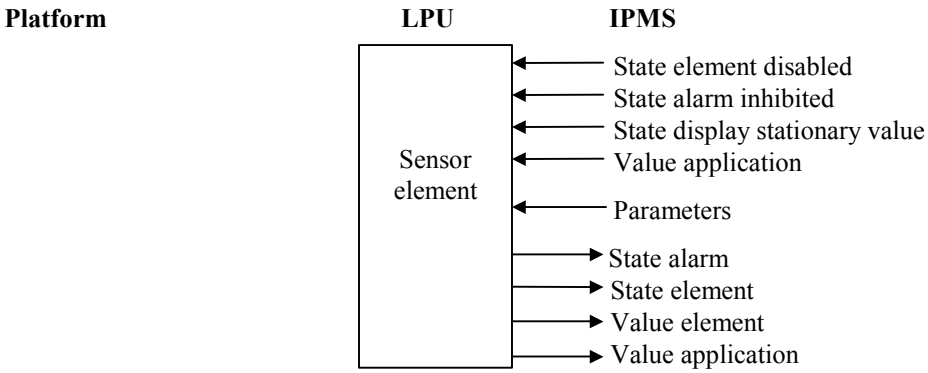


Figure 19-1 Sensor element interface

The next sections specify the sensor element interface.

19.2.1 Platform interface

A platform interface doesn't apply to this element.

19.2.2 IPMS interface

The IPMS interface is summarized by Table 19-2

Name	Value
Input	
Value application	Value (not scaled)
State element disabled	[Disabled | Enabled]
State alarm inhibited	[Not inhibited | Inhibited]
State display stationary value	[Display stationary value | Display sensor value (scaled)]
Parameters	[HAV + HHAV + XHAV + HY + TA+ V20+ V4 + STA]
Output	
State alarm	[None | HA | HHA | XHA | OORL | OORH]
State element	[Disabled | Value OK | HA | HHA | XHA | OORL | OORH]

Name	Value
Value element Value application	Value in EU (to HMI) Value in EU (to application)

Table 19-1 Sensor-element IPMS interface

19.3 Parameters

The parameters that apply to this element are listed by Table 19-3

Parameter	Description	Unit	Value	Adjustable
HAV	High alarm value	EU		Yes
HHAV	Highhigh alarm value	EU		Yes
XHAV	Extra high alarm value	EU		Yes
HY	Hysteresis applicable to all high alarms	EU		Yes
TA	Time delay applicable to all high alarms	s		Yes
STA	Stationary Value	EU		No

Table 19-2 Sensor-element parameters

19.4 Processing

The element processing comprises:

- Alarm evaluation;
- Alarm / Element state determination;
- Sensor value conversion;
- Value selection.

These functions along with their interconnections are visualized by Figure 19-2

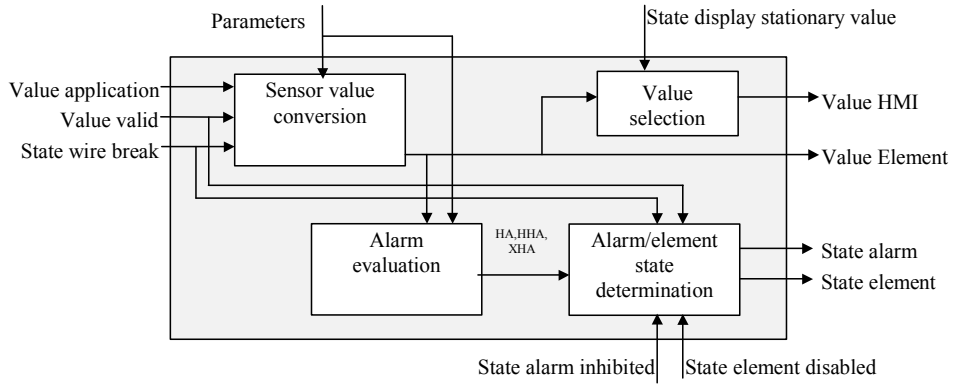


Figure 19-2 Sensor-element processing

The functions are described by the next paragraphs.

19.4.1 Sensor value conversion

IF (State element disabled = disabled) OR
(Value application valid = invalid) OR
(State wire break = wire break) THEN
Value Element = Unavailable;
ELSE
Value Element = Value application / SF;
END

19.4.2 Value selection

IF (State display stationary value = display stationary value) THEN
Value HMI = Stationary value;
ELSE
Value HMI = Value Element;
END

19.4.3 Alarm evaluation

The alarms are generated by the alarm evaluation function. The next alarms apply to this element:

- HA;
- HHA;
- XHA;

HA

IF (Value element > HAV during t > TA) AND (OORH≠1) THEN
HA = 1;
END
IF (Value element <= (HAV - HY) during (t > TA)) THEN
HA = 0;
END

HHA

IF (Value element > HHAV during t > TA) AND (OORH≠1) THEN
HHA = 1;
END
IF (Value element <= (HHAV - HY) during (t > TA)) THEN
HHA = 0;
END

XHA

IF (Value element > XHAV during t > TA) AND (OORH≠1) THEN
XHA = 1;
END
IF (Value element <= (XHAV - HY) during (t > TA)) THEN
XHA = 0;
END

19.4.4 Alarm / element state determination

The alarm/element state determination is shown in Table 19-3

State element disabled	State Inhibited	Wire break	HA	HHA	XHA	State alarm	State element
Disabled	x	x	x	x	x	None	Disabled
Enabled	x	1	x	x	x	WB	WB
Enabled	x	0	x	x	1	XHA	XHA
Enabled	x	0	x	1	0	HHA	HHA
Enabled	Inhibited	0	1	0	0	Inhibited	Value OK
Enabled	Not inhibited	0	1	0	0	HA	HA
Enabled	Not inhibited	0	0	0	0	None	Value OK

Table 19-3 Sensor element alarm/element state determination

19.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections specify command - and status word arrangements.

19.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 19-4 Sensor element Command word HMI

19.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	-
0010	0-3	-
0011	0-3	-
0100	0-3	Normal
0101	0-3	-
0110	0-3	-
0111	0-3	-
1000	0-3	Reserved
1001	0-3	Reserved
1010	0-3	Alarm high
1011	0-3	Wire break

SM	Bit	Description
1100 1101 1110 1111	0-3 0-3 0-3 0-3	Alarm highhigh Alarm extra high
	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Status bit 0 Status bit 1 Status bit 2 Status bit 3 - - - - Alarm inhibited - - - - - - -

Table 19-5 Sensor element Status word

20. Switch element (basic) (SWB)

20.1 Function

The SWB element interfaces a discrete (digital) input in a basic way. That is it does not support any alarm or parameter functionality neither disable/enable functions. It is mend to monitor a digital status either issued by a digital input module or derived from a logical expression.

20.2 Interface

The element interface is shown in Figure 20-1.

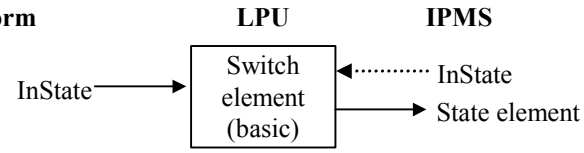


Figure 20-1 Switch-element-bit interface

The interfaces are described in the next paragraphs.

20.2.1 Platform interface

The platform interface of the element is shown in Table 20-1.

Name	Value	I/O specification
Input InState*	 [TRUE | FALSE]	 DINO / DINC

Table 20-1 Switch element (basic) platform interface

*: This element suits monitoring internal logical states also. In that case the platform interface doesn't apply

20.2.2 IPMS interface

The IPMS interface of the element is shown in Table 20-2.

Name	Value
Input InState* **Output** State element	 [TRUE | FALSE] [State 0 | State 1]

Table 20-2 Switch-element-bit IPMS interface

*: This element suits monitoring discrete platform inputs also. In that case the IPMS interface doesn't apply

20.3 Parameters

This element does not use any parameters

20.4 Processing

The element processing comprises the next function:

- Element state determination;

The processing is shown in Figure 20-2

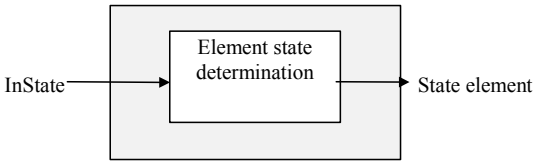


Figure 20-2 Switch-element-bit processing

This function is described in the next section.

20.4.1 Element state determination

```
IF (InState = TRUE) THEN
    State element = State 1
END
IF (InState = FALSE) THEN
    State element = State 0;
END
```

20.5 Command word and status word

This element has no command word or status word. For animation a single bit embedded into an array of double words represents the status of the element. This array is forwarded to the HMI.

21. Switch-element (SWE)

21.1 Function

The SWE function is to interface a discrete (digital) input or a logically derived status.
An alarm status may apply to either the open (Normally Closed) or closed (Normally Open) state of the switch.
A spurious alarm caused by a certain (known) platform state can be inhibited by driving the alarm inhibit input

21.2 Interface

The element interface is shown in Figure 21-1.

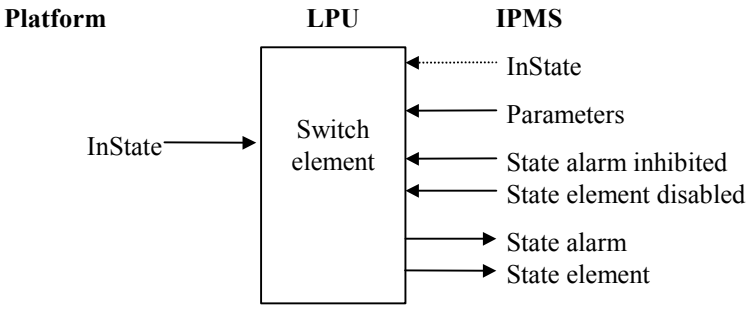


Figure 21-1 Switch-element interface

The next sections describe the interfaces.

21.2.1 Platform interface

The platform interface of the element is shown in Table 21-1.

Name	Value	I/O specification
Input InState*	[TRUE | FALSE]	DINO / DINC

Table 21-1 Switch-element platform interface

*: This element suits monitoring internal logical states also. In that case the platform interface doesn't apply

21.2.2 IPMS interface

The IPMS interface of the element is shown in Table 21-2.

Name	Value
Input	
InState*	[TRUE | FALSE]
Parameters	[NO/NC + TDELAY + MODE]
State element disabled	[Disabled | Enabled]
State inhibited	[Not inhibited | Inhibited]
Output	
State alarm	[None | Alarm]
State element	[Disabled | State 0 | State 1 | Alarm]

Table 21-2 Switch-element IPMS interface

*: This element is also suitable for monitoring a discrete digital input state. In that case the IPMS interface doesn't apply.

21.3 Parameters

The parameters of the element are shown in Table 21-3.

Parameter	Description	Unit	Value	Adjustable
NO/NC	Input signal type	-		No
MODE	Alarm / No alarm configuration	-		No
TDELAY	Time delay on switch	s		Yes

Table 21-3 Switch-element parameters

21.4 Processing

The element processing comprises the next functions:

- Alarm/element state determination;
- Signal delay.

The processing is shown in Figure 21-2.

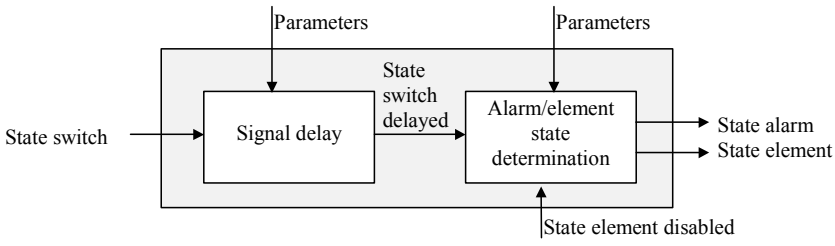


Figure 21-2 Switch-element processing

The functions are described in the next paragraphs.

21.4.1 Signal delay

IF (State switch = TRUE for t > TDELAY) THEN
State switch delayed = TRUE;
END
IF (State switch = FALSE for t > TDELAY) THEN
State switch delayed = FALSE;
END

21.4.2 Alarm/element state determination

The alarm/element state determination is shown in Table 21-4.

State element disabled	State alarm inhibited	Mode	NO / NC	State switch delayed	State alarm	State element
Disabled	x	x	x	x	None	Disabled
Enabled	Inhibited	Alarm	NO	TRUE	Inhibited	State 0
Enabled	Inhibited	Alarm	NC	FALSE	Inhibited	State 0
Enabled	x	No Alarm	NO	TRUE	None	State 0
Enabled	x	No Alarm	NC	FALSE	None	State 0
Enabled	x	No Alarm	NO	FALSE	None	State 1
Enabled	x	No Alarm	NC	TRUE	None	State 1
Enabled	Not inhibited	Alarm	NO	TRUE	Alarm	Alarm
Enabled	Not inhibited	Alarm	NC	FALSE	Alarm	Alarm

Table 21-4 Switch element alarm/element state determination

21.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections specify command - and status word arrangements.

21.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 21-5 Switch element Command word HMI

21.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	State 0
0010	0-3	State 1
0011	0-3	-
0100	0-3	-
0101	0-3	-
0110	0-3	-
0111	0-3	-
1000	0-3	-
1001	0-3	-
1010	0-3	-
1011	0-3	-
1100	0-3	-
1101	0-3	-
1110	0-3	-
1111	0-3	Alarm
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	-
	5	-
	6	-
	7	-
	8	Alarm inhibited
	9	-
	10	-
	11	-
	12	-
	13	-
	14	-
	15	-

Table 21-6 Switch element Status word

22. Switch-element with NBCD function (SWN)

22.1 Function

Basically the Switch-element with NBCD has the same features as the SWE. Additionally it features an 'Evaluate' function which compares the current element state with a required element state regarding a certain NBCD threat level. Since a simple activation of the NBCD threat level might cause a great number of alarms regarding all NBCD elements that don't comply, the evaluate function makes it possible to achieve a preview of all the NBCD elements on the platform not being in their required state before the NBCD threat is actually activated.

22.2 Interface

The element interface is shown in Figure 22.1.

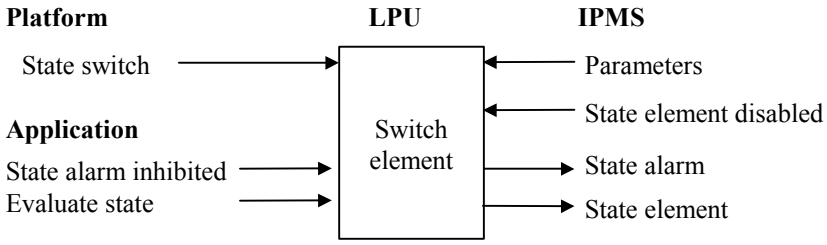


Figure 22.1 NBCD Switch-element interface

The interfaces are described in the following paragraphs.

22.2.1 Platform interface

The platform interface of the element is shown in Table 22.1

Name	Value	I/O specification
Input		
State switch	[False | True]	DI

Table 22.1 NBCD Switch-element platform interface

22.2.2 Application interface

The application interface of the element is shown in Table 22.2

Name	Value
Input	
State alarm inhibited	[Not inhibited | Inhibited]
Evaluate State	[False | True]

Table 22.2 NBCD Switch-element application interface

22.2.3 IPMS interface

The IPMS interface of the element is shown in Table 22.3.

Name	Value
Input	
Parameters	[TDELAY + MODE]
State element disabled	[Disabled | Enabled]
Output	
State alarm	[None | Alarm | Inhibited]
State element	[Disabled | State 0 | State 1 |Warning| Alarm]

Table 22.3 NBCD Switch-element IPMS interface

22.3 Parameters

The parameters of the element are shown in Table 22.4.

Parameter	Description	Unit	Value	Adjustable
MODE	Alarm / No alarm	-		No
TDELAY	Time delay on switch	s		Yes

Table 22.4 NBCD Switch-element parameters

22.4 Processing

The processing of the element comprises the following functions:

- Alarm/element state determination;
- Signal delay.

The processing is shown in Figure 22.2.

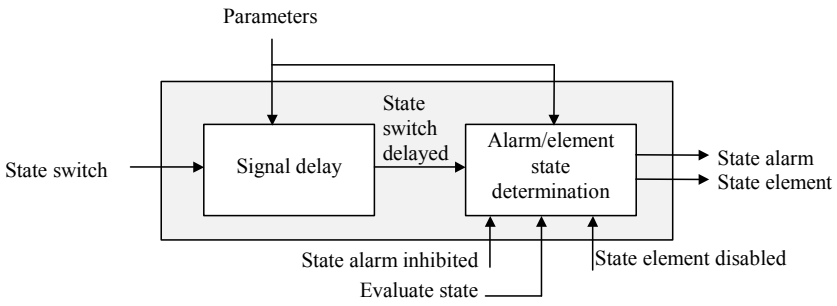


Figure 22.2 NBCD Switch Element processing

The next sections specify these functions.

Signal delay:
IF (State switch = True during t > TDELAY) THEN
State switch delayed = True;
END
IF (State switch = False) THEN
State switch delayed = False;
END

22.4.1 Alarm/element state determination

The alarm/element state determination is shown in Table 22.5.

State element disabled	State alarm inhibited	Evaluate	Mode	State switch delayed	State alarm	State element
Disabled	x	x	x	x	None	Disabled
Enabled	Inhibited	False	x	False	Inhibited	State 1
Enabled	Inhibited	False	x	True	Inhibited	State 0
Enabled	Inhibited	True	x	False	Inhibited	State 1
Enabled	Inhibited	True	x	True	Inhibited	Warning
Enabled	Not inhibited	x	No Alarm	False	None	State 1
Enabled	Not inhibited	x	No Alarm	True	None	State 0
Enabled	Not inhibited	x	Alarm	False	None	State 1
Enabled	Not inhibited	x	Alarm	True	Alarm	Alarm

Table 22.5 NBCD Switch-element alarm/element state determination

22.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections specify command - and status word arrangements.

22.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 22.6 NBCD Switch element Command word HMI

22.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	State 0
0010	0-3	State 1
0011	0-3	-
0100	0-3	-
0101	0-3	-
0110	0-3	-
0111	0-3	-
1000	0-3	-
1001	0-3	-
1010	0-3	Warning
1011	0-3	-
1100	0-3	-
1101	0-3	-
1110	0-3	-
1111	0-3	Alarm
	4	-
	5	-
	6	-
	7	-
	8	Alarm inhibited
	9	-
	10	-
	11	-
	12	-
	13	-
	14	-
	15	-

Table 22.7 NBCD Switch element Status word

23. Valve-element electrical (VCE)

23.1 Function

This element interfaces an electrically controlled valve with state feedback. The actual state of the valve interfaces the element by two digital inputs i.e. 'closed' or 'open'. Besides interfacing a valve this type of element might used to interface other components such as clutches also.

23.2 Interface

The element interface is shown in Figure 23-1.

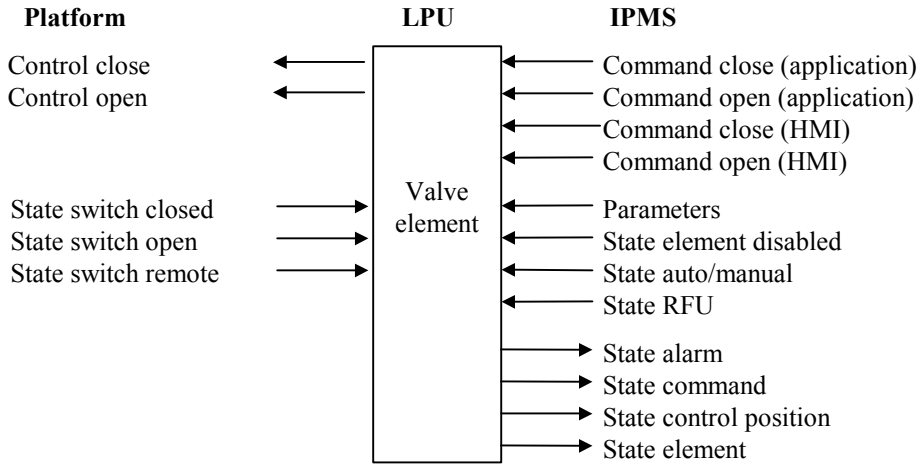


Figure 23-1 Electrical valve-element interface

The interfaces are described in the next sections.

23.2.1 Platform interface

The platform interface of the element is shown in Table 23-1.

Name	Value	I/O specification
Input		
State switch closed	[Closed | Not closed]	DINO
State switch open	[Open | Not open]	DINO
State switch remote	[Local | Remote]	DINO
Output		
Control close	[Not activated | Activated]	DO
Control open	[Not activated | Activated]	DO

Table 23-1 Electrical valve-element platform interface

23.2.2 IPMS interface

The IPMS interface of the element is shown in Table 23-2.

Name	Value
Input	
Command close (application)	[Not activated | Activated]
Command open (application)	[Not activated | Activated]
Command close (HMI)	[Not activated | Activated]
Command open (HMI)	[Not activated | Activated]
Parameters	[Ttrans + Tctrl]
State element disabled	[Disabled | Enabled]
State auto/manual	[Manual | Auto]
State RFU	[Ready for Use | Not Ready for Use]
Output	
State alarm	[None | Failed to Close | Failed to open | Unknown]
State command	[None | Command close | Command open]
State control position	[None | Local | Manual | Auto]
State element	[Disabled | Closed | Open | Transition | Not RFU | Open failure | Close failure | Unknown]

Table 23-2 Electrical valve-element IPMS interface

23.3 Parameters

The element parameters are shown in Table 23-3.

Parameter	Description	Unit	Value	Adjustable
Ttrans	Time delay on transition	s		Yes
Tctrl	Pulslength (0=continuous control)	s		Yes

Table 23-3 Electrical valve-element parameters

If Tctrl = 0, then the relevant output is driven continuously (I.e. not by a pulse)
If Ttrans = 0, then no time-out alarm will be generated.

23.4 Processing

The element processing comprises the next functions:

- Command/alarm/element state determination;
- Control position determination;
- Platform control.

The processing is shown in Figure 23-2.

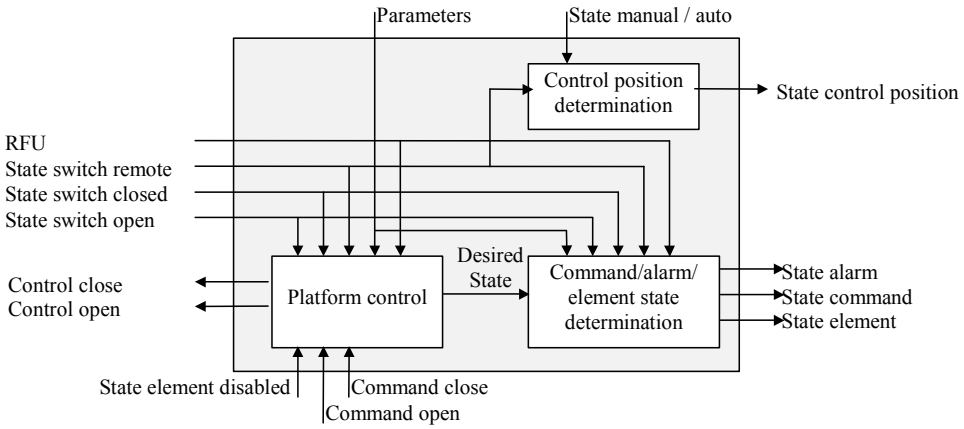


Figure 23-2 Electrical valve-element processing

The functions are described in the next paragraphs.

23.4.1 Platform control

```
IF      (State element disabled = Disabled) THEN
        Control close = Deactivated AND Control open = Deactivated;
        Desired State = none;
ELSEIF      (Command close = Activated) THEN
        Control open  = Deactivated;
        Desired State = Closed;
        IF      (Tctrl = 0) THEN
                Control close = Activated continuously;
        ELSE
                Control close = Activated during t = TCtrl;
        END
ELSEIF      (Command open = Activated) THEN
        Control close  = Deactivated;
        Desired State = Command open;
        IF      (TCtrl = 0) THEN
                Control open = Activated continuously;
        ELSE
                Control open = Activated during t = TCtrl;
        END
END
```

Whenever the element is (re-) initialised (LPU state toggles from offline to online) or when the element control mode is switched from ‘local’ to ‘remote’ or when the element is enabled then the desired state must be forced to match the actual state of the breaker. In all other cases the desired state must keep up with the command input state.

```
IF      ((Initialising) OR (State switch remote = Open -> Closed) OR
        (State element disabled = Disabled -> Enabled)) THEN
        IF      (State switch closed = Closed) THEN
                Desired state = Closed;
        ELSEIF (State switch open = Open) THEN
                Desired state = Open;
        ELSE
                Desired state = None;
        END
END
```

23.4.2 Control mode determination

The control mode is determined by the Remote/Local switch and the Manual/Auto switch as shown in Table 23-4.

State switch Remote	State Manual /Auto	Control mode
Local	x	Local
Remote	Manual	Manual
Remote	Auto	Auto

Table 23-4 Electrical valve-element control mode determination

23.4.3 Alarm/element state determination

The alarm/element state determination is shown in Table 23-5.

State element disabled	RFU	State witch remote	Desired State	State switch closed	State switch open	Ttrans	timer *)	State alarm	State element
Disabled	x	x	x	x	x	x	x	None	Disabled
Enabled	x	x	x	Closed	Open	x	x	Unknown	Unknown
Enabled	NRFU	x	Closed	Closed	Not open	x	x	None	Not RFU
Enabled	NRFU	x	Open	Not closed	Open	x	x	None	Not RFU
Enabled	RFU	Local	x	Closed	Not open	x	x	None	Closed
Enabled	RFU	Local	x	Not closed	Not open	x	x	None	Transition
Enabled	RFU	Local	x	Not closed	Open	x	x	None	Open
Enabled	RFU	Rem	Closed	Closed	Not open	x	x	None	Closed
Enabled	RFU	Rem	Closed	Not closed	x	>0	t<Ttrans	None	Transition
Enabled	RFU	Rem	x	Not closed	Not open	=0	x	None	Transition
Enabled	RFU	Rem	Closed	Not closed	x	>0	t>=Ttrans	Close failure	Close failure
Enabled	RFU	Rem	Open	x	Not open	>0	t<Ttrans	None	Transition
Enabled	RFU	Rem	Open	Not closed	Open	x	x	None	Open
Enabled	RFU	Rem	Open	x	Not open	>0	t>=Ttrans	Open failure	Open failure

Table 23-5 Electrical valve-element alarm/element state determination

*) The timer is reset on a positive edge of the command close, command open signal.

23.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections specify command - and status word arrangements.

23.5.1 Command word HMI

Bit	Description
0	Close
1	Open
2	-
3	-
4	-
5	Manual
6	Auto
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 23-6 Electrical valve-element Command word HMI

23.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	Closed
0010	0-3	Opened
0011	0-3	-
0100	0-3	-
0101	0-3	Transition
0110	0-3	-
0111	0-3	-
1000	0-3	-
1001	0-3	-
1010	0-3	Not Ready for use
1011	0-3	-
1100	0-3	Failed to close
1101	0-3	Failed to open
1110	0-3	Unknown
1111	0-3	-
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	Last command was: Close
	5	Last command was: Open
	6	-
	7	-
	8	Reserved
	9	True = Hand / False = Auto
	10	True = Local / False = Remote
	11	-
	12	-
	13	-
	14	-
	15	-

Table 23-7 Electrical valve-element Status word

24. Valve-element hydraulic (VCH)

24.1 Function

The function of this element is to interface a hydraulically controlled valve. The valve state is controlled by two digital outputs. One is used for starting a hydraulic pump while the other one is used for the direction in which the valve will move. To toggle the valve state the element must start the pump while the direction output is in the relevant state. The timing diagram is shown in Figure 24-1.

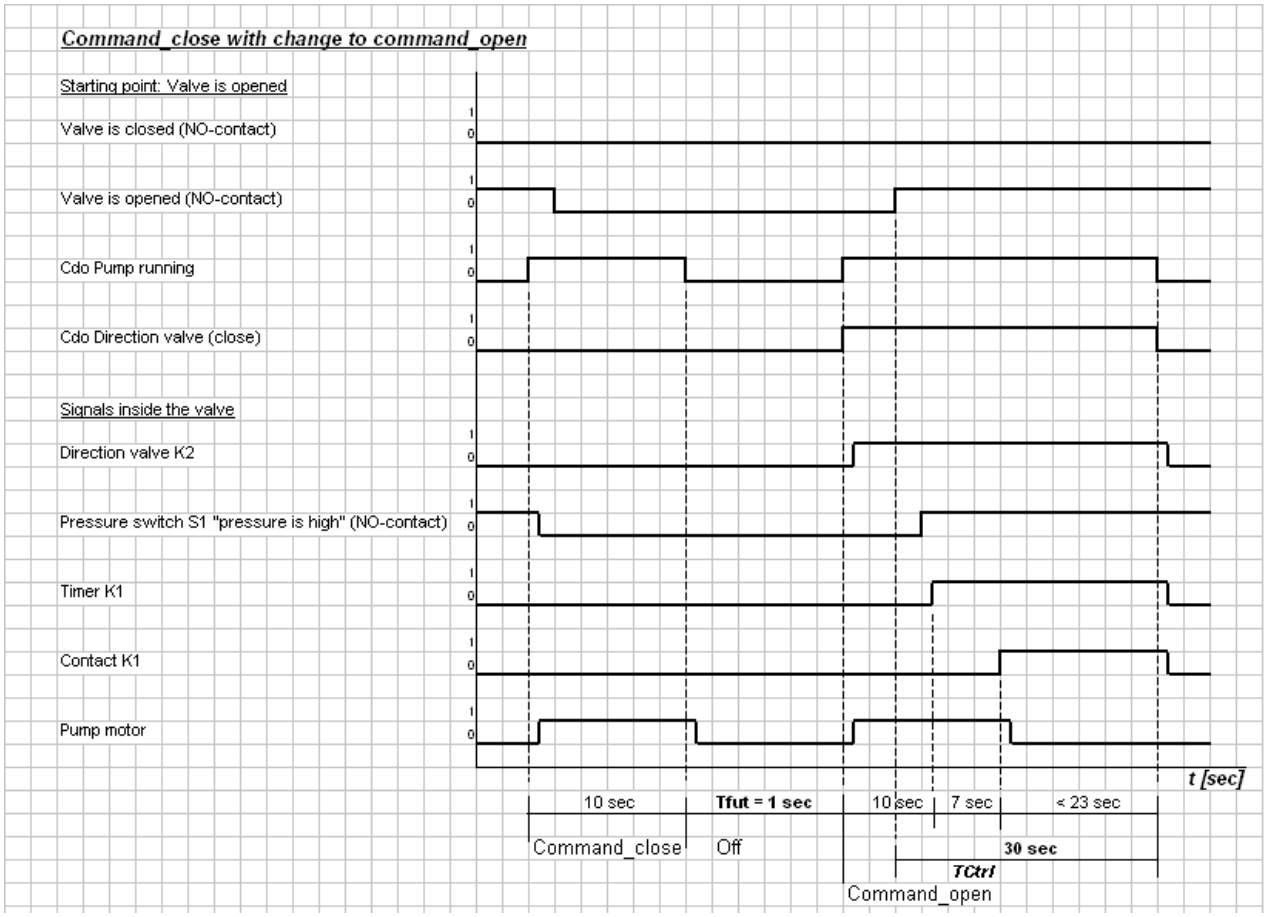


Figure 24-1 Timing diagram hydraulic valve

24.2 Interface

The interface of the element is shown in Figure 24-2.

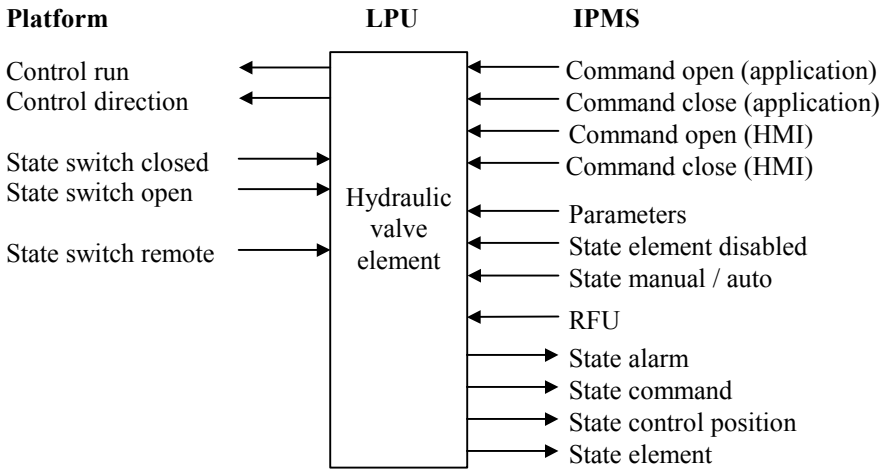


Figure 24-2 Hydraulic valve-element interface

The next sections describe the interfaces.

24.2.1 Platform interface

The platform interface of the element is shown in Table 24-1.

Name	Value	I/O specification
Input		
State switch closed	[Closed | Not closed]	DINO
State switch open	[Open | Not open]	DINO
State switch remote	[Local | Remote]	DINO
Output		
Control run	[Run | Stop]	DO
Control direction	[Open | Close]	DO

Table 24-1 Hydraulic valve-element platform interface

24.2.2 IPMS interface

The IPMS interface of the element is shown in Table 24-2.

Name	Value
Input	
Command open (appl)	[Not activated | Activated]
Command close (appl)	[Not activated | Activated]
Command open (HMI)	[Not activated | Activated]
Command close (HMI)	[Not activated | Activated]
Parameters	[Ttrans + TCdd + Tctrl]
State element disabled	[Disabled | Enabled]
State manual / auto	[Manual | Auto]
RFU	[RFU | Not RFU]
Output	
State alarm	[None | Open failure | Close failure | Unknown]
State command	[None | Command close | Command open]
State control position	[None | Local | Manual | Auto]
State element	[Disabled | Closed | Open | Transition | Not RFU | Close failure | Open failure | Unknown]

Table 24-2 Hydraulic valve-element IPMS interface

24.3 Parameters

The parameters of the element are shown in Table 24-3.

Parameter	Description	Unit	Value	Adjustable
Ttrans	Time delay on transition	s		Yes
TCdd	Time needed between change of direction	s		No
TCtrl	Time needed to close or open valve	s	1	Yes

Table 24-3 Hydraulic valve-element parameters

If Tctrl = 0, then the relevant output is driven continuously (I.e. not by a pulse)
If Ttrans = 0, then no time-out alarm will be generated.

24.4 Processing

The element processing comprises the next functions:

- Command/alarm/element state determination;
- Control position determination;
- Platform control.

The processing is shown in Figure 24-3.

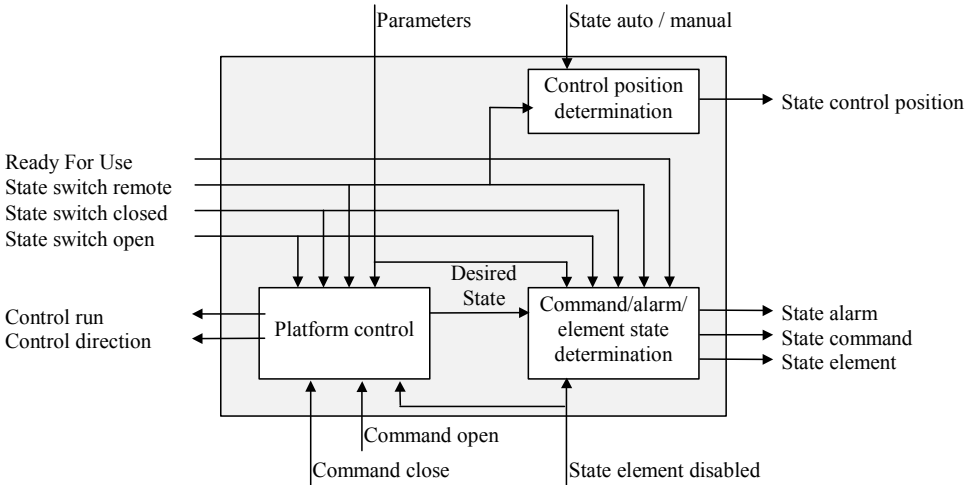


Figure 24-3 Hydraulic Valve element processing

The next sections describe these functions.

24.4.1 Platform control

```
IF      (State element disabled = Disabled) THEN
        Control run = Deactivated AND Control direction = Deactivated;
        Desired state = none;
ELSEIF      (Command open = Activated) THEN
        Control direction = Deactivated;
        Desired state = Open;
        IF      (TCtrl = 0) THEN
                Control run = Activated continuously
        ELSE
                Control run = Activated during t = TCtrl + TCcd;
        END
ELSEIF (Command close = Activated) THEN
        Control direction = Activated;
        Desired state = Closed;
        IF      (TCtrl = 0) THEN
                Control run = Activated continuously;
        ELSE
                Control run = Activated during t = TCtrl + TCcd;
        END
END
```

Whenever the element is (re-) initialised (LPU state toggles from offline to online) or when the element control mode is switched from ‘local’ to ‘remote’ or when the element is enabled then the desired state must be forced to match the actual state of the breaker. In all other cases the desired state must keep up with the command input state.

```
IF      ((Initialising) OR (State switch remote = Open -> Closed) OR
        (State element disabled = Disabled -> Enabled)) THEN
        IF      (State switch close = Closed) THEN
                Desired State = Closed;
        ELSEIF          (State switch open = Closed) THEN
                Desired State = Open;
        ELSE
                Desired State = None;
        END
END
```

24.4.2 Control mode determination

The control mode is determined by the Remote/Local switch and the Manual/Auto switch as shown in Table 24-4.

State switch Remote	State Manual / Auto	Control mode
Local	x	Local
Remote	Manual	Manual
Remote	Auto	Auto

Table 24-4 Hydraulic valve element control mode determination

24.4.3 Alarm/element state determination

The alarm/element state determination is shown in Table 24-5

State element Disabled	State switch remote	RFU	Desired State	State switch closed	State switch open	timer *)	State alarm	State element
Disabled	x	x	x	x	x	x	None	Disabled
Enabled	x	x	x	Closed	Open	x	Unknown	Unknown
Enabled	Local	x	x	Closed	Not open	x	None	Closed
Enabled	Loc	x	x	Not closed	Open	x	None	Open
Enabled	Loc	x	x	Not closed	Not open	x	None	None
Enabled	Rem	Not RFU	x	x	x	x	None	Not RFU
Enabled	Rem	RFU	None	Not closed	Not open	x	None	None
Enabled	Rem	RFU	None	Closed	Not open	x	None	Closed
Enabled	Rem	RFU	None	Not closed	Open	x	None	Open
Enabled	Rem	RFU	Close	Not closed	Not open	t<Ttrans	None	Transition
Enabled	Rem	RFU	Close	Not closed	Not open	t=>Ttrans	Failed to close	Close failure
Enabled	Rem	RFU	Close	Closed	Not open	x	None	Closed
Enabled	Rem	RFU	Close	Not closed	Open	t<Ttrans	None	Transition
Enabled	Rem	RFU	Close	Not	Open	t=>Ttrans	Failed to close	Close failure

State element Disabled	State switch remote	RFU	Desired State	State switch closed	State switch open	timer *)	State alarm	State element
Enabled	Rem	RFU	Open	Not closed	Not open	t<Ttrans	None	Transition
Enabled	Rem	RFU	Open	Not closed	Not open	t=>Ttrans	Failed to open	Open failure
Enabled	Rem	RFU	Open	Not closed	Open	x	None	Open
Enabled	Rem	RFU	Open	Closed	Not open	t<Ttrans	None	Transition
Enabled	Rem	RFU	Open	Closed	Not open	t=>Ttrans	Failed to open	Open failure

Table 24-5 Hydraulic valve-element alarm/element state determination

*) The timer is reset on a positive edge of the command close, command open signal.

24.5 Command word and status word

The PLC to HMI interfacing incorporates a command word and a status word. The command word is used for remote operator commands (HMI to PLC) whilst the status word is used for monitoring purposes (PLC to HMI). The least significant four bits of the status word designate the element status.
The next sections specify command - and status word arrangements.

24.5.1 Command word HMI

Bit	Description
0	Close
1	Open
2	-
3	-
4	-
5	Manual
6	Auto
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 24-6 Hydraulic valve-element Command word HMI

24.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	Closed
0010	0-3	Opened
0011	0-3	-
0100	0-3	-
0101	0-3	Transition
0110	0-3	-

SM	Bit	Description
0111	0-3	-
1000	0-3	-
1001	0-3	-
1010	0-3	Not Ready for use
1011	0-3	-
1100	0-3	Failed to close
1101	0-3	Failed to open
1110	0-3	Unknown
1111	0-3	-
	0	Status bit 0
	1	Status bit 1
	2	Status bit 2
	3	Status bit 3
	4	Last command was: Close
	5	Last command was: Open
	6	-
	7	-
	8	Reserved
	9	True = Hand / False = Auto
	10	True = Local / False = Remote
	11	-
	12	-
	13	-
	14	-
	15	-

Table 24-7 Hydraulic valve-element Status word

25. Valve-element, proportional controlled (VCP)

25.1 Function

This element interfaces a proportionally controlled valve with state feedback. The actual state of the valve interfaces the element by an analogue input.

25.2 Interface

The element interface is shown in Figure 25.1.

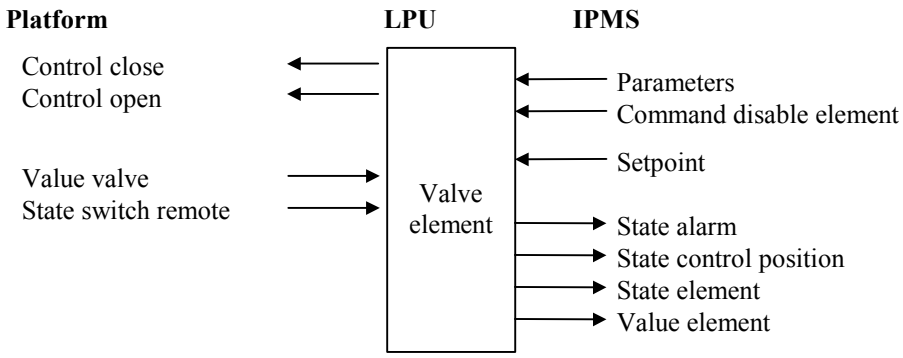


Figure 25.1 Proportional valve-element interface

The following sections describe the interface.

25.2.1 Platform interface

The platform interface of the element is shown in Table 25.1

Name	Value	I/O specification
Input		
Value valve	4 – 20 mA	AI (4- 20 mA)
State switch remote	[1=Remote | 0=Local]	DI
Output		
Control close	[1=Activated | 0=Not activated]	DO
Control open	[1=Activated | 0=Not activated]	DO

Table 25.1 Proportional valve-element platform interface

25.2.2 Application interface

This element has no application interface

25.2.3 IPMS interface

The IPMS interface of the element is shown in Table 25.2.

Name	Value
Input	
Parameters	[Ttrans]
State element disabled	[Disabled | Enabled]
Output	
State alarm	[None | Control open failure | Control close failure | OORL | OORH]

Name	Value
State control position	[None | Local | Remote]
State element	[Disabled | Closed | Open | Transition | NRFO | NRFC | Control open failure | Control close failure | OORL | OORH]
Value element	Value open percentage (0 %– 100 %)

Table 25.2 Proportional valve-element IPMS interface

25.3 Parameters

The parameters of the element are shown in Table 25.3

Parameter	Description	Unit	Value	Adjustable
Ttrans	Time delay on transition (0 = no timeout alarms)	s		Yes

Table 25.3 Proportional valve-element parameters

25.4 Processing

The element processing comprises the following functions:

- Command/alarm/element state determination;
- Control position determination;
- Platform control.

The processing is shown in Figure 25.2

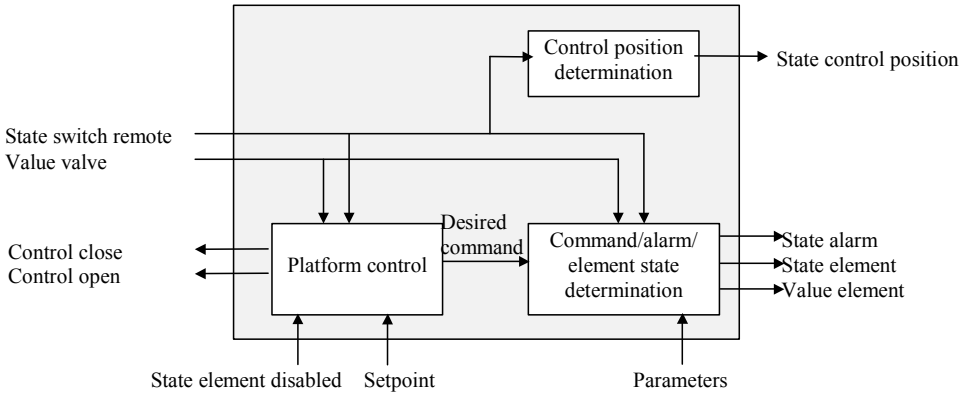


Figure 25.2 Proportional valve-element processing

The functions are described in the following paragraphs.

25.4.1 Platform control

IF (Setpoint > Value valve) THEN
Control open = activated;
Control close = deactivated;
ELSEIF (Setpoint < Value valve) THEN
Control open = deactivated;
Control close = activated;
ELSE
Control close = Deactivated
Control open = Deactivated;
END

Whenever the element is (re-) initialised (LPU state toggles from offline to online) or when the element control mode is switched from 'local' to 'remote' or when the element is enabled then the desired state must be forced to match the actual state of valve. In all other cases the desired state must keep up with the command input state.

IF ((Initialising) OR (State switch remote = Open -> Closed) OR
(State element disabled = Disabled -> Enabled)) THEN
Setpoint = Value valve 'open'
END

25.4.2 Control mode determination

The control mode determination is shown in Table 25.4.

State switch remote	State control Position
x	None
Local	Local
Remote	Remote

Table 25.4 Proportional valve-element control mode determination

25.4.3 Alarm/element state determination

The alarm/element state determination is shown in Table 25.5

State element disabled	State witch remote	Desired command	Value valve	timer *)	State alarm	State element
Disabled	x	x	x	x	None	Disabled
Enabled	Local	x	x	x	None	Closed/ Open %
Enabled	Remote	Setpoint	Value valve = Setpoint	x	None	Closed/ Open %
Enabled	Remote	Setpoint	Value valve <> Setpoint	t<Ttrans	None	Transition
Enabled	Remote	Setpoint	Value valve <> Setpoint	t>=Ttrans	Control failure	Control failure
Enabled	x	x	OORL	x	OORL	OORL
Enabled	x	x	OORH	x	OORH	OORH

Table 25.5 Proportional valve-element alarm/element state determination

*) The timer is reset once the setpoint changes.

25.5 Command word and status word

The communication between the PLC and the HMI uses a command word and a status word. The command word is used for commands from the HMI to the PLC and the status word for the statuses from the PLC to the HMI.
The least significant four bits of the status word represent the element status.
The following sections describe the command word and status word.

25.5.1 Command word HMI

Bit	Description
0	-
1	-
2	-
3	Sp Exe
4	-
5	Manual
6	Auto
7	-
8	Disable element
9	Enable element
10	-
11	-
12	-
13	-
14	-
15	Parameter update request

Table 25.6 Proportional valve-element Command word HMI

25.5.2 Status word

SM	Bit	Description
0000	0-3	Element disabled
0001	0-3	Closed
0010	0-3	Opened
0011	0-3	-
0100	0-3	-
0101	0-3	Transition
0110	0-3	-
0111	0-3	-
1000	0-3	-
1001	0-3	-
1010	0-3	-
1011	0-3	-
1100	0-3	Control Open Failure
1101	0-3	Control Close Failure
1110	0-3	OOL
1111	0-3	OOH
	4	-
	5	-
	6	-
	7	-
	8	-
	9	-
	10	True = Local / False = Remote
	11	-
	12	-
	13	-
	14	-
	15	-

Table 25.7 Proportional valve-element Status word