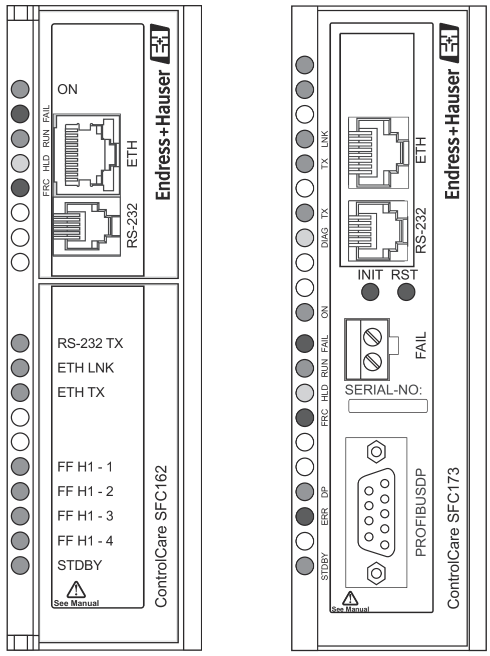
Level | Pressure | Flow | Temperature | Liquid Analysis | Registration | Systems Components | Services | Solutions

System Overview

ControlCare – Field-based Control System

Components, architecture and performance

PROFIBUS
FOUNDATION
MODBUS



BA 016S/04/en/06.10
Software Version 2.05.xx
Nr. 56004883

Endress+Hauser
People for Process Automation

Table of Contents

Revision History

Product Version	Manual	Change	Remarks
V1.00.xx	BA016S/04/en/07.02	Original Version	
V2.00.xx	BA016S/04/en/01.05	General Revision	▪ Removal of all operative information to relevant manual ▪ Adding of information on associated components
V2.01.xx	BA016S/04/en/08.05	Editorial	Update Product Version table, minor editorial
V2.02.xx	BA016S/04/en/07.06	Product	▪ Field Control IEC OPC Server, Chapter 2.4.3 ▪ No of function blocks, Chapter 2.4.4
		Editorial	▪ Fieldgates removed to components section
V2.03.xx	BA016S/04/en/06.07	Editorial	▪ Java Applets removed (withdrawn) ▪ Minor updates to text
V2.04.xx	BA016S/04/en/12.08	Editorial	▪ Hybrid block/Local I/O description revised ▪ References to Modbus supervisory blocks removed
V2.05.xx	BA016S/04/en/06.10	Editorial	▪ Modbus enhancement: Chapter 3.4.3 added ▪ Support for Windows Server 2008 and Windows 7

Product Version

Details of product version and the individual components of Application Designer Suite can be seen in the About ControlCare dialog:

Start=>Programs=>Endress+Hauser=>ControlCare=>Tools=>About ControlCare

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PROFIBUS®
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FOUNDATION™ Fieldbus
Trademark of the Fieldbus Foundation, Austin, TX 78759, USA

HART®
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1 Safety

1.1 Designated use

ControlCare is a field-based control system comprising hardware and software modules. It can be used to visualize, monitor and control production processes. The hardware described in this manual allows a modular FOUNDATION Fieldbus or PROFIBUS Field Controller to be built. It comprises a number of separate units that may include power supply modules, power conditioning modules, fieldbus linking devices, controllers, interfaces, analog I/O and discrete I/O units. The approved usage of the individual units used in the system can be taken from the corresponding parts of these operating instructions.

1.2 Installation, commissioning and operation

ControlCare Field Controller modules have been designed to operate safely in accordance with current technical safety and EU directives. Essential to their use is the ControlCare Application Designer Suite software, which allows control strategies to be created for both FOUNDATION Fieldbus and PROFIBUS applications. Field devices, links, junction boxes, cables and other hardware comprising the Fieldbus sytem must also be designed to operate safely in accordance with current technical safety and EU directives.

If devices are installed incorrectly or used for applications for which they are not intended, or if the Field Controller is not configured correctly, it is possible that dangers may arise. For this reason, the system must be installed, connected, configured, operated and maintained according to the instructions in this and the associated manuals: personnel must be authorised and suitably qualified.

1.3 Operational safety

Location

Field Controllers must be mounted in a permanent and weather-protected location in a safe area. The environment shall be a metal cabinet or an installation frame with a well grounded mounting plane. The environment shall be protected.

Hazardous areas

The Field Controller must be connected to networks operating in explosion hazardous areas via barriers or other safety components. When installing components in explosion hazardous areas:

- Ensure that all installion and maintenance personnel are suitably qualified
- Check that all equipment has the appropriate safety certificates
- Observe the specifications in the device certificates as well as national and local regulations.

This topic is discussed in BA013S (FF Guidelines) and BA034S (PROFIBUS Guidelines).

EMC

All modules are suitable for industrial use and conform with the following standard, see Appendix:

- EN 61326: 1997/A1: 1998
  Interference emmision: Class A apparatus
  Interference immunity: as per Annex A, industrial environment

Depending upon the environment in which the bus is operating, particular attention should be paid to the grounding of the bus cables. This topic is discussed in BA013S (FF Guidelines) and BA034S (PROFIBUS Guidelines).

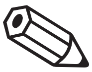
Technical improvement

Endress+Hauser reserves the right to make technical improvements to its software and equipment at any time and without prior notification. Where such improvements have no effect on the operation of the equipment, they are not documentated. If the improvements effect operation, a new version of the operating instructions is normally issued.

1.4 Conventions and icons

In order to highlight safety relevant or alternative operating procedures in the manual, the following conventions have been used, each indicated by a corresponding icon in the margin.

Safety conventions

Icon	Meaning
	A note highlights actions or procedures which, if not performed correctly, may indirectly affect operation or may lead to an instrument response which is not planned
	**Caution!** Caution highlights actions or procedures which, if not performed correctly, may lead to personal injury or incorrect functioning of the instrument
	**Warning!** A warning highlights actions or procedures which, if not performed correctly, will lead to personal injury, a safety hazard or destruction of the instrument

Explosion protection

Icon	Meaning
	**Device certified for use in explosion hazardous area** If the device has this symbol embossed on its name plate it can be installed in an explosion hazardous area in accordance with the specifications in the certificate or in a safe area
	**Explosion hazardous area** Symbol used in drawings to indicate explosion hazardous areas. Devices located in and wiring entering areas with the designation “explosion hazardous areas” must conform with the stated type of protection
	**Safe area (non-explosion hazardous area)** Symbol used in drawings to indicate, if necessary, non-explosion hazardous areas. Devices located in safe areas stiill require a certificate if their outputs run into explosion hazardous areas.

Electrical symbols

Icon	Meaning
	**Direct voltage** A terminal to which or from which a direct current or voltage may be applied or supplied
	**Alternating voltage** A terminal to which or from which an alternating (sine-wave) current or voltage may be applied or supplied
	**Grounded terminal** A grounded terminal, which as far as the operator is concerned, is already grounded by means of an earth grounding system
	**Protective grounding (earth) terminal** A terminal which must be connected to earth ground prior to making any other connection to the equipment
	**Equipotential connection (earth bonding)** A connection made to the plant grounding system which may be of type e.g. neutral star or equipotential line according to national or company practice

1.5 ControlCare documents

Table 1.1 indicates the documents, planned and realized, containing safety relevant information, installation, commissioning and operating instructions for the equipment and software associated with Field Controller.

All documentation available at the time of release is included on the ControlCare CD-ROM and is installed in **Start=>Programs=>Endress+Hauser=ControlCare=Manuals** during set-up.

Component	Description	Document type	Designation	Order No.
System	ControlCare System Overview	Operating manual	BA016S/04/en	56004883
	ControlCare System Design	Operating manual	BA039S/04/en	Planned
	ControlCare System Specifications	Operating manual	BA040S/04/en	56004888
Software	Application Designer Overview	Operating manual	BA017S/04/en	70104301
	Application Designer: Local I/O Tutorial	Operating manual	BA032S/04/en	71095009
	Application Designer: FF Tutorial	Operating manual	BA019S/04/en	70101151
	Application Designer: PROFIBUS Tutorial	Operating manual	BA036S/04/en	70101152
	Application Designer: MODBUS Tutorial	Operating manual	BA037S/04/en	70101153
	Application Designer: IEC 61131-3 Ladder Logic Tutorial	Operating manual	BA038S/04/en	70101386
	Application Designer: IEC 61131-3 Structured Text Tutorial	Operating manual	BA056S/04/en	71060063
	Field Control (OPC) Servers	Operating manual	BA018S/04/en	71031428
	SFC162 Visitor	Operation manual	BA069S/04/en	71113457
Field Controller	Hardware Installation Guide	Operating manual	BA021S/04/en	56004885
	Commissioning and Configuration	Operating manual	BA035S/04/en	56004887
Function Blocks	Function Block Manual	Operating manual	BA022S/04/en	56004886
Set-Up	Getting Started	Operating manual	BA020S/04/en	56004884
General	FOUNDATION Fieldbus Guidelines	Operating manual	BA013S/04/en	70100707
	PROFIBUS Guidelines	Operating manual	BA034S/04/en	56004242

Table 1-1: ControlCare documentation

2 ControlCare Field-based Control System

2.1 What is ControlCare?

ControlCare field-based control system is a combination of software and hardware components based on open standards, the purpose of which is to connect Endress+Hauser devices to process control, operating and maintenance systems. It provides quick and easy system integration and ensures that the benefits of fieldbus technology are available at all levels of the control hierachy. ControlCare system components can be used to supplement a third-party system by working as a sub-system or be used as a control system within its own right.

The main components are as follows

- ControlCare - P View:
  SCADA program for visualisation and monitoring tasks
- ControlCare - Application Designer Suite:
  Application suite for network set-up, device and control strategy configuration
- ControlCare - Field Control (OPC) Servers
  Application providing vertical integration of field device data into supervisory systems
- ControlCare - Field Controllers
  Field Controller assemblies for FOUNDATION Fieldbus and PROFIBUS, providing the possibility for continuous, discrete or hybrid control
- ControlCare - I/O modules
  Hardware for the integration of analog, discrete and pulse signals into the control system
- ControlCare - Fieldgates
  Hardware with integrated Web server that may be used as remote access points in maintenance or monitoring applications or Plant Access Points in control systems

These components are supplemented by others from Endress+Hauser and third party suppliers:

- Field devices
  Endress+Hauser temperature, pressure, level, flow and analytic transmitters providing process values as conventional, HART, Modbus RTU, PROFIBUS or FOUNDATION Fieldbus signals.
- Control equipment
  Third-party valves, positioners, motor starters, annunciators etc. as required by the application
- Registration devices
  Endress+Hauser displays and electronic logging devices, e.g. Memograph etc.
- Remote I/O
  Third-party multiplexers or remote I/O equipment for the integration of e.g. HART, 4...20 mA, digital devices etc. into PROFIBUS DP and FOUNDATION Fieldbus (via Modbus TCP) systems
- FieldCare
  Endress+Hauser's Plant Asset Management tool for device configuration, document management and condition monitoring.

A ControlCare field-based control system is normally delivered as a functioning system. The following optional services are subject to contract between customer and their local Sales Center:

- Engineering of the system
- Installation of the system in an existing cabinet or production of a new cabinet to customer specifications, complete with layout and wiring diagrams.
- Installation of all sensors, including wiring to the cabinet and where appropriate to the supervisory system, with installation and wiring diagrams.
- Start-up and commissioning of the system including third-party device integration, calibration of all sensors, configuration of the sensor parameters to suit the customer application, with final acceptance test and certification.
- Service contract with Sales Center for complete system covering regular and extraordinary visits, spare parts and charges.

2.2 ControlCare components

2.2.1 ControlCare P View

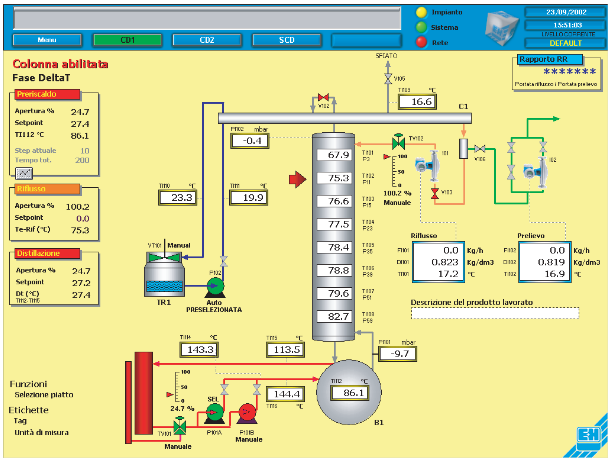


Fig. 2-1: Example of fthe visualization of distillation column control

ControlCare P View is a powerful PC-based SCADA program for visualisation and monitoring tasks. It operates over Ethernet TCP/IP with HART, PROFIBUS, FOUNDATION Fieldbus and MODBUS via OPC server. It supports client server operation, access by modem for remote diagnosis and wireless communication with a PDA, e.g. Field Xpert.

ControlCare P View has a user administration system where access rights to be managed according to user function and logs user actions as required in regulated inductries. Math and logic functions allow e.g. the integration of strapping tables, limit building or simple on/off control. An alarm and event management system logs signals and initiates the appropriate actions, e.g. sending of an e-mail or SMS. The real-time database collects and distributes information, e.g. to OPC server, Office programs and MES software. P View has been developed in accordance with FDA regulations and can be used in applications requiring 21 CFR Part 11 conformance.

Templates

ControlCare P View SPV150 templates offer an economical solution for simple visualisation tasks such as tank or silo monitoring. Up to 16 preconfigured overviews with up to eight vessels (= max. 128) are possible, each of which can be viewed as an individual measuring point. The overview shows the current level in the eight vessels.

Each individual view contains up to five measured values: level, pressure, temperature, volume and mass. Up to four limit values (LL, L, H, HH) can be freely defined per measured value. Violations are entered into an alarm list and the user is informed via display. An additional alarming via e-mail is optionally available. The historical trend of the values is shown in the trend display.

2.2.2 ControlCare Application Designer Suite

All system configuration, set-up, commissioning and maintenance is done with the ControlCare Application Designer Suite. This uses the topology model in the ISA S88/IEC 61512-1 standard to describe the plant. The model divides the plant into a logical project, describing the relationship between the plant sections and the control strategies they include, and a physical project, which is basically the physical arrangement of the fieldbus network. The common element between the two is the function blocks.

ControlCare Application Designer Suite allows the control strategy and physical project to be configured off-line. The projects are then downloaded, to the actual fieldbus devices on the network. The distribution of the control task among field devices (for FOUNDATION Fieldbus) and multiple decentralized Field Controller systems increases the overall performance, reliability of the system and plant availability.

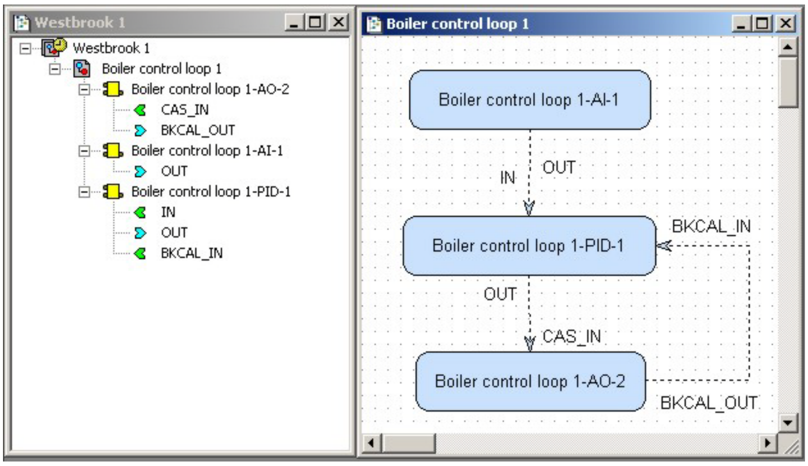


Fig. 2-2: Field control strategies for temperature control: the tree on the left represents the logical project.

Function blocks as process automation language

ControlCare Field Controllers are completely configurable through FOUNDATION Fieldbus and hybrid function blocks (programmable with IEC 61131-3). In addition to standard blocks, there are special blocks for the I/O modules as well as for PROFIBUS devices and Modbus master and slave connections. This allows the entire system, Field Controller and field devices, to be configured by a single engineering tool. Function Block language is ideal for process control, since it represents all the process functions required by automation professionals. Process control, logic interlocks, alarms, recipes, calculations and equations can be configured in a single environment.

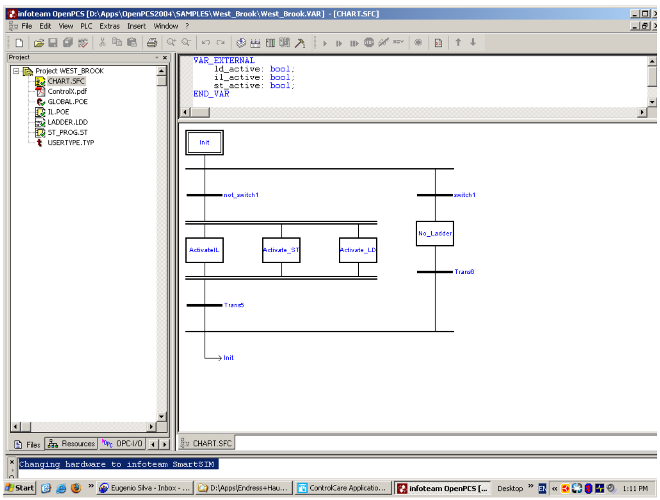


Fig. 2-3: Hybrid function block programming (IEC 61131-3, SFC language)

2.2.3 ControlCare Field Control (OPC) Servers

The Field Control (OPC) Servers are resident in the host ControlCare computer and allow simple communication via High Speed Ethernet between client applications, e.g. HMI or Asset Management programs and a database mapping the parameters of the FOUNDATION Fieldbus or PROFIBUS network that reside in the Field Controller. There are two servers:

- Field Control HSE OPC Server, for standard function block parameters
- Field Control IEC OPC Server, for all IEC 61131 variables declared with the prefix "OPC_" or under the variable attribute "OPC" in the hybrid function blocks.

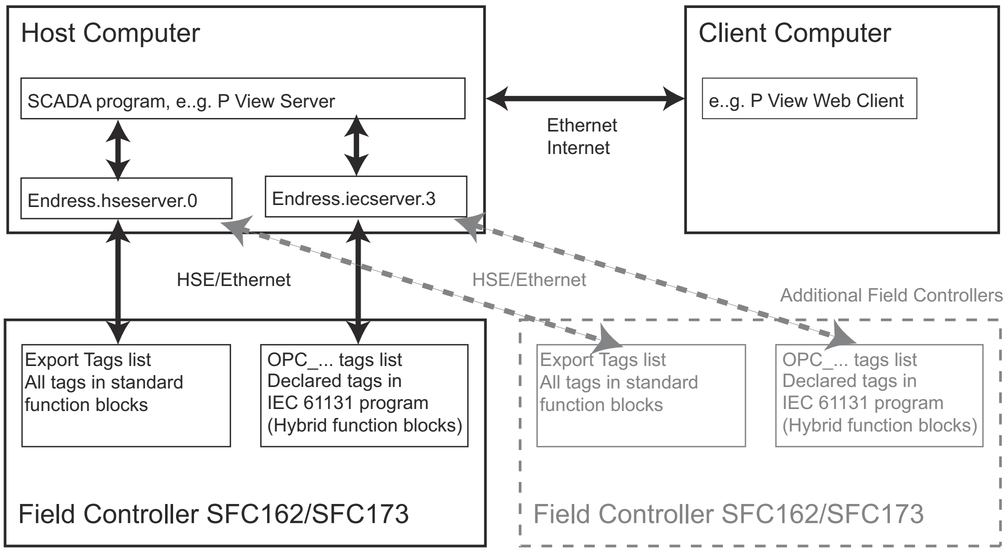


Fig. 2-4: Block diagram of data exchange via Field Control (OPC) Servers

OPC standard

The server complies to the OPC DA standard (OLE for Process Control) which in turn is based on Microsoft's OLE (now called ActiveX), COM (Component Object Model) and DCOM (Distributed Component Object Model) technology. OPC comprises a standard set of interfaces, properties and methods for use in process control and manufacturing-automation applications. The ActiveX/COM technologies define how individual software components can interact and share data. Backed by Microsoft's NT technology, OPC thus provides a common interface for communicating with diverse process-control devices, regardless of the controlling software or devices in the process.

More information on the OPC standard can be found on www.opcfoundation.org.

Benefits

The benefits to the user are:

- Single data base mapping to users and applications, ensuring true interoperability between server and client applications.
- Use of services in a networked environment regardless of location, machine architecture, or implementation environment.
- Server can communicate with a client.
- Plug and play communication with any client application supportiing the OPC standard.
- Additional Endress+Hauser functions for plant configuration via OLE. This provides a way for both Supervision and Configuration clients to work at the same time.

2.2.4 ControlCare Field Controllers

ControlCare Field Controllers access devices with fieldbus communication interfaces and offer continuous, discrete or hybrid control functions. Two versions are available:

- SFC162 FOUNDATION Fieldbus Field Controller
- SFC173 PROFIBUS Field Controller

SFC162 Field Controller

The SFC162 Field Controller together with a backplane power supply, fieldbus power supply and fieldbus power conditioner form the basic controller assembly. By adding I/O modules it is possible to integrate conventional discrete and analogue signals. Each Field Controller can directly access 14 racks, each with 4 slots. Depending upon function each I/O module accomodates either 4, 8 or 16 I/O points.

The following communication ports are available:

- Four FF H1 channels
- FF High Speed Ethernet (100 Mbit/s)/MODBUS TCP
- MODBUS RS-232 serial

The Field Controller supports continuous, discrete and hybrid control with up to 250 function blocks. Four of these are always required by the controller and max. 50 can be hybrid blocks. In normal operation, it acts as a Link Active Scheduler (LAS) for the H1 segments, maintaining a live list, controlling the cyclic and acyclic traffic, publishing the time stamp etc.. It is designed for HSE operation and H1-H1 and H1-HSE-H1 bridging.

Note!
- The use of a common OUT value in two different H1 segments is not supported

A CommDTM for the SFC162 Field Controller is available that allows the parametrization of the connected devices with FF DTMs by the FieldCare asset management tool.

SFC173 Field Controller

The SFC173 Field Controller together with a backplane power supply form the basic controller assembly. It is connected to PROFIBUS PA via a segment coupler or link. Remote I/O acting as a PROFIBUS DP slave can be used for integrating conventional discrete and analog as well as HART signals. Local I/O can also be added as described above.

The following communication ports are available:

- PROFIBUS DP, Master Class 1 (DPV1), baudrate configurable from 9.6 kbit/s to 12 Mbit/s
- FF High Speed Ethernet (100 Mbit/s)/MODBUS TCP
- MODBUS RS-232 serial

The Field Controller supports continuous, discrete and hybrid control with up to 250 function blocks. Four of these are always required by the controller and max. 50 can be hybrid blocks. In normal operation, the Field Controller acts as PROFIBUS Master Class 1 to the connected PROFIBUS DP segment.

-The SFC173 Field Controller also has a CommDTM that allows the parametrization of the connected devices with the FieldCare asset management tool.

2.2.5 ControlCare local I/O modules

In order to feed conventional analog, discrete and pulse signals into the control system and to provide facilities for controlling valves, starters, pumps, switches etc., a number of local I/O modules can be added to the Field Controller rack assembly.

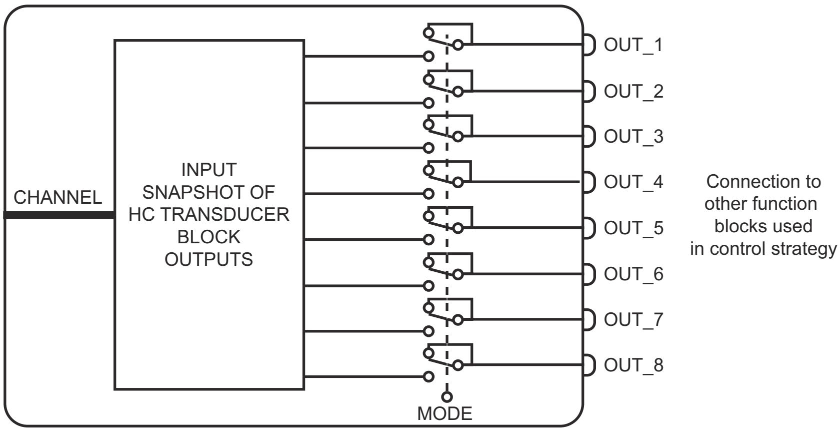


Fig. 2-5: Multiiple Analog Input block (MAI) used to integrate Analog Input devices into the control strategy

The modules are addressed by means of a channel number in a special Field Controller Hardware transducer block and, depending upon type and function, connected to the Field Controller control strategy by means of multiple or standard input and output blocks. Depending upon I/O type, an Analog or Discrete Multiple function block provides a connection for up to 16 input or output signals. The I/O modules available are listed in the Table 2-1.

I/O modules

Designation	Description
SFC411	Discrete Input, 2x8 DI (24 VDC)
SFC415	Discrete Input, 2x8 DI (24 VDC sink)
SFC420	Discrete Input, 1x8 DI (on/off switches)
SFC428	Discrete Output 2x8 DO (Relay NO)
SFC432	Discrete Input/Output 1x8 DI (24 VDC) + 1x4 DO (Relay NO)
SFC435	Discrete Input/Output 1x8 DI (24 VDC) + 1x4 DO (Relay NC)
SFC438	Discrete Input/Output 1x8 DI (24 VDC) + 1x2+2 DO (Relay NO/NC)
SFC441	Discrete Input, 2x8 DI (Impulse 100 Hz)
SFC442	Discrete Input, 2x8 DI (Impulse 10 kHz)
SFC467	Discrete Input, 2x DI Pulse Input (AC)
SFC444	Analog Input, 1x8 AI (with shunt)
SFC445	Analog Input, 1x8 AI (Temperature RTD, Thermocouple)
SFC446	1x4 AOAnalog Output,
SFC457	Analog Input, 1x8 AI (differential with shunt)

Table 2-1: ControlCare I/O modules

Hybrid function block

From ControlCare Version 2.04.xx onwards, strategies requiring local I/Os can be created with the Hybrid Block with Embedded I/Os. In applications involving pump, motor and on/off valve control, this allows a strategy written in an IEC 61131 language to be run within a single block that has direct connections to Local and Remote I/O. Mutiple instances of the same HFB can be run within the same macrocycle, thus greatly improving the I/O response time. More information on this is to be found in the Application Designer Local I/O Tutorial, BA032S/04/en.

2.3 Supplementary components

ControlCare is supplemented by a number of other components that do not fall within the platform itself. These may be Endress+Hauser products or third-party components. This Section gives a short description of the items in question.

2.3.1 Field devices

Endress+Hauser offers a comprehensive range of temperature, pressure, level, flow and analytic transmitters providing process values as conventional, HART, PROFIBUS or FOUNDATION Fieldbus signals. PROFIBUS and FF devices are integrated by direct network connection to the Field Controller, HART devices can be connected to a Remote I/O supporting HART/PROFIBUS DP or HART/Modbus conversion.

The Table below summarises the availability of the various device types as a function of input signal. More information can be for in the Product pages of www.endress.com.

Measurement Principle	Switch*	4–20 mA	HART	PROFIBUS	FF	MODBUS
Pressure	x	x	x	x	x	
Differential Pressure		x	x	x	x	
Temperature	x	x	x	x	x	
Level	x	x	x	x	x	
Capacitance	x	x	x	x		
Conductance	x	x	x	x		
Hydrostatic pressure		x	x	x	x	
Ultrasonic	x	x	x	x	x	
Radar		x	x	x	x	
Guided radar		x	x	x	x	
Radiation	x	x	x		x	
Vibration (switch)	x			x		
Mechanical (plumb line)		x				
Paddle	x					
Flow		x	x	x	x	x
Magnetic		x	x	x	x	x
Coriolis		x	x	x	x	
Vortex		x	x	x	x	
Ultrasonic		x	x	x	x	
Thermal mass		x	x			
Analysis		x	x	x		
pH		x	x	x	x	
Conductivity		x	x	x	x	
Other (see internet pages)		x	x	x	x	x

Table 2-2: Endress+Hauser instrumentation

** Note: This column is checked only if devices exist that are built purely as switches. Many continuous devices offer the possibility of setting limits on the process value, which trigger a relay output.*

2.3.2 Fieldgates

Fieldgates are Ethernet interfaces with integrated Web server that may be used as remote access points in maintenance or monitoring applications or plant access points in control systems. The following types are available:

- FXA320: 4 - 20 mA analog or 8mA/16mA switched input
- FXA520: HART 4 - 20 mA or multidrop input
- FXA720: PROFIBUS input

Technical data

The Table below summarises the main technical data of the Fieldgates available. The FXA320 and FXA520 have limited application in control system applications. The FXA720 on the other hand is used in pass-through mode, and thanks to its CommDTM can be used to provide a separate path from the control system to the devices for a FDT-based asset management program such as FieldCare, when a separate system is required.

Fieldgate	**FXA320**	**FXA520**	**FXA720**
Network connection	Ethernet, LAN/WLAN, Phone line, GSM/GPRS	Ethernet, LAN/WLAN, Phone line, GSM/GPRS	Ethernet, LAN/WLAN
Sensor connection	2 x 4..20mA, 4 x Switch	2 x 4..20 mA, 2 x HART master	1..3 x PROFIBUS DP
Power supply	VAC or VDC or Solar/ Battery	VAC or VDC	VDC
Sensor power supply	Loop power	External	External
Accessories	Solar Panel, Battery, GSM Antenna	HART® Multiplexer, Multidrop Connector, Digital/Analog inputs GSM Antenna	Segment Coupler for PROFIBUS® PA, Remote I/O with CommDTM
Data collection	OPC/HTML/XML via LAN, Intranet or PSTN, e-mail	OPC/HTML/XML via LAN, Intranet or PSTN, e-mail	OPC/HTML/XML via LAN or Intranet, e-mail
Remote service for connected devices	No	HART® via LAN, Intranet, Internet or PSTN	PROFIBUS® via LAN and Firewall

Table 2-3: Fieldgate properties

2.3.3 Control equipment

Since Endress+Hauser is primarily a supplier of measuring devices and associated instruments, it has no preference for products from particular manufacturers. On the other hand, the ControlCare platform builds on and uses the information provided by the fieldbus protocols PROFIBUS, FOUNDATION Fieldbus and HART, so it makes sense to select equipment which supports these technologies wherever possible. There is also no problem with the integration of MODBUS equipment into the system.

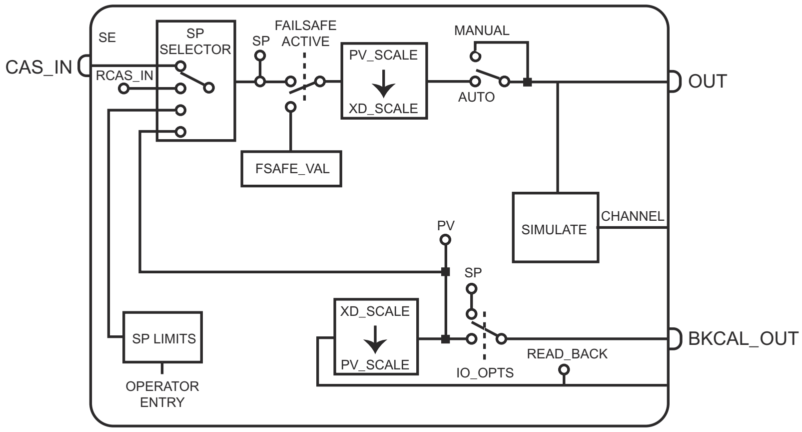


Fig. 2-6: Analog Output block for driving, e.g. a valve positioner

The control equipment is connected to the system via Discrete, Analog or Multiple Output blocks. As Fig. 2-6 shows, ControlCare function blocks support READ_BACK and BKCAL_OUT values. This allows the result of the control action to be monitored and the status of the equipment to be constantly checked. The system can then react immediately to, e.g. a valve failure, by ensuring it adopts a safe position. The user is immediately informed through a bad status message.

There are many control valves, positioners and converters that support the PROFIBUS or FOUNDATION Fieldbus protocol. Those successfully tested with ControlCare in Endress+Hauser's fieldbus laboratory include:

- Metso ND832/ND800 FF positioner, ND9000 PROFIBUS positioner
- Invensys FoxTop control valve(FF and PROFIBUS)
- Samson 3787 FF positioner and 3785 PROFIBUS positioner
- Smar FY302 FF positioner

For PROFIBUS devices, it is an advantage to select devices with a DeviceDTM, since this allows the devices to be configured centrally with an FDT Configuration Tool such as FieldCare. Since the SFC162 also has CommDTM, FF devices with DeviceDTMs, e.g. from Metso and Samson, are also of interest.

2.3.4 Registration devices

Endress+Hauser has a number of devices that allow the registration of process values. These range from simple "listener" displays to sophisticated recorders, which are capable of executing simple on/off control themselves. The Memograph range of recorders are also 21 CFR 11 compliant, and thus suitable for use in regulated industries.

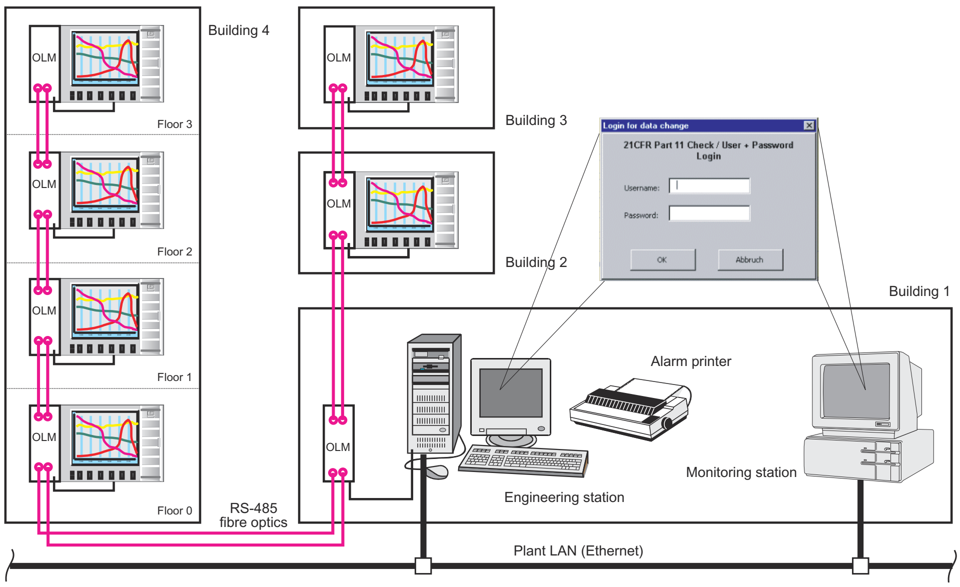


Fig. 2-7: 21 CFR 11 compliant monitoring of storage conditions in a pharmaceutical warehouse complex using Endress+Hauser's Memograph recorders

Fig. 2-7 shows an 21 CFR 11 compliant application in which Endress+Hauser Memograph recorders were used to monitor the temperature and humidity in six different storage areas. The results were visualised at a central monitoring station.

The components of interest to ControlCare-based solutions are:

- RID 261 Profibus PA display
  PROFIBUS PA devices that listens to the traffic on its segment and displays process values, alarms violations. It is also suitable for use in hazardous areas.
- Memograph paperless recorder
  PROFIBUS DP multi-channel recorder with 8 or 16 universal analog inputs, 37 digital inputs, 4 mathematics channels and 8 combinations for the digital inputs. Offers trends, bargraph, event list and digital display with limit recording.
- Memograph S paperless recorder
  As Memograph, but 21 CFR 11 compliant

2.3.5 Remote I/O

Third-party Remote I/Os are used to integrate HART analog input/output or discrete input/output signals into ControlCare via a PROFIBUS DP network. This allows the process values and status information offered by a HART device to be routed to the system. If the Remote I/O has a CommDTM, it also allows the HART devices connected to it to be configured centrally via the SFC173 PROFIBUS Field Controller and FieldCare.

Some manufacturers also offer their Remote I/O with a Modbus RTU or Modbus TCP interface. Since both Field Controllers are equipped with a Modbus serial or TCP interface, this provides an alternative method of integration, in particular for FOUNDATION Fieldbus.

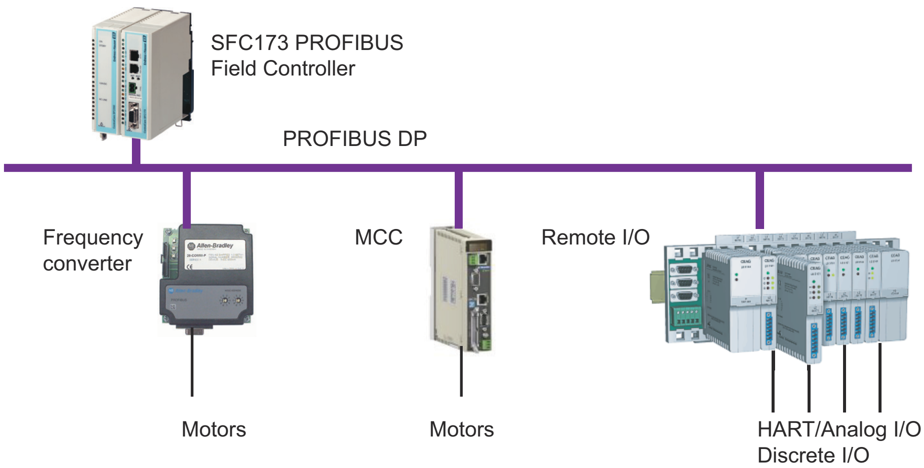


Fig. 2-8: In PROFIBUS systems, HART and discrete sugnals are handled via Remote I/O

The customer has a wide choice of Remote I/Os. The following Table lists components from a number of manufacturers have both analog HART and Discrete inputs and outputs. It has no claim to completeness, and inclusion in the list does not imply a recommendation by Endress+Hauser.

Manufacturer	Type	Ex rating	Redundancy	DTM	HART
ABB	S900	Ex Zone 1		yes	yes
Bartec	Safe.t	Ex Zone 1		yes	
CEAG	FB	Ex Zone 1	yes	yes	yes
MTL	MTL8000	Ex Zone 1	yes	yes	yes
Pepperl+Fuchs	IS-RPI	Ex Zone 1		yes	yes
Phoenix	ILB, FLS	Non-Ex		yes	yes
Rockwell	Flex I/O	Ex Zone 1		yes	yes
Siemens	ET200M	Non-Ex			yes
Stahl	IS1	Ex Zone 1		yes	yes
Turck	Ex Com	Ex Zone 1	yes	yes	yes
WAGO	Series750	Non-Ex			

Table 2-4: Partial list of Remote I/O suppliers, valid at the time of publishing
Subject to change: full details should be taken from the manufacturer's specfications

2.3.6 FieldCare

FieldCare is the Endress+Hauser Plant Asset Management platform. FDT-based, it can configure all intelligent field devices in a plant and supports their management. By using status information, it also provides a simple but effective means of checking their health.

- Supports Ethernet, HART®, PROFIBUS® and FOUNDATION Fieldbus™
- Operates all Endress+Hauser devices
- Operates all third-party actuators, I/O systems and sensors supporting the FDT standard
- Ensures full functionality for all devices with DTMs
- Offers generic profile operation for any third-party fieldbus device that does not have a vendor DTM
- Manages documentation, e.g. SOPs, calibration protocols, certificates, manuals etc.
- Logs user actions as well as events
- Monitors the condition of the devices in the plant

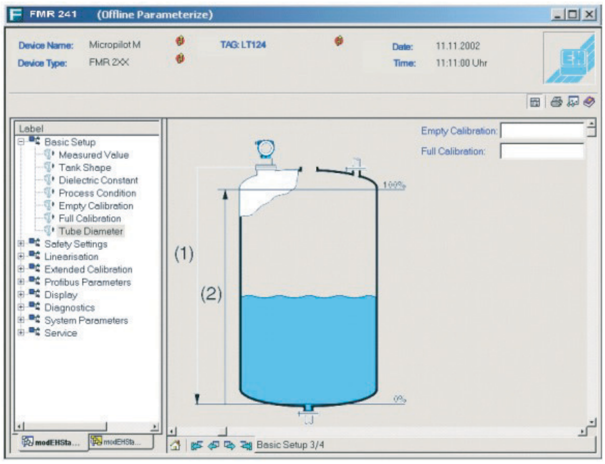


Fig. 2-9: Configuring the Micropilot radar level device through its DTM

Within a ControlCare system, FieldCare can operate in parallel to the PROFIBUS Field Controller as a Class 2 master, accessing its information by acyclic services through a FXA720 Fieldgate. Alternatively, it can access the network directly through the SFC173 Field Controller via acyclic DPV1 services, since this also has a CommDTM. Provided all other communication components have CommDTMs, it will then be possible to set-up all devices, actuators and auxiliary equipment from the the FieldCare Workstation.

The CommDTM for the SFC162 FOUNDATION Fieldbus Field Controller allows its use as a LAS or visiting device.

2.4 Data exchange

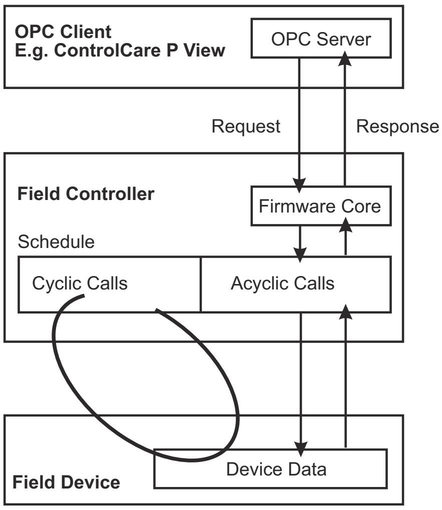


Fig. 2-10: Data exchange mechanisms within the ControlCare system

Fig. 2-1 shows the basic data exchange mechanisms behind the ControlCare system.

- At field level, depending upon architecture, HART, PROFIBUS and FOUNDATION Fieldbus devices are polled cyclically for their process value and status information. How this is done depends upon the fieldbus protocol in operation. Discrete and pulse signals are acquired either through remote I/O, local I/O or PROFIBUS. Acyclic calls are used for device configuration, maintenance and fieldbus management tasks

- For PROFIBUS architectures, all control functionality is located within the Field Controller. For FOUNDATION Fieldbus architectures, control function blocks may be executed in the field devices also. In both cases, it is possible to integrate data from legacy devices via MODBUS RTU or MODBUS TCP.

- The ControlCare Field Controller publishes its information to the OPC server at the request of the Application OPC client. Such a client is the ControlCare Application Designer during the configuration and commissioning phase or the SCADA program ControlCare P View.

- An application such as FieldCare may work in through the Field Controller itself or in the case of PROFIBUS, parallel to the Field Controller through a Fieldgate, and uses acyclic services to gather asset management data from the field devices.

- If PROFIBUS fieldgates are used in the system, two operating modes are possible. In pass-through mode, they behave as a normal interface in a control system. A SCADA program such as ControlCare P View or asset management program such as FieldCare then has direct access to the devices. In web server mode, they gather data from the devices connected and publish them via Ethernet to a Web-client application such as ControlCare P View.

More details on the data exchange mechanisms are to be found in the following sections. For more information on Visualization and Monitoring, visit www.endress.com/P View.

2.4.1 HART

HART (Highway Addressable Remote Transmitter) is a master-slave protocol, information being transferred point-to-point by superimposing a digital signal on a standard 4...20 mA output. The protocol also allows for a multi-drop bus structure, however, at the expense of the conventional output. Table 2-5 gives overview of the principle technical data. Typical system architectures are described in Section 3.3.

HART is supported by the HART Communication Foundation, an independent body of users and vendors that is responsible for development and conformity testing.

Property	HART point-to-point (4–20 mA)	HART multidrop (digital)
Standard	Industrial Standard maintained by HART Communication FOUNDATION	
Physical layer	Bell 202 FSK (Frequency Shift Keying) "0": 2200 Hz, "1": 1200 Hz	
Length	As for analogue signals on UTP cable	Max. 1500 m with multi-core STP cable, Max. 5000 m with two-core STP cable
Transmission rate	Digital information at 1200 bit/s with simultaneous analogue transmission	1200 bit/s
Bus access method	For digital communication, master-slave with secondary master	Master-slave with secondary master
Participants	1 slave per connection	Max. 15 slaves with central power supply

Table 2-5: Principle technical data of HART

Currently, HART devices can be integrated into the ControlCare platform in one of two ways: conventionally via the appropriate local I/O module or via Remote I/O. From the point of view of information flow, remote I/O is the preferred option, provided that this supports the HART protocol via PROFIBUS DP, e.g. Rockwell Flex I/O and Turck (partners) Remote I/O.

HART devices are connected point-to-point to the Remote I/O, which is normally integrated into ControlCare via PROFIBUS DP. The Remote I/O provides loop power where necessary, and is often transparent, allowing direct configuration of the devices by an appropriate engineering tool. When a Remote I/O supporting the FDT standard standard is used, see the devices can be configured with the FieldCare plant asset management platform, see Table 2-4 in Section 2.3.4.

The data exchange mechanism is that described in the PROFIBUS section (Section 2.4.2), the Remote I/O acting as a PROFIBUS slave. It assembles the process value and status for every connected device into a single telegram that is read cyclically by the ControlCare Field Controller.

HART devices can also be integrated via Remote I/O with MODBUS RTU and MODBUS TCP interfaces. More information on this protocol is to be found in Section 2.4.4.

2.4.2 PROFIBUS

PROFIBUS is an open fieldbus standard. The application profiles PROFIBUS DP (Decentralised Periphery) and PROFIBUS PA (Process Automation) used in process automation are incorporated into the IEC 61158. An overview of the technical data is given in Table 2-6. Typical system architectures are described in Section 3.2.

PROFIBUS is supported by an international network of PROFIBUS User Organizations, which are also responsible for the maintenance of the standards and certification and testing of the devices.
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Property	PROFIBUS PA	PROFIBUS DP
Standard	DIN 19245 Part 4; EN 50170, Part 2; IEC 61158 Type 3	DIN 19245 Parts 1 to 3, Version DPV1; EN 50170, Part 2; IEC 61158 Type 3
Protocol	PROFIBUS DPV1	PROFIBUS DPV1
Physical layer	IEC 61158-2	RS-485 and/or fiber optics
Length	Max. 1900 m for safe and EEx ib areas, Max. 1000 m for EEx ia	Up to 1200 m, depending upon transmission rate
Transmission rate	31.25 kbit/s	9600 bit/s to 12 Mbit/s
Bus access method	Master-slave (DP master)	Master-slave with token passing
Participants	32 in safe areas, approx. 24 in EEx ib and approx. 10 in EEx ia	Per segment: max 32, Logical: max 126 (using repeaters), including max. 32 as masters

Table 2-6: Principle technical data of PROFIBUS

The SFC173 PROFIBUS Field Controller acts as a Class 1 master and communicates cyclically with drives, valve positioners and sensors etc. on the PROFIBUS DP/PROFIBUS PA network in a master-slave relationship. PROFIBUS PA devices are connected to the PROFIBUS DP network via segment couplers or links. HART devices can be integrated into a PROFIBUS DP network via Remote I/Os acting as PROFIBUS DP slaves.

In contrast to FOUNDATION Fieldbus, which allows control in the field, see Section 2.4.3, all control tasks are executed within the Field Controller. This uses FOUNDATION Fieldbus and IEC 61131-3 Hybrid function blocks to execute the control stategy. The process value and status of the sensors are read and mapped into function blocks, the control strategy executed and the resulting control signals sent to the actuators.

The ControlCare Field Controller also the process value and status of every sensor in the PROFIBUS DP network and makes this information available via function blocks to supervisory applications via High Speed Ethernet (HSE). The communication mechanisms at this level correspond to those described in Section 2.4.4.

ControlCare allows the connection of several PROFIBUS Field Controllers to the HSE backbone, and uses the HSE bridging mechanism to exchange process data and other information between different PROFIBUS DP networks. It also allows the use of FieldCare for configuration and asset management tasks. There are two possibilities for connection:

- via the Field Controller itself, using its CommDTM to pass through.
- via a Fieldgate FXA720 (with CommDTM) used parallel to the Field Controller in pass-through mode.

Where the ControlCare Field Controller is operating in parallel to a Fieldgate FXA720, the latter acts as a Class 2 master. Configuration and asset management are performed with the PROFIBUS acyclic services. The media is shared between the two masters by token passing.

2.4.3 FOUNDATION Fieldbus

FOUNDATION Fieldbus is an open fieldbus standard to IEC 61158 that was developed and is supported by the Fieldbus FOUNDATION. It has been designed to solve the measurement and control tasks associated with process automation. Two transmission media have been specified:

- HSE (High Speed Ethernet) for high speed communication using standard Ethernet technology running at a fixed rate of 100 Mbit/second. This acts as a backbone for traffic between controllers, Remote I/Os, computers and other control equipment.
- H1 for low speed communication. This handles traffic between the process sensors and actuators and powers the devices.

The FOUNDATION Fieldbus protocol is used for both HSE and H1 levels. Table 2-7 gives an overview of the principle technical data. Typical system architectures are described in Section 3.1.

Property	FOUNDATION Fieldbus H1	FOUNDATION Fieldbus HSE
Standard	IEC 61158 Type 1	IEC 61158 Type 5
Protocol	FOUNDATION Fieldbus	FOUNDATION Fieldbus
Physical layer	IEC 61158-2	100BaseTX, 100Base FX
Length	Max 1900 m for Non-Ex Max. 1000 m for Ex ia	Up to to 100 m (copper), Approx. 2 km (fibre optics)
Transmission rate	31.25 kbit/s	100 Mbit/s
Bus access method	Bus arbitrator (Token passing)	CSMA/CD
Participants	32 in safe areas, approx. 10 in Ex ia (FISCO)	Logical: limited by address range only, Practical: limited by response time

Table 2-7: Principle technical data of FOUNDATION Fieldbus

H1 fieldbus

Access to the H1 fieldbus is managed through a deterministic centralised bus scheduler called the Link Active Scheduler (LAS). This normally resides in the SFC162 Field Controller, but a back-up LAS can be located in any field device that supports the functionality. All transmissions, whether scheduled or unscheduled are instigated at the request of the LAS:

- Scheduled transmissions are used to cyclically transmit process values and control block I/O parameters. The LAS sends a compel data (CD) request at the scheduled time, and the device publishes its data on the bus for reading by other subscribers.
- Unscheduled transmissions are made during the periods when the field devices are executing their function blocks or at the end of the CD schedule. The LAS gives the device temporarily permission to transmit in a client-server or source-sink relationship, by sending a pass token message.

The values required for control are acquired cyclically by a publisher-subscriber mechanism. The ControlCare Field Controller works through its schedule and allows each device in turn to publish its cyclic data. All devices on the network listen continuously and consume the values that are of interest to them. The fieldbus network and control strategy are created graphically in ControlCare Application Designer Suite. When a link is configured between two function blocks, the device with the function block that sends the data is configured as a publisher, and the device that has the block receiving the data is configured as a subscriber.

Values required by an application client are acquired on a client-server basis, i.e. the client requests a value, the request is queued in the acyclic part of the schedule and the device is polled for the value. Where several values are required, they can be obtained as standard FF views. Alternatively, special user views can be configured for each device.

Table 2-8 overleaf gives more details of how the various communication methods are used.

Publisher/Subscriber	Client/Server	Report distribution (source-sink)
Scheduled	Unscheduled	Unscheduled
Used for publishing process value and other block output parameters	Used for operator messages	Used for event notification and trend reports
Sends parameters between blocks, e.g. the PV value to a PID control block and operator console	Setpoint changes, Mode changes, Tuning changes, Upload/Download, Alarm management, Access display views, Remote diagnostics	Sends process alarms to operator consoles, Sends trend reports to data historians

Table 2-8: Data exchange mechanisms for FOUNDATION Fieldbus

HSE Ethernet backbone

Data exchange on the HSE Ethernet backbone is performed primarily on a client-server or source-sink basis, see Table 2-8 above. Exceptions are publisher/subscriber messages required by links between function blocks operating in different H1 subnetworks, and automatically configured in the Controlcare Application Designer

The media is accessed using the stochastic CSMA/CD method and data are transferred in accordance with the Ethernet IP, TCP and UDP protocols. This is ideal for the transfer of non-time critical information, but requires an additional means of controlling medium access for deterministic control applications. This function is performed indirectly by the Field Controller during sequential execution of the control strategy.

The ControlCare SFC162 Field Controller acts as a bridge on the HSE Ethernet backbone. It performs four activities, whereby more details can be found in the FOUNDATION Fieldbus Guidelines, BA013S/04/en:

- Message forwarding using Client/Server relationships
- Data Republishing using Publisher/Subscriber relationships
- Report forwarding using Report Source/Sink relationships
- Application Clock Time Distribution.

HSE applications communicate with the Field Controller via the HSE server, which contains a virtual map of the values of every device in the network. The server is configured on-line with the Export Tags function in ControlCare Application Designer. Thereafter the Server polls the ControlCare Field Controller, which automatically transmits the requested data via standard FF views. Different refresh rates can be set according to whether data changes frequently or is quasi-static.

Individual values required by an application client are acquired on a client-server basis, i.e. the client requests a value from the server, which passes on the request to the Field Controller. This queues the request in the acyclic part of the schedule and the device is polled for the value. The value is then forwarded to the HSE Server.

2.4.4 MODBUS

MODBUS is a de-facto industrial standard, supported by Modbus IDA, www.modbus.org, with a messaging service that may run on a variety of physical layers. ControlCare supports two open versions for communication with legacy equipment, which cannot be used in parallel:

- MODBUS RTU, using RS-232/RS-485 (or RS-422) as physical layer allows the connection of MODBUS devices to Field Controller in a bus structure, whereby, analog devices can be connected via gateways.
- MODBUS TCP (also known as MODBUS TCP/IP) as physical layer allows the exchange of data between a PLC/DCS, Panel PCs, Remote I/O and Field Controller using Ethernet.

Table 2-9 gives an overview of the principle technical data. Typical system architectures are described in Section 3.4.

Property	MODBUS RTU	MODBUS TCP
Standard	Industrial Standard	Industrial Standard
Physical layer	Not specified, but usually RS-422, RS-485	10BaseTX, 100BaseTX
Length	1200 m at 19.2 kbit/s	100 m
Transmission rate	Max. 115 kbit/s	10 Mbit/s
Bus access method	Master-slave	CSMA/CD
Participants	1 master, max 247 slaves	Logical: limited by address range only, Practical: limited by response time

Table 2-9: Principle technical data of MODBUS serial and TCP

The MODBUS protocol exchanges data in a master-slave relationship. Each slave has a unique address, and the data are identified by their location in the slave address register. ControlCare Field Controller can act as either a MODBUS master or slave:

- As a master it can be connected to one or more MODBUS slaves or exchange data with e.g. a PLC configured as a slave
- As a slave it can exchange process data with e.g. a PLC configured as a master
- As a master and slave it can e.g. use a Modbus Remote I/O as slave to integrate binary, pulse and analog signals, whilst at the same time being connected to a supervisory Modbus master

The various use cases are discussed in more detail in Chapter 3.4 and in BA0337S/04/en, MODBUS Tutorial. They are applicable to both PROFIBUS and FF Field Controllers and also provide a means of integrating HART devices.

The MODBUS protocol controls the query and response cycle between master and slave devices. Only the master can initiate a transaction. A query and response involves either a single slave or it is in the form of a broadcast, in which case the slaves do not answer. The query is contained in a frame that includes the address of the intended receiver, what this slave is to do, data needed to perform the action, and a means of checking for errors. The slave checks if errors have occurred and performs the desired action. After the action is performed the slave builds the response and returns it to the master. The master can send another message to any slave as soon as it receives a valid response or after a user-selected time interval. This "time-out" time has to be selected on the master device and depends on the slave response time. For MODBUS TCP the serial frame is simply inserted into the Ethernet data frame, which can be up to 1024 bytes long.

For ControlCare Field Controllers, communication is handled by means of special Modbus function blocks that are configured within the ControlCare Application Designer. All required links etc. are automatically established when the project is downloaded to the Field Controller.

2.4.5 Field Control (OPC) Servers

OPC (OLE for Process Control, OLE = Object Linking and Embedding) is a series of specifications based on basic software standards and technology that provides open connectivity in industrial automation and enterprise systems. The standards are created, maintained and adapted to new technologies by the OPC Foundation, www.opcfoundation.org, a user group which owns the technology, defines new standards and provides compliance testing.

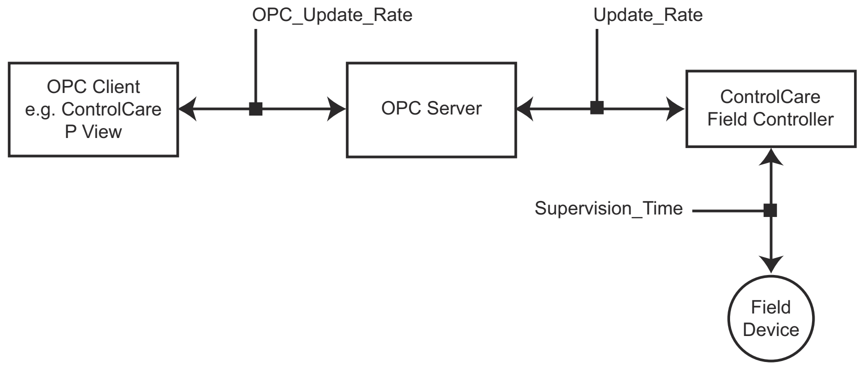

Fig. 2-11: Optimisation parameters for the OPC server

Field Control Servers are OPC servers installed on the host PC together with ControlCare Application Designer. It is used for the exchange of data with e.g. HMI applications such as ControlCare P View. It is automatically populated from the ControlCare Application Designer when the Export Tags function is executed on-line. ControlCare will eventually support three features for optimisation of data exchange between field devices and HSE client application:

- Multivariable optimisation
  Normally device data are transmitted through function block views. Each function block has four different views. Multivariable optimisation improves the efficiency of communication to the HSE client application by using a multiple variable container object (MVC). The device parameters required by the client application are assembled in this container and sent to it in a single communication transaction. MVC is implemented in ControlCare Device Revision 4 onwards for Publisher/Subscriber and Client/Server services.

- Supervision time
  This is the time required for the ControlCare Field Controller to acquire the entire data of the field device destined for the HSE client application and completely refresh its database. This data is acquired during the background time portion of the macrocycle. With the system up and running, ControlCare Application Designer calculates the function block execution time and offers it together with the background time the function block cycle time. The background time can be adjusted, if necessary, when the device is on line.

- Update time
  The update time is the time that it takes for data shown in the workstation screen to be refreshed. During the update time the HSE client software reads the interface device database and updates its own database. ControlCare tracks the values of of the parameters it acquires and differentiates between dynamic (changed) data and static data (unchanged data). A refresh rate can be set of each type, ensuring that there is no unnecessary overhead on communication between client, HSE server and the ControlCare Field Controller.

Note!

- Some OPC Clients may not be able to use all of the services supported by OPC servers.

2.5 Control strategy

The ControlCare platform can be used for continuous, discrete and hybrid control. To this end it supports both FOUNDATION Fieldbus function blocks (configurable) and the IEC 61131-3 progamming environment. Both types of programming strategy can be used used in ControlCare Application Designer and downloaded to the SFC162 and SFC173 Field Controllers.

2.5.1 Function blocks

Field Controller is completely configurable through FOUNDATION Fieldbus and IEC 61131-3 hybrid function blocks. In addition to standard I/O blocks and FF Function blocks, there are special configuration blocks for the I/O modules as well as for Modbus master and slave connections. This allows the entire system, Field Controller and field devices, to be configured by a single engineering tool. Function Block language is ideal for process control, since it represents all the control level process functions required by automation professionals. Process control, logic interlocks, alarms, recipes, calculations and equations can be configured in a single engineering environment.

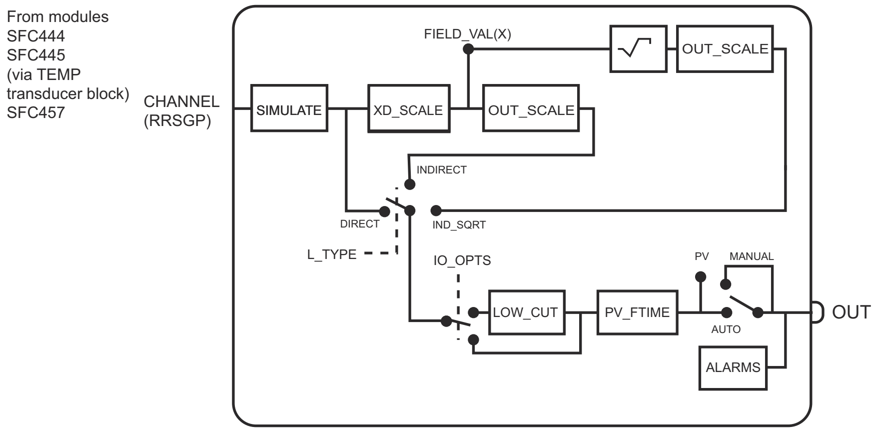

Fig. 2-12: Analog Input function block

For PROFIBUS, control strategies are programmed as "classic" controller functions, i.e. all control blocks are resident in the ControlCare Field Controller. FOUNDATION Fieldbus, on the other hand, allows control function blocks to be resident in the field devices as well.

In both cases, ControlCare Application Designer Suite is used to build the hybrid control strategies. It offers a uniform, graphical environment for the selection and linking of function blocks. To build a strategy, the user merely has to select the appropriate blocks offered by each device in his control loop and link the outputs and inputs together. Alternatively, the strategy can be built and the function blocks assigned to the devices at a later date. The Table overleaf lists the blocks available in the ControlCare Field Controllers and field devices. More information is to be found in the Function Block manual, BA022S/04/en.

Function block types

TYPE	DESCRIPTION
Resource Block	
RS	RESOURCE - contains data that is specific to the hardware associated with the resource.
General Transducer blocks	
DIAG	DIAGNOSTICS - provides online measurement of block execution time, check of links between blocks and other features
DSP	DISPLAY - normally supported by devices with LCD display only. Can be used to monitor and actuate in local parameters of blocks.
HC	HARDWARE CONFIGURATION - configures the module type for each slot in the Field Controller
MBCF	MODBUS CONFIGURATION - used to configure general features related to Modbus gateway.
Input transducer blocks	
TEMP	TEMPERATURE - for I/O module SFC445, an eight low signal input module for RTD, TC, mV, Ohm.
Input function blocks	
AI	ANALOG INPUT - takes the analog input data from the analog input signal and it makes available to other function blocks. It has scaling conversion, filtering, square root, low cut and alarm processing.
DI	DISCRETE INPUT - takes the discrete input data from the discrete input signal, and it makes available to other function blocks. It has option to invert, filtering and alarm processing.
MAI	MULTIPLE ANALOG INPUT - provides a way to receive 8 analog variables from I/O modules.
MDI	MULTIPLE DISCRETE INPUT - provides a way to receive 8 discrete variables from I/O modules.
PUL	PULSE INPUT - provides an analog value that represents a totalization of pulses from a physical discrete input, e.g. SFC442 pulse input module.
Logic, Control and Calculation blocks	
PID	PID CONTROL - standard block for Proportional-Intgral-Differential Control with features such as setpoint treatment (value and rate limiting), filtering and alarm on PV, feedforward, output tracking and others.
EPID	ENHANCED PID - has all the standard PID features plus bumpless or hard transfer from a "manual" mode to an "automatic" mode and bias.
APID	ADVANCED PID - has all the standard PID features bumpless or hard transfer from a "manual" mode to an "automatic" mode, bias. adaptive gain, PI sampling, deadband for error, special treatment for error, ISA or parallel algorithm,..
ARTH	ARITHMETIC - provides a selection of pre-defined equations ready for use in applications as flow compensation, HTG, ratio control and others.
OS	OUTPUT SPLITTER - is used in two typical applications: split ranging and sequencing. It receives the output of PID block, that is processed according to the selected algorithm, then it generates the values for the two analog output blocks.
CHAR	SIGNAL CHARACTERIZER - has capability for two signal characterization based on the same curve. The second input has an option for swapping "x" to "y", providing an easy way to use the inverse function, that may be used in signal characterization of readback variables.
CCHAR	CASCADE SIGNAL CHARACTERIZER - as CHAR but with 51 value pairs per channel and the possibily of linking to other CCHAR blocks for even more resolution.
INTG	INTEGRATOR - integrates a variable in function of the time. Has a second flow input that may be used in the following applications: net flow totalization, volume/mass variation in vessels and precise flow ratio control.
AALM/ EAAL*	(*ENHANCED) ANALOG ALARM - alarm block with dynamic or static alarm limits, hysteresis, temporary expansion of alarm limits on step setpoint changes to avoid nuisance alarms, two levels of alarm limits and delay for alarm detection.
ISEL	INPUT SELECTOR - has four analog inputs that may be selected by an input parameter or according to a criterion as first good, maximum, minimum, middle and average.
SPG/ ESPG*	(*ENHANCED) SETPOINT RAMP GENERATOR - generates setpoint following a profile in function of the time. Typical applications are temperature control, batch reactors, etc.
TMR	TIMER and Logic - has four discrete inputs, that are processed by a combination logic. The selected timer processing type operates on the combined input signal to produce a measurement, delay, extension, pulse or debounce.
LL	LEAD-LAG - provides dynamic compensation of a variable. It is used normally in a feedforward control.
OSDL/ OS*	(*ENHANCED) OUTPUT SELECTOR / DYNAMIC LIMITER - has two algorithms: Output selector - selection of output by a discrete input Dynamic limiter - this algorithm was developed specially for double cross limit in combustion control.
DENS	DENSITY - has a special algorithm to calculate the density in different types of engineering units: plato degree, INPM and others.
CT	CONSTANT - provides analog and discrete output parameters with constant values.
CTRW	CONSTANT READ/WRITE - as CONSTANT but can also read/write in contained parameters of other blocks into the same device
FFET	FLIP-FLOP AND EDGE TRIGGER - can be configured to work as SR flip-flop, RS flip-flop, D-LATCH and EDGE TRIGGER (rising, falling or bi-directional)

TYPE	DESCRIPTION
AEQU	ADVANCED EQUATIONS - specially designed to support specific calculations, e.g. ln, log10, e^x, dew point temperature
DENS	DENSITY - customized block designed to make density measurement in kg/m^3, Plato etc.
Output function blocks	
AO	ANALOG OUTPUT - provides an analog value to generate an analog output signa. It provides value and rate limiting, scaling conversion, fault state mechanism and other features.
DO	DISCRETE OUTPUT - provides a discrete value to generate a discrete output signal. There is option to invert the discrete value, fault state mechanism and other features.
MAO	MULTIPLE ANALOG OUTPUT - provides a way to send 8 analog variables to I/O modules.
MDO	MULTIPLE DISCRETE OUTPUT - provides a way to send 8 discrete variables to I/O modules.
STEP	STEP OUTPUT PID - It is used when the final control element has an actuator driven by an electric motor.
Hybrid function block	
HY_MA_IO	HYBRID FUNCTION BLOCK WITH MULTIPLE ANALOG INPUT/OUTPUT This block embeds a customer program developed using IEC 61131-3 language.
HY_MD_IO	HYBRID FUNCTION BLOCK WITH MULTIPLE DISCRETE INPUT/OUTPUT This block embeds a customer program developed using IEC 61131-3 language.
HY_EMB_IO	HYBRID FUNCTION BLOCK WITH EMBEDDED MULTIPLE ANALOG AND DISCRETE INPUT/OUTPUT This block embeds a customer program developed using IEC 61131-3 language.
Modbus support blocks	
MBCS	MODBUS CONTROL SLAVE - When the device is working as gateway between Field Contoller as Modbus slave and Modbus (slave device), this block may be used to exchange control data.
MBCM	MODBUS CONTROL MASTER - When the device is working as gateway between Field Contoller as Modbus master and Modbus (master device), this block may be used to exchange control data.

2.5.2 Hybrid function block

For tasks involving sequential and hybrid control, ControlCare Application Designer Suite offers a programming environment for the FOUNDATION Fieldbus Hybrid Function Block. The Hybrid Function Block is simply a wrapper around a hybrid control algorithm written in an IEC 61131-3 programming environment. The block offers a fixed number of analog and discrete inputs that may be linked through the algorithm to a fixed number of analog and discrete outputs. Unused inputs and outputs are inactive and they are not linked to other function blocks or hybrid blocks.

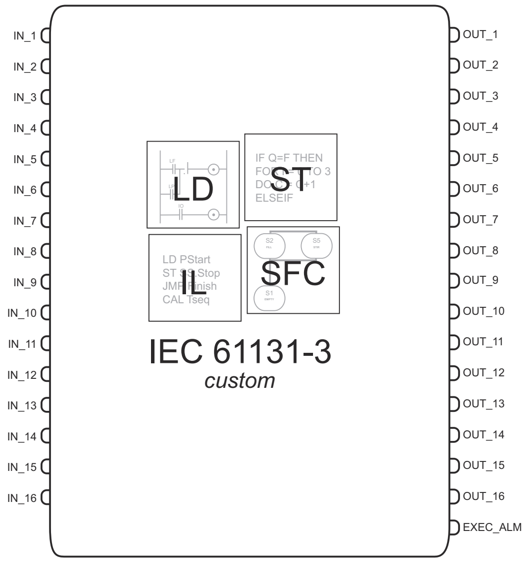

Fig. 2-13: Example of hybrid function block HY_MA_IO

IEC 61131-3 programming

IEC 61131-3 offers a standardised method of programming control alogorithms. It allows the algorithm to be written in one of six ways:

- Instruction List, IL
- Structured Text, ST
- Ladder Diagram, LD
- Sequential Function Chart, SFC
- Function Block Diagram, FBD
- Continuous Function Chart, CFC

The individual control modules created in one of the above languages can be combined to produce the complete control, logic and hybrid algorithm. Once written, the complete strategy or any part of it can be stored in e.g. a library, for reuse in other applications.

Three Hybrid blocks are available:

- HY_MA_IO: hybrid block with multiple analog input/outputs
- HY_MD_IO: hybrid block with multiple discrete input/outputs
- HY_EMB_IO: hybrid block with embedded multiple analog and discrete input/outputs

In ControlCare Application Designer the programming sequence is started by adding a Hybrid Function Block to the control strategy. This is available in the ControlCare Field Controller block list. A click on the graphical user interface will reveal an image similar to the one in Fig. 2-13.

The next step is create the strategy by linking the inputs and outputs to other blocks. In the case of the block with embedded I/Os, local I/Os are linked directly to inputs and outputs using the Field Controller Hardware Configuration block and the I/O tool. The inputs and outputs created during the programming are automatically linked to the corresponding inputs and ouputs on the wrapper, so that when creating control strategies, the Hybrid Function Block acts just like any other block.

On completion, the block is assigned to a Field Controller and the Hybrid Block Programming Tool can be called. On download of the project to the ControlCare Field Controller and assignment of the input/output function blocks to physical devices, the control strategy is ready to run.

2.6 Redundancy

Redundancy is supported at several levels within a ControlCare system, both on the component and network level. More information on the associated architectures can be taken from the various sections in Chapter 3.

2.6.1 H1 fieldbus

It is possible to provide power and network redundancy for FOUNDATION Fieldbus H1 segments by simply connecting together the fieldbus outputs of two Field Controllers. This will also provide additional security against a breakage in the network cable. A prerequisite is that the Field Controllers are mounted on separate backplanes, i.e. have completely separate power supplies. Any interface failure is detected by the system diagnostics. This enables not only the execution of the bumpless switchover from primary to secondary communication scheduler, but also warns the operator, so that the parts can be quickly replaced.

At the moment 100% fieldbus redundancy is not available for PROFIBUS PA. It is possible, however, to ensure power redundancy by the use of splitters and special segment couplers.

2.6.2 Control (application)

Control distributed to the field instruments is one of the keys to high availability and increased loop integrity in FOUNDATION Fieldbus. Provided power is still supplied to the instruments and a secondary Link Active Scheduler is available, any loss of a Field Controller will have no effect on the process.

There are, however, many cases where control may be shared or done centrally in any of the ControlCare Field Controllers, as is always the case for PROFIBUS. ControlCare does not yet support redundancy of control strategy, however, two Field Controllers loaded with the same project can be swapped extremely simply and in a very short time using the exchange mechanism.

2.6.3 HSE backbone

The operator's ability to see the entire plant relies on the host level network. This is why it has to be redundant and consequently fault tolerant. The HSE wiring including hubs/switches must have dual redundancy for high availability. If the primary network fails, the secondary is automatically used, eliminating single points of failure. Industrial network hubs or switches with redundant power supply are available. Additional availability can be achieved using a fibre optic ring topology.

2.6.4 Workstations

A system may have several operator workstations where operation, engineering and maintenance can be carried out from the same or independent stations. The workstations are connected to the redundant host OPC server and HSE backbone.

A system typically has two or more workstations. Should any workstation fail, the others are capable of operating the whole system. Workstations may be fitted with dual network interface cards (NICs) for redundant OPC server communication, and multiple hard disks for redundant data storage, as well as UPS for the power.

3 System Architecture

This chapter gives an overview of how the ControlCare system platform can be used to integrate devices operating with various fieldbus into a working architecture.

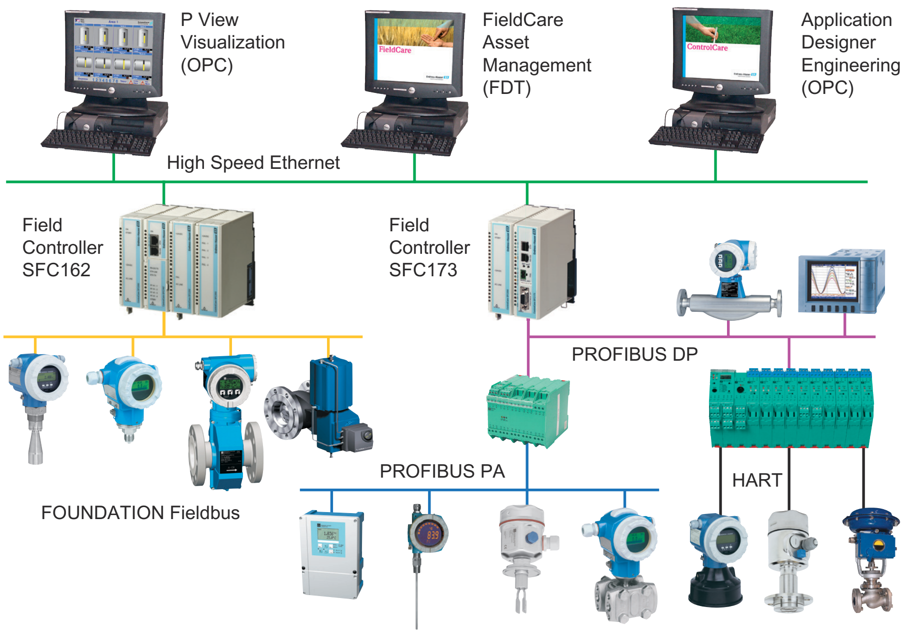

Fig. 3-1: Simplfied view of ControlCare system architecture

Fig. 3-1 shows a simplified view of the ControlCare system architecture.

- The system is based on HART, PROFIBUS and FOUNDATION Fieldbus devices which, if necessary, are connected to Field Controllers and/or Fieldgates via Remote I/O, multiplexers or segment couplers. Discrete and conventional analog signals are handed by remote or local I/O modules.
- Field Controllers and associated equipment are available for both FOUNDATION Fieldbus and PROFIBUS. For FOUNDATION Fieldbus, I/O requirement is normal handled by local I/O modules connected to the controller. For PROFIBUS various remote I/O units are readily available on the market and/or local I/O can be used.
- Where no control requirement exists, a direct connection can be made to the between field and application via a Fieldgate as a Plant Access Point. These exist for conventional, HART and PROFIBUS signals.
- The system backbone to which applications and Field Controllers are connected is FF HSE (High Speed Ethernet). Since the ControlCare platform supports HSE bridging, the system can be expanded by simply adding more ControlCare Field Controllers. There is no restriction on the type of Field Controller, so that FOUNDATION Fieldbus and PROFIBUS systems can coexist in the same application.
- The HSE system backbone offers an open solution for the integration of ControlCare as a subsystem into other systems with HSE-support.
- ControlCare Field Controllers also support MODBUS (not shown), either by a serial connection or via MODBUS TCP. This enables legacy systems or control equipment such as a DCS/PLC, Remote I/O, Operator Panels etc. to be easily integrated in a ControlCare system.

3.1 FOUNDATION Fieldbus

ControlCare Field Controller SFC162 is designed as a HSE bridge and forms the linking element between FOUNDATION Fieldbus HSE and H1 networks. Together with the backplane power supply, fieldbus power supply and fieldbus power conditioner, it can be used in a number of architectures, the most important of which are described in this section.

Note!

- Additional information on segment length, cables, grounding etc. be found in FOUNDATION Fieldbus Guidelines, BA 013S/04/en.

3.1.1 Standard topology

Fig. 3-1 shows a standard FOUNDATION Fieldbus topology with two ControlCare Field Controllers which communicate with the host via FOUNDATION Fieldbus HSE.

- ControlCare Application Designer and other applications, e.g. P View HMI/SCADA, and the Field Controller SFC162 are connected to the HSE backbone. A switch is used to enable and control media access.
- For applications in non-hazardous areas, the Field Controller assembly, comprising backplane power supply, Field Controller, fieldbus power supply and fieldbus power conditioner is connected to up to four H1 segments.
- For applications in hazardous areas, the Field Controller assembly comprises a backplane power supply and Field Controller only. Connection to each H1 segment is made via a separate FISCO power conditioner, which may be mounted in the control cabinet or a an Ex-protected location in the field. Alternately, an Exe power supply and Exe/Exi multibarriers can be used.
- The number of devices that can be connected to each segment depends upon a number of factors. Usually it varies between 8 and 16, depending upon application and power consumption of the devices. More information is to be found in BA013S/04/en, FOUNDATION Fieldbus Guidelines.

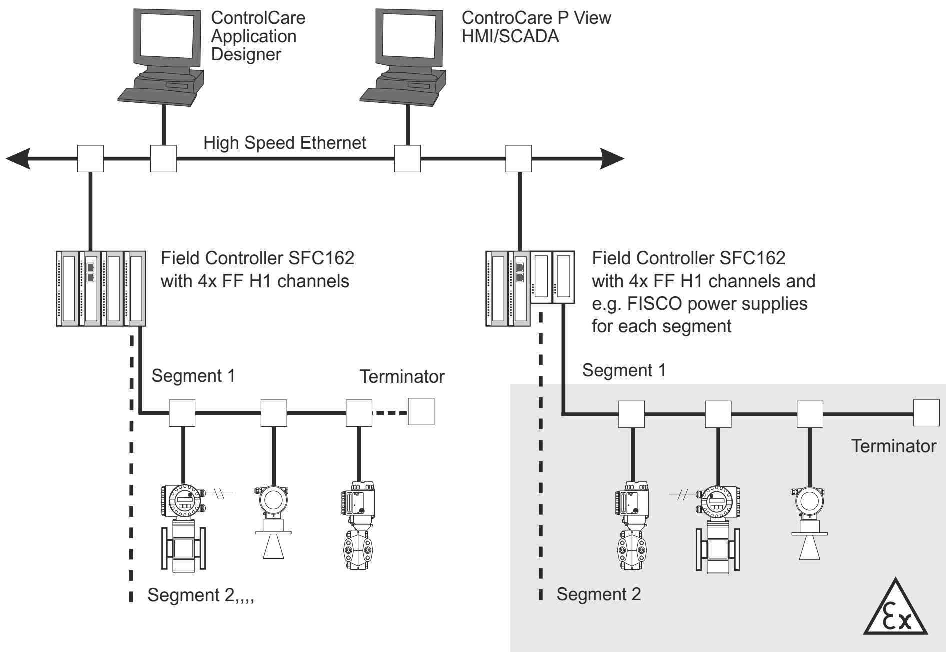

Fig. 3-2: Standard Topologies for FOUNDATION Fieldbus application

3.1.2 Redundant fieldbus power

A redundant fieldbus power supply is made by simply connecting up the outputs of two ControlCare SFC252 or SFC260 fieldbus power supply modules, see Fig. 3-3. For applications in non-hazardous areas, the SFC353 fieldbus power conditioner can be used for connection to the fieldbus, otherwise up to four intrinsically safe power conditioners can be connected to the fieldbus power supplies.

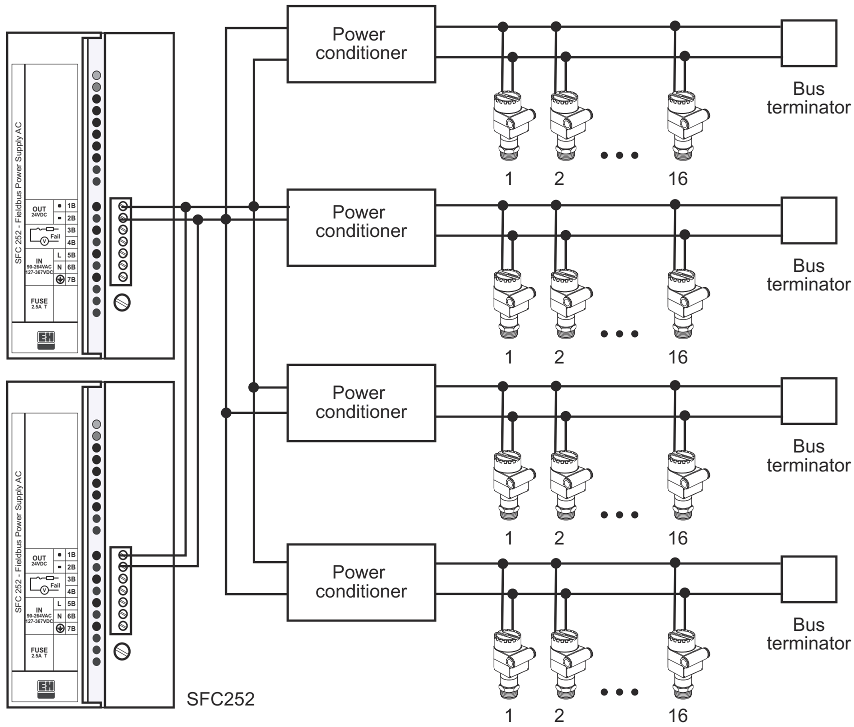

Fig. 3-3: Redundant fieldbus power supply: other modules and external power connections omitted for clarity.

3.1.3 Redundant fieldbus power and conditioning

Two ControlCare SFC252/SFC260 and SFC353 modules can be used to provide redundant fieldbus power and conditioning by connecting the respective outputs (+ and –) in parallel. When used in this way an external bus terminator should be used to allow a change between modules without interrupting fieldbus operations.

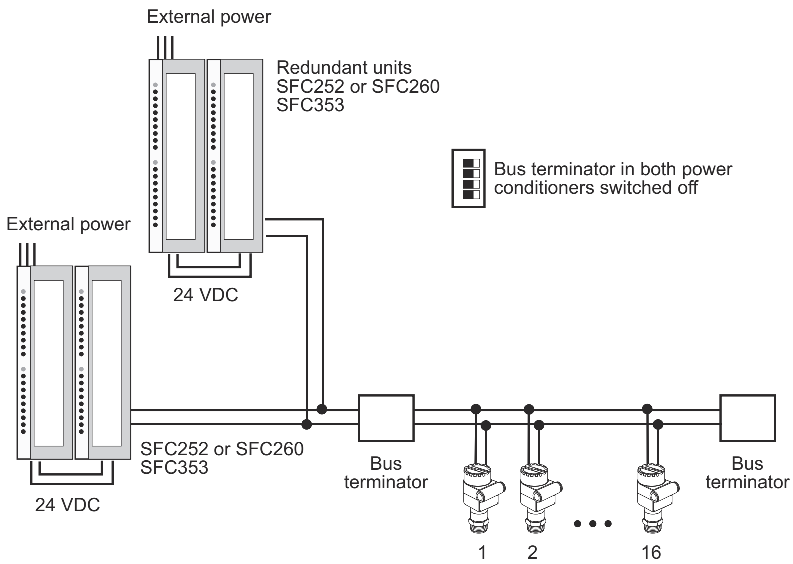

Fig. 3-4: Power wiring suggestion for redundant applications: other modules omitted for clarity.

A second possibility for producing a redundant application is to feed the bus from both sides. The bus terminators in the conditioners are turned off and external terminators used to ensure continuity of power and operation should one of the units fail.

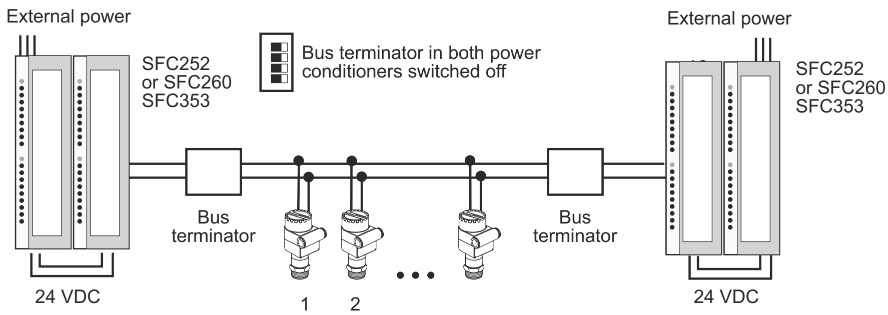

Fig. 3-5: Alternative power wiring suggestion for redundant applications: other modules omitted for clarity

3.2 PROFIBUS

ControlCare Field Controller SFC173 is designed as a HSE gateway and forms the connecting element between FOUNDATION Fieldbus HSE and PROFIBUS DP networks. Together with the backplane power supply and a segment coupler of link, it can be used in a number of architectures, the most important of which are described in this section.

Note!

- Additional information on segment length, cables, grounding etc. be found in the PROFIBUS Guidelines, BA 034S/04/en.

3.2.1 Standard topology

Fig. 3-6 shows a standard PROFIBUS topology with two Field Controllers which communicate with the host via FOUNDATION Fieldbus HSE.

- ControlCare Application Designer and other applications, e.g. P View HMI, FieldCare and Field Controller SFC173 are connected to the HSE backbone. A switch is used to enable and control media access.
- ControlCare Field Controller assembly comprises backplane power supply and Field Controller.
- Fieldgate FXA720 gives access to the DP network for applications that run in parallel to the Field Controller, e.g. Asset Management with FieldCare.
- Drives, instruments, recorders etc. are connected to the PROFIBUS DP bus
- A segment coupler or link connects the field devices to the Field Controller. Depending upon type, this supplies (intrinisically safe) power to the bus.
- The number of devices that can be connected to each segment depends upon a number of factors. More information is to be found in BA034S/04/en, PROFIBUS Guidelines.

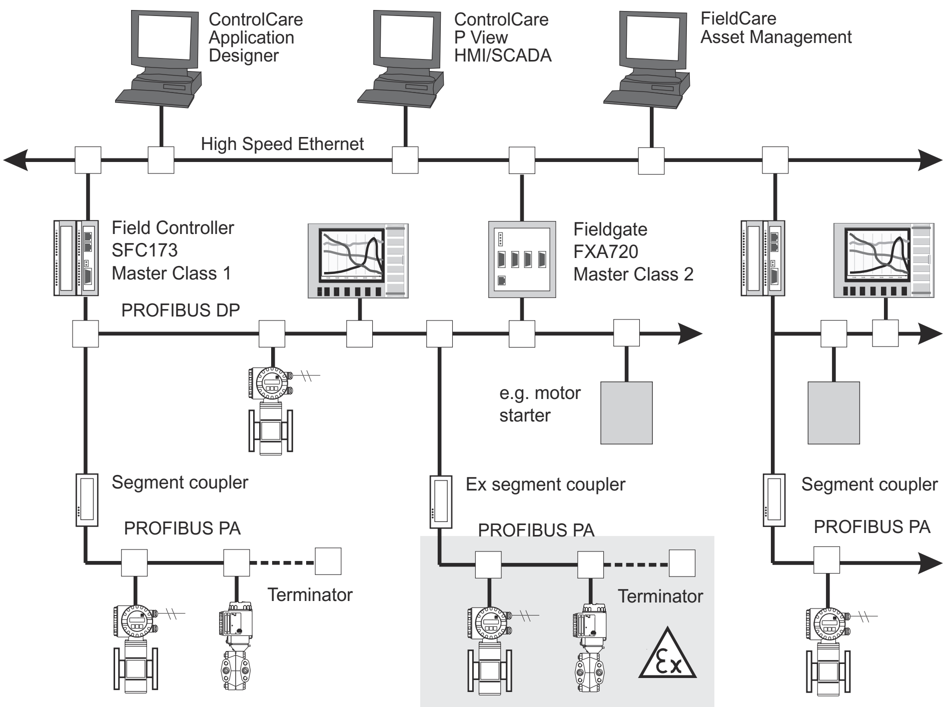

Fig. 3-6: Standard architecture PROFIBUS

3.3 HART

HART devices are often to be found in legacy systems. They can be integrated into the ControlCare platform by three basic methods:

- For control purposes, via PROFIBUS DP using a Remote I/O
- For control purposes, via MODBUS RTU or MODBUS TCP, see next section
- For visualization with e.g. P View or Java Applets, via Ethernet using Fieldgate FXA520 and multiplexer

3.3.1 Standard topology

Fig. 3-7 shows the standard architecture for integrating HART and discrete signals into a PROFIBUS control network:

- The devices are integrated into the PROFIBUS DP network via Remote I/O – these also allow integration of analog and discrete signals
- If asset management is required in parallel to process control, FieldCare accesses the HART devices via a Fieldgate FXA520 Plant Access Point, provided that any Remote I/O and the devicecs have DTMs
- Foe time-uncritical applications, it is also possible for FieldCare to access the devices through the Controlcare SFC173 Field Controller, since this also has a DTM

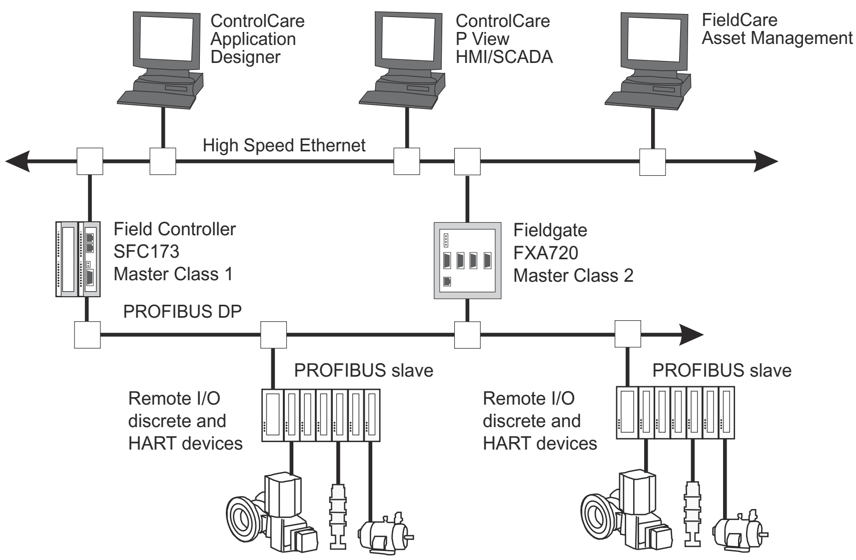

Fig. 3-7: Standard architcture for the integration of HART and discrete signals into the PROFIBUS control network

3.3.2 Topology for legacy systems

Fig. 3-8 shows an architecture in which the information provided by HART devices can accessed via Fieldgate FXA520 for visualisation and asset management:

- Control is done by using the analog signals
- The HART signals of the devices connected to the Field Controller are acquired by the multiplexer.
- Fieldgate FXA520 scans the multiplexer output and publishes the measured value and signal status in its web-server
- The client application communicates with the web server via Ethernet, telephone or GSM.
- ControlCare P View Web-client provides a simple means of visualizing the values received.
- FieldCare can be used to configure the devices when Fieldgate FXA520 is operated in pass-through mode, provided that any Remote I/O and the devicecs have DTMs
- Other client applications using XML data, e.g. MS Excel, can also be run.

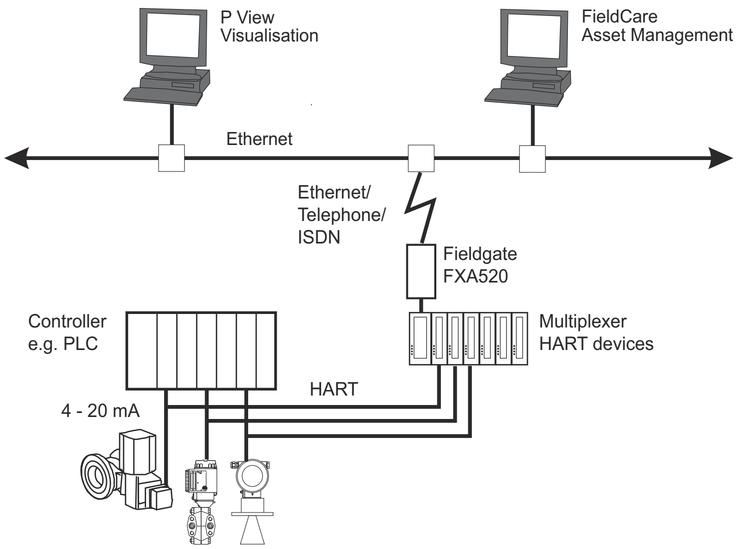

Fig. 3-8: Harvesting HART information in legacy systems

3.4 MODBUS

Existing plants often have many devices and subsystems using MODBUS. ControlCare Field Controllers SFC162 and SFC173 are both equipped with an EIA-232 (RS-232C) serial communication port for connection to legacy equipment using the MODBUS protocol. It can also be connected using the Ethernet port (with Modbus TCP). ControlCare Field Controllers can act as a master or as a slave.

If communication is required with more than one slave a RS-232/RS-485 converter must be used between the Field Controller and Modbus Slaves.

More information on the use of Modbus with ControlCare can be found in the Modbus Tutorial, BA037S/04/en.

3.4.1 Topology for Master-Slave communication

When used in master mode, the Field Controller can read data from and write data to the Modbus slaves. Fig 3-9 shows the possible network topology.

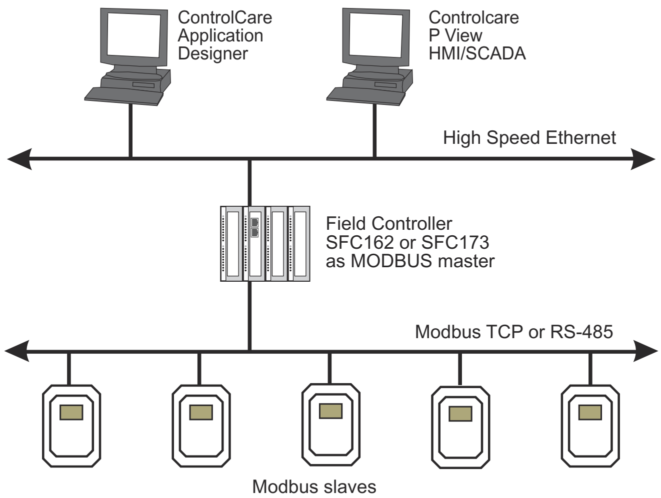

Fig. 3-9: Use of the Field Controller to access parameters on a Modbus line

ControlCare Field Controllers use the standard Modbus commands for read and write, making the slave data available for use in the control strategy or for display and trending in the operator workstation. Operator may also actuate on the slave devices and perform other supervisory functions. Inputs are made available as normal parameters, which may be used as part of the control strategy or simply for monitoring, alarm and trend.

3.4.2 Topology for controller-to-controller communication

Most legacy systems such as DCS or PLC have serial interface modules that support MODBUS. This may be used to supervise Fieldbus instruments through a ControlCare Field Controller acting as a gateway as shown in Fig. 3-10, allowing the existing system to access some of the capabilities provided by Fieldbus devices. Traditional process variables and controller gains can be mapped from Fieldbus to the database of existing system

Data in the Field Controller can be read or written by a Modbus master when the former operates in a slave mode. Special functions allow data to be read and write to discrrete inputs/outputs (Functions 1, 2, 5 and 15) or 16-bit registers (Functions 3, 4, 6 and 16).

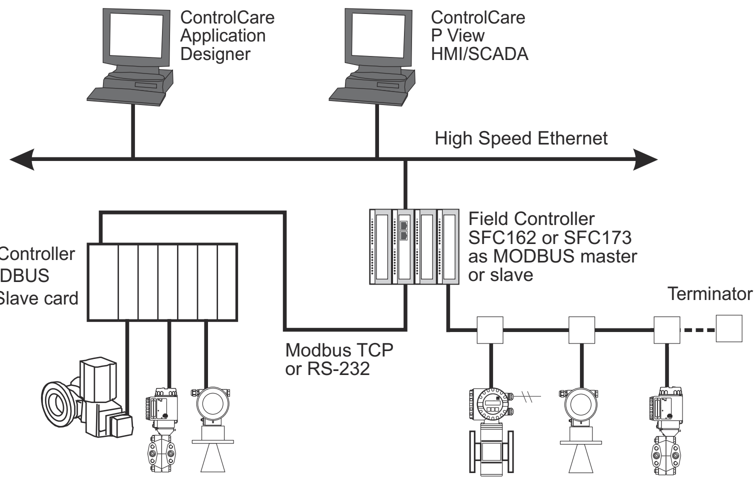

Fig. 3-10: Architecture for controller to controller communication

3.4.3 Topology for master and slave communication

The ability of the Field Controller to act simultaneously as both master and slave allows an architecture such as that shown in Fig. 3.11. Here a Modbus controller acts as master to the Field Controller slave. At the same time the Field Controller is master to a Modbus remote I/O slave. The devices commuunicate with each other by a full TCP/IP connection or one TCP/IP and one serial connection.

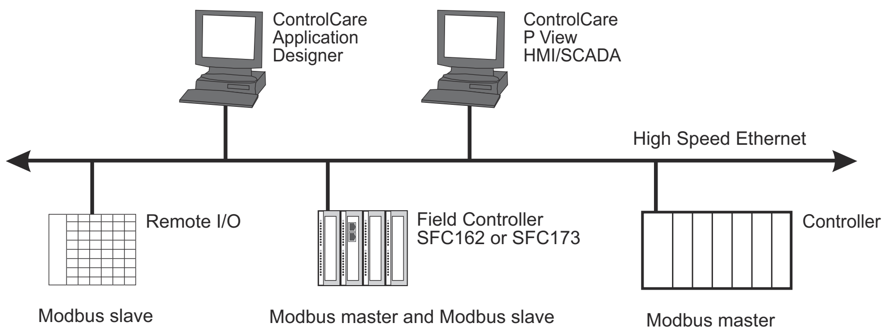

Fig. 3-11: Architecture for combined master ans slave operation

4 Planning Information

This chapter is concerned with the planning of the system. It does not concern itself with the design and dimensioning of the fieldbus network, however, since this is described in the following manuals:

- BA013S/04/en: FOUNDATION Fieldbus Guidelines
- BA034S/04/en: PROFIBUS Guidelines

4.1 System requirements

ControlCare is supplied as a complete engineered package. The workstations supplied will have been stipulated in the functional specification. The table below gives a typical configuration used at the time of writing.

General	IBM-compatible PCs for Operation, Engineering, Maintenance etc.. Each workstation can be dedicated to a single function, or functions can be combined as required.	
Operation system	ControlCare Application Designer Suite Rellease 2.05.xx has been tested and approved for the following operating systems: ■ Windows 2000 with SP4 ■ Windows XP with SP1 or SP2 ■ Windows 2003 Server with SP1 ■ Windows Vista ■ Windows 2008 server ■ Windows 7	
Hardware (recommended)	■ Processor Type	Pentium 500 MHz processor
	■ Main Memory (RAM)	256 MB RAM
	■ Hard-disk (HDD) Capacity	40 GB IDE or Higher 310 MB free space for installation directory 350 MB free space on the system drive 115 MB temporary free space
	■ Recommended Monitor	21", SVGA
	■ Monitor Resolution	1280 x 1024, 64k colours
	■ Data Updating Cycle	1 sec - 2 sec
	■ CD-ROM Drive	CD-RW 40x/10x/40-IDE
	■ Redundancy of operator Console	All workstations can be configured to access all data, allowing a full workstation redundancy
Power Supply	■ Country specific	
Max. No of stations	■ Unlimited	
Printer	■ Laser, Inkjet, dot matrix, b/w or colour as required	

4.2 System performance: FOUNDATION Fieldbus

In a FOUNDATION Fieldbus system, the user has several possibilities for designing control strategy and executing the control. Where control is executed can also have a significant effect on the performance of the system, so that good physical and logical design is also an important factor in optimising FOUNDATION Fieldbus systems. This section describes how the system works and the steps that can be taken to optimise performance.

4.2.1 Control in the Field

Control in the field is one FF feature that can be used to optimise system performance. It is no more than the execution of control function blocks in field devices. A control loop is set up by linking together the inputs and outputs of the constituent function blocks, exactly as if the control was running in the Field Controller. The only difference is that the control blocks themselves will be "attached" or assigned to field devices. For ControlCare Application Designer, it is as simple as dragging and dropping the function block to a field device rather than a linking device or Field Controller.

Virtual Communication Relationship (VCR)

As the control strategy is built up in the foreground, a list of all the links is compiled in the background. When the project is downloaded to the real network, every link is mapped onto a communication channel or so-called Virtual Communication Relationship (VCR). A VCR is like a telephone line that allows two or more devices to talk to each other. In reality, three types of VCR are used by FOUNDATION Fieldbus: publisher-subscriber, client-server and report distribution. Publisher-subscriber VCRs are used for links between blocks and are scheduled and deterministic. Client-server VCRs are used for the unscheduled transfer of view data for e.g. visualization. Report distribution, also known as source-sink, is use to distribute trend and alarm information.

Link Active Scheduler

Communication on the fieldbus is controlled by the Link Active Scheduler (LAS). This normally resides in the Field Controller, but may also be located in a field device. A field device may also perform the function of backup LAS on the bus. A link is understood as a connection between the output value of one function block to the input value of another, e.g. OUT to IN, or BACKCAL_OUT to BACKCAL_IN. Execution of links is part of the scheduled traffic on the bus.

The LAS directs the scheduled traffic by means of the so-called Compel Data (CD) schedule. This lists all the publishers with the exact instant and period they should be given permission to publish. The LAS synchronises control by working successively though the list, compelling each block to publish in turn. All devices requiring the published value (subscribers) are updated at the same instant in time. In the periods between scheduled traffic the LAS handles system requests for view data, write commands or broadcasts administrative data. The time taken to refresh the process data of the complete system is determined by the macrocycle, which comprises the CD schedule plus an additional fixed period for unscheduled traffic. It should be noted that depending on macrocycle length and amount of unscheduled traffic, it can take more than one macrocycle to update HMI data via the OPC server. In this case it is possible to adjust the period allowed for background traffic to optimise the application.

4.2.2 Optimising macrocycle

The macrocycle comprises the operational and background traffic. It can be roughly estimated as follows:

- Ideal macrocycle = ((30*NDEV)+(30*NEL))*1.2 ms

where NDEV is the number of field devices in the fieldbus network
NEL is the number of external links (between field devices)
A field device is any device which communicates on the network

An exact calculation must take into account other factors such as function block execution time.

One way to optimise control is to reduce the macrocycle by cutting the scheduled traffic on the bus. This means reducing the links required to execute the control. Fig. 4-1 shows an example of a PID control loop, where a flowmeter is used to control the valve positioner.

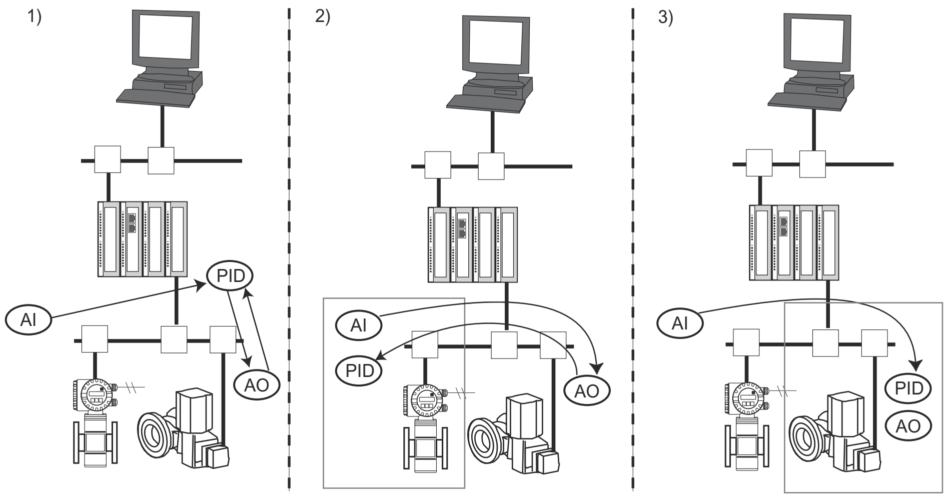

Fig. 4-1: Three ways of executing control

There are three methods by which the control can be done:

1 When the PID loop is located in the Field Controller, three external links are required:
   – to send data from the transmitter AI block to the PID block
   – to send the result of the PID execution to the actuator AO block
   – to send the back calculation data from the actuator AO block to the PID block.

2 When the PID loop is located in the transmitter, two external links are required:
   – to send the result of the PID execution to the actuator AO block
   – to send the back calculation data from the actuator AO block to the PID block.

3 When the PID block is located in the actuator, only one external link is required:
   – to send data from the transmitter AI block to the PID block.

For a single control loop, the savings are relatively small compared to the execution time of the blocks, especially when it is considered that loop execution is quicker in the Field Controller. When several loops are running simultaneously, however, the execution time becomes much less significant, and the number of links becomes the decisive factor in optimising the macrocycle. Moreover, reducing the number of external links increases the loop integrity. In this respect, Method 3 offers the highest integrity level and process optimization.

For a loop with 8 devices and 12 links (e.g. four times the arrangement in Section 1) of Figure 4-2, the macrocycle is roughly (30*8 + 30*12) *1.2 = 720 ms. The same arrangement with four links has a macrocycle of 422 ms.

4.2.3 Function blocks

Another important aspect of system performance is the number and type of device function blocks available to the system. The larger the number variety, the easier it is to optimise the performance of the system. Most function blocks address continuous control, Hybrid Function Block technology, however, offers the possibility to seamlessly integrate continuous and discrete control (hybrid). Both the ControlCare Field Controllers, SFC162 and SFC173, support the use of 250 instantiable function blocks, where up to 50 can be hybrid function blocks, whereby four function blocks are not linkable. An unlimited number of function blocks may be provided by the devices in the field.

Field Controller SFC162 supports 512 internal links and 1024 HSE-HSE links. Field Controller SFC173 also supports 512 internal links and 1024 HSE-HSE links. Should this number not be sufficient, the user has the option of adding Field Controllers to the system, thus increasing control power and performance.

It makes no sense, however, to overburden a device with function blocks that will probably not find application, as this places an unnecessary load on device memory. FOUNDATION Fieldbus offers a solution in instantiation, allowing function blocks to be created ad hoc or to be downloaded to the devices from the system library. This option is supported by the ControlCare platform. The user has the freedom to distribute control blocks where they are best used.

To guarantee maximum flexibility and scalability, it is also important that the same set of blocks are operating in the Field Controller and devices. Where fixed blocks are in use, it must be guaranteed that they are identical throughout the system. The function blocks used in ControlCare Field Controller SFC162 and Endress+Hauser devices are from a single source, guaranteeing functionality, uniformity and interoperability. This also ensures uniform configuration and a standard function block library.

4.2.4 Virtual Communication Relationships (VCRs)

As described earlier, a VCR is like a telephone line, and a device must have one line for each external link. Devices may offer fixed numbers of VCRs of a given type or may offer complete flexibility of use. Some devices support very few VCRs, a limiting factor if several links are required. This is the case in more sophisticated control strategies that cater for device redundancy, alarming or cascade control with block recovery/override facilities. While not being a knock-out criterion for control in the field, devices offering as many VCRs as possible certainly increase loop integrity and the flexibility of system design. ControlCare Field Controllers support up to 512 OLs (Object Links) as well as 1024 VCRs to be used for HSE links (number of publishers and subscribers may not exceed 1024). In the case of the SFC162 FOUNDATION Fieldbus Field Controller, 90 publishers and 90 subscribers are supported for each of the four FF-H1 channels.

4.2.5 Multi-Variable Optimisation

The function block parameters of a field device are made available to the host in any of four standardised views. The whole view is transmitted, even if only one parameter is required. The host data base is updated by unscheduled communication in a client-server relationship, each view taking around 500 ms to transmit. When control blocks are executed in the field, the view traffic increases – a situation that can be exacerbated if the parameters selected for monitoring are in different views. If the control task dictates a short macrocycle, therefore, it may take more than one cycle to refresh the view data.

The unscheduled traffic can be significantly reduced, and hence response time improved, if the host system supports another FOUNDATION Fieldbus standard specification, Multi-Variable Optimisation (MVO). A device supporting this feature will bundle together view parameters from several function blocks into a single object. This can then be transferred in one transaction, greatly reducing the traffic on the bus. This results in a significant improvement in refresh time.

4.3 System performance: PROFIBUS

Note!

- In the majority of cases, the performance of the SFC173 Field Controller will be determined by the macrocycle time of the function block execution rather than the polling of the PROFIBUS devices.

In a PROFIBUS control system, control is always executed in the Field Controller, which acquires its data with cyclic services using the master-slave mechanism. Thus data exchange between ControlCare Field Controller SFC173 (a Class 1 master) and the field devices occurs automatically in a fixed, cyclic order. The cycle times determine how much time is required until the data of all the devices in the network are updated.

The total cycle time for the updating of network data is calculated as follows:

- **Total cycle time** = Sum of the cycle times of the field devices
  + internal Controller cycle time
  + PROFIBUS-DP transmission time

The cycle time of the ControlCare Field Controller is typically 100 ms. The cycle time for field devices depends on the number bytes transmitted, which in turn depends on the number of values offered and activated for output. As a rule of thumb, the device cycle time can be taken as:

- Device cycle time =10 ms + 1.5 (N-1) ms

  where N = number of values transmitted

A continuous measuring device offering only the process value and status has a device cycle time approximately 11.5 ms, where as a flow device outputting five different process values has a device cycle time of 17.5 ms.

The PROFIBUS DP system reaction time is normally given by the token rotation time. In a mono-master system, however, it is dependent upon the number of slaves and the retry setting. Both are dependent upon the baudrate which may range from 45.45kbit/s to 12 Mbit/s depending upon the components used.

The total cycle time of a large system can be reduced considerably by the use of links, since Field Controller does not have to poll all the slaves in the network individually. Since the internal cycle of the link runs independently of the Field Controller, the total refresh time is then primarily dependent on the slowest link.

More exact cycle times for Endress+Hauser devices can be taken from Table 4-9 in the PROFIBUS Installation Guidelines, BA034S/04/en. This also contains specimen calculations for the PROFIBUS DP/PA couplers and links on the market.

4.4 I/O performance

The performance specifications of the local I/O that can be used with the Field Controllers, as well as the rack power calculation are contained in the System Specifications, BA040S/04/en.

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