

Fieldbus and Control Networks

GP 15-10-02

Scope

- 1) This Global Practice (GP) defines basic technical requirements for the design of generic Foundation Fieldbus (FF) based process control systems (PCS). This GP covers the minimum requirements for the design and installation of a FOUNDATION™ Fieldbus system based on the 31.25 kbits/s physical layer per ISA S50.02. A functional specification shall be prepared to define plant/project specific requirements. This Practice shall be used in conjunction with the functional specification to form the technical portion of a bid package.
 - 2) This Practice defines minimum requirements for design, installation, and operation of a FF portion of a PCS, as well as requirements for redundancy, reliability, and testing.
 - 3) The Foundation Fieldbus portion of a PCS covers :
 - a) Hardware associated with the FF H1 segment, including:
 - i) FF field devices including transmitters and valve positioners
 - ii) Wiring
 - iii) Terminators
 - iv) Junction box devices
 - v) Power supplies and conditioners
 - vi) PCS H1 communications cards
 - vii) Handheld communication/configuration/diagnostic devices
 - b) Operability issues associated with FF design, including:
 - i) Loading of an H1 Segment
 - ii) Redundancy and reliability
 - iii) Testing, commissioning, and documentation
 - 4) This GP must be used in combination with PCS design criteria defined by the project and by [GP 15-11-03](#).
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1. Required References

This Section lists Practices and Standards that are generically referenced and assumed to be a part of this document. Unless otherwise specified herein, use the latest edition.

1.1. Global Practices–ExxonMobil Engineering Practices

GP 03-06-01	Piping for Instruments
GP 12-01-01	Upstream Numbering System for Project Documents
GP 12-01-02	Upstream Identification of Equipment, Components and Devices, Lines, and Valves
GP 15-06-01	Electronic and Pneumatic Instruments
GP 15-06-02	Environmental Protection for Instrumentation
GP 15-07-02	Protective Systems
GP 15-10-01	Instrument Transmission Systems
GP 15-11-03	Process Control Systems
GP 15-11-01	Instrument Control Panels
GP 16-08-01	Instrument and Essential Services Power Supplies
GP 70-01-12	Upstream Human Factors

1.2. ExxonMobil Data Sheets

ExxonMobil Data Sheets	Data Sheet Home Page
D151103C01	Distributed Control Systems - Documentation Requirements Sheet
I151103C01	Distributed Control Systems - Inspection and Testing Requirements Sheet
T151103C01	Distributed Control Systems - Customary Units
T151103M01	Distributed Control Systems - Metric Units

1.3. Fieldbus Foundation

FF-816	FOUNDATION™ Specification 31.25 kbits/s Physical Layer Profile
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1.4. IEC–International Electrotechnical Commission

IEC 60079-14	Electrical Apparatus for Explosive Gas Atmospheres - Part 14: Electrical Installations in Hazardous Areas (Other Than Mines)
IEC 60445	Basic and Safety Principles for Man-Machine Interface, Marking and Identification - Identification of Equipment Terminals and of Terminations of Certain Designated Conductors, Including General Rules for an Alphanumeric System
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
IEC 61511-1	Functional safety - Safety instrumented systems for the process industry sector - Part 1: Framework, definitions, system, hardware and software requirements

1.5. IEEE–Institute of Electrical and Electronic Engineers

IEEE 730	Standard for Software Quality Assurance Plans IEEE Computer Society Document
IEEE 828	Standard for Software Configuration Management Plans IEEE Computer Society Document
IEEE C37.90.1	Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

1.6. ISA–International Society for Measurement and Control

ISA 50.02	Fieldbus Standard for Use in Industrial Control Systems, all parts
ISA 71.01	Environmental Conditions for Process Measurement and Control Systems: Temperature and Humidity
ISA 71.04	Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants-Formerly ISA - S71.04

1.7. Military Handbook

MIL-HDBK-217F CHG NOTICE 2	Reliability Prediction of Electronic Equipment
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1.8. NEMA–National Electrical Manufacturers Association

NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
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1.9. NFPA—National Fire Protection Association

NFPA 70	National Electrical Code
NFPA 496	Standard for Purged and Pressurized Enclosures for Electrical Equipment (National Fire Codes, vol. 7)

1.10. UL—Underwriters Laboratories

UL 913	UL Standard for Safety Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division I, Hazardous (Classified) Locations
UL 1424	UL Standard for Safety Cables for Power-Limited Fire-Alarm Circuits

2. General

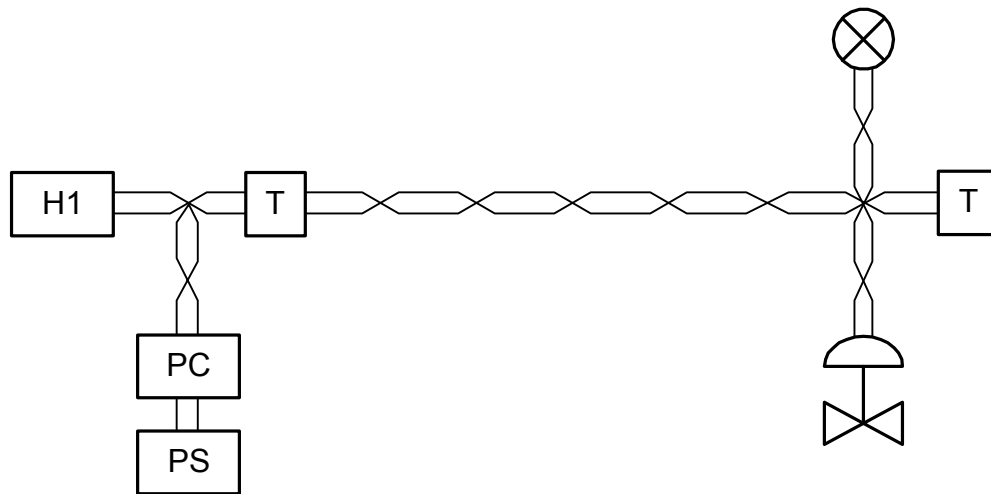
- 1) [I] This GP presents the design requirements for a FOUNDATION™ Fieldbus based control system. This practice will only discuss the voltage mode (parallel coupling) medium attachment unit, as defined in ISA S50.02, operating at a signal speed of 31.25 kilobits per second (i.e., H1).
- 2) [I] The Fieldbus system design process will be somewhat different than that for a traditional (4.-20mA based) Process Control System (PCS). Tasks associated with PCS implementation, such as instrument selection, instrument placement, junction box design, etc., are commonly completed independently of each other. This is not the case, however, for the design of a Fieldbus based system. Since many traditional control functions can reside in Fieldbus instruments, design considerations traditionally associated with the PCS must now expand to incorporate field instrumentation.
- 3) [I] A typical Fieldbus segment consists of the following components (refer to Figure 1):
 - a) H1—Fieldbus interface card
 - b) PC—Power Conditioner
 - c) PS—Bulk VDC supply to Power Conditioner
 - d) T—Terminator
 - e) Fieldbus devices (e.g., transmitters, transducers, etc.)

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Figure 1: Fieldbus Segment Components

3. Definitions

[I] The following represent definitions of terms commonly encountered in the use and application of Fieldbus technology.

Term	Description
Brick	Fully connectorized passive junction located on the bus.
Bus	A H1 Fieldbus cable between a host and field devices connected to multiple segments, normally through the use of repeaters.
Communication Element	Part of a Fieldbus device that communicates with other elements via the bus.
Communications Stack	Layered software supporting communication between devices. A Communications Stack is device communications software, which provides encoding and decoding of User Layer messages, deterministic control of message transmission, and message transfer.
Configurable	The capability to select and connect standard hardware modules to create a system; or the capability to change functionality or sizing of software functions by changing parameters without having to modify or regenerate software.
Configuration	The physical installation of hardware modules to satisfy system requirements; or the selection of software options to satisfy system requirements.
Connector	A Connector is a coupling device used to connect the wire medium to a Fieldbus device or to another segment of wire.

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Term	Description
Console	A collection of one or more workstations and associated equipment such as printers and communications devices used by an individual to interact with the automation system and perform other functions.
Control Loop	A Control Loop is a group of Function Blocks (FBs) that execute at a specified rate within a Fieldbus device or distributed across the Fieldbus network.
Coupler	A Coupler is a physical interface between a Trunk and Spur, or a Trunk and a device.
Cycle	The scanning of inputs, execution of algorithms and transmission of output values to devices.
Deterministic	Ability to measure the maximum worst-case delay in delivery of a message between any two nodes in a network. Any network protocol that depends on random delays to resolve mastership is nondeterministic.
Device:	Physical entity connected to the Fieldbus that is composed of at least one communication element and may have a control element (transducer, actuator, etc.).
Device Description (DD)	A Description (DD) provides an extended description of each object in the Virtual Field Device (VFD), and includes information needed for a control system or host to understand the meaning of data in the VFD.
Discrete Control	Control where inputs, algorithms, and outputs are based on logical (yes or no) values.
DI	Discrete Input – the signal is from the field device to a host system or other device
DO	Discrete Output – the signal is generated by the host system or device and transmitted to a field device.
FF	FOUNDATION™ Fieldbus
Factory Acceptance Test (FAT)	The final test at the vendor's facility of the integrated system being purchased.
Fieldbus	A Fieldbus is a digital, two-way, multi-drop communication link among intelligent measurement and control devices. It serves as a Local Area Network (LAN) for advanced process control, remote input/output, and high-speed factory automation applications.
FISCO	Fieldbus Intrinsic Safe Concept. Allows more power to an IS segment for approved FISCO devices, allowing for more devices per IS segment.
FNICO	Fieldbus Nonincendive Concept. Allows more power to a Fieldbus segment, thus allowing for more devices per IS segment.
H1	H1 is a term used to describe a Fieldbus network operating at 31.25 kbit/second.



Term	Description
H1 Field Device	An H1 Field Device is a Fieldbus device connected directly to an H1 Fieldbus. Typical H1 Field Devices are valves and transmitters.
H1 Repeater	An H1 Repeater is an active, bus-powered or non-bus-powered device used to extend the range over which signals can be correctly transmitted and received for a given medium. A maximum of four Repeaters and/or active Couplers can be used between any two devices on an H1 Fieldbus network.
HIST	Host Interoperability Support Test. Voluntary testing is performed by the Fieldbus Foundation to indicate functions or features available with a host. There are 18 different features evaluated. If present, these features must be implemented in a way that conforms to the FF specifications.
Input/Output (I/O) Subsystem Interface	An Input/Output (I/O) Subsystem Interface is a device used to connect other types of communications protocols to a Fieldbus Segment or Segments.
Interchangeability	Interchangeability is the capability to substitute a device from one manufacturer with that of another manufacturer on a Fieldbus network without loss of functionality or degree of integration.
Interoperability	Interoperability is the capability for a device from one manufacturer to interact with that of another manufacturer on a Fieldbus network without loss of functionality.
IS	Intrinsic Safety
ITK	Interoperability Test Kit used by the Foundation to tick mark devices and confirms compliance with the relevant Foundation Fieldbus standards. This is a pass/fail test. Only devices passing the full suite of tests receive the FF "tick mark."
Junction Box / Quick Connection Station	A junction box station allows for quick installation of four to eight field instruments via Terminal, Euro-fast, and/or Mini-fast connectors
Link	A Link is the logical medium by which H1 Fieldbus devices are interconnected. It is composed of one or more physical segments interconnected by bus Repeaters or Couplers. All of the devices on a link share a common schedule that is administered by that link's current LAS.
Link Active Scheduler (LAS)	A Link Active Scheduler (LAS) is a deterministic, centralized bus scheduler that maintains a list of transmission times for all data buffers in all devices that need to be cyclically transmitted. Only one Link Master (LM) device on an H1 Fieldbus Link can be functioning as that link's LAS.



Term	Description
Link Master (LM)	A Link Master (LM) is any device containing Link Active Scheduler (LAS) functionality that can control communications on an H1 Fieldbus Link. There must be at least one LM on an H1 Link; one of those LM devices will be elected to serve as LAS.
Medium	Cable, optical fiber, or other means by which communication signals are transmitted between two or more points.
Mode	Function block operational condition, such as manual, automatic, or cascade.
Object Dictionary	An Object Dictionary (OD) contains all the communications objects in a FBAP/MIB VFD, including Function Block (FB), Resource Block (RB), and Transducer Block (TB) parameters used in a device. Through these parameters, the blocks may be accessed over the Fieldbus network.
Operator Console	A console used by an operator to perform the functions required to monitor and control his assigned units.
Physical Layer	The Physical Layer receives messages from the Communications Stack and converts the messages into physical signals on the Fieldbus transmission medium, and vice-versa.
Redundant Configuration	A system/subsystem configuration that provides automatic switchover, in the event of a failure, without loss of a system function.
Regulatory Control	The functions of process measurement, control algorithm execution, and final control device manipulation that provide closed loop control of a plant process.
Schedules	Schedules define when Function Blocks (FBs) execute and when data and status is published on the bus.
Segment	A Segment is a section of an H1 Fieldbus that is terminated in its characteristic impedance. Segments can be linked by Repeaters to form a longer H1 Fieldbus. Each Segment can include up to 32 H1 devices. Commentary: See ANSI/ISA-50.02, Part 2 (IEC 61158-2): SEGMENT = The section of a Fieldbus that is terminated in its characteristic impedance. Segments are linked by repeaters to form a complete Fieldbus. Several communication elements may be connected to the trunk at one point using a multi-port coupler. An active coupler may be used to extend a spur to a length that requires termination to avoid reflections and distortions. Active repeaters may be used to extend the length of the trunk beyond that of a single segment as permitted by the network configuration rules. A fully loaded (maximum number of connected devices) 31,25 kbit/s voltage-mode Fieldbus segment shall have a total cable length, including spurs, between any two devices, of up to 1 900 m. There shall not be a nonredundant segment between two redundant segments.



Term	Description
Splice	A Splice is an H1 Spur measuring less than 1 m (3.28 ft) in length.
Spur	A Spur is an H1 branch line connecting to the Trunk that is a final circuit. A Spur can vary in length from 1 m (3.28 ft) to 120 m (394 ft).
Standard Function Block (FB)	Standard Function Blocks (FBs) are built into Fieldbus devices as needed to achieve the desired control functionality. Automation functions provided by Standard FBs include Analog Input (AI), Analog Output (AO), and Proportional/Integral/Derivative (PID) control. The Fieldbus Foundation™ has released specifications for 21 types of Standard FBs. There can be many types of FBs in a device. The order and definition of Standard FB parameters are fixed and defined by the specifications.
Tag	A collection of attributes that specify either a control loop or a process variable, or a measured input, or a calculated value, or some combination of these, and all associated control and output algorithms. Each tag is unique.
Tag Id	The unique alphanumeric code assigned to inputs, outputs, equipment items, and control blocks. The tag ID might include the plant area identifier.
Terminator	Impedance-matching module used at or near each end of a transmission line that has the same characteristic impedance of the line. Terminators are used to minimize signal distortion, which can cause data errors by converting between current variations and voltage variations.
Topology	Shape and design of the Fieldbus network (for example, tree branch, daisy chain, point-to-point, bus with spurs, etc.).
Transducer Block (TB)	A Transducer Block (TB) decouples Function Blocks (FBs) from the local Input/Output (I/O) functions required to read sensors and command output hardware. Transducer Blocks (TBs) contain information such as calibration date and sensor type. There is usually one TB channel for each input or output of a Function Block (FB).
Transmitter	A Transmitter is an active Fieldbus device containing circuitry that applies a digital signal on the bus.
Trunk	A Trunk is the main communication highway between terminators on an H1 Fieldbus network. The Trunk acts as a source of main supply to Spurs on the network.
User Application	The User Application is based on "blocks," including Resource Blocks (RBs), Function Blocks (FBs), and Transducer Blocks (TBs), which represent different types of application functions.
User Layer	The User Layer provides scheduling of Function Blocks (FBs), as well as Device Descriptions (DDs), which allow the host system to communicate with devices without the need for custom programming.

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Term	Description
Virtual Field Device (VFD)	A Virtual Field Device (VFD) is used to remotely view local device data described in the object dictionary. A typical device will have at least two Virtual Field Devices (VFDs).

4. Segment Design

[I] The following information is necessary before segment design can begin:

- 1) Complete P&IDs
- 2) Fully defined process control strategies
- 3) Instrument database with device manufacturers and models
- 4) Ancillary components to be used
- 5) Hazardous area wiring method
- 6) Physical locations of both field devices and PCS cabinets (block plan)
- 7) Cable tray layout, including elevations
- 8) Spare capacity requirements
- 9) Category level assignments

4.1. Instrument Location

- 1) [I] The physical location of FF valve positioners or transmitters is no different from conventional control system. The primary consideration for determining where an instrument or a valve positioner is installed is its process control application relative to the plant's process. The fact that Fieldbus devices will be used does not change this basic design principal. In general, instruments and their transmitters should be placed where the most accurate or appropriate measurements of the desired process variables can be taken. Valves and valve positioners should be installed where the best control can be achieved.
- 2) [O] What does change in a FF location is that instruments are grouped into segments and certain constraints exist for designing segments. The physical location must be taken into account in the H1 segment design. Unless otherwise approved in writing by ExxonMobil, INtools shall be used to enter lengths for spurs and segments.

4.2. Process Control Requirements

4.2.1. General

- 1) * [I] Before a determination of whether functionality other than input and output should be performed in the Fieldbus device, it is necessary to determine how the measurement will be used in the control system (e.g., is the measurement only for monitoring or is it used in control or calculations?). This will normally be defined on the P&ID and control/calculation diagrams. Based on this information, the following design considerations must be addressed:

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