

FOUNDATION™ Fieldbus High Speed Ethernet Control System

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ABSTRACT

FOUNDATION™ fieldbus is described in part by the International Electrotechnical Committee (IEC) Draft Standard IEC 61158 and the CENLEC 50170 Standard. The lower-speed H1 communication, running at 31.25 kbit/s, provides an open and interoperable solution for most field instruments and applications including intrinsically safe networks. High Speed Ethernet (HSE) communication running at 100 Mbit/s, is intended to be the redundant, high speed connection between various H1 segments and host systems including PLCs, providing a fieldbus “backbone” network.

While both H1 and HSE are suitable for many industrial applications, HSE offers a cost-effective, high speed, redundant network solution using commercial off-the-shelf (COTS) Ethernet components. HSE provides a fault tolerant synchronized high performance fieldbus backbone as well as fault tolerant devices that are connected to the fieldbus backbone.

INTRODUCTION

The Fieldbus Foundation’s HSE technology is described in part by the 100 Mbit/s Fast Ethernet protocol specified by IEEE 802.3u and ISO/IEC 8802-3. HSE uses the standard Ethernet 48-bit addressing scheme and 64-byte minimum Ethernet frames that can carry standard FOUNDATION fieldbus H1 services as well as messages specifically created for HSE. HSE provides a large bandwidth in the field, which benefits the transfer of large files and high speed I/O such as analyzers and PLCs. It also provides an enhancement to H1 applications by linking multiple devices and segments through “Linking Devices.” HSE’s speed, bandwidth, transparent redundancy, time synchronization, and support of multiple protocols make it an excellent choice for use as the backbone in any application.

H1 TECHNOLOGY OVERVIEW

FOUNDATION fieldbus H1 is a digital, two-way, multi-drop communication link among intelligent measurement and control devices, and automation and display systems. H1 specifies Layers 1,2, and 7 of the OSI Model. H1 stacks cover the functionality of Layer 2-7, while the Physical Layer covers Layer 1. The FOUNDATION fieldbus User Layer functionality is not defined by the OSI Model, but resides as an additional layer.

H1 PHYSICAL LAYER

The FOUNDATION fieldbus H1 Physical Layer is an approved IEC and ISA Standard (IEC 1158-2, Part 2; and ISA-S50.02, Part 2). The standards include provisions for twisted-pair wire, providing a communication medium of 31.25 kbit/s. The bus can either be powered or non-powered, and can be used in intrinsically-safe applications. The twisted pair Type A can be run up to 1900 meters without a repeater, or with up to 4 repeaters per segment to extend the cabling range. An option to the twisted pair cable is the use of fiber optic cable also running at 31.25 kbit/s.

H1 COMMUNICATION STACK

The H1 Communication Stack supports three types of communication. The Client/Server model of unscheduled request/response is used for communication between hosts and devices. The Publisher/Subscriber model of scheduled data acquisition is used for linking inputs and outputs to allow cyclic transfer of control loop data between devices. The Event Notification or Unscheduled Multicast is used for alarming and trending. Since each device has the ability to report alarms based on local limits, alarms are time stamped when they occur and reported at the next period between scheduled messages when the device receives the token.

Scheduled H1 communications are managed by the Link Active Scheduler (LAS) which can reside in a field device, host system, or both locations. The LAS maintains the time synchronization, handles the live list of communicating devices, and manages token passing. H1 allows for redundancy of LAS on a single segment; if one LAS fails, one of the other link masters will become the LAS. It also is designed to “fail operational” to reduce downtime.

USER LAYER

The FOUNDATION fieldbus User Layer supports Standard Function Blocks (FF-890, 891, 892), System Management (FF-880), Device Descriptions (FF-900), and Capabilities Files (FF-103). Function Blocks run on H1 and HSE. The Standard Function Blocks provide a consistent definition of inputs and outputs that allow seamless distribution and integration of functionality from various vendors (i.e., interoperability). The System Management provides deterministic scheduling of function blocks, including node address assignment, application clock synchronization, and support for bringing devices into an operational state. The Device Descriptions provide the drivers for the devices that allow host systems to operate the devices without custom programming. The Capabilities File allows the host system to configure the system while off-line by providing the communication values of a device.

HIGH SPEED ETHERNET TECHNOLOGY

High Speed Ethernet (HSE) enhances the H1 applications of FOUNDATION fieldbus by providing a high-speed backbone, increased bandwidth, redundancy, and bridging capabilities for multiple protocols. Eleven new specifications are added above the Standard Ethernet (IEEE 802) Physical Layer and “stack” to meet the requirements of Ethernet in industrial applications.

HSE ARCHITECTURE

The Fieldbus Foundation’s HSE architecture is an enhanced Standard Ethernet (IEEE 802) model. The HSE System and Network Management Agents, function blocks, HSE Management Agents and Field Device Access Agents all reside at the Application Layer, above the Network Layers of the OSI model. The additional functionality can seamlessly operate within the HSE model as shown in Figure 1.

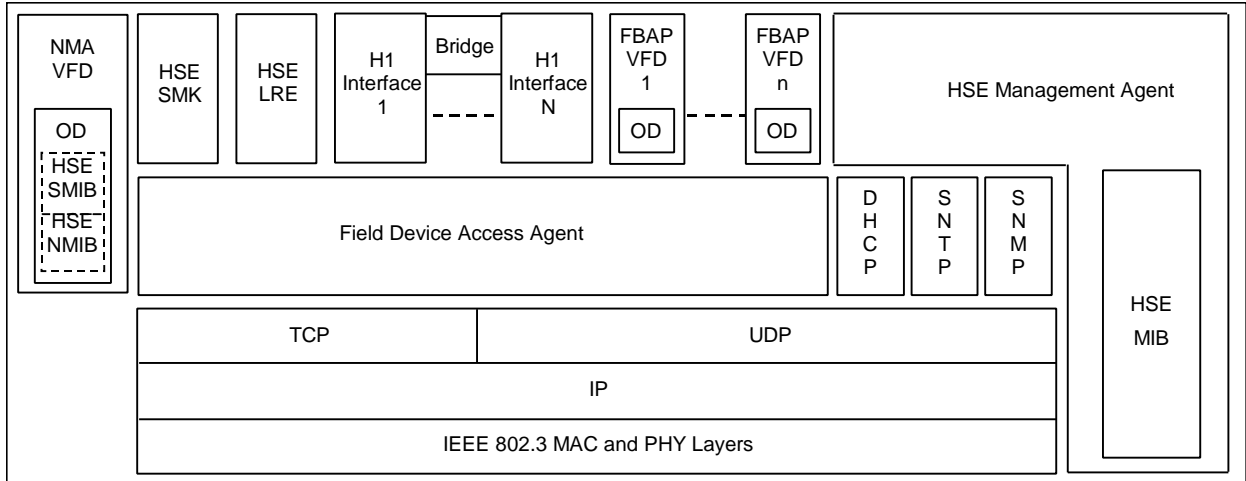


Figure 1. High Speed Ethernet Architecture

An HSE stack contains the Distributed Host Control Protocol (DHCP), Simple Network Time Protocol (SNTP), and Simple Network Management Protocol (SNMP) which in turn use the Transport Control Protocol (TCP) and User Data Protocol (UDP) services.

TCP and UDP in turn use the standard Internet Protocol (IP) services, which use the standard IEEE Ethernet 802.3 Media Access Control (MAC) and Physical (PHY) Layers.

The use of standard Ethernet/Internet stacks in HSE system architecture ensures interoperability among the different stack manufacturers.

HSE DEVICE ADDRESS ASSIGNMENT

High Speed Ethernet uses the Dynamic Host Configuration Protocol (DHCP), Internet Protocol (IP), as well as System Management functionality to assign addresses. The process begins with a device requesting an IP address from a DHCP Server. The server responds to the device request by supplying the device with a valid IP address. The device sends an annunciation message to the System Manager to identify which device received an address. The System Manager will then assign the Physical Device Tag to the device. Once the device's address and communications are established, the System Manager can begin the download of device configurations.

HSE REDUNDANCY

HSE makes extensive use of “commercial off-the-shelf” (COTS) Ethernet equipment and software. The specifications include provisions for using redundancy as employed in standard Ethernet applications. The HSE redundancy provides redundant communication paths (redundant networks) and redundant devices, and allows selective connectivity through all ports. The redundant network is either a dual network or single fault tolerant as shown in Figures 2 and 3.

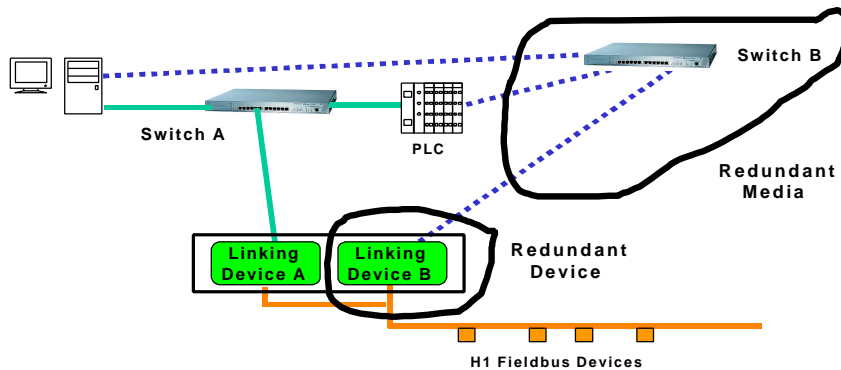


Figure 2. HSE Redundancy - Single Fault Tolerant Network

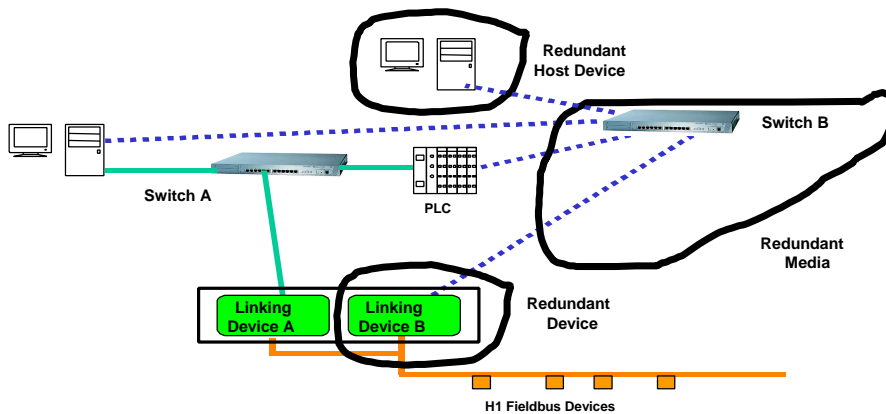


Figure 3. HSE Redundancy Dual Network

REDUNDANT MEDIA

The redundant communication paths allow Physical Layer media redundancy between HSE switches, linking devices and host systems. The redundant paths are transparent to applications. If either path is broken, the secondary path is available for communication.

REDUNDANT LINKING DEVICES

To prevent failure due to loss of a linking device, multiple linking devices may be attached to the same network. Each HSE Device and HSE Linking Device contains an HSE Local Area Network (LAN) Redundancy Entity (HSE LRE). The HSE LRE provides fault tolerance to single failure through the use of redundancy. Each HSE LRE periodically sends and receives Redundancy Diagnostic Messages. Each HSE device or linking device constructs a local Network Status Table (NST). The NST provides a detailed status on the condition of every HSE device connected to the Ethernet Networks (support of multiple networks). The HSE LRE determines which Ethernet Network is used for message transmission.

The switchover of redundant HSE Linking Devices and Ethernet Networks is distributed to the HSE devices and system using COTS Ethernet equipment. The HSE redundancy supports redundant HSE Linking Devices and Ethernet Networks.

PORT CONNECTIVITY

The status of the network is shared among all devices. The shared network status allows devices to independently pick ports for communication. The connectivity through all ports allows devices to avoid bad or busy ports. All devices periodically transmit diagnostic messages containing the view of network health and status as seen by the device. The devices use these diagnostic messages to build a Network Status Table for port selection. Diagnostic messages include information such as sequence numbers, device number, number of ports, port used for this message, status of all ports, and current selected transmission port.

FLEXIBLE FUNCTION BLOCK

The Flexible Function Block (FFB) is a “wrapper” for an application–specific algorithm that extends the function block model into discrete manufacturing applications. Blocks covered by FFB include 8-channel multiple analog output, analog input, discrete input, discrete output, and application-specific blocks. Standard programming languages such as those defined by IEC 61131 can be used to create FFBs.

Applications for the FFB include use for sequence of events, supervisory data acquisition, I/O subsystem interfaces, and coordinated drives (roll handling). FFB allows multiplexers, PLCs, and gateways to other protocols to use the HSE backbone. FFB gateways allow FOUNDATION fieldbus H1 and other protocols to communicate on the same media with host systems, PLCs, and other devices. The addition of the FFB provides users with a standardized enterprise integration protocol.

The combination of H1, HSE, Standard Function Blocks, and the FFB enables the FOUNDATION fieldbus to cover a very broad range of applications as shown in Figure 4.

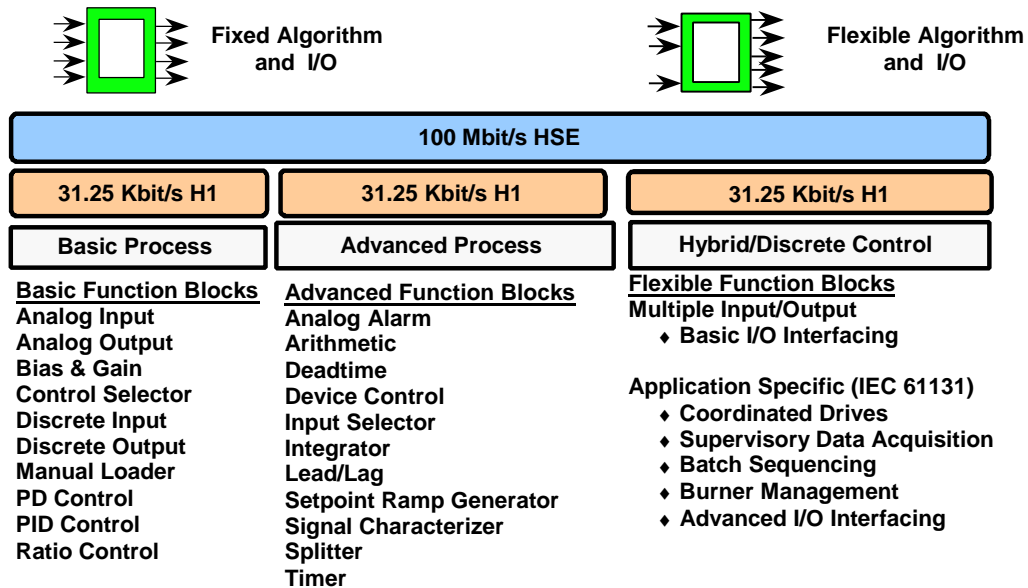


Figure 4. Range of Applications

SUMMARY

High Speed Ethernet (HSE) provides specifications for a cost-effective, high-speed, plant-wide network for process and hybrid/discrete control using commercial off the shelf (COTS) Ethernet hardware and software. HSE running at 100 Mbit/s is intended for use in high-speed process automation, batch sequencing, and discrete applications while also providing information integration with plant management and MIS systems. Redundant devices and media, including wire and fiber optic, are allowed. The Fieldbus Foundation-developed Flexible Function Block extends FOUNDATION fieldbus into discrete manufacturing applications. Due to the use of commercially available, “off-the-shelf” products, costs are minimized while performance is enhanced and interoperability is maintained.

REFERENCES

FF H1 Specifications

Number	Revision	Specification
FF-801	FS 1.4	Network Management
FF-806	FS 1.0	Data Link Protocol - Bridge Operation Addendum
FF-821	FS 1.4	Data Link Services Subset
FF-822	FS 1.4	Data Link Protocol Subset
FF-870	FS 1.4	Fieldbus Message Specification
FF-875	FS 1.4	Fieldbus Access Sublayer
FF-880	FS 1.4	System Management
FF-890	FS 1.4	Function Block Application Process-Part 1

FF HSE Specifications

Number	Revision	Specification
FF-803	FS 1.0	HSE Network Management
FF-586	FS 1.0	HSE Ethernet Presence
FF-588	FS 1.0	HSE Field Device Access Agent
FF-589	FS 1.0	HSE System Management
FF-593	PS 2.0	HSE Redundancy

This paper is based on a paper entitled "FOUNDATION™ Fieldbus High Speed Ethernet: Fast Ethernet Control" written by the same author, © Copyright 2000 Instrument Society of America.