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# Comparative Analysis of HART and Foundation Fieldbus Technologies in Process Control

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**Abstract:** ***This paper aims to provide a comprehensive analysis of both HART and Foundation Fieldbus technologies in the context of process control systems. It seeks to shed light on the differences, strengths, and limitations of these technologies, equipping readers with the knowledge necessary to make informed decisions when selecting control systems. To achieve this, we will delve into the historical development, key features, and practical considerations surrounding HART and Foundation Fieldbus.***

**Keywords:** HART, Foundation fieldbus, Process Control System, Analysis, Control system selection

## 1.Introduction

For the past four decades, the process control industry has relied on HART (Highway Addressable Remote Transducer) technology, while Foundation Fieldbus technology has been available for the last two decades, offering significant advantages over HART. Despite these advantages, the preference for HART technology often persists when selecting control systems. This paper aims to shed light on the differences and key considerations surrounding both technologies. It explores the factors that influence technology selection and presents essential facts to aid in informed decision-making. By examining the strengths and limitations of HART and Foundation Fieldbus, this paper provides valuable insights into their respective roles in modern process control systems.

## 2.History

The evolution of process control technology has been marked by significant milestones, each contributing to the advancement of automation and efficiency in process plants.

1. **Pneumatic Systems (1950s-1960s):** Plant automation heavily relied on pneumatic systems. These systems-controlled process plants by transmitting control signals through pneumatic pressure signals, typically ranging from 0.2 to 1.0 kg/cm2 (20 to 100 kPa).
2. **Transition to Electronic Components (1960s):** The next phase of technological development, starting in the 1960s, witnessed a shift from pneumatic systems to discrete electronic components. Data transmission was revolutionized with the adoption of electric analog signals, typically in the range of 10 to 50 mA DC. This current signal specification later evolved to the well-known 4 to 20 mA DC standard, primarily aimed at enhancing plant safety.
3. **Emergence of Field Device CPUs (1980s):** In the 1980s, a significant milestone was achieved with the installation of small Central Processing Units (CPUs) in field devices. This marked a substantial improvement in measurement accuracy, reducing it from approximately 0.5% of the full span to a more precise 0.1%.
4. **HART Communication Protocol:** The HART (Highway Addressable Remote Transducer) communication protocol was developed by Rosemount to introduce digital communication alongside the existing 4 to 20 mA current signal loop. HART allowed for the transmission of both process data and field device information, including self-diagnostic data, through digital communication. Consequently, individual device management systems were integrated into process control systems to monitor and utilize this field device information. This development significantly enhanced the capabilities of process control systems.
5. **Foundation Fieldbus (FF) Technology:** Unlike HART, which maintained the presence of the 4 to 20 mA signal, FF technology revolutionized data transmission by eliminating the analog signal entirely. FF communication is bidirectional, enabling easier field device parameter setting. Furthermore, FF communication adheres to international standards, specifically IEC-61158, ensuring a multi-vendor open system environment.

These historical developments have paved the way for more advanced and efficient process control systems, with FF technology standing out as a notable leap forward in achieving comprehensive digital communication and improved control capabilities in modern industrial environments.

**HART vs. Foundation Fieldbus (FF) Technologies:**

HART (Highway Addressable Remote Transducer) and Foundation Fieldbus (FF) are both communication protocols used in process control systems, but they have distinct characteristics and capabilities:

**1. Communication Method:**

- **HART:** HART is superimposed on the 4-20 mA analog signal. It allows for two-way communication with smart field instruments while still transmitting the analog process variable signal. HART communicates at a relatively slow rate of 1200 bps (bits per second).
- **FF:** Foundation Fieldbus is a fully digital, bidirectional communication protocol. It does not rely on the 4-20 mA signal and instead provides real-time, closed-loop control between intelligent field instruments and host systems. FF operates at a significantly higher data rate i. e., 31.250 bps (bits per second).

**2. Data Transmission:**

- **HART:** In HART, a single pair of cables is typically installed for each device. The 4-20 mA signal is used to transmit the process variable, while digital HART data is communicated simultaneously.
- **FF:** Foundation Fieldbus does not use the 4-20 mA signal for communication. Instead, all information, including process variables and diagnostic data, is transmitted digitally over the communication network.

**3. Topology:**

- **HART:** HART communication is designed as a Master/Slave system. Typically, there can be only two Masters in a HART network, such as the control system and a handheld device. Communication between field devices and the host is mediated through this Master/Slave architecture.
- **FF:** Foundation Fieldbus employs a peer-to-peer system. Communication can occur directly between two fieldbus-enabled field devices without requiring a central mediator. It also allows communication between field devices and control or asset management systems.

**Additional Design Considerations in Foundation Fieldbus (FF) Compared to HART:**

**1. Segment Design:**

In Foundation Fieldbus (FF) communication, segment design is a crucial consideration that is not as prominent in HART systems. Segments are groups of related devices connected to the same communication segment. Proper segmentation is essential to maintain network reliability and minimize signal degradation.

**2. Cycle Time Validations:**

In FF systems, cycle time validation becomes an important design consideration. Engineers must calculate and adhere to specified cycle times as per guidelines to maintain the efficiency and effectiveness of process control. Meeting cycle time requirements ensures that critical control tasks are executed in a timely manner.

**3. Cable Length Check:**

FF communication imposes limitations on cable length, a factor that is not as restrictive in HART systems. For instance, in the context of the High Power Trunk (HPT) concept within FF, there are specific cable length restrictions. The maximum allowable cable length, including trunk cables and all spur cables, is typically defined and should not exceed a certain limit (e. g., 1900 meters). Adhering to cable length limitations is essential to prevent signal attenuation and maintain the robustness of the FF network.

These additional design considerations in Foundation Fieldbus compared to HART highlight the need for careful planning and adherence to specific guidelines to ensure the proper functioning and reliability of FF communication in process control systems. While FF offers advanced capabilities, it also comes with more stringent requirements and constraints that must be addressed during the design phase to achieve optimal performance and stability.

**Key points of comparison between Foundation Fieldbus (FF) and HART:**

**1. Communication Speed:**

HART: HART operates at a slow baud rate of 1200 bits per second.
FF: FF H1 operates at a much higher baud rate of 31250 bits per second, making it significantly faster.

**2. Multidrop Capability:**

HART: HART is primarily point-to-point but supports limited multidrop (typically 2 masters).
FF: FF is a true multidrop technology, theoretically supporting up to 32 devices (practically 12-16) on a single segment.

**3. Diagnostics:**

HART: HART provides diagnostics for individual devices but has no knowledge of other devices on the network.
FF: FF enables communication between devices, facilitating advanced diagnostics and plant health monitoring systems.

**4. Communication Method:**

HART: HART is superimposed on the 4-20 mA analog signal.
FF: FF does not rely on the analog signal and communicates digitally over the network.

**5. Push vs. Poll:**

HART: HART transmitters are polled periodically, potentially missing intermittent issues.
FF: FF devices push data with events latched and time-stamped, ensuring no missed field problems.

**6. Control in the Field:**

HART: HART does not support PID control in the field.
FF: FF supports PID control in the field, allowing for distributed control capabilities.

**7. Plug and Play:**

HART: HART has limited ability to access transmitter details.
FF: FF, if configured correctly, allows easy access to all device details upon connection.

**8. Commissioning Speed:**

HART: Commissioning HART devices can take up to 4 hours for individually wired devices and may require physical intervention.

FF: FF's networking capabilities enable quick commissioning of field devices, often taking only minutes.

**FF Limitations:**

Foundation Fieldbus (FF) offers numerous advantages in process control, but it also has its limitations and specific scenarios where it may not be the most suitable choice:

1. **Fast Control System Response:**

FF may not be ideal for applications requiring extremely fast control system response times (typically
200 milliseconds or below). Examples include Anti-Surge control systems that demand rapid response to prevent compressor surges.

**2. High Signal Bandwidth:**

Applications that require high signal bandwidth, such as Machine Condition Monitoring systems, Tank Data Acquisition System (TDAS), Flow Metering System (FMS), and similar data-intensive systems, may not be best served by FF due to potential bandwidth limitations.

**3. Safety Instrumented Systems (SIS) and Fire and Gas Alarm Systems (FGAS):**

For critical safety-related applications like Safety Instrumented Systems (SIS) and Fire and Gas Alarm Systems (FGAS), there may be concerns regarding FF's ability to meet stringent safety requirements. In such cases, alternative technologies may be preferred for their established track record in safety-critical applications.

**4. Third-Party Packages:**

Many large-scale industrial projects incorporate mechanical or instrument packages with their dedicated Programmable Logic Controller (PLC)-based control systems. In such scenarios, HART may be the predominant or sole communication protocol supported by these third-party packages, limiting the feasibility of integrating FF within the existing infrastructure.

**Technology FF OR HART for Brownfield and Greenfield:**

The choice of technology for industrial installations, whether brownfield or greenfield, should be made based on careful consideration of the specific requirements, constraints, and objectives of the project. Here's a summary of the technology recommendations for different scenarios:

**Brownfield Installations:**

**1. Majority HART Devices:**

In brownfield installations where the majority of devices are HART-based, the logical choice is to continue with HART technology. It allows for seamless integration with existing infrastructure and minimal disruption.

**2. Major Upgrades:**

For small upgrades in brownfield installations, especially when working with legacy systems, HART is the preferred migration path. It ensures compatibility and preserves previous investments.

**3. Major Upgrades:**

When considering major upgrades in brownfield installations, the existing technology (HART or FF) should generally be followed for operational and maintenance consistency. HART, given its widespread adoption, is often the preferred choice. However, if considering FF in an existing HART installation, factors like wiring changes, future diagnostics needs, commissioning timeframes, and training costs should be assessed.

A technoeconomic evaluation should guide the final decision.

**Greenfield Installations:**

**1. Foundation Fieldbus (FF):**

FF has proven to be more cost-effective in greenfield applications when there's a strong emphasis on training and competencies across the entire project lifecycle, including design, fabrication, FAT (Factory Acceptance Testing), installation, commissioning, and maintenance. FF offers advantages in terms of communication speed, advanced diagnostics, and control capabilities.

**2. Safety Applications (ESD & FGS):**

For safety-critical applications like Emergency Shutdown Systems (ESD) and Fire and Gas Systems (FGS), HART remains a vital solution due to its established track record.

In greenfield installations, a combination of both HART and FF may be the most practical and effective approach, ensuring safety compliance and reaping the benefits of FF for other process control aspects.
Ultimately, the choice of technology should align with the specific needs and objectives of the project, considering factors like existing infrastructure, cost implications, safety requirements, and the availability of skilled personnel. A thorough evaluation that considers both technical and economic considerations is crucial for making an informed decision.

## 3.Conclusion

Both HART and Foundation Fieldbus (FF) will remain indispensable options for the foreseeable future. Each technology offers its distinct advantages and limitations, making them suitable for specific applications and scenarios.

Foundation Fieldbus, with its strengths such as reduced cable length, faster plant start-up, advanced diagnostics, and enhanced control capabilities, is a compelling choice for many modern industrial applications. However, it does have

limitations when it comes to safety-critical applications, integration with third-party packages, and certain legacy systems.

On the other hand, HART technology, with its extensive installation base and versatility, continues to be the preferred choice in the process industry. It excels in various applications, from monitoring and control to safety-critical functions. Its compatibility with existing infrastructure and widespread adoption contribute to its enduring popularity.

The selection between HART and FF should always be guided by a careful assessment of specific project requirements, safety considerations, budget constraints, and future scalability. While FF may offer advanced features and benefits in certain contexts, HART's reliability, familiarity, and adaptability make it a trusted and widely embraced technology in the field of process control. The choice between these technologies should be made with a clear understanding of how they align with the unique needs and goals of each industrial application.

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