



# The Integration of Fieldbus Devices to an Existing DCS

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## **ABSTRACT**

Existing analog strain gauge transducers and signal conditioners were replaced with new Foundation™ Fieldbus Transmitters in the Distributed Control System, DCS, at the NASA Glenn Research Center (GRC). The reasons for implementing this upgrade and an evaluation of the results of the project are the subjects of this paper. Problems and advantages with the original transducers and the newly installed transmitters are described and compared. Detail of the physical network layer between the Foundation™ Fieldbus Transmitters, Programmable Logic Controllers (PLCs), Multipurpose Micro-Processor (MMPs) and the operator workstations are illustrated. The complex nature of the facility and methods of future control of the associated processes are also discussed.

## **INTRODUCTION**

Up until the 1990's, analog strain gauge transducers and signal conditioners were used in the NASA Glenn Central Process DCS to provide remote monitoring of process parameters within the system. For many years, these devices were the core of process instrumentation around the facility. As new industrial control and communication technologies emerged at an increased rate, the benefits of abandoning traditional instrumentation schemes for newer approaches became attractive. For this reason, NASA recently replaced several transducers and signal conditioners with Foundation™ Fieldbus hardware hoping to evaluate the interoperability of this new technology.

The new technology provides improved sensor accuracy and much more information from the transmitters remotely, which supports diagnostic capability, tuning and calibrations. These transmitters also provide local PID control algorithms for much faster and tighter control.

### Plant Description

The Central Air Dispatch, CAD, system at NASA Glenn routes combustion air and altitude exhaust to various wind tunnel and test cell customers throughout the center for the purpose of simulating altitude conditions of up to 90,000 feet for aeropropulsion and turbomachinery testing. The CAD system consists of 20 miles of piping and 300 valves that runs throughout the center. A large DCS/PLC system provides monitoring and control for the vast amount of equipment across the facility which supports these essential services.

## Original System Operation

Historically, instrumentation for monitoring pressures consisted of distributed analog strain gauge transducers mounted near process piping and connected to tap locations by copper tubing. The millivolt-level output signal wires originating from the transducers were routed to rack mounted signal conditioner cabinets, each housing approximately 50 signal conditioners each. The signal conditioners then converted each millivolt level signal to 4-to-20 mA for input to DCS drops distributed around the facility.

Similarly, instrumentation for monitoring temperatures consisted of thermocouples installed inside thermowells, which were mounted at the process piping. These were connected by thermocouple wires to signal conditioners that are located around the facility. Likewise these converted the thermocouple signals to 4-to-20 mA for DCS input.

## Reasons for Conversion to Transmitters

Although the existing instrumentation was adequate at one time, reasons for its replacement became more apparent. While the existing analog strain gauge transducers were readily available in the 1980's, more recently parts to repair them and direct replacements were difficult to find. They had the advantage of being very inexpensive but what was gained in savings was lost in accuracy. Also, the full-scale output of the transducers was 100mv, rendering them susceptible to electrical noise.

In addition to these problems, both the pressure transducers and thermocouples required individual signal conditioners to convert the low-level signals to 4-to-20ma for DCS input. Cabinets containing up to 50 or so rack-mounted signal conditioner modules were used. Foundation™ Fieldbus transmitters are loop powered and require no extra signal conditioning. Although the temperature signal conditioners offered cold junction compensation, they contributed another source of error by providing no correction for the inherent nonlinearity of the thermocouples. Further, both the temperature and pressure signal conditioners required frequent calibrations because they drifted from their settings.

For these reasons and the capability of using existing wiring, Foundation™ Fieldbus technology was investigated as a replacement to the existing instrumentation and was subsequently adopted as platform for an initial test installation.

## Hardware Installation

The components of this application include Fieldbus transmitters, pressure and temperature, a loop power supply and conditioner, Fieldbus approved twisted shielded pair cabling, Fieldbus connectors, terminal strips, Fieldbus Controller and PLC, which communicates the retrieved data to the DCS. Like with the transducer instrumentation, the primary function of the system is to provide process data to the DCS, which is made available for operators at a remote location. The basic system architecture is given in figure 1.

In all cases, existing thermocouples and thermocouple wiring could be reused as part of the new temperature instrumentation scheme. The new temperature transmitters were mounted near the existing

thermocouples and the thermocouple wires were connected directly to the new transmitters. Long thermocouple wire runs back to the signal conditioner cabinets were eliminated.

For the pressure transmitters, some new ¼” stainless tubing was installed and some existing tubing was reused, depending upon the condition of the existing hardware and other particulars. In one case, a lone pressure transducer mounted far from its associated tap, had been connected with a long, complex tubing run containing many fittings and taps for other users. In the new installation, the new transmitter was mounted and connected directly at the pressure tap and a single new Fieldbus approved cable was installed. In another case, where pressure transducers were grouped in a specific process area, an analog cable for each transducer was formerly required, necessitating a conduit run of multiple cables to this area. The new Fieldbus replacement transmitters could reuse a single existing analog cable as the network segment to that particular group. In keeping with the original physical arrangement of the transducers and thermocouples, a “chickenfoot” or tree topology suited the new installation best. The Fieldbus Controller, loop power supply and conditioner were installed in an existing cabinet. A new PLC, connected to the Fieldbus controller via Ethernet, was installed in a nearby cabinet as part of the project. All old signal conditioner hardware, modules and racks, were eliminated. One signal conditioner cabinet was reused by housing a newly installed Fieldbus multi-port junction or “brick.” This and one terminal strip in a rooftop enclosure serve as two drop points for the transmitter clusters.

The wiring layouts between the components are shown in figure 2 and 3

### Software Installation

The software for this application includes Fieldbus transmitter drivers, Fieldbus controller software, PLC software, MMP software, and operator console software. The drivers allow communication between the Fieldbus transmitters and the Fieldbus controller over the H1 network. The Fieldbus controller is designed and programmed to receive information from the transmitters. The PLC receives data from the Fieldbus controller and makes it available for the MMP. The MMP contains the Modbus FDI to receive data into the DCS and to make it available to the operator consoles.

A stand-alone computer, attached by Ethernet to the Fieldbus controller and PLC, contains a software package for programming these devices. This computer also enables remote operators to perform diagnostics and to calibrate the Fieldbus transmitters.

### System Architecture

Initially the new system included three pressure transmitters and four temperature transmitters. A more recent addition to the Fieldbus installation involves 23 transmitters. The primary connection point for the Fieldbus network is the Fieldbus controller, which in its present configuration, provides only raw process data to the DCS. It can, however, provide advanced programming capability and diagnostic information when connected to a standalone computer. The Fieldbus controller has four H1 segment connections for communication to individual H1 segments each to be powered by an individual power supply and conditioner. For the initial installation, only one H1 segment was used to support the new transmitters. The more recent installation made use of the remaining three segment connection blocks on the Fieldbus controller.

The next device in the communication path is a PLC which, in this case, is primarily used as a protocol converter, accepting 100 MBaud Ethernet communications from the Fieldbus controller and passing that information along to the MMP over a serial communication link. Additionally there is scaling and status checking done in the PLC. The MMP, running an FDI (foreign device interface) program, is a critical point in the exchange of Fieldbus information to the DCS. The DCS operator interface stations, manned at a central control facility, communicate to the MMP via a 10 MBAUD highway that runs throughout the lab. All DCS information, including the Fieldbus data, can be made available to any DCS node in the system. In this case, the existing transducer displays were replaced with the new Fieldbus readings on those consoles displaying the original process points.

One of the powerful features of the transmitters is to troubleshoot problems and the capability to re-program the transmitters, including re-calibration of zeros and span, from a remote location.

Another benefit of Fieldbus transmitters over conventional 4-to-20 ma transmitters is that the Fieldbus transmitters shall read 5 percent over maximum pressure accurately, above which, they go into saturation. The value displayed at the operator console is not clamped between the calibrated ranges.

### Testing of New Transmitters

Some problems were encountered while commissioning the Fieldbus installation. One of these involved minor wiring errors made on a Fieldbus terminal strip where one transmitter was not properly jumpered to the H1 segment. This was a relatively easy fix. Using non-polarized transmitters simplified the installation and troubleshooting process.

Another problem occurred upon initial startup of the network when one particular transmitter simply would not come online. The controller indicated that error codes were being generated on the network by the transmitter but these codes were relatively unhelpful. Eventually after a series of power-down cycles, transmitter substitutions and downloads of the controller program, the problem transmitter became operative with no further difficulties. No substantial reason was ever found for the problem.

It was, however, interesting to observe that a Fieldbus device is not location dependent; place one physically anywhere in the network and it will report its data to the DCS data display that it is mapped to, regardless of where it is physically installed. This underscores the importance of installing new transmitters at the proper process points.

All the newly installed transmitters in this project were checked for proper location and calibration back to the DCS display. Any deviations in calibration were undetectable with the equipment used.

### General Evaluation

Although the analog transducers were sufficient by prior standards, it was believed that the newer industrial technologies were at the very least worthy of trial in the CAD application. No historical data is presented here to detail the performance of the traditional transducer/signal conditioner systems, but years of experience with them does give one an overall appreciation for the strengths and shortcomings of the vintage technology in general terms. All said, this type of instrumentation has, except perhaps in less demanding roles, outlived its usefulness in modern control and supervisory systems.

Thus far, the new Fieldbus transmitters have proved to be very accurate. They have shown no indication of failing or drifting from their original calibrations. However, one drawback to the system is that the data to the DCS takes almost 2 to 3 seconds to update compared to 1 to 2 seconds with the old instrumentation. This delay is due to a relatively low Fieldbus network bandwidth which bogs down with the large data packets being transmitted. For this reason, the number of transmitters per segment was kept to a maximum of 7. The current update rate is, however, appropriate for these non-critical process points.

Perhaps one of the greatest advantages to the Fieldbus technology, yet to be fully valued in this instance, is the amount of live data available for the diagnosis of problems or remote calibration. In a sense, this alone makes the switch to Foundation™ Fieldbus an extremely attractive alternative.

#### Future Applications

There is a future plan to add one new Fieldbus system in another portion of the DCS at GRC. This system shall also consist of pressure transmitters and temperature transmitter. It is expected that the benefits will become even more apparent as more process readings are converted to Fieldbus.

### **SUMMARY**

The new Foundation™ Fieldbus Transmitters provide simple installation, more accurate data and improved diagnostic capability than the old transducer systems at GRC. Therefore, in the long run we can foresee the utilization of Foundation™ Fieldbus technology as an enhancement to our facility DCS and therefore a benefit to our customers.

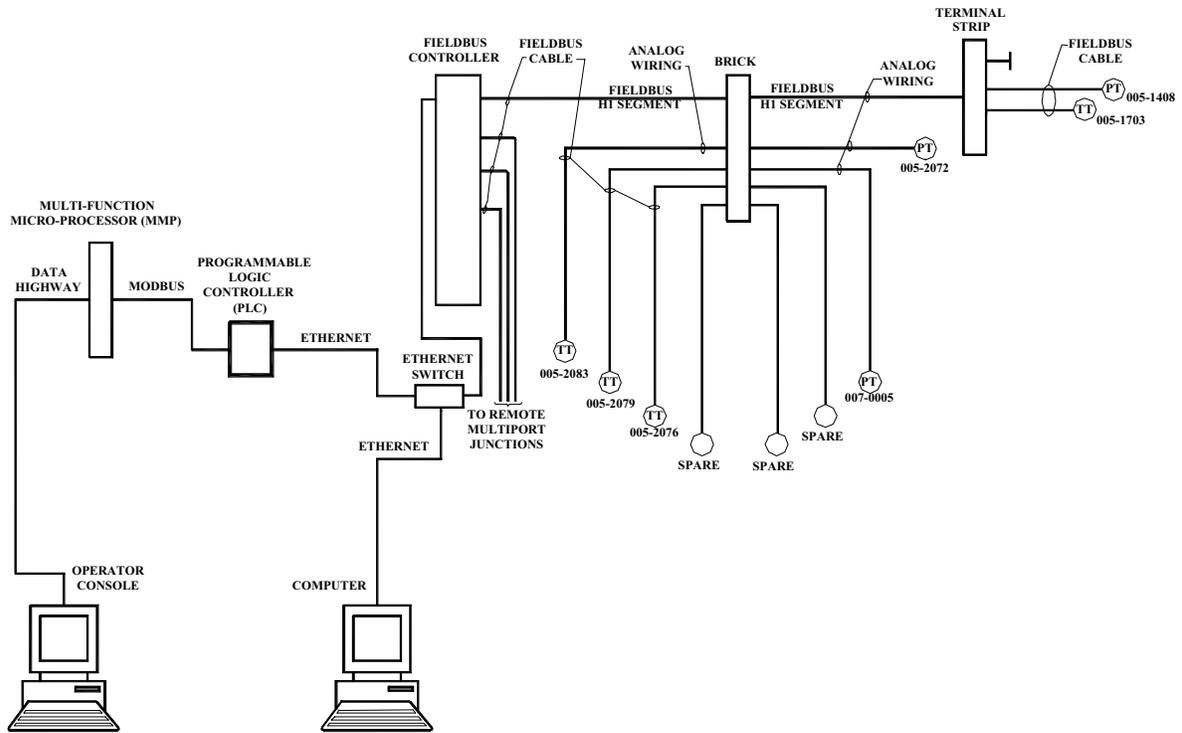


Figure 1.—Overall communication network of the Fieldbus System. Network provides communication between Field Sensors, Transmitters, Fieldbus Controller, Programmable Logic Controller, Mult-Function Micro-Processor, and Operator Console.

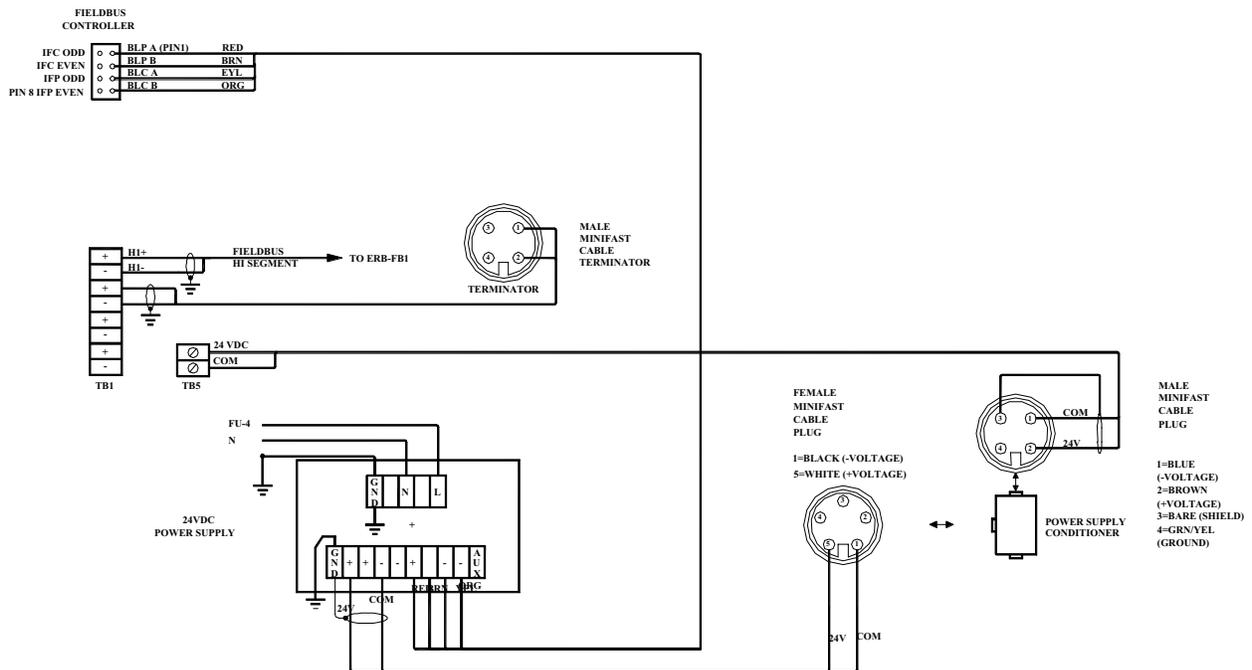
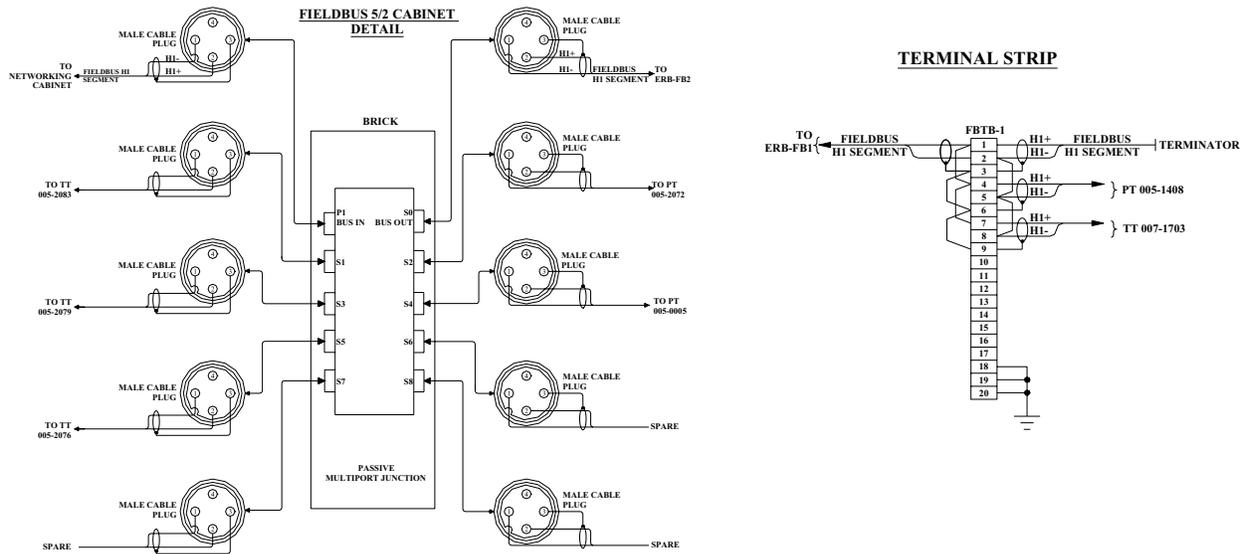
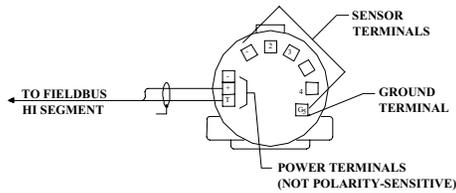


Figure 2.—Connections at Fieldbus Controller and its various components.



**TEMPERATURE TRANSMITTER FIELDBUS DETAIL**

(4 TYP: 005-2083, 005-1703, 005-2079, 005-2076)



**PRESSURE TRANSMITTER FIELDBUS DETAIL**

(3 TYP: 005-2072, 007-0005, 005-1703)

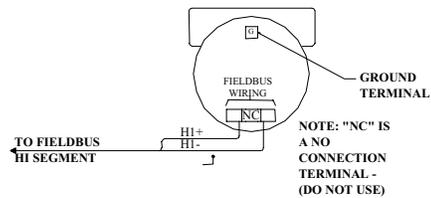


Figure 3.—Connections at various components of the Fieldbus System.

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