Adesto

WHITEPAPER

Total Integration of Industrial Interfaces

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Introduction

Industrial control systems consist of many components that communicate through various interfaces/protocols. Some of these have been introduced decades ago, and although there is a significant shift towards industrial Ethernet today, these legacy protocols may still be a feasible option due to their maturity, robustness and huge amount of existing installations.

This white paper deals with two communication protocols, Highway Addressable Remote Transducer (HART) protocol and FOUNDATION Fieldbus, and focuses on their implementation, from a legacy point of view through commercial off the shelf (COTS) components and through an advanced method of System on Chip (SoC).

Automation Protocols

There are many different automation protocols, each of them suitable for different tasks in the industrial control system.

The second-to-lowest level of industrial control system is the control level, which includes devices like programmable logic controllers (PLC) and human-machine interfaces (HMI). These devices communicate with each other and with sensors and actuators that lie at the level just below.

The protocols, used at this level, are not required to provide high data throughput. Instead, they provide robustness, long span and usually power supply over the same cable. If the protocol is used for closed control tasks, it provides low communication latency and determinism as well.

The two examples of these protocols are Highway Addressable Remote Transducer (HART) and FOUNDATION Fieldbus, both of which are maintained by FieldComm Group association.

HART

The Highway Addressable Remote Transducer (HART) communication protocol was introduced in mid-1980s. It is a digital extension of legacy 4-20mA analog current loops.

The HART protocol is based on a frequency shift keying (FSK) principle. The digital signal is converted to sine waves of two frequencies, 1200Hz for value 1 and 2200Hz for value 0, which are superimposed on a direct-current analog signal. As the average value of this superimposed signal is always zero, communication that relies on the original analog signal is not affected.

Communication speed at the physical layer is 1200bps, which is not fast enough for process control, but sufficient for reading process and diagnostics data from remote nodes, which simplifies system setup and operation and improves availability.

The HART protocol is very popular due to large installed base of 4-20mA systems.

FOUNDATION Fieldbus

FOUNDATION Fieldbus H1 is a communication protocol for closed-loop control systems. It was introduced in 1996, and was intended as a replacement of legacy analog 4-20mA current loops, rather than their extension.

The interface uses differential voltage signalling and Manchester encoding.

Communication speed is 31.25kbps. The low data rate was chosen to ensure proper function even in the case of imperfect interconnection structure and noisy environment.

Legacy COTS

Legacy implementations consist of commercial off the shelf (COTS) components that are integrated on a PCB. The level of semiconductor integration is very low.

HART

Typically, systems with HART interface usually consist of a discrete microcontroller (MCU) IC and separate HART modem IC. The MCU contains a common UART module, which communicates with the HART modem. Discrete operational amplifier ICs and passive components are needed as well for signal conditioning (analog active filters) at both RX and TX side.

FOUNDATION Fieldbus

Systems with the FOUNDATION Fieldbus interface contain an MCU, a digital Fieldbus controller IC and a mixed-signal Media Access Unit (MAU) IC. The interface between the MCU and the Fieldbus controller may be common serial interfaces, like UART or SPI, or a parallel interface. Operational amplifier ICs, bipolar transistors and passive components are needed for signal conditioning at both RX and TX sides.

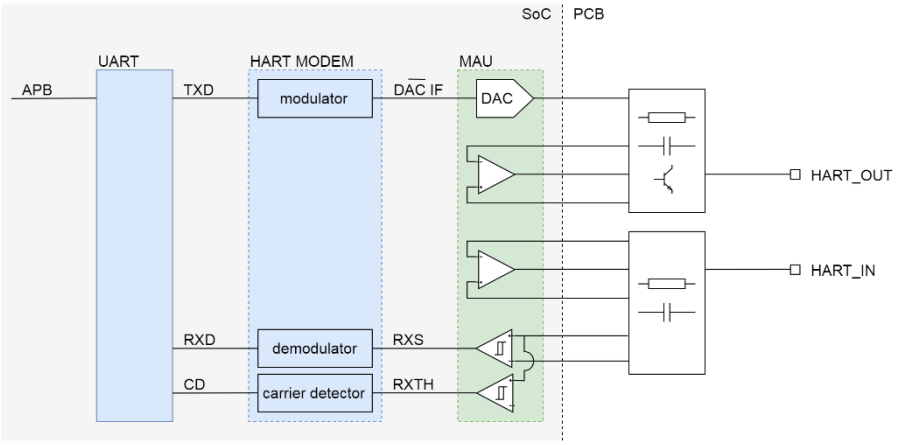
System on Chip

As mentioned above, implementation of both HART and FOUNDATION Fieldbus protocols through COTS components require many discrete components.

An alternative approach is to implement both these interfaces in a single System on Chip (SoC), providing a vastly smaller, and cost-effective alternative to a large PCB populated with lots of discrete components.

HART

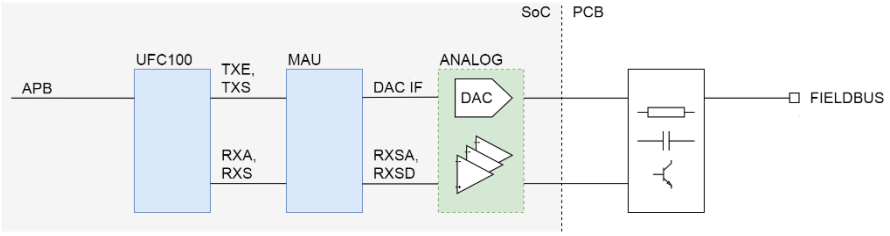
Implementation of HART interface in the SoC consists of a processor subsystem and a HART modem. The HART modem consists of a modulator and a DAC at the transmitter (TX) side and an ADC, digital filters and a demodulator at the receiver (RX) side. The HART modem is controlled via an embedded UART module. The operational amplifiers, which used to be a discrete IC in the legacy implementation, are embedded in the SoC IC as well.



The list of parts that remain outside the SoC is thus reduced to passive components for filters that extracts FSK signal from the current loop and passive components and bipolar transistors that superimpose the output FSK signal to the current loop signal.

FOUNDATION Fieldbus

Similarly, to the HART interface, all active components can be embedded in a single SoC. It includes digital soft IP cores for the processor subsystem and FOUNDATION Fieldbus controller and hard macros for mixed-signal MAU block and operational amplifiers.



As above, just a few passive components and bipolar transistors remain outside of the SoC.

Adesto SmartEdge™ Platform

Adesto SmartEdge™ platform incorporates all the Sensor AFE (Analog Front End), Calibration, Control, Security and Industrial Communication elements of a smart edge device, all integrated onto a single cost-effective chip. With more than 20 years' experience designing advanced embedded mixed-signal chips for hundreds of customers in every major region, Adesto's ASIC & IP division delivers a new breed of design-centric semiconductor supplier capable of optimizing its designs for every customer, yet achieving cost economies not thought possible with custom chips designs until now