Implement PROFIBUS in Industrial Automation Applications Using a Single-chip Solution

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PROFIBUS (Process Field Bus) is a standard for industrial automation technology. It was first developed in 1989 in Germany, and today, there are more than 35 million PROFIBUS nodes installed. The PROFIBUS industrial field bus is used to connect controllers to remote input/output (I/O) units, sensors, actuators and inter-networking components. The applications where PROFIBUS is deployed include factory automation, drives and motion control, process automation and safety critical applications.

PROFIBUS increases communication efficiency in a factory by connecting a number of nodes over a single connection. This single connection not only eliminates the need for dedicated wiring for each node, it also allows reduced complexity, reduced investment and easier deployments. PROFIBUS communication technology has multiple protocols – PROFIBUS decentralized periphery (DP) and PROFIBUS process automation (PA) – that are used depending upon the application requirements. PROFIBUS protocol also defines the role of master and slave nodes to manage the communication among the PROFIBUS nodes.

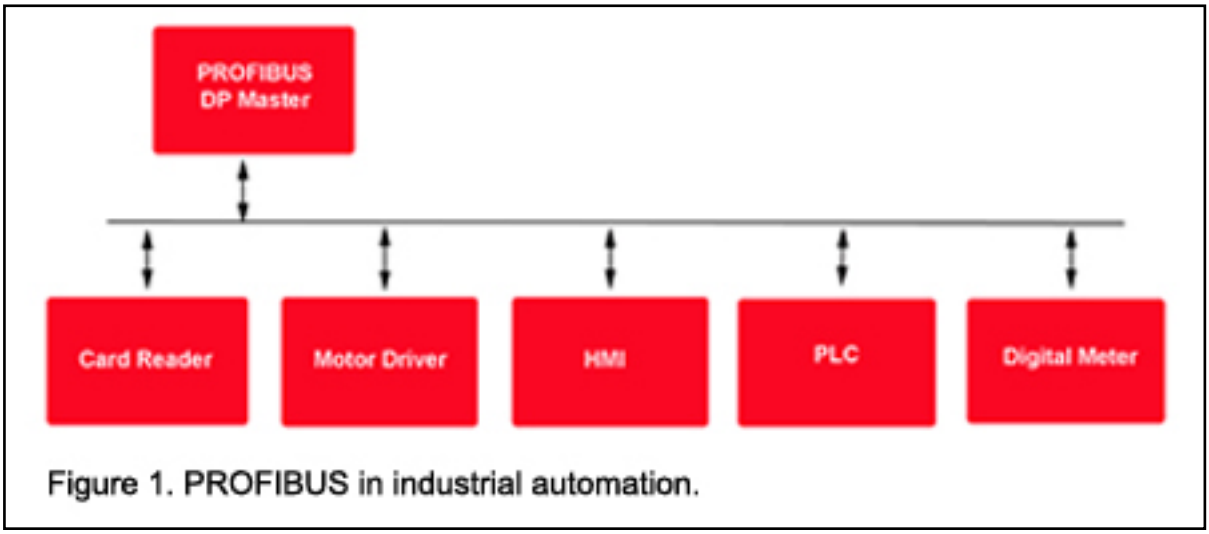

Figure 1. PROFIBUS in industrial automation.

PROFIBUS Decentralized Periphery (DP) is the most popular PROFIBUS protocol. It has three versions within the application layer – DP-V0, DP-V1 and DP-V2. DP-V0 provides cyclic data exchange and diagnostic messages. DP-V1 adds acyclic data exchange and alarm handling. DP-V2 is isochronous mode and data exchange broadcast like slave-to-slave communication.

PROFIBUS Process Automation (PA) is used in hazardous environments. Both data and power are transmitted on the same link, and a reduced power level is used to minimize the risk of explosion. PA has a fixed transmission rate at 31.25kBaud. Usually, the PROFIBUS DP to PROFIBUS PA coupler is used to create PROFIBUS network segments in a larger factory network. These couplers are also used to supply power to meet safety requirements.

PROFIBUS can be customized for end application needs by using application profiles. For some of the common applications, the PROFIBUS organization has standardized the application profiles. The PROFIsafe and PROFIdrive are two such profiles that are used in safety or in motor drives applications.

Components of a PROFIBUS Node

Each PROFIBUS node has three components – the electrical layer, the data link layer and an application layer. The electrical layer is implemented using RS-485, fiber-optic or Manchester Bus Power (MBP) media. The data link layer is called Fieldbus Data Link (FDL), and it implements master-slave communication. The application layer is one of DP-V0, DP-V1 and DP-V2 etc. and it supports messaging between the PROFIBUS nodes. These messages can involve data exchange, diagnosis, and alarms. For DP-V0 and DP-V1, the PROFIBUS master is allowed to start a transmission, while the slave is only allowed to respond to a message that matches with its slave address. A maximum of 126 devices (masters and slaves) with unique addresses are permitted in a single system.

To ensure wide interoperability among devices designed with PROFIBUS interfaces, the PROFIBUS organization has a certification program which ensures that a device is in compliance with the rules and specifications of the protocols. Each new device or already certified device but with hardware or software change needs to pass certification to claim PROFIBUS compliance and use the official PROFIBUS logo. Certification is done by authorized certification labs that follow the test procedures defined by PROFIBUS International (PI). The PI website provides a list of certification labs. A typical solution in use today has architecture similar to the illustration in Figure 2.

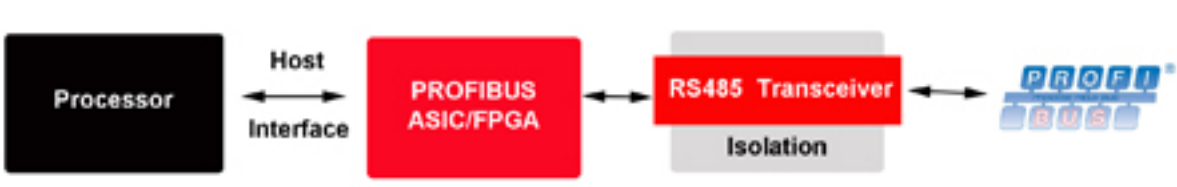

Figure 2. A typical PROFIBUS implementation.

In a typical PROFIBUS solution, a microprocessor runs the PROFIBUS application level stack and implements the industrial application; a separate ASIC or FPGA implements the PROFIBUS protocol; and an RS-485 transceiver provides the connection to the physical layer. The PROFIBUS device connects to the microprocessor over a parallel or a serial interface. At the physical layer, an RS-485

transceiver with galvanic isolation is used.

Single-chip PROFIBUS Solutions

While the typical solution might be a popular architecture, a single-chip solution can reduce bill of materials (BOM) costs by as much as 30 percent, as well as design complexity and footprint. The illustration in Figure 3 shows single-chip ARM9 and ARM Cortex-A8 solutions that enable PROFIBUS, featuring both master and slave solutions. These devices connect directly to the transceiver and do not require an external PROFIBUS ASIC or FPGA.

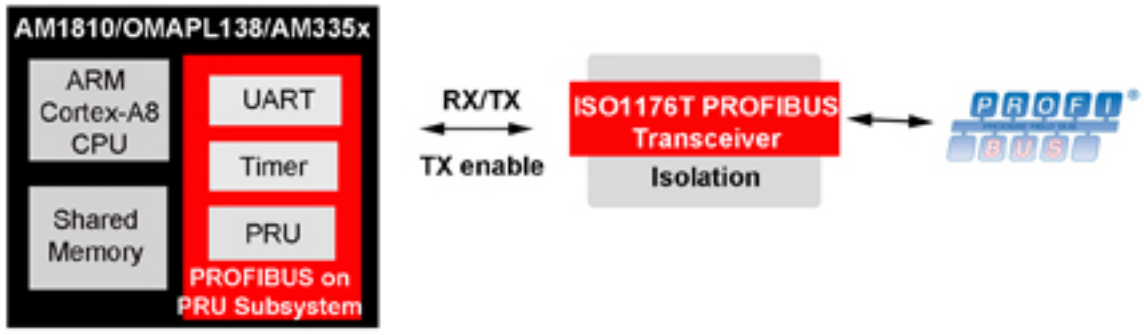

Figure 3. A PROFIBUS solution from Texas Instruments.

The PROFIBUS real-time frame handler (Fieldbus Data Link or FDL) is encapsulated in the programmable real-time unit (PRU) subsystem integrated on the PROFIBUS capable devices. For example, in the Sitara AM1810 ARM9 microprocessor (MPU) from Texas Instruments (TI), the first generation of PRU subsystem was integrated while Sitara AM335x ARM Cortex-A8 MPUs integrate the second generation of PRU subsystem which is capable of supporting industrial Ethernet standards in addition to PROFIBUS.

In each variant of the PRU subsystem, the PRUs implement real-time PROFIBUS message transmission, frame validation and communication with the ARM processor. Interrupts are used to communicate with the ARM where the PROFIBUS stack (Layer 7, DP-Protocol) and the industrial application are run. All process data handling like cyclic, acyclic and service access point (SAP) between the PROFIBUS stack on ARM and the PRU is through the internal memory. One of the PRUs controls the integrated on-chip universal asynchronous receiver/transmitter (UART) that is designated for PROFIBUS communication at up to 12 Mbaud data rate. The industrial application and the PROFIBUS DP-Protocol (Layer 7) are operated on the ARM. The solution can be completed with an RS-485 transceiver suitable for harsh environments, such as TI’s ISO1176T PROFIBUS transceiver.

PROFIBUS Software Architecture

In a single-chip PROFIBUS solution, such as the ones mentioned here, there are three software components:
1. Micro code that implements FDL functionality in the PRU;
2. PROFIBUS-DP protocol that runs on the ARM MPU;
3. An industrial application that is dependent on the end equipment in which this

solution is used.

The single-chip PROFIBUS solutions support both high-level operating systems such as Linux, as well as applications with no operating system. In either architecture, the software structure is consistent. Note that this PROFIBUS solution is agnostic to the OS and the PROFIBUS DP stack and increases flexibility in choosing the OS and PROFIBUS-DP protocol stack.

Single-chip ARM devices enabling PROFIBUS results in lower cost end products without compromising the functional or operational requirements. With comprehensive software and hardware development tools and worldwide support, customers can look forward to greatly simplified PROFIBUS integration with added benefit of significant cost savings.