APPLICATION OF AS-INTERFACE TO A SMALL ANGLE NEUTRON SCATTERING EXPERIMENT

H. Kleines, F. Suxdorf, ZEL,
FZ Jülich, Jülich Germany

Abstract

AS-Interface (Actuator Sensor Interface, AS-I) according to IEC 62026-2 is a simple low level field bus system that is well established in industrial automation. It is designed for the easy connection of simple sensors and actuators like switches or valves and can be seen as a low level complement to primary fieldbus systems like PROFIBUS or DeviceNet. Although it is a well established and proven industrial technology, it is rarely seen in research applications.

In order to simplify cabling and improve overall diagnostics, Forschungszentrum Jülich introduced AS-Interface into the control system of the small angle neutron scattering experiment KWS-2. The paper gives an overview of the AS-I technology. The control system of KWS-2 and experiences with AS-I are presented.

INTRODUCTION

In order to further strengthen its neutron research, Forschungszentrum Jülich founded the JCNS (Jülich Center of Neutron Science) on its own campus with branch labs at the ILL in Grenoble, at the SNS in Oak Ridge and at the FRM-II (Forschungsreaktor München II). FRM-II is a new high flux neutron source operated by the Technical University of Munich in Garching near Munich. JCNS built and now operates 7 neutron scattering instruments at the FRMII, partly based on instruments that have been operated at the research reactor FRJ-2 in Jülich before its shutdown in May 2006. 4 additional instruments are under design now, which will be built in the next few years.

ZEL (Zentralinstitut für Elektronik), the central electronics facility of Forschungszentrum Jülich responsible for the design and implementation of all new control and data acquisition systems for neutron instruments in Jülich has started a close cooperation with the instrumentation group at the FRM-II. Together both defined a common framework for all new control and data acquisition systems of neutron instruments in Garching, the so-called “Jülich-Munich Standard” [1], which is followed by most instruments at the FRM-II. A guiding principle for definition of the framework was to minimize the development efforts and to acquire as much from the market as possible. The framework is based on the middleware system TACO, which has been developed by the ESRF [2].

Slow control in neutron scattering experiments is related to the accurate movement of a diverse range of mechanical parts, to pressure or temperature control and safety instrumentation. Because ZEL introduced industrial control equipment already in the 80s to experiment instrumentation, a key component of the framework is the consequent use of industrial technologies like PLCs, fieldbus systems or decentral periphery in the front end. Main motivations are:

- low prices induced by mass market,
- inherent robustness
- long term availability and support from manufacturer
- powerful development tools

Since Siemens is the dominating supplier for PLCs in Europe, the front-end systems being build by ZEL are based on Siemens products, especially S7-300 PLCs and ET200S decentral periphery connected via PROFIBUS DP.

PROFIBUS DP has been designed for the connection of decentral periphery systems to a central PLC. But ZEL uses it also for the communication between PLCs or other process devices and the supervisory computer, since PROFIBUS DP, which now is the world’s leading fieldbus, has become a de facto standard with products available from many companies. It is especially well supported by Siemens S7 PLCs used in Jülich and provides high performance and a simple and efficient communication model.

For the interconnection of spatially distributed simple sensors or actuators like switches or valves even PROFIBUS DP seems to complex and we have been looking for a low level complement to it. A natural candidate is the AS-I (Actuator Sensor Interface)[3] which is internationally standardized in EN50295 and IEC62026-2. It has all required technical features, as pointed out in the next section. More important, it is a proven technology that is available since more than 10 years. AS-I is well supported by a huge variety of manufacturers of field sensors and actuators and it is directly integrated into many products, e.g. in inductive limit switches or valves. Gateway solutions to other fieldus systems, especially to PROFIBUS DP, are available, thereby enabling the direct attachment of an AS-I installation to a PROFIBUS segment. Being also well supported by the Simens S7 PLC family, integration of AS-I to an instrument following the “Jülich-Munich Standard” should be possible with minor effort. In order to evaluate AS-I we decided to introduce AS-I for the connection of devices in the collimation of KWS-2, a small angle neutron scattering instrument.

OVERVIEW OF AS-I

AS-I is a simple low cost fieldbus system that has been developed by a industrial consortium of manufacturers of field devices around 1990 for the lowest automation level, the actuator and sensor level. It is optimized for the connection of simple binary sensors and actuators.

The Physical Layer of AS-I

AS-I uses Alternate Pulse Modulation (APM) with Manchester II encoding at a bitrate of 166.6 kBit/s. Data and 24 V DC power (between 2A and 8A) are transmitted over the same wire pair. The power transmission requires a central power supply in the system. In APM modulation each sender acts as a current source with $\sin^2$-shaped pulses in order to improve electromagnetic compatibility. The central AS-I power supply contains inductivities which generate voltage pulses by differentiating the current pulses. As a consequence, receiver and sender electronics can be very simple.

The standard AS-I cable is a mechanically coded two wire flat cable that is not shielded, not twisted and not terminated. Connection of devices is very easy by using a piercing technology, where piercing teeth cutting through the insulation provide the electrical contact. The self-healing capability of the cable guarantees IP67, even after disconnecting. AS-I allows arbitrary topologies (bus, ring, tree, star, ….) with a maximum cable length of 100m (extendible to 500m by repeaters).

The design of the physical layer makes AS-I very robust and insensitive to noise with good electromagnetic compatibility and protection level IP67. Handling of the cabling system and connection of devices is extremely easy.

The Data Link Layer of ASI

AS-I is a master slave system with cyclic polling and up to 32 slaves (61 in extended mode). The user data size in an AS-I frame is 4 bit. As a consequence, each slave can have up to 4 digital inputs and 4 digital outputs (only 3 outputs in extended mode, since the 4th bit is used for addressing). Analogue values have to be multiplexed over several frames. Cyclic polling and small frame size guarantee a deterministic response time below 5ms.

The Application Layer of AS-I

Beyond the normal data transfer function, the application layer of AS-I provides additional services. These services allow to change the address of a slaves, to reset slaves, to read identification and configuration data from slaves and to parameterize slaves.

INTEGRATION OF AS-I INTO KWS2

Overview of KWS-2

KWS-2 is a classical 40m long pinhole instrument for small angle neutron scattering. A Dornier velocity selector is used as a monochromator. The collimation can be varied between 2 m and 20 m (by moving 1m neutron guide segments) with 5 variable apertures at fixed positions. An additional sample aperture is equipped with 4 axes. Movement of the sample is based on a linear sample changer with an additional rotational axis. Ancillary equipment includes several controllers for temperature, pressure and electrical field.

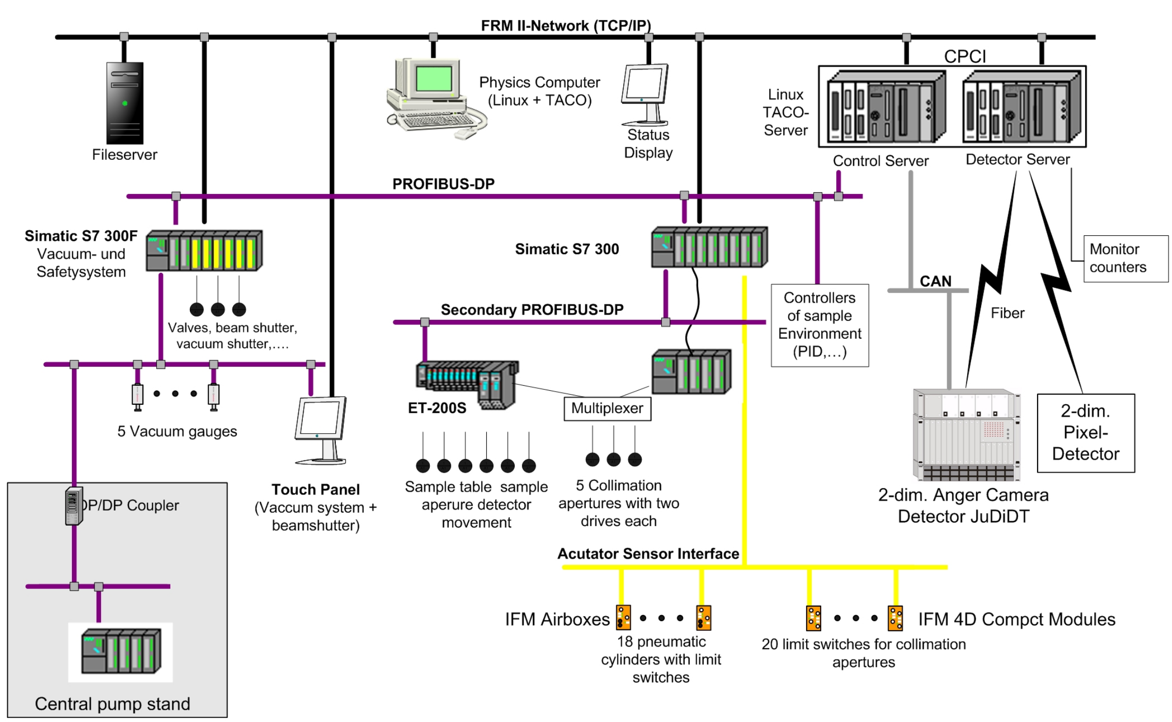

Figure 1: Physical structure of the control and data acquisition system of KWS2.

The two-dimensional main detector is based on the Anger camera principle and can be moved in 3 dimensions in a 20 m long detector tube. An additional high resolution pixel detector can be moved in two dimensions before the main detector. Both detectors have been developed by the detector group of ZEL and the readout electronics is connected via the optical CPCI bridge MXI-4 from National Instruments to the readout computer.

The Structure of the Control and Data Acquisition System of KWS-2

According to Fig. 1 the control and DAQ system is implemented as a distributed system with a hierarchical architecture. On top of the system resides the so-called physics computer with all application software – GUI-based as well as script-based. Via the experiment network the physics computer accesses the “server computers”, to which all front end systems (detectors, monitors, position encoders, motor controllers, vacuum devices,…) are attached. On the “server computers” TACO servers are running, which access the peripheral devices via dedicated device drivers.

The “slow control” peripherals are indirectly connected to the “server computers” via a PROFIBUS segment connecting two S7-300 PLCs and all the controllers from the sample environment. Most motor controllers and position encoders interfaces reside in ET200 decentral periphery systems scattered over the instrument, which are connected to the PLCs via two additional subordinate PROFIBUS segments.

The implemented software is distributed between three levels of the system hierarchy. The software on the lowest level runs on PLCs in the front end. The software on the next level is running on the server computers. This comprises TACO servers and device drivers for dedicated HW modules, e.g. detector electronics, counter board or PROFIBUS controller. The TACO middleware is the glue that connects the server computers to the control computer, where the client application programs as well as the TACO manager and database (all above the upper dashed line) are running. Since TACO is location-transparent, the application programs could run on any Linux-based system.

The AS-I Subsystem of KWS2

The collimation line of the KWS-2 is a natural candidate for the introduction of AS-I, since the devices (pneumatic valves and limit switches) are scattered over a distance of 20m. Pneumatic valves with integrated AS-I in digital inputs for the limit positions were available on the market (IFM airbox AC 2046). So we implemented an ASI-subsystem as a bus segment with 18 airboxes. For each of the 5 collimation apertures one compact module with 4 digital inputs is mounted on the same bus, in order to read the limit switches of the apertures. The AS-I bus segment is connected to one of the S7-300 PLCs via the communication controller CP343-2, which acts as an AS-I master system.

CONCLUSIONS

Introduction of AS-I reduced the cabling effort considerably and lead to improved diagnostics. Handling of AS-I was extremely easy and also the programming effort was low, since AS-I devices could be accessed like local digital IOs from the PLC program. The AS-I subsystem of KWS-2 works stable since more than one year. Therefore the KWS-1, a similar instrument that is under construction now, will also be equipped with AS-I.

REFERENCES

[1] H. Kleines et al., “Implementation of the Control and Data Acquisition Systems for Neutron Scattering Experiments at the New “Jülich Center for Neutron Science” According to the “Jülich-Munich Standard”, Proceedings of the ICALEPCS 2005, Geneva, 2005.

[2] A. Götz, et al., “TACO: An object oriented system for PCs running Linux, WindowsNT, OS-9, LynxOS or VxWorks”, Proceedings of the PCaPAC96 Workshop, Hamburg, November 1996.

[3] R. Becker et al., “AS-Interface - The Automation Solution”, 2002 AS-International Association, Internet: www.as-interface.net