A Functional Profile for Laboratory Measurement Equipment based on Measurement Bus and Profibus-DP/PA

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Abstract. A new functional profile for labaroratory devices is the result of a working group "Laboratory Data Communication" in the Standardization Committee "Laboratory Devices and Laboratory Equipment" of DIN. Based on a very complex functional profile for process devices (Class A) of the Profibus User Organisation (PNO), a set of only seven simplified function blocks have been proposed, wich meets the main communication requirements of low-cost laboratory devices. Two fieldbus systems are elected for the necessary transport-oriented communication services: Measurement Bus ("DIN-Messbus") and Profibus-DP/PA. All function blocks and its defined variables will be mapped on the specific application services of these two bus systems.

1 Laboratory Automation

Measurement and automation devices used in chemical, physical, biological, pharmaceutical and medical laboratories are provided mostly just with analog output or digital point-to-point-interfaces with varying protocols and communication skills. Consistent measured data acquisition, parameter entry and control of these appliances from a laboratory-guide-system, normally a PC, are therefore only possible with significant hardware- and programming efforts. The development and standardization of a consistent range of functions for the communication to the measurement and automation devices, based on selected communication systems (e.g. field bus systems) will open - comparable to other areas of automation - new cost-effective and timesaving possibilities for networking, program development and the actually laboratory working process.

2 Standardizing a Laboratory Communication Functional Profile

2.1 Communication Requirements

For the device specific communication in the area of laboratory measuring and control techniques the following requirements have been found:

- up to 30 participants with Master-Slave-operation
- broadcasting to all participants or groups of participants

- user data range of 1 to 50 byte
- reaction time of max. 100 ms
- implementation with standard microcontrollers and standard peripherals
- cost of one node max 50,- Euro

On the basis of these requirements all established and standardized field bus systems have been checked by the responsible working group in respect to their qualification for the intended laboratory communication system. The fieldbus systems *'Measurement Bus'* and *'Profibus-DP/PA'* have been selected as best qualified communication systems by the standard committee. One or both of these communication systems may be used at the proposed laboratory communication system with a standardized laboratory data functional profile (see Fig. 1.).

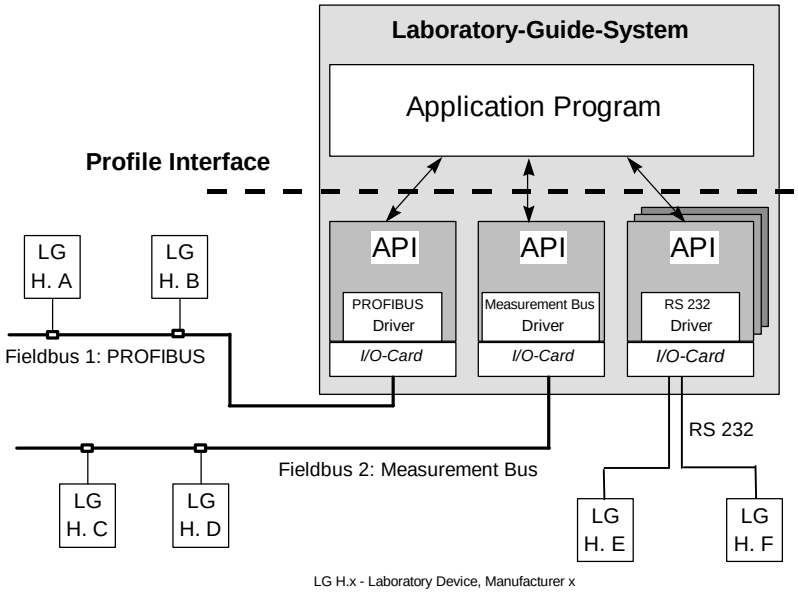

Fig.1. Architecture of a Laboratory Communication System: Functional Profile for different Measurement Devices and a Laboratory Guide System

2.2 Functional Requirements

According to *different technical functions* inside of the laboratory measurement and experimental equipment a set of function blocks and their parameters have to be defined. The result of this will be a *"Laboratory Functional Profile"*, usefull also as a basic principle for all similar measuring equipments and will allow a consistant method of application programming, e.g. assisted by use of commercial measuring and control operation programms.

For typical low-cost laboratory devices the following functions are most important for monitoring and control by a laboratory guide system:

- Analog measuring instruments, e.g. temperature or pressure measurement
- Analog sources or actuators, e.g. stirrer or heat source
- Binary sensor or actuator, e.g. pneumatic valves or switches
- Control units
- Time programmable control unit
- Terminal and display unit

2.3 Function Blocks

To handle these technical device functionality by a laboratory communication system the following (logical) function blocks have been provided:

- Binary-Input (binary sensor)
- Binary-Output (binary actuator, optionally with feedback message)
- Analog-Input (analog sensor, transducer, optionally with scaling)
- Analog-Output (analog actuator, transmitter of analog quantities, opt. with scaling)
- Control Function (laboratory device containing a control unit)
- Programmer (output of a time function for control of an analog output device or laboratory device containing control unit)
- Operator's Communication Unit (keyboard-display-unit).

Each realized specific measurement device profile of a laboratory device consists of some device independant *basic functions* (physical block and block list) and at a minimum one selectable function block (see Fig. 2.).

The *physical block* consists of 18 common used device specific variables or constants, e.g. identification data and software version-number. 9 of these parameters are mandatory. The *block list* contains a header and the list of implemented function blocks and their (device specific) absolute adress indizes.

A *function block* consists of 8 basic parameters (see table 1., only five of them are mandatory) and a variable number of block specific parameters. For each proposed function block the mandatory or optional parameters are standardized by identifier, name, data type, size, access mode, type of storage, update mode and default value.

The specification of the individual function block parameters was worked out - in opposition with other functional profiles of automation technology - not in the way of specific measuring variables (e.g. "rotational speed") instead of in the manifold applications of the measuring practice appropriating common method (e.g. for the function block analog-input in the sense of an "actual measured value"). In Fig. 2. an example of a measuring device with one analog measuring input and one (bus controlled) binary output is shown. Note that a function block not describes the complete hard- or software functionality of a specific device but only the part of

functionality which is able to be controlled by the connected communication system, e.g. a fieldbus system.

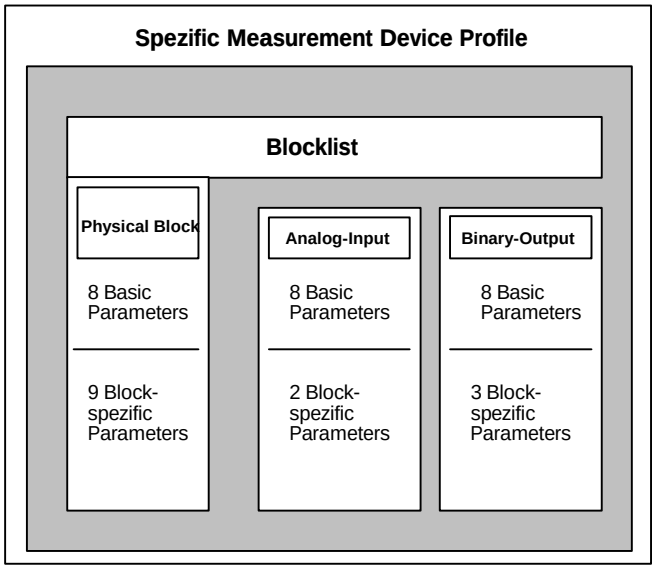

Fig. 2. Example of a spezific Laboratory Measurement Device with Function Blocks "Analog-Input" and "Binary-Output"

To give an impression of the parameter description, in the following tables all parameters, needed in the above example are listed. First the basic parameters are shown in Table 1. wich have to be implemented triple, specific for the physical block, the analog input function block and the binary output funktion block.

Table 1. Basic Parameters, necessary for each Function Block

Rel. Index	Parameter Name	Mand. Opt.	Objekt type	Data type	Size	Access	Store	Method of Updating	Default value
0	BLOCK_OBJECT	m	Record	DS-32	20	r	Cst	async	block-spec.
1	ST_REV	m	Simple	Unsigned 16	2	r	N	async	0
2	TAG_DESC	o	Simple	Octet-String	32	r,w	S	async	32xSP
3	STRATEGY	o	Simple	Unsigned 16	2	r,w	S	async	0
4	ALERT_KEY	o	Simple	Unsigned 8	1	r,w	S	async	0
5	TARGET_MODE	m	Simple	Unsigned 8	1	r,w	S	async	block-spec.
6	MODE_BLK actual permitted normal	m	Record	DS-37	3	r	 N Cst Cst	async	block-spec.
7	ALARM_SUM	m	Record	DS-42	8	r	D	async	0,0,0,0

In Table 2. the - ownly two - parameters of an analog input function block are shown. The parameter OUT contains the actual measuring value and shall be updated synchronously.

Table 2. Parameters of the Function Block "Analog-Input"

Rel. Index	Parameter Name	Mand. Opt.	Objekt type	Data type	Size	Access	Store	Method of Updating	Default value
0 to 7: Basic Parameters (see Table 1)									
10	OUT	m	Record	DS-33	5	r	D	sync	-
12	OUT_SCALE	o	Record	DS-36	11	r,w	S	async	0 resp. 100 %

Table 3. shows the list of parameters of the binary output function block. Only the parameter SP_D is mandatory, who contains the - binary - value, which the laboratory guide system has sent, to set the specified output actuator, e.g. a switch. The - optional - parameters offer the possibility to reed the setted binary output value (OUT_D) and/or to reed the actual state of the actuator if there a binary state-sensor is implemented (REEDBACK_D).

Table 3. Parameters of the Function Block "Binary-Output"

Rel. Index	Parameter Name	Mand. Opt.	Objekt type	Data type	Size	Access	Store	Method of Updating	Default value
0 to 7: Basic Parameters (see Table 1)									
8	REEDBACK_D	o	Record	DS-34	2	r	D	async, sync	-
9	SP_D	m	Record	DS-34	2	r,w	D	async, sync	-
10	OUT_D	o	Record	DS-34	2	r	D	async	measured of the variable, state

Fig. 3. shows the state diagramm of a simple function block (note that this is not the state diagramm of the complete device). The Running-Mode must be implemented for each specified function block; this is the normal mode.

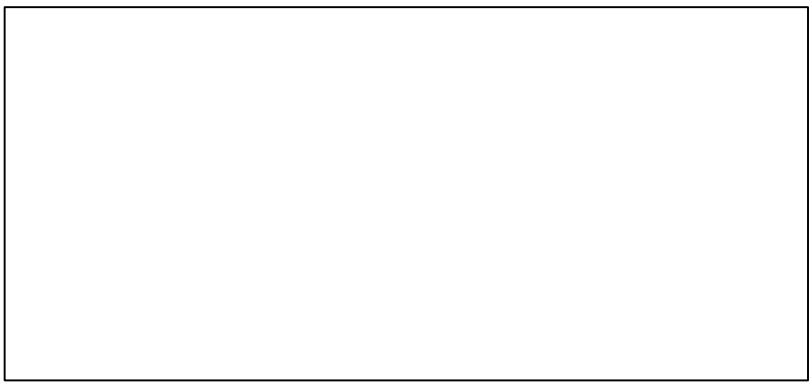

Fig. 3. State Diagram of the Function Block "Analog-Input"

Diagnosis-Mode and Out-of-Service-Mode are optional and offer the possibility for - manual operating - diagnosis mode and/or in case of a hardware defect a selfdiagnosis

state. A change of state needs a ‘write-of-variable’ telegram to change the parameter TARGET_MODE.

The proposed *Control Function Block* consists of 8 basic + 19 specific parameters (6 of them are mandatory). This function block serves for control and monitoring of laboratory devices which contain an automatic control unit, e.g. a laboratory centrifuge. More complex application may be realized by using this function block multiple and or using in combination with other function blocks.

The *Programmer Function Block* has been defined to generate a time-dependent output function. The output parameter OUT must be the input value of another function block, e.g. an analog output function block of the same device. Thus it is possible to generate a linear spline profile beginning at a start-value and changing this value at every following time-step. The programmer function block contains (8+) 12 parameters, which all are mandatory.

The *Operators Communication Unit Function Block* is defined for use of a terminal-display-unit and consists of (8+) 5 mandatory parameters.

3 Realization

The proposal for a laboratory functional profile is nearly finished. Several companies have already begun to realize this functional profile for their measuring and laboratory devices based on Measurement Bus and Profibus-DP/PA. The necessary link between the outlined function blocks and the standardized fieldbus services of OSI layer 1 to 7 will be the next item of the working group. Two researching groups have begun with mapping the function blocks to either Measurement Bus or Profibus-DP/PA application layer services.

Thus using a standardized fieldbus system and the appropriate function blocks for his laboratory application programming the user is able to work independent from device manufacturers.

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