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Functions of Building Automation and Control Systems

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Thomas Wimmer

Matrikelnummer 0525006

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Institut für Rechnergestützte Automation

Betreuung:

Ao.Univ.Prof. Dipl.-Ing. Dr.techn. Wolfgang Kastner

Mag. Dipl.-Ing. Fritz Praus

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Kurzfassung

In den letzten Jahren wurden die Schlagworte Smart Home und Smart Building immer populärer. Dies ist einerseits auf das immer stärker werdende Energiebewusstsein der einzelnen Personen und Firmen zurückzuführen als auch auf den steigenden Anspruch auf Komfort in den eigenen vier Wänden bzw. in Büroräumlichkeiten. Um die Implementierung eines Automationssystems zu vereinfachen, wurden in den letzten Jahren auch Normen zu diesem Thema veröffentlicht.

In dieser Arbeit wird auf zwei dieser Normen, DIN EN ISO 16484-3 [1] und VDI 3814-1 [5], konkret Bezug genommen. Es wird ein kurzer Einblick in die behandelten Themen gegeben und im Anschluss auf die Unterschiede in den Normen eingegangen. Desweiteren wird die Funktionsliste dieser beiden Normen in einem praktischen Beispiel an einem Gebäudeautomationsmodell des Institutes für Rechnergestützte Automation angewendet. Dieses Modell ist auch Bestandteil des letzten Teils, in welchem Produkte der Firma Saia-Burgess [2] dazu verwendet werden, das Modell zu steuern und zu regeln.

Functions of Building Automation and Control Systems

Abstract

Smart buildings and homes have become increasingly popular within the last few years. This is because energy saving is becoming gradually more important for individuals and companies, and an increased need for comfort has risen in this century. Some standards are published to make an implementation of building automation and control systems (BACS) easier.

This thesis shortly describes two of them, namely DIN EN ISO 16484-3 and VDI 3814-1. A list of the included topics is presented and a short comparison of both standards is outlined. As a practical part, the BACS function list is used for a heating ventilation and air conditioning (HVAC) model of the Institute of Computer Aided Automation, which is also part of the last topic, where this model is used in combination with products of the company Saia-Burgess.

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1 Introduction

1.1 Motivation

Smart buildings and homes have become increasingly popular within the last few years, particularly in functional buildings, as well as in the dwelling sector. Energy saving is one of the key factors where automation systems can help, to switch the sensors and actuators on/off only when they are needed and also to get statistical data as a baseline for decisions. In parallel, automatically adjusting comfort parameters has become gradually more important in our century. To mention but a few points, people like to have stable room conditions or the lighting switches on when entering a room. Within the market, there are different solutions for all of these problems and there are different ways of implementing such a system or renovating an existing one. This makes it difficult to plan and control such a project.

To overcome this problem, a wide range of standards have been published, which describe a standardized way of integrating an automation system into a building. These standards describe in detail all the functionality which could be part of an automation system and outline ways planning and documenting a necessary workflow. Working with these standards makes it a lot easier for all of the involved people to plan the necessary functionality and also to calculate the required budget.

1.2 Objectives

The functions of Building Automation and Control Systems (BACS) are discussed within two standards, namely DIN EN ISO 16484-3 and VDI 3814-1. These two standards will also be the baseline for this thesis. They also include a good way of documenting an automation system when using the BACS function list layed down there.

However, it may be difficult to use these standards in a practical way. Particularly in old buildings, it is sometimes impossible to change the environment when updating the system to state of the art technology. In addition, problems arise when an environment

continually expands, but as technology is changing there are now different solutions in progress and it is difficult to get data from a central point of view.

Therefore, it is possible to use some components from the manufacturer Saia-Burgess. Their focus is to create products for this market. They produce programmable logic controllers (PLC) which have to be populated with separate modules to get the I/Os needed for the individual solution. This allows changes to the programming/controlling logic of an environment using the existing sensor/actuator system within the building. But these systems are also perfect to combine different solutions to one central unit, which could save the statistical data for management decisions.

Therefore, this thesis describes a particular PLC and a room controller from Saia-Burgess, which will be used to control an HVAC model of the institute.

1.3 Structure of the thesis

This thesis is structured as follows: Chapter 2 gives a short introduction into two standards of building automation and control systems, DIN EN ISO 16484-3 and VDI 3814-1. After this introduction, the differences between both standards are discussed. Finally, the described workflow of producing a BACS function list is used to create the function list for the HVAC model. Chapter 3 focuses on the application of the theoretical information with practical examples. It will contain a short introduction into the used Saia-Burgess components and then describe some examples of using the hardware and also the PG5 Software from Saia-Burgess together with the model. Chapter 4 and 5 provide a short outlook and summarize the thesis.

2 Standards

2.1 DIN EN ISO 16484-3

The DIN EN ISO 16484-3 was created from the technical Committee ISO/TC 205 “Building environment design” together with the technical Committee CEN/TC 247 “Building automation, controls and building management”.

It is part of the EN ISO 16484 with the title “Building automation and control systems (BACS)” which contains the following parts

- Part1: Overview and vocabulary
- Part2: Hardware
- Part3: Functions
- Part4: Applications
- Part5: Data communication protocol
- Part6: Data communication conformance
- Part7: Project implementation

Part 3 of the standard describes the functions and software of a building automation system. It is subdivided into three parts

- System management and application software
- Software and tools for engineering
- Processing programs and project specific functions for BACS

The topic *system management and application software* describes the requirements for the software and the operating system used in a BACS. Within the standard the software is divided into

- *System management programs* contains all of the general functions of the system, including time management and diagnostic functions. Within this topic, it is also discussed how to name data points and who is allowed to use the system. There is also information about data storage and archiving.
- *Communication programs* covers the access from outside and all other network topics. Another part gives information about communication to other systems.
- *Overall application and optimisation programs* discusses alerts and how to provide this information to the people who are interested.
- *Programs for the human system interface* describes the software for human system interfaces and gives an enumeration of different ways that people can interact with the system.
- *Engineering programs* addresses information on tools to maintain the system.
- *Operating system* includes information about the operating systems which are involved in the automation system.

The part *software and tools for engineering* describes the engineering task used in a BACS. These are

- *Engineering* gives information on the individual requirements of the planned automation system.
- *Configuration of hardware* contains all the necessary hardware and infrastructure with all the necessary wires and connections.
- *Configuration of the automation strategy* describes the information about the automation strategies like documentation and download the program into the hardware.
- *Configure the management and operator functions* gives information to bring the management and human system interfaces in a running state.
- *Tools for the commissioning* discusses information about tool software, which is needed for the commissioning of the different functions.

The last part *processing programs and project specific functions for BACS* describes the functions used in a BACS and how to document them. This document is useful and mandatory for all projects, because it gives a good overview of all used functions and the reflecting efforts considering the software and the engineering process. The functions are divided into

- *I/O functions* contains information about switching and adjusting digital and analogue data points. It also contains the receiving side of the data points.

- *Processing functions* describe the way how to create output based on input parameters. Processing functions are used for monitoring and counting tasks, but also for controlling the used actuators like engines within the system. Here all the possible functions of controlling and regulation of the automation system are addressed.
- *Management functions* gives information about functions which are used to store the information of the automation system. This is necessary for e.g. trending, to see how the system was working in the past and also to make decisions for the future.
- *Operator functions* contain the functions related to the human system interfaces.

2.2 VDI 3814-1

The VDI 3814 in the actual version was created after publication of the DIN EN ISO 16484. As the international standard does not contain regional requirements, e.g. for Central Europe, they are covered within this VDI standard. The VDI 3814 is subdivided into several parts:

- Part1: System basics
- Part2: Legislation, technical rules
- Part3: Advice for operators
- Part4: Points lists and functions - Examples
- Part5: Intersystem communication
- Part6: Representation of logic interlocks
- Part7: User interface design

The VDI 3814-1 defines system principles for BACS, which are

- General system features
- Building automation and control and technical building management
- Data point addressing
- Automation schematic
- BACS function list
- BACS functions

- Requirements for process interfaces and field devices
- Requirements for documentation
- Requirements for implementation

The section *general system features* gives a short and general introduction into the topics. It includes

- *System model* gives a picture of a general system model containing the field devices, automation area and the management area.
- *Field devices* describes in a short way what field devices are existing and for what purpose they are used. For example, a temperature sensor gives a special temperature to the PLC.
- *Building automation programs* describes the used software within an automation system.

The *building automation and control and technical building management* topic gives a short introduction into how a BACS fits into a technical building management (TBM) system.

The next topic *data point addressing* describes the requirement of using a standard addressing and designation system within a project.

The next three parts address the need of documentation and describe two ways of documenting the project. These are the *automation schematic* and the *BACS function list*. Another topic describes the requirements for BACS functions which are divided into the following functions, which are

- I/O functions
- Processing functions
- Management functions
- Operator functions

This is one of the main parts of the standard, which gives detailed information of the different functions and the way to document them in the BACS function list

Section *requirements for process interfaces and field devices* gives a short information about how to use process interfaces, event notification, measuring, counting, switching and positioning and which conditions they shall meet.

The next topic describes the different phases during implementation and gives a list of documents which have to be developed in each phase.

In the last section, there is some information for implementing the project with two or more different planners working on the same project.

2.3 Analysis

The EN ISO 16484-3 includes only three topics

- system management and application software,
- software and tools for engineering, and
- processing programs and project specific functions for BACS

These topics are described in a detailed form. The *system management and application* software part is divided into the different types of programs and describes functions like system time, diagnostic functions, data point addressing, data archiving to mention but a few.

The next part, *software and tools for engineering*, gives an introduction into the different phases of a BACS and the used tools.

The last topic is the largest one and describes the way to produce the attached BACS function list and all the used functions.

In comparison, the VDI 3814-1 covers more topics which are part of EN ISO 16484-3 and also EN ISO 16484-2, therefore the description is not that detailed.

The *software part*, for example, is covered in a half page; in the EN ISO 16484-3, this part needs 15 pages. Another difference is that the *data point addressing* is a separate topic and not a subtopic of the BACS software.

The main part of this standard is the *BACS function list* which is described in the same level of detail as in the 16484-3.

The VDI 3814-1 also includes a section for *requirements for process interfaces and field devices* where requirements on hardware are discussed. This discussion is not part of 16484-3.

The topics *requirements for the documentation* and *requirements for the implementation* contain information about the different phases of a BACS project and the documentation for each of these phases. This is similar but not equal to the topic *software and tools for engineering* from the 16484-3 standard.

2.4 BACS function list

One of the main parts of the two mentioned standards is the BACS function list. In this section, the suggested way of producing the BACS function list is followed to create the function list of the HVAC model. The model is used to teach the students in a practical way the most important topics of building automation and control systems. The model itself contains only field devices and no automation equipments. It is then the task of the students to engineer the automation equipment of different manufacturers

and learn how to handle their specific tools for engineering and programming. Therefore the BACS function list is rather small, because it only contains some I/O functions.

The model is divided into two parts. Within the Direct Digital Control (DDC) the air can be prepared. The fresh air comes into the system and can be changed to the conditions needed within the room. The air comes out of the room into the DCC and can be used again in a loop or be transported out of the system.

In the DDC, there are 7 temperature sensors (B01 - B07), to check the temperature in different places within the system. First, there is a sensor for the outside temperature (B01), then there are two sensors to get the temperature for the feed lines of the heating (B07) and air conditioning system (B05). The temperature of the supply air is also recorded after the heating system (B02) and as a last point before the air comes into the room (B03). The temperature of the discharging air is checked when it comes out of the room (B04) and before it leaves the system (B06).

As it was always difficult to connect the temperature sensors with DDCs of different manufactures, these sensors are now connected over a BTR Module using LonWorks.

The temperature sensors B03 and B04 are combined temperature and humidity sensors. These sensors are located directly before the entrance to the room and when the air comes out of the room.

The humidity value is a 0 – 10V signal which can directly be used from the model.

To control the amount of fresh and looping air there are 3 damper actuators within the system. They are merged together to one 0 – 10V control signal (M01) within the model.

Concerning ventilation, the DDC provides different data points: two fans and their corresponding speed are controlled via a 0 – 10V signal (M04, M05). In addition, there are two separate switches to turn them on/off. There are failure notifications for these ventilators (S02 and S03), which simulate an error condition by the help of a switch controlling a 24V signal.

To change the condition of the air, there are 3 components used. First there is the heating system, which is a small hot water boiler. From here the water is transferred with a pump (M03) into a heat exchanger and the room.

For controlling this part, there is a switch to turn on/off the hot water boiler (A06) and a 0 – 10V signal to change the speed of the pump. As the pump is working with 12V, this 0 – 10V signal is used to control a PWM module which then gives the 12V to the pump. The heating system has also a simulated disable notification for frost protection

(S01), which is only a 24V signal and is not connected directly.

The air conditioning works with the same configuration as the heating. A pump (M02) is used to bring the cold water into a heat exchanger and the room.

It is also controlled by a switch (A03) and the same configuration for the pump.

A humidifier is connected with the supply air and can be controlled with a switch (A04) to be turned on/off.

The second part is the single room. Here some sensors and actuators are used to achieve comfortable conditions within the room. There is a 4 pipe fan coil system with separate pumps for heating (M06) and cooling (M07), and a shared 3 step ventilator (M08).

To control the pumps again the configuration 0 – 10V and 12V PWM signals are used. The 3 steps of the ventilator are connected over relays which can be controlled by different 24V signals. There are 3 fake disable notifications for on-site notification (S04), window contact (S06) and condensate protection (S05) which are connected to a 24V signal.

In the room there exists a second rather slow heating system (A14), which can be controlled with a 0 – 10V signal that is normally connected to the DDC.

Within the room there are two separate lights (A12 and A13) and a shutter (A11). They are connected via relays and need 24V to change the condition.

As a last part there is a room controller which is used for a combined temperature and humidity sensor. Here normally only the humidity sensor (B08), which is a 0 – 10V signal, is used, because if the room later is controlled with components of different manufacturers there is always an own room controller with a specific temperature sensor.

DDC			
Datapoint	Short code	Datatype	PLC Value
Temperature outside	B01	AI	LON
Temperature supply air	B02	AI	LON
Temperature supply air	B03	AI	LON
Temperature discharging air	B04	AI	LON
Temperature feed line cold	B05	AI	LON
Temperature discharging air	B06	AI	LON
Temperature feed line hot	B07	AI	LON
Humidity supply air	B03	AI	0-10 V
Humidity discharging air	B04	AI	0-10 V
Damper actuators	M01	AO	0-10 V
Ventilator supply air	M04	AO	0-10 V
	M04	DO	1/0
Ventilator discharging air	M05	AO	0-10 V
	M05	DO	1/0
Ventilator disable notification supply air	S02	DI	1/0
Ventilator disable notification discharging air	S03	DI	1/0
Heating system	M03	AO	0-10 V
	A06	DO	1/0
Disable notification frost protection	S01	DI	1/0
Air condition system	M02	AO	0-10 V
	A03	DO	1/0
Humidifier	A04	DO	1/0
ROOM			
Datapoint	Short code	Datatype	PLC Value
FANCoil - Pump heating system	M06	AO	0-10 V
FANCoil - Pump air condition system	M07	AO	0-10 V
FANCoil - Ventilator	M08	DO	1/0
Disable notification onside	S04	DI	1/0
Disable notification window contact	S06	DI	1/0
Disable notification condensate protection	S05	DI	1/0
Heat source room slow	A14	A0	0-10 V
Light room 1	A12	DO	1/0
Light room 2	A13	DO	1/0
Sun blind room	A11	DO	1/0
Humidity room	B08	AI	0-10 V

Table 1: List of datapoints

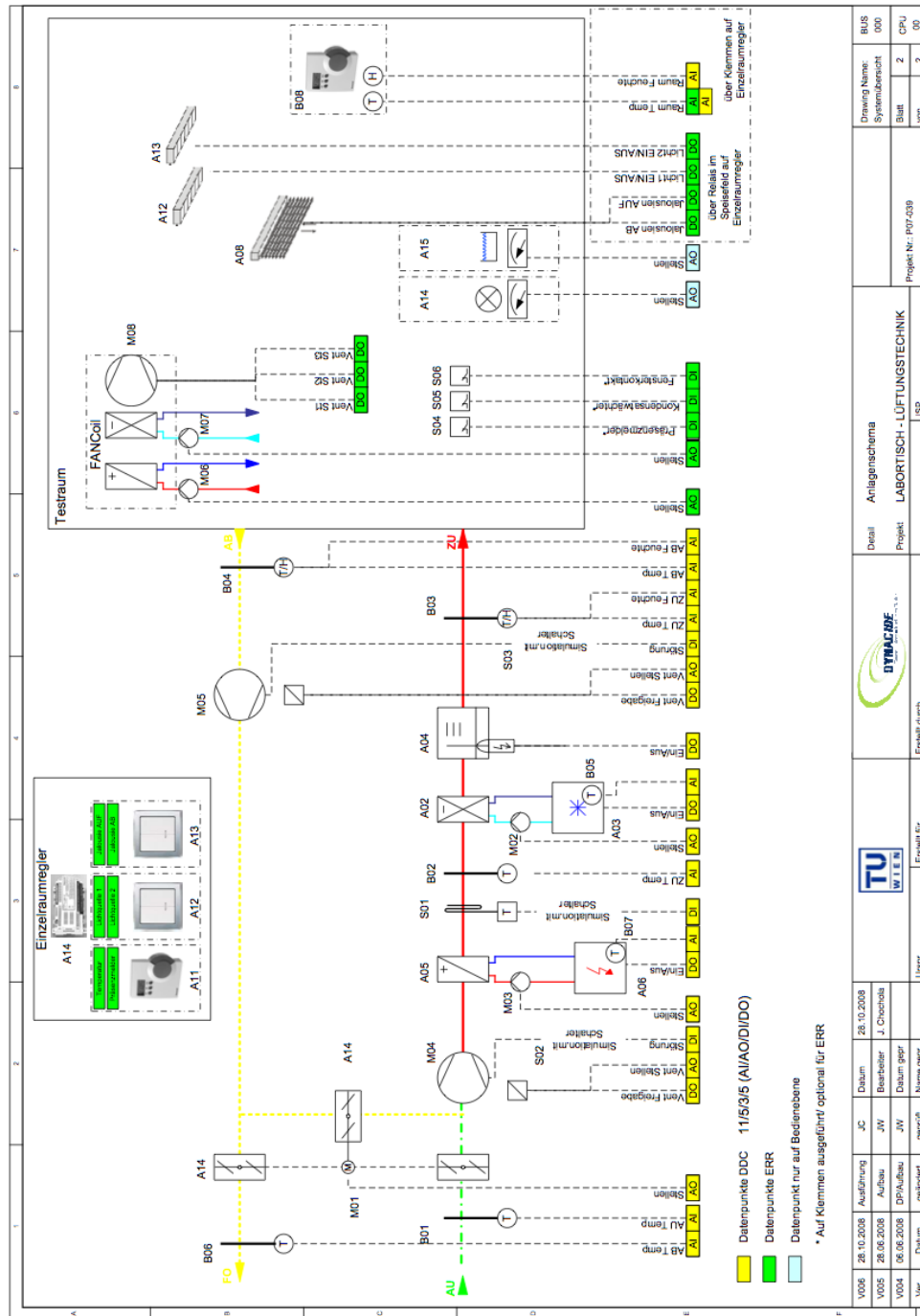


Figure 1: Plant schematic of the HVAC model



Figure 2: Picture of the HVAC model

Trade:		IO Functions		Monitoring		Interlocks		Processing Functions										Management Functions										Operator Functions			
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3 Saia-Burgess

3.1 Introduction

Saia-Burgess is a manufacturer of electronic components, devices and systems for control engineering, with special strength in developing and servicing niche markets. They work together with system integrators, OEMs and brand label customers. The companies headquarters is in Murten (CH), but there is also an office in Salzburg (A).

For the practical part of this thesis, Saia-Burgess products are used to control the HVAC model from the Distributed Automation Systems Lab. The programmable logic controller PCD2.M170 [7] is used as DDC and the single room is controlled by a room controller PCD7.L601 [8, 9]. Both products are configured with the PG5 2.0 software from Saia-Burgess. [6]

The DDC PCD2.M170 is the main part of this installation. The unit is freely programmable and configurable and offers next to some on board interfaces for RS-232 and RS-485 communication, 8 module slots for add-on modules. Using different add-on modules make it easier to configure the DDC for individual needs. In this case, the DDC is equipped with 4 modules and enhanced with modules for LonWorks and Ethernet.

PCD2.A220	PCD2.E610	PCD2.W605	PCD2.W525
PCD7.F800	PCD7.F655		PCD7.F110

Figure 4: Configuration of the PCD2.M170 with add-on modules

The *PCD2.A220*, a digital out module contains 6 relays with normally-open contacts and is used to control the enable-switch for both supply air and discharging air ventilation, for the HVAC system and for the humidifier.

The *PCD2.E610* is a digital input module and is used to determine the disable notification from the supply air and discharging air ventilation, the frost protection and the condensate. In the used HVAC model, these data points are not really connected to the mentioned equipment. They are simulated and can be activated by a switch on the HVAC model.

An analogue out module *PCD2.W605* is used for all positioning tasks: Controlling the speed of the ventilators for supply air and discharging air, positioning of the dampers and controlling the circulatory speed for the air conditioning and heating pumps.

The last module *PCD2.W525* is a combined analogue output and input module which is used for the heating of the single room and to get humidity values from the supply air, the discharging air and the single room. On the last analogue input, a PT1000 temperature sensor is used to get the room temperature as an independent value.

For communication with LonWorks, Ethernet and RS485 the DDC is equipped with three communication modules called *PCD7.F800*, *PCD7.F655* and *PCD7.F110*. These technologies are used to include the temperature sensors from the HVAC model (LON), to connect the DDC with the Saia-Burgess room controller (RS-485) and the network of the institute (Ethernet). The Ethernet connection is also used to program and configure the DDC with the PG5 software.

For the single room of the HVAC model, a Saia-Burgess room controller *PCD7.L601* is used together with some enhancement equipment for lighting and shutters

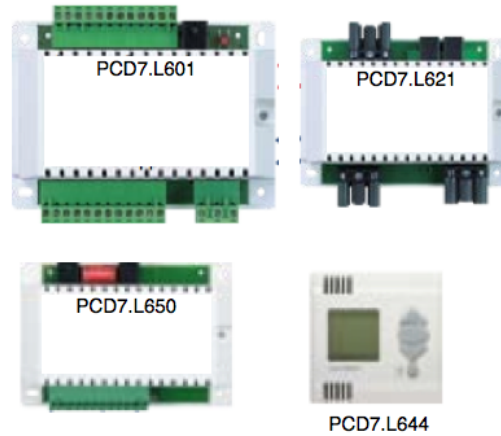


Figure 5: Saia-Burgess equipment for room controlling [adopted from [9]]

The *PCD7.L621* is used for the two lights and the control of the shutter. On the *PCD7.L650*, 8 potential-free contact inputs can be used for lighting and shading. The *PCD7.L644* is used to control the room controller and also includes a temperature sensor and a LCD display.

PG5 is the software to program and configure the Saia-Burgess equipment. The main part of this tool is the Project Manager, where new projects are defined and all the hardware configuration and software for the DDC come together. The Project Manager is also used to compile all the files and to load them into the DDC.

To set up the hardware, there is first a tool called Device Configurator, where the specific DDC and all the add-on modules should be chosen. The more detailed configuration of the hardware is part of the program which is then loaded into the DDC. To create a program the PG5 toolbox offers different technologies like Instruction List File and Fupla File to mention but a few. For the following examples, the Fupla File will be used. With this method, the user can input predefined boxes into the program and by connecting them create the needed workflow.

Within the Program Files part it is also possible to configure and download the LON part of the DDC. This is needed later in a LonWorks tool, like the LonMaker, to include the Saia-Burgess DDC into an existing LON network.

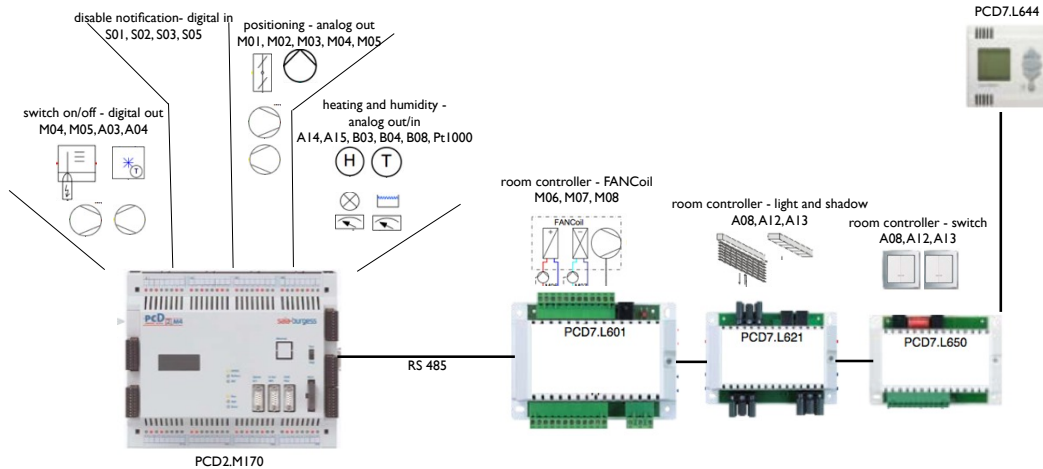


Figure 6: Configuration with Saia-Burgess products

3.2 Configuration

To be able to use all the data points available in the model, it is necessary to configure them within the PG5 [10]. This happens in an own Fupla file and a LON file where also the analogue cards are configured. Special boxes for each analogue module have to be selected where it is possible to enter specific properties, like 0 – 10V.

Properties

Analog Module: PCD2.W525

General

(Name)

Comment

Adjust Parameters

Frequency for 50/60Hz: 50Hz

Input Channel 0

Scaling: User defined

User Scaling 0% Val: 0

User Scaling 100% Val: 1000

Mode Selection: 0..10V

Filter Configuration: 50Hz/60Hz

Input Channel 1

Scaling: User defined

User Scaling 0% Val: 0

User Scaling 100% Val: 1000

Mode Selection: 0..10V

Filter Configuration: 50Hz/60Hz

Input Channel 2

Scaling: User defined

User Scaling 0% Val: 0

User Scaling 100% Val: 1000

Mode Selection: 0..10V

Figure 7: Properties from module W525

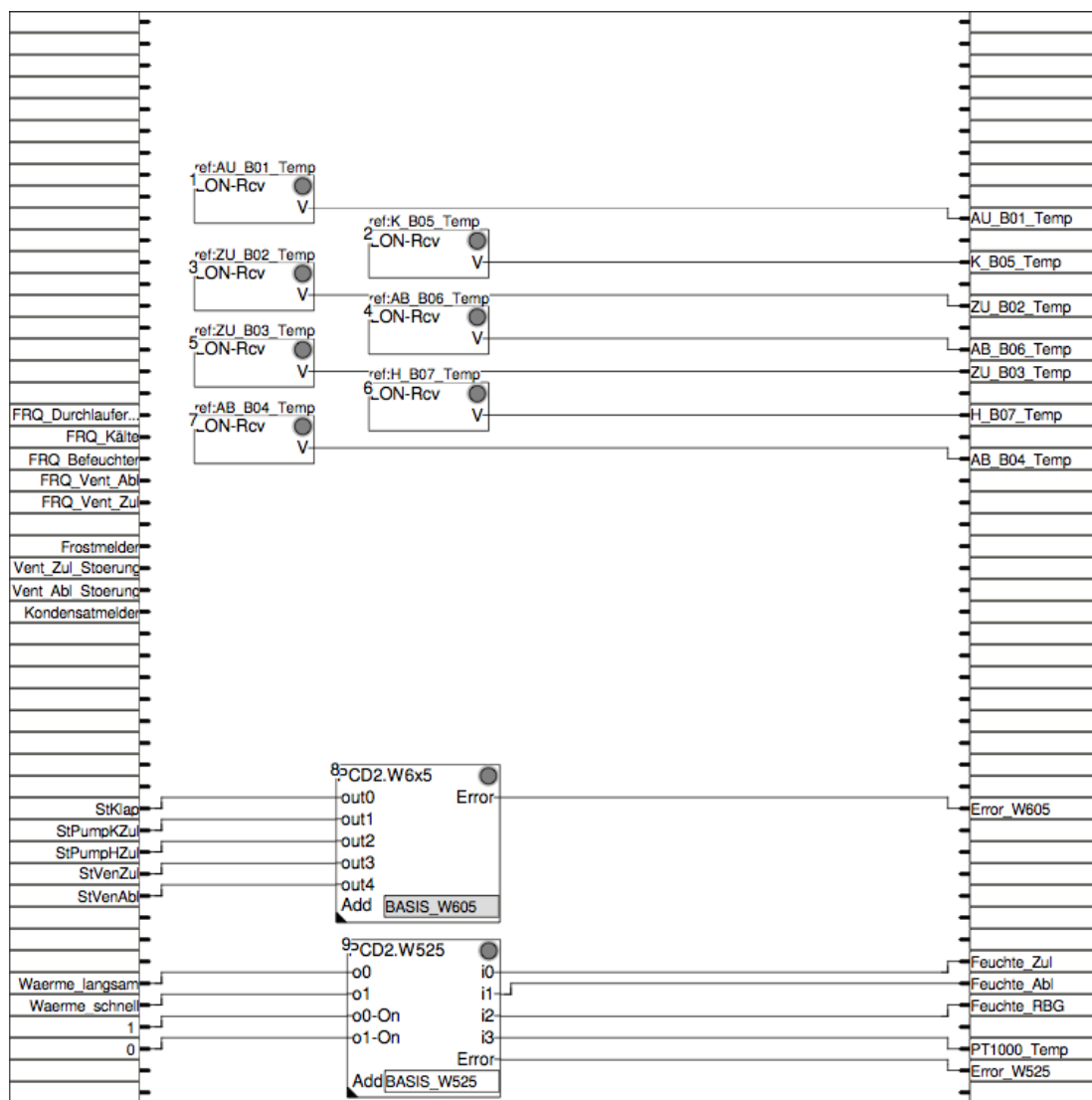


Figure 8: Configuration

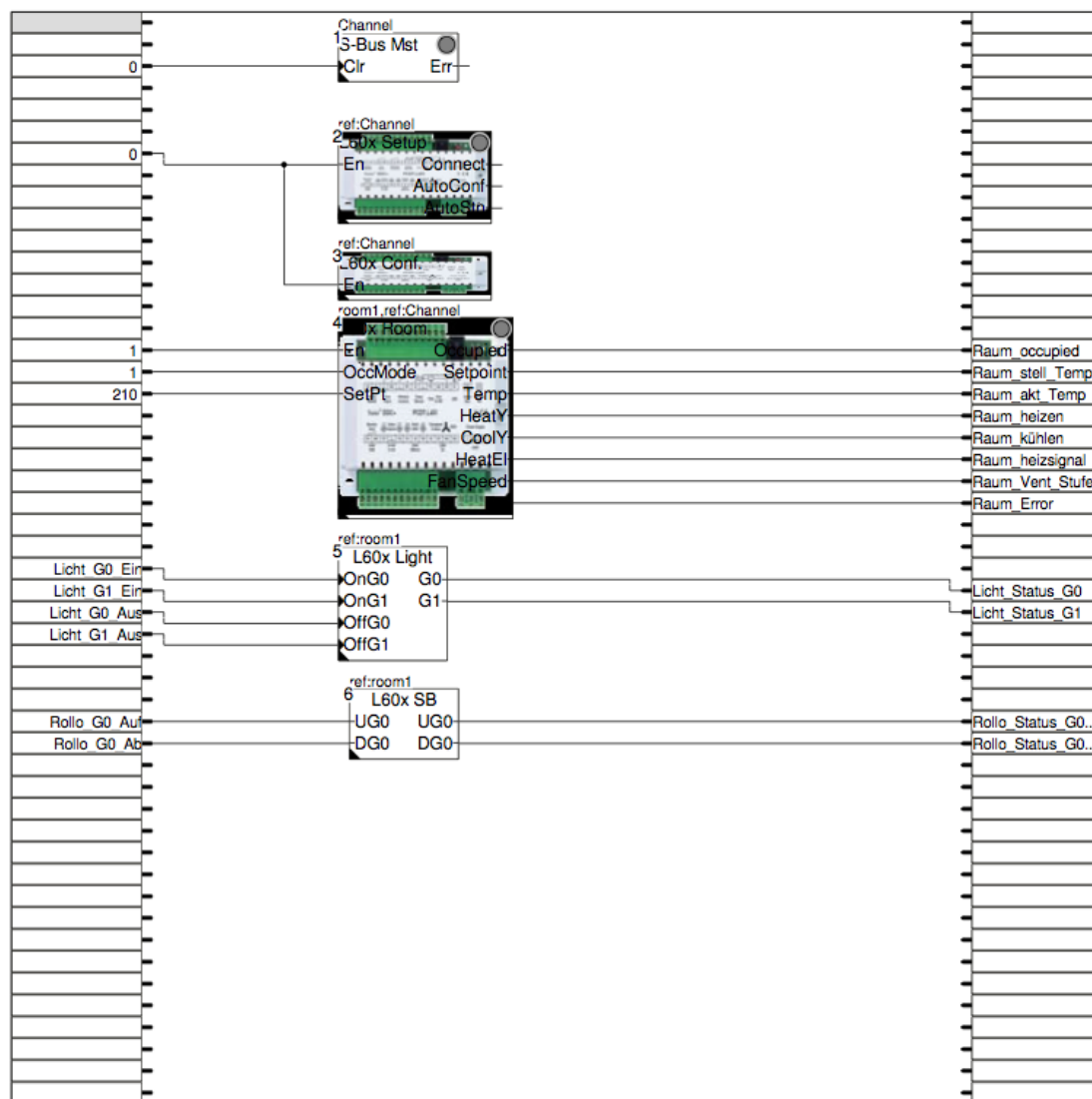


Figure 9: Configuration (cont.)

DDC			
Datapoint model	Short code	Datatype	Datapoint example
Temperature outside	B01	AI	AU_B01_Temp
Temperature supply air	B02	AI	ZU_B02_Temp
Temperature supply air	B03	AI	ZU_B03_Temp
Temperature discharging air	B04	AI	AB_B04_Temp
Temperature feed line cold	B05	AI	K_B05_Temp
Temperature discharging air	B06	AI	AB_B06_Temp
Temperature feed line hot	B07	AI	H_B07_Temp
Humidity supply air	B03	AI	Feuchte_Zul
Humidity discharging air	B04	AI	Feuchte_Abl
Damper actuators	M01	AO	StKlap
Ventilator supply air	M04	AO	StVenZul
	M04	DO	FRQ_Vent_Zul
Ventilator discharging air	M05	AO	StVenAbl
	M05	DO	FRQ_Vent_Abl
Ventilator disable notification supply air	S02	DI	Vent_Zul_Stoerung
Ventilator disable notification discharging air	S03	DI	Vent_Abl_Stoerung
Heating system	M03	AO	StPumpHZul
	A06	DO	FRQ_Durchlauferhitzer
Disable notification frost protection	S01	DI	Frostmelder
Air condition system	M02	AO	StPumpKZul
	A03	DO	FRQ_Kälte
Humidifier	A04	DO	FRQ_Befeuchter
ROOM			
Datapoint model	Short code	Datatype	Datapoint example
FANCoil - Pump heating system	M06	AO	-
FANCoil - Pump air condition system	M07	AO	-
FANCoil - Ventilator	M08	DO	-
Disable notification onside	S04	DI	-
Disable notification window contact	S06	DI	-
Disable notification condensate protection	S05	DI	Kondensatmelder
Heat source room slow	A14	AO	Waerme_langsam
Light room 1	A12	DO	Licht_G0_Ein/Licht_G0_Aus
Light room 2	A13	DO	Licht_G1_Ein/Licht_G0_Aus
Sun blind room	A11	DO	Rollo_Go_Auf/Rollo_Go_Ab
Humidity room	B08	AI	Feuchte_RBG
Additional Datapoints			
Datapoint example	Explanation		
Error_W605	Error Message from Module W605		
Error_W525	Error Message from Module W525		
PT1000_Temp	PT1000 Temperature sensor to get one direct value from the environment		
Waerme_schnell	Datapoint A15 in model, but this actor is not available at the moment		
Raum_occupied	Actual information of room controller configuration		
Raum_stell_Temp			
Raum_akt_Temp			
Raum_heizen			
Raum_kuehlen			
Raum_heizsignal			
Raum_Vent_Stufe			
Raum_Error			
Licht_Status_G0	Actual status of Light G0		
Licht_Status_G1	Actual status of Light G1		
Rollo_Status_G0_Ab	Endpositon sun blind up		
Rollo_Status_G0_Auf	Endpositon sun blind down		

Table 2: List of datapoints used in the configuration

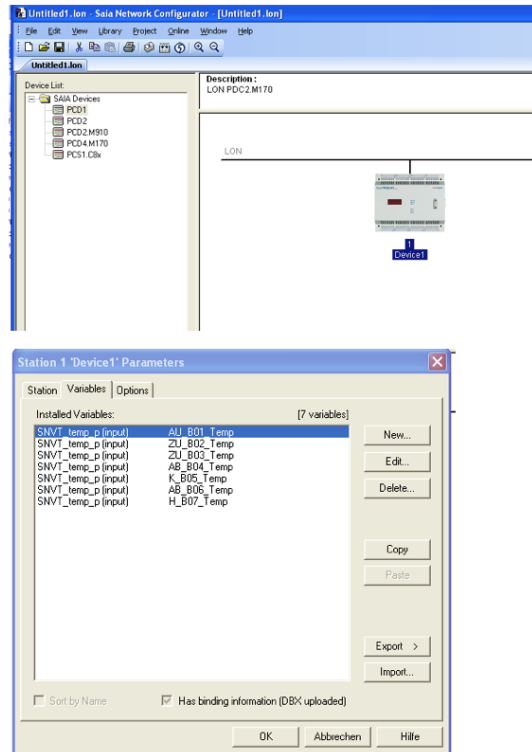


Figure 10: LON configuration within the DDC

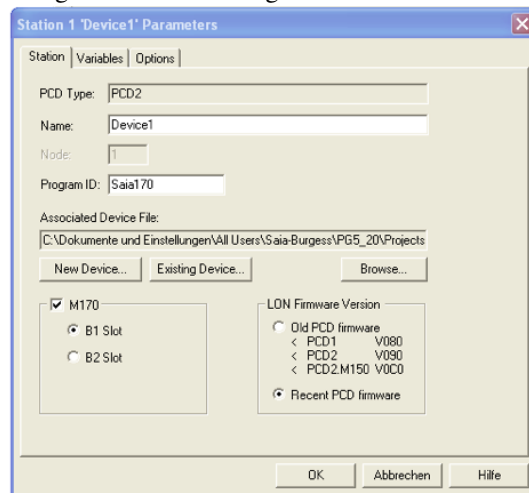


Figure 11: LON configuration within the DDC

3.3 Exercises

3.3 Exercise 1

Description

Write a Fupla program which contains the following scenario:

Fully open the damper actuators (M01) and start the ventilators (M04, M05) with 50% power. Check if the outside temperature (B01) is smaller than the discharging air temperature (B06). In this case start the heating (A06) and adjust the pump (M03) to 50% (otherwise it should be 0%). If the outside temperature is bigger than the discharging air temperature, start the air conditioning (A03) and adjust this pump (M02) to 50% (else 0%). If the humidity (B03) is lower than 50% then start the humidifier (A04).

Realisieren Sie ein Fupla Program für folgendes Szenario:

Die Klappen (M01) sollen vollständig geöffnet werden und die Ventilatoren (M04, M05) freigegeben und auf 50% Leistung eingestellt werden. Desweiteren soll abgefragt werden, ob die Aussentemperatur (B01) kleiner der Fortlufttemperatur (B06) ist. Wenn dies der Fall ist, soll die Heizung (A06) freigegeben werden und die zugehörige Pumpe (M03) auf 50% eingestellt werden (bei Nichtverwendung soll die Pumpe auf 0% eingestellt sein). Sollte die Aussentemperatur grösser sein, dann soll die Klimaanlage (A03) aktiviert werden und ebenso die zugehörige Pumpe (M02) auf 50% eingestellt werden (bei Nichtverwendung soll die Pumpe auf 0% eingestellt sein). Wenn die Luftfeuchte der Zuluft (B03) unter 50% fällt, soll der Befeuchter (A04) eingeschaltet werden.

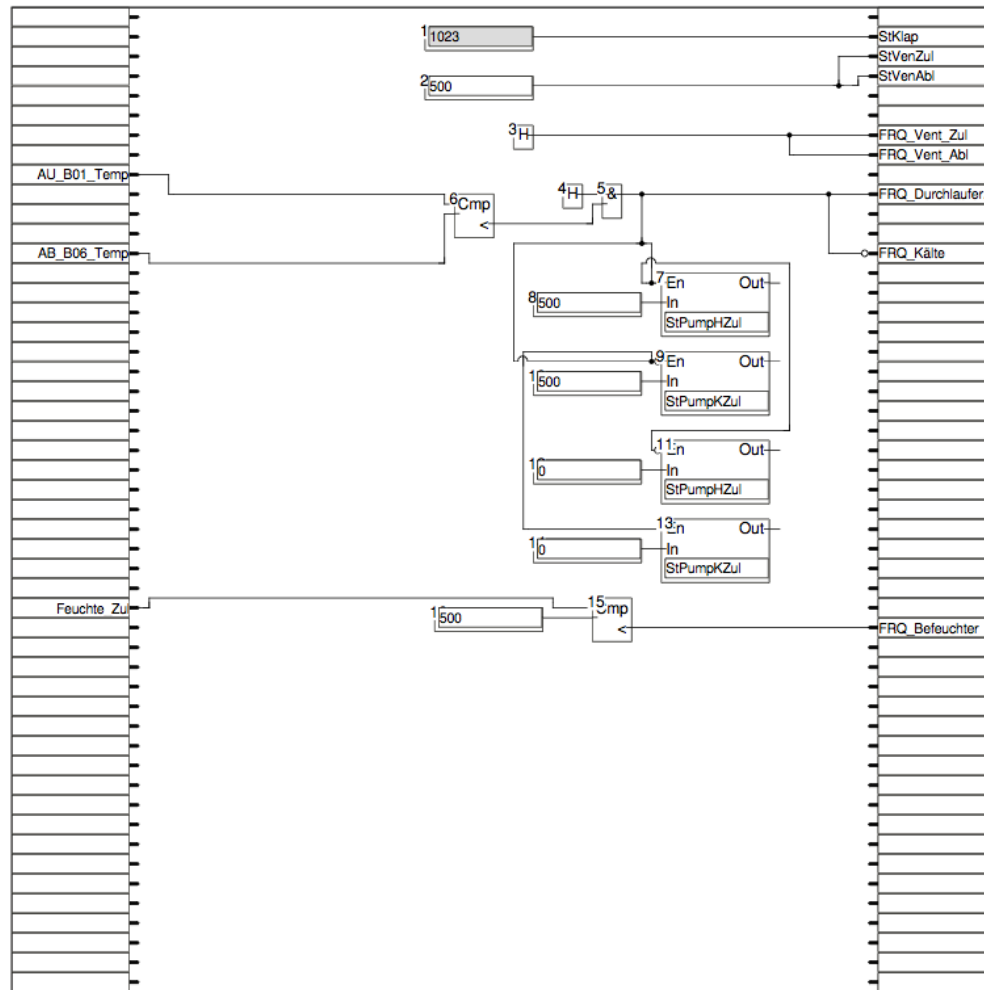
Solution

Figure 12: Fupla program for example 1

Trade:		IO Functions										Processing Functions										Calculation/Optimisation										Management Functions										Operator Functions									
Plant:		Monitoring										Closed Loop Control										Communication										Event Management										Alarm Management									
Description		Physical										Methods										Proportional/Integral/Derivative										Control										Control									
Data point/Device		Input										Output										Control										Control										Control									
Section No.		1										2										3										4										5									
Comments		1										2										3										4										5									
1		1										2										3										4										5									
2		1										2										3										4										5									
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Building Automation and Control System BACS-points list

1) Shared IO data points from foreign systems for interrelated functions, and, via DDU

2) Per input point address for collected, delayed or suppressed information

3) Per output point address

4) Per input point address for collected, delayed or suppressed information

5) If required, indicate whether applies to client „A“ or server „B“

6) For cooling/heating use 2X On/Off outputs

7) Per input point address

8) e.g. Device, schedule, flexibly, loop, file (see EN ISO 16484-5)

9) If required, indicate whether applies to client „A“ or server „B“

Trade:		IO Functions										Processing Functions										Calculation/Optimisation										Management Functions										Operator Functions									
Plant:		Monitoring										Closed Loop Control										Communication										Event Management										Alarm Management									
Description		Physical										Methods										Proportional/Integral/Derivative										Control										Control									
Data point/Device		Input										Output										Control										Control										Control									
Section No.		1										2										3										4										5									
Comments		1										2										3										4										5									
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Building Automation and Control System BACS-points list

1) Shared IO data points from foreign systems for interrelated functions, and, via DDU

2) Per input point address for collected, delayed or suppressed information

3) Per output point address

4) Per input point address for collected, delayed or suppressed information

5) If required, indicate whether applies to client „A“ or server „B“

6) For cooling/heating use 2X On/Off outputs

7) Per input point address

8) e.g. Device, schedule, flexibly, loop, file (see EN ISO 16484-5)

9) If required, indicate whether applies to client „A“ or server „B“

Trade:		IO Functions										Processing Functions										Calculation/Optimisation										Management Functions										Operator Functions									
Plant:		Monitoring										Closed Loop Control										Communication										Event Management										Alarm Management									
Description		Physical										Methods										Proportional/Integral/Derivative										Control										Control									
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Building Automation and Control System BACS-points list

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4) Per input point address for collected, delayed or suppressed information

5) If required, indicate whether applies to client „A“ or server „B“

6) For cooling/heating use 2X On/Off outputs

7) Per input point address

8) e.g. Device, schedule, flexibly, loop, file (see EN ISO 16484-5)

9) If required, indicate whether applies to client „A“ or server „B“

Trade:		IO Functions										Processing Functions										Calculation/Optimisation										Management Functions										Operator Functions									
Plant:		Monitoring										Closed Loop Control										Communication										Event Management										Alarm Management									
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3.3 Exercise 2

Description

Write a Fupla program which contains the following scenario:

If the outside temperature (B01) is higher than 23 degree Celsius then

- switch light 0 (A12) on
- close the sun blind (A11)
- switch on the AC system (A03) and adjust the pump (M02) to 50% (normally 0%)

If the outside temperature is lower then

- switch light 0 off
- open the sun blind
- switch on the heating (A06) and adjust the pump (M03) to 50% (normally 0%)

Realisieren Sie ein Fupla Program für folgendes Szenario:

Überprüfen Sie die Aussentemperatur (B01). Sollte diese grösser 23 Grad Celsius (in PG5 als 2300 einzugeben) sein, dann

- schalten Sie die Lichtgruppe 0 (A12) ein
- schliessen Sie die Jalousie (A11)
- aktivieren Sie die Klimaanlage (A03) der DDC
- stellen Sie die Pumpe der Klimaanlage (M02) auf 50% ein (bei Nichtverwendung soll die Pumpe auf 0% eingestellt sein)

Sollte dies nicht der Fall sein, dann soll folgendes gemacht werden

- schalten Sie die Lichtgruppe 0 aus
- öffnen Sie die Jalousie
- aktivieren Sie die Heizung (A06) der DDC
- stellen Sie die Pumpe der Heizung (M03) auf 50% ein (bei Nichtverwendung soll die Pumpe auf 0% eingestellt sein)

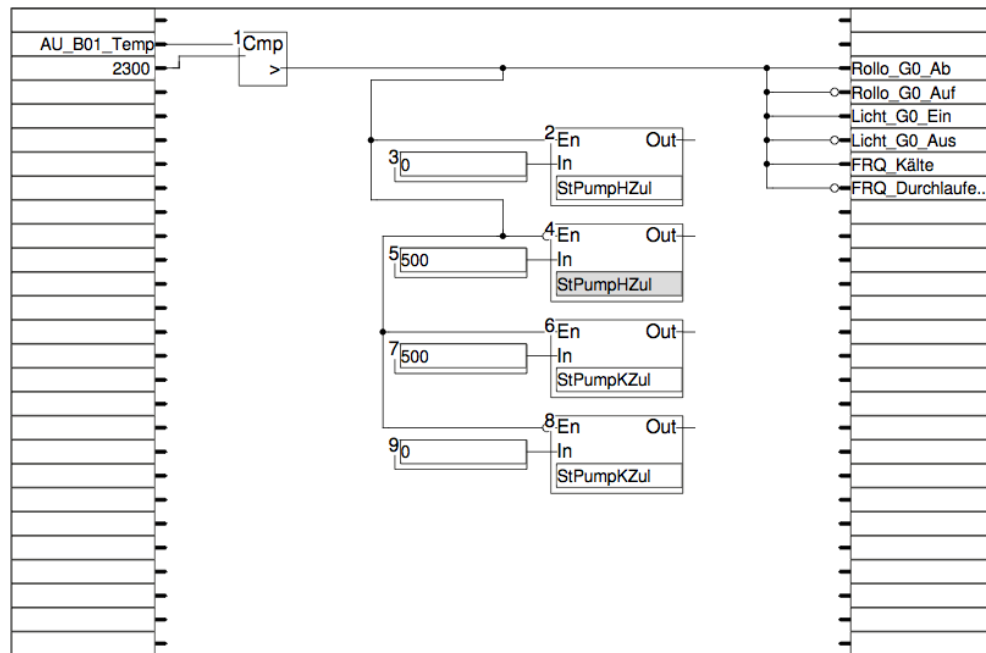
Solution

Figure 14: Fupla program for example 2

Figure 15: BACS function list of example 2

3.3 Exercise 3

Description

Write a Fupla program which contains the following scenario:

If the outside temperature (B01) is smaller than the supply air temperature (B03) and the discharging air temperature (B04) then open the damper actuators (M01) 20% else 50%.

The supply air ventilator (M04) should run with 50%, but in case the frost protection (S01) is on, it should run with 100%. The discharging air ventilator (M05) should also run with 50%, but if the discharging air temperature is bigger than the supply air temperature and the supply air temperature is smaller than 23 degree celsius then it should run with 100%.

If the humidity (B03) is lower than 50% then start the humidifier (A04).

If the supply air temperature is lower than 23 degree Celsius then start the heating (A06) else start the AC system (A03). The correct pump (M02, M03) should also be adjusted with 50% the other one with 0%.

If the condensate protection (S05) is on then switch the light on (A12, A13) and close the sun blind (A11) else switch the light off and open the sun blind.

Realisieren Sie ein Fupla Program für folgedes Szenario:

Überprüfen Sie, ob die Aussentemperatur (B01) kleiner der Zuluft (B03) und grösser der Abluft Temperatur (B04) ist. Ist dies der Fall sollen die Klappen (M01) nur 20% geöffnet werden, sonst 50%.

Der Zuluft Ventilator (M04) soll mit 50% laufen, wird jedoch der Störmelder Frostschutz (S01) aktiv, soll der Zuluft Ventilator mit 100% angetrieben werden. Der Abluft Ventilator (M05) soll ebenso mit 50% laufen, ausser die Überprüfung (Temperatur Abluft grösser Temperatur Zuluft und Temperatur Zuluft kleiner 23 Grad Celsius (in PG5 als 2300 anzugeben)) ist TRUE, dann soll der Abluft Ventilator mit 100% laufen.

Desweiteren muss die Luftfeuchte der Zuluft (B03) überwacht werden und im Falle, dass diese unter 50% fällt, der Befeuchter (A04) eingeschaltet werden.

Sollte die Zuluft Temperatur unter 23 Grad Celsius fallen, muss die Heizung (A06) eingeschaltet werden, ansonsten ist die Klimaanlage (A03) aktiv. Es soll auch immer die passende Pumpe (M02, M03) mit 50% Leistung betrieben werden. Die nichtverwendete Pumpe soll deaktiviert sein.

Als letzter Punkt soll bei aktivem Kondensatmelder (S05) das Licht (A12, A13) eingeschalten und die Jalousie (A11) geschlossen werden, ansonsten das Licht ausgeschalten und die Jalousie geöffnet werden.

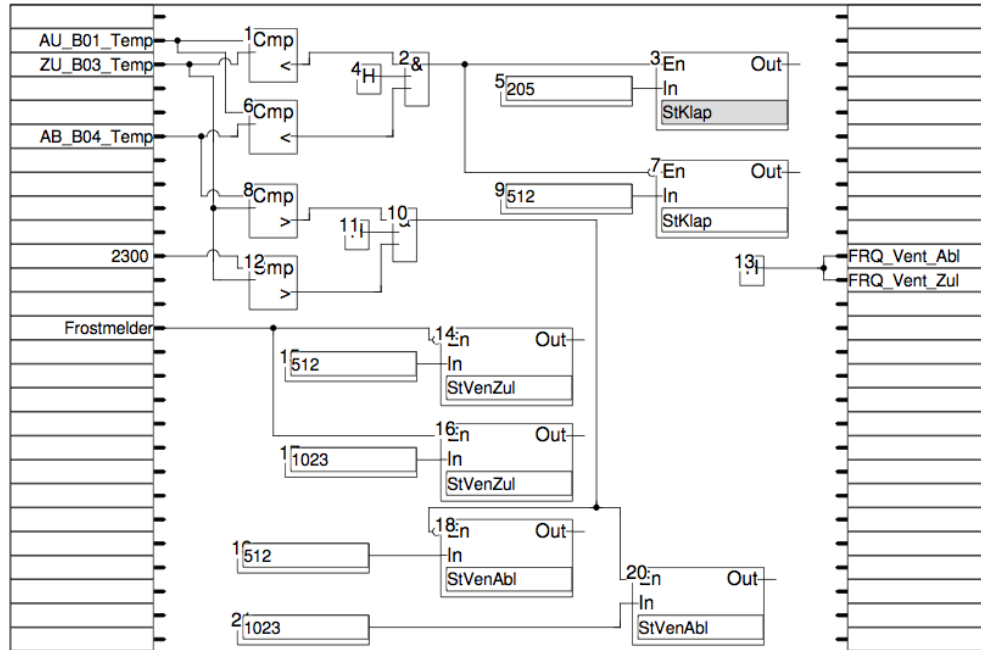
Solution

Figure 16: Fupla program for example 3, page 1

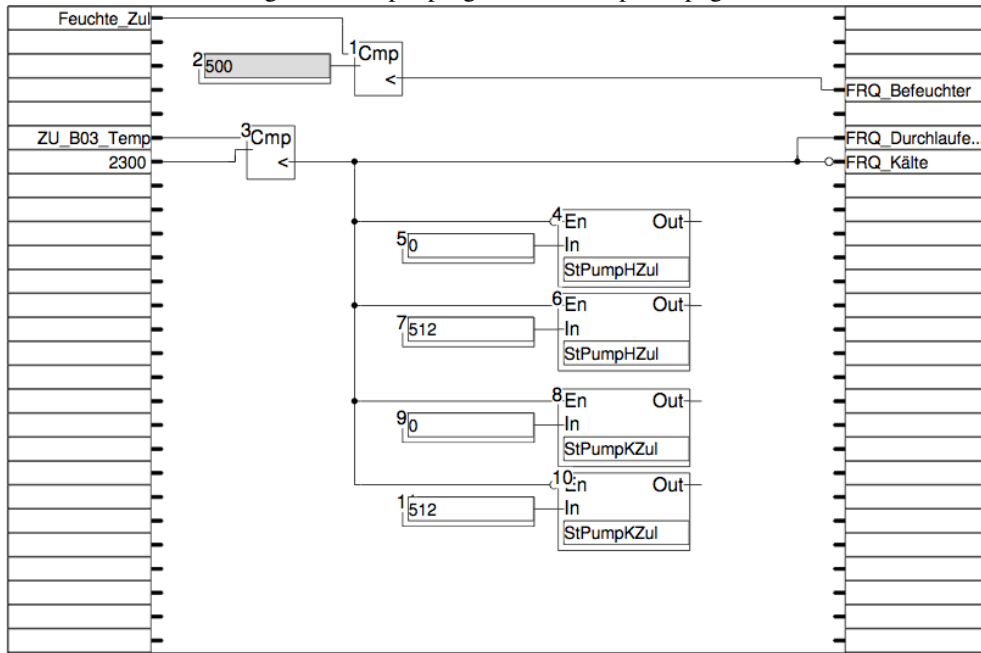


Figure 17: Fupla program for example 3, page 2

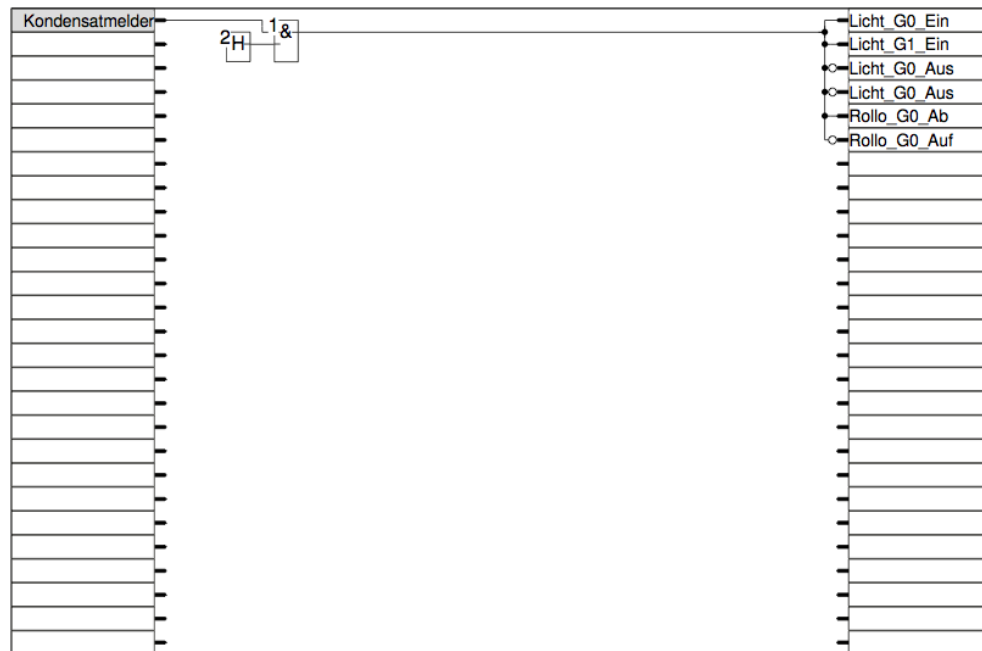


Figure 18: Fupla program for example 3, page 3

Trade:		IO Functions										Processing Functions										Calculation/Optimisation										Management Functions										Operator Functions									
Plant:		Monitoring										Closed Loop Control										Control										Control										Control									
Description		Physical										Methods										Methods										Methods										Methods									
Data point/object		Physical										Methods										Methods										Methods										Methods									
1) Steady State Output: e.g. 0.1 to 2.80		Physical										Methods										Methods										Methods										Methods									
2) Active or passive		Physical										Methods										Methods										Methods										Methods									
3) Shared IO data points from foreign systems for intergrated functions, incl. via DDU		Physical										Methods										Methods										Methods										Methods									
4) For input point address for collected delay or suppressed information		Physical										Methods										Methods										Methods										Methods									
5) For output point address		Physical										Methods										Methods										Methods										Methods									
6) For coding/heating use 25 On/Off outputs		Physical										Methods										Methods										Methods										Methods									
7) For input point address		Physical										Methods										Methods										Methods										Methods									
8) e.g. Device, schedule, library, loop, file (see EN ISO 14644-5)		Physical										Methods										Methods										Methods										Methods									
9) If required, indicate whether applies to client „A“ or server „B“		Physical										Methods										Methods										Methods										Methods									
10) For output point address		Physical										Methods										Methods										Methods										Methods									
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4 Outlook

The described exercises for the Saia-Burgess components done within this work are the basis for future extensions.

Currently, the VDI is working on the VDI 3813-2 standard [4]. This standard, together with the VDI 3813-1 [3], should support investors, owners, users and all the other people involved in a building automation project during the planning phase. Room automation can help in a lot of cases to make the room more comfortable and to save energy and costs in the end. But it is sometimes hard to find a good solution at the beginning of the project, as the owners and investors have not enough information about room automation, and planners of different companies have different solutions used in former times. Here the VDI 3813 should help to explain all the details used within the room automation and give the planners a documented way to describe all the requirements and desires of the owners. VDI 3813-1 starts to describe the room control functions on the basis of utilization requirements, without defining the hardware, software and communications technology used in the end. With VDI 3813-2 it is now possible to document the functions of a room automation system in a well known and standardized way, which makes it again easier to plan and calculate the project in the beginning.

This standard, especially the second part, includes some good examples which can be implemented with the Saia-Burgess components. First, the students should find out how functions are described within the VDI 3813. Then they should work out several functions using the Saia-Burgess configuration.

One example can be to work out the staircase light function. With this function the light could be turned on for a predefined time. If the user presses a switch the time will be reseted, otherwise lights are switched off again automatically. It is also possible to warn the user before lights are switched off.



Abkürzungen im Funktionsblock		
Bezeichnung	Typ	Beschreibung
<i>Eingabeinformationen</i>		
L_MAN	Licht	Stellwert der Beleuchtung durch Bedienfunktion
<i>Ausgabeinformationen</i>		
L_SET	Licht	Stellwert für zugehörige Aktorfunktionen inkl. Verzögerung
<i>Parameter</i>		
PAR_HOLD	Zeit	Treppenlichthaltezeit
PAR_WARN	Zeit	Abschaltvorwarnzeit

Figure 20: Functionblock staircase light

5 Conclusion

The theoretical part of this thesis focused on two standards, namely DIN EN ISO 16484-3 and VDI 3814-1. They describe in detail the function of a Building Automation and Control System and give people a good overview to implement and maintain such systems. Especially the part of the functions is similar in both standards. This is because the DIN EN ISO 16484-3 is an international standard which is also part of the regional standard VDI 3814-1, which extends the international standard only in some parts where the regional law is different. On the other hand these standard are also in some other topics different which was discussed in a short comparison within this thesis.

To have a look how to work in a practical way with these standards one topic of this thesis was to create the BACS function list of an HVAC model from the Distributed Automation System Lab. The second practical part was to use this model in combination with Saia-Burgess products. It was shown how to configure the DDC with the Software PG5. The thesis is concluded with three lab exercises pointing out how the underlying DDC must be programmed to control parts of the HVAC model.

References

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- [2] *Official homepage of Saia-Burgess; www.saia-pcd.com.*
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- [6] Saia-Burgess. *Das Programmier-Werkzeug der Steuerungen SAIA PCD.*
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- [10] Thomas Wimmer. *Kurzdokumentation und Übungsbeispiele zu Saia-Burgess. Technical Report 183/1-150, A-Lab @ Automation Systems Group, TU Vienna, April 2010.*