JAI Congress 2007, VIGO

Benefits of modern PLC technology for industrial applications

November 30th, 2007

Vigo, JAI Congress 2007

University of Applied Science
Department of Electrical Engineering
Goebenstr. 40
D-66117 Saarbrücken

Curriculum Vitae

Data:

Name: Benedikt Faupel

Education:

1981-1987 Study of Electrical Engineering at the University of Aachen / Qualification Graduate (Diploma)

1987-1992 Member of Laboratory of Machine Tools and Production Technology at the University of Aachen (WZL)
Qualification: PhD
Research Work: Expert systems / Technical Diagnosis

www.rwth-aachen.de

Curriculum Vitae

Since 2002	HTW, University of Applied Science Department of Electrical Engineering
www.htw-saarland.de	
1992-1997	SICOWA Process technology for building materials Leader of department of Electrical, Control- and Automation Technoloy
1998-2002	Otto-Junker GmbH – Heat Treatment Technology Leader of Process Technology

Curriculum Vitae / Career as Professor

Since 2002

www.htw-saarland.de

HTW, University of Applied Science
Department of Electrical Engineering

Leader Laboratory Process Automation &
Control Technology

Research: Automation with PLC-Technology
Use of Simulation Tools

Eduacation: Control Loop Technology
Process Automation
Simulation Technology

Organization: Member/Leader of ECTS-Team

Research Topic – Use of Simulation Tools

Matlab/Simulink

- Control Loop Technology
- Process Identification
- Fuzzy Control
- State control technology
- Digital Control Technology

New: LabVIEW

- Measurement & Control Loop Application

Research Topic – Automation with PLC

Training in PLC-Systems (Siemens)

- Modern Programmable Languages (S7-HiGraph, SL, CFC, SIMIT)
- Communication technology (ASI, Profibus DP, Hart, Ethernet)
- Safety Concepts (ProfiSafe)
- Automation and Drive Control
- Process Control and Controller Design
- Visualization with WinCC-flexible

Realized Industrial Projects

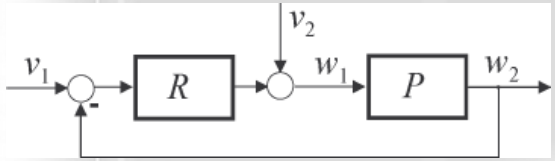
- Process Control „Heat-Treatment-Application“ (2007)
- Automation of a Lab-Press System (2007)
- Drive Control „Flying Saw-Application“ (2006)
- Process Optimization „Brewery Karlsbräu Saverne“ (2005-2007)
- Simulation Testsystem „Dillinger Hütte“ (2007)

Process Control Application

Education
- Operation of controller design
- Process-Modelling
- State of the Art
- View on industrial approaches

Economics
- Low costs for realization
- Short implementation time
- Staff training

Lab application



Industrial application

Technical Requirements
- Process-Identification
- Controller Design
- Process-Optimization

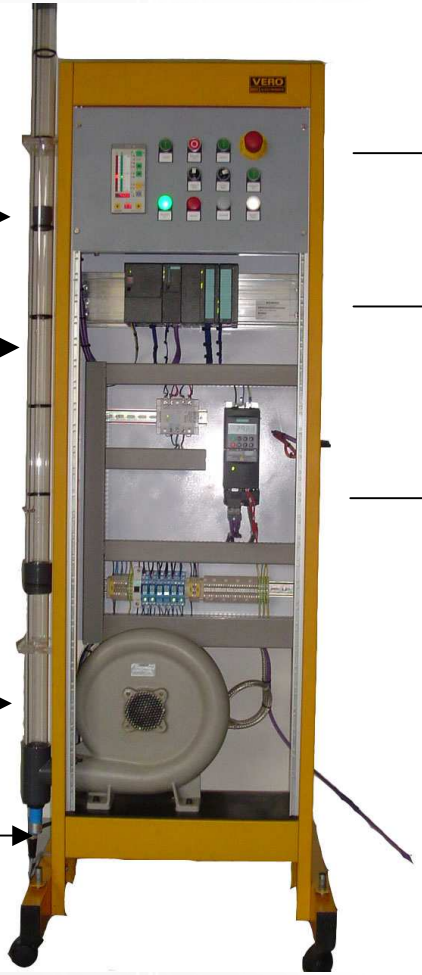
Technical Requirements
- Substitution / Modernization
- Process-Optimization
- Standard Function Blocks
- Quality Management

Process Control Application

Lab application

Industrial application

Lab application



float type

pipe

fan

ultrasonic sensor

operation panel
process controller

PLC (S7-313C-2DP)
interface to engineering station

frequency converter

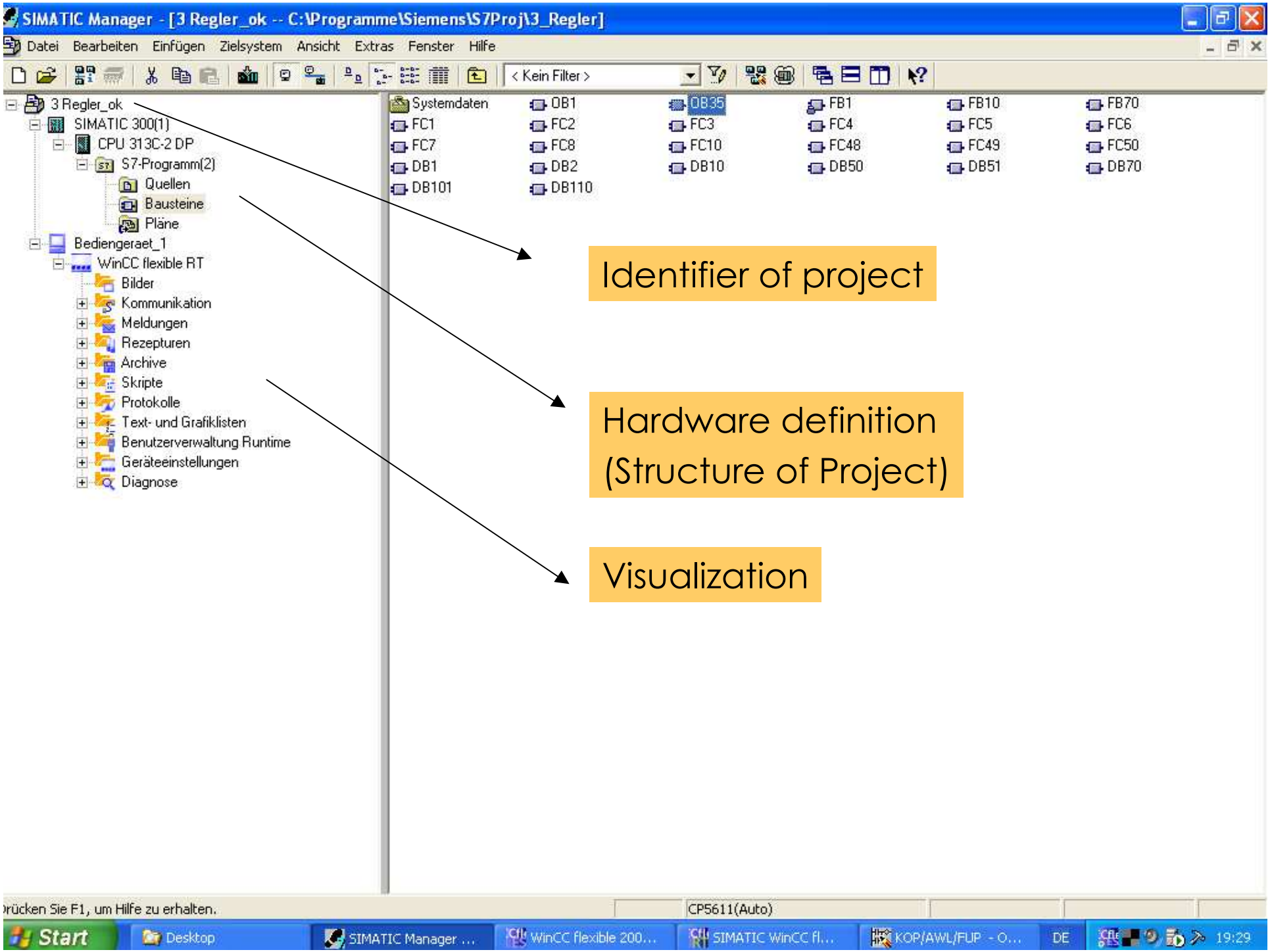
Lab application

Task: Level Control Design

- Realization of PLC-Solution
- Experience with different Controller Tools
- Experience with signal matching sensors/actuators
- Finding of optimized controller settings
- Data Exchange / Communication
- Process-Optimization
- Vizualization

Selection guide for controller devices

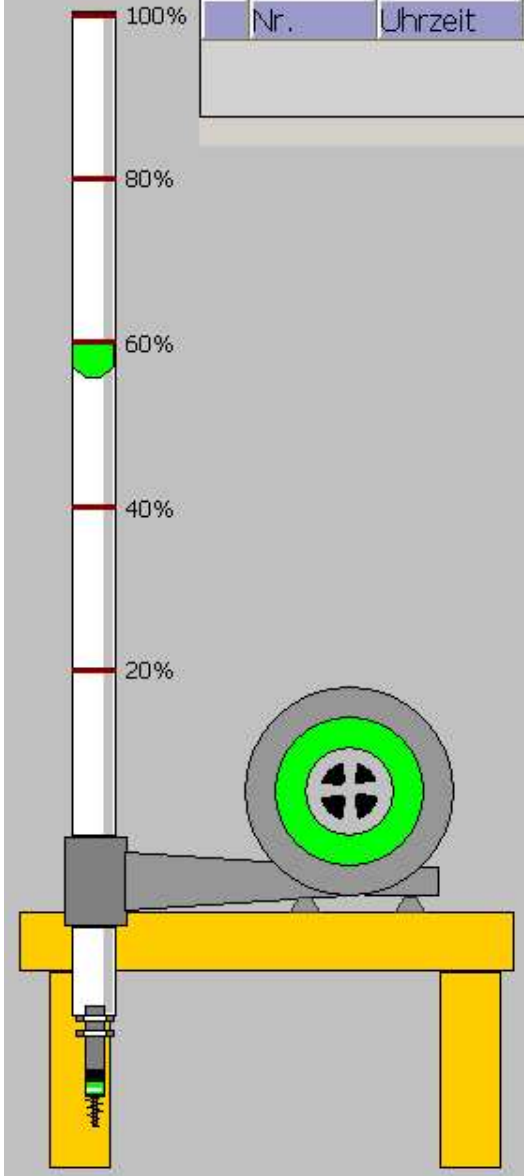
Task	Process Control device for temperature, flow level and pressure control			
Require-ments	Simple	Middle	High permformance	
Realization	Software	Software	Software	HW-IO-Device
Product label	PID Control	Standard PID-Control	Modular PID-Control	FM 355C, FM 355S FM 455C, FM 455S
Type	Flexible integrated in SIMATIC S7-300, S7-400, C7, ET200			
Features	continuous controller; step-controller; pulse-controller			
Functions	• Basic control loop functions	• Basix & specialized control loop functions		• Specialized control loop functions • Active in case of stop or CPU failure
	Comfortable online optimization for all controllers using PID-Self Tuner			
Function blocks	FB 41 FB 42 FB 43	FB 1 FB 2 FC 1	27 standard function blocks	K-controller: FM 355C/455C S-controller: FM355S/455S Pulse-controller: FM 355S/455S
Controller Structure	Integrated functions Flexible settings of parameters possible		Free configur-able: Function-blocks can be combined and connected	Already defined; adapted configuration of control structure and processing functions
Added tools	Tabulated overview on parameter settings	Graphic tools with comfortable masks to adapt parameter settings; online changes directly active and documentated		


SIMATIC Manager - [3 Regler_ok -- C:\Programme\Siemens\S7Proj\3_Regler]
Datei Bearbeiten Einfügen Zielsystem Ansicht Extras Fenster Hilfe
< Kein Filter >
3 Regler_ok
SIMATIC 300(1)
CPU 313C-2 DP
S7-Programm(2)
Quellen
Bausteine
Pläne
Bediengeraet_1
WinCC flexible RT
Bilder
Kommunikation
Meldungen
Rezepturen
Archive
Skripte
Protokolle
Text- und Grafiklisten
Benutzerverwaltung Runtime
Geräteeinstellungen
Diagnose
Systemdaten
OB1
OB35
FB1
FB10
FB70
FC1
FC2
FC3
FC4
FC5
FC6
FC7
FC8
FC10
FC48
FC49
FC50
DB1
DB2
DB10
DB50
DB51
DB70
DB101
DB110
Identifier of project
Hardware definition
(Structure of Project)
Visualization
rücken Sie F1, um Hilfe zu erhalten.
CP5611(Auto)
Start
Desktop
SIMATIC Manager ...
WinCC flexible 200...
SIMATIC WinCC fl...
KOP/AWL/FUP - O...
DE
19:29

Startbild

19:02:45
30.10.2007

Nr.	Uhrzeit	Datum	Zustand	Text	QGR



Bedienfunktionen:

Langsam | Ventilator Aus | Schnell

Ventilator Ein

Störung

Betrieb Vor Ort | Betrieb mit WinCC

Betriebsartenauswahl:

Hand | Standard PID

Wellen-Reuther | Prozessregler SIPART DR 21

Objekthöhe 60,4 %

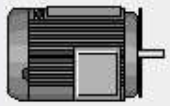
Reglereinstellungen (Standard PID):

Sollwert (w):	60,0	Istwert (x):	60,4
Regeldif. (e):	-0,4	Stellgröße (y):	32,1

KP: 18

TD: 0 ms TI: 1700 ms

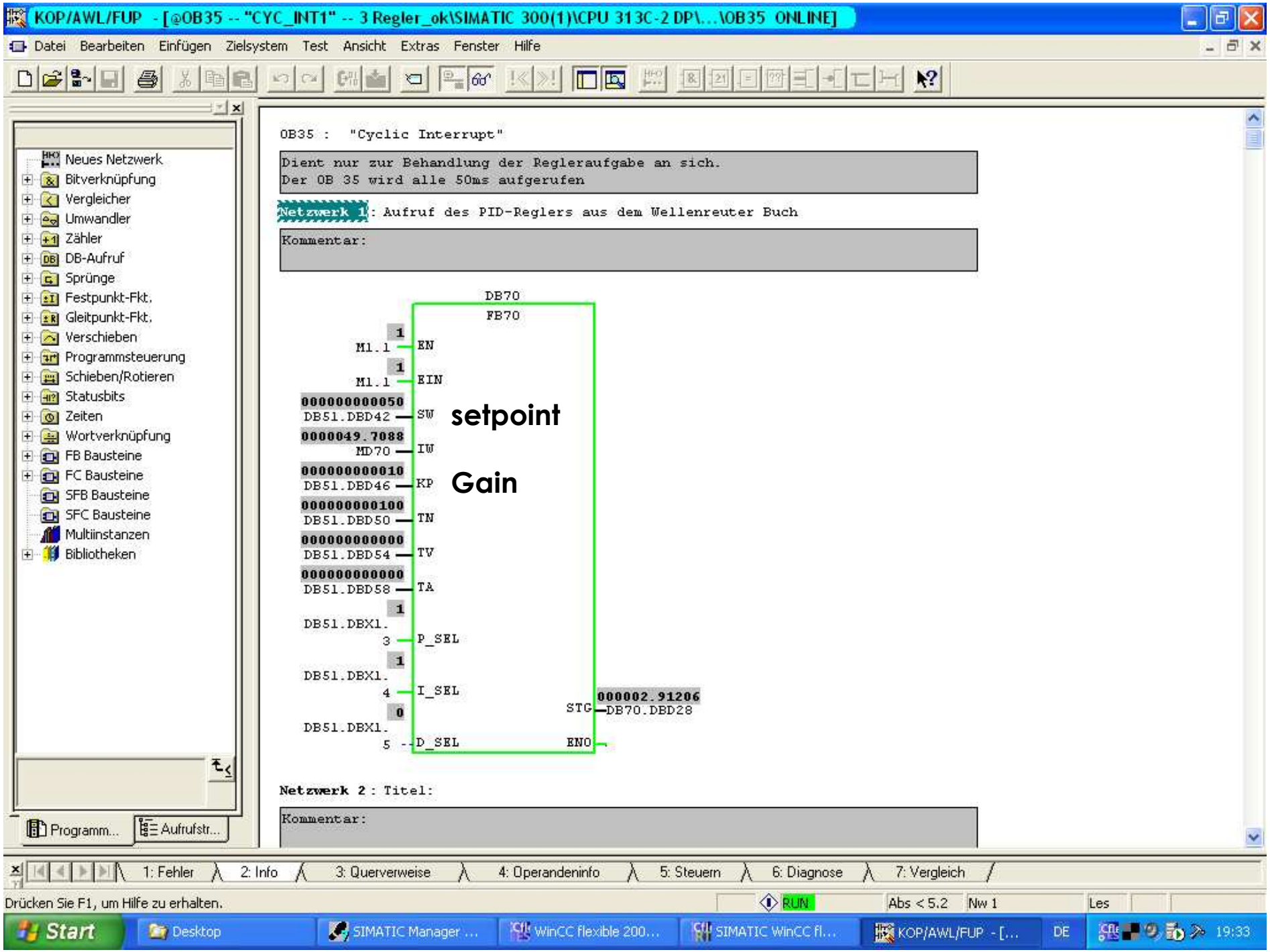
Motordaten:



Frequenz: 31,98 Hz: Drehzahl: 0 1/min

Labor für Prozessautomatisierung
Prof.Dr.Ing. Bendedikt Faupel
Dipl.Ing. Christian Dräger

Startbild | Detailansicht Handbetrieb | Detailansicht Standard PID | Detailansicht Wellenreuther | Detailansicht Prozessregler | Meldungen | Runtime Verlassen


KOP/AWL/FUP - [@OB35 -- "CYC_INT1" -- 3 Regler_ok\SIMATIC 300(1)\CPU 313C-2 DP\...\OB35 ONLINE]
Datei Bearbeiten Einfügen Zielsystem Test Ansicht Extras Fenster Hilfe
Neues Netzwerk
Bitverknüpfung
Vergleicher
Umwandler
Zähler
DB-Aufruf
Sprünge
Festpunkt-Fkt.
Gleitpunkt-Fkt.
Verschieben
Programmsteuerung
Schieben/Rotieren
Statusbits
Zeiten
Wortverknüpfung
FB Bausteine
FC Bausteine
SFB Bausteine
SFC Bausteine
Multiinstanzen
Bibliotheken
Programm...
Aufrufstr...
OB35 : "Cyclic Interrupt"
Dient nur zur Behandlung der Regleraufgabe an sich.
Der OB 35 wird alle 50ms aufgerufen
Netzwerk 1: Aufruf des PID-Reglers aus dem Wellenreuter Buch
Kommentar:
DB70
FB70
1
M1.1 EN
1
M1.1 EIN
000000000050
DB51.DBD42 SW
setpoint
0000049.7088
MD70 IW
000000000010
DB51.DBD46 KP
Gain
000000000100
DB51.DBD50 TN
000000000000
DB51.DBD54 TV
000000000000
DB51.DBD58 TA
1
DB51.DBX1.
3 P_SEL
1
DB51.DBX1.
4 I_SEL
0
DB51.DBX1.
5 D_SEL
000002.91206
STG DB70.DBD28
ENO
Netzwerk 2 : Titel:
Kommentar:
1: Fehler
2: Info
3: Querverweise
4: Operandeninfo
5: Steuern
6: Diagnose
7: Vergleich
Drücken Sie F1, um Hilfe zu erhalten.
RUN
Abs < 5.2
Nw 1
Les
Start
Desktop
SIMATIC Manager ...
WinCC flexible 200...
SIMATIC WinCC fl...
KOP/AWL/FUP - [...
DE
19:33

Wellenreuther (FB70)

19:04:58
30.10.2007

100%
80%
60%
40%
20%

Objekthöhe 78,2 %

Motordaten:

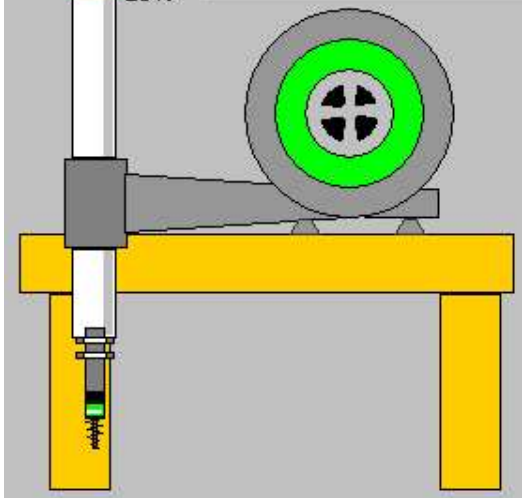
Frequenz: 32,6

Drehzahl: 0

Ventilator Ein | Störung | Ventilator Aus

Betrieb Vor Ort

Betrieb mit WinCC



Auswahl Anteil:

P | I | D

Reglereinstellungen (FB70):

Sollwert (w): 80,0 | Istwert (x): 78,2

Regeldif. (e): 1,8 | Stellgröße (y): 6,4

KP: 4

TN: 3 ms TV: 0 ms TA: 0 ms

Offsetwerte und Anpassungen:

Offset bei positiver Führungsgröße:

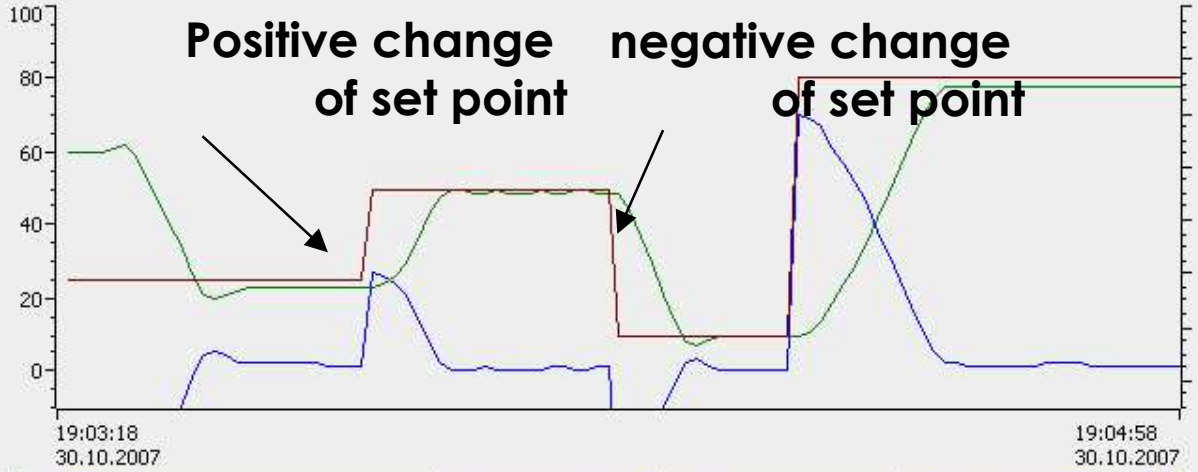
Offsetwert: 29,68 Hz:

Offset bei negativer Führungsgröße:

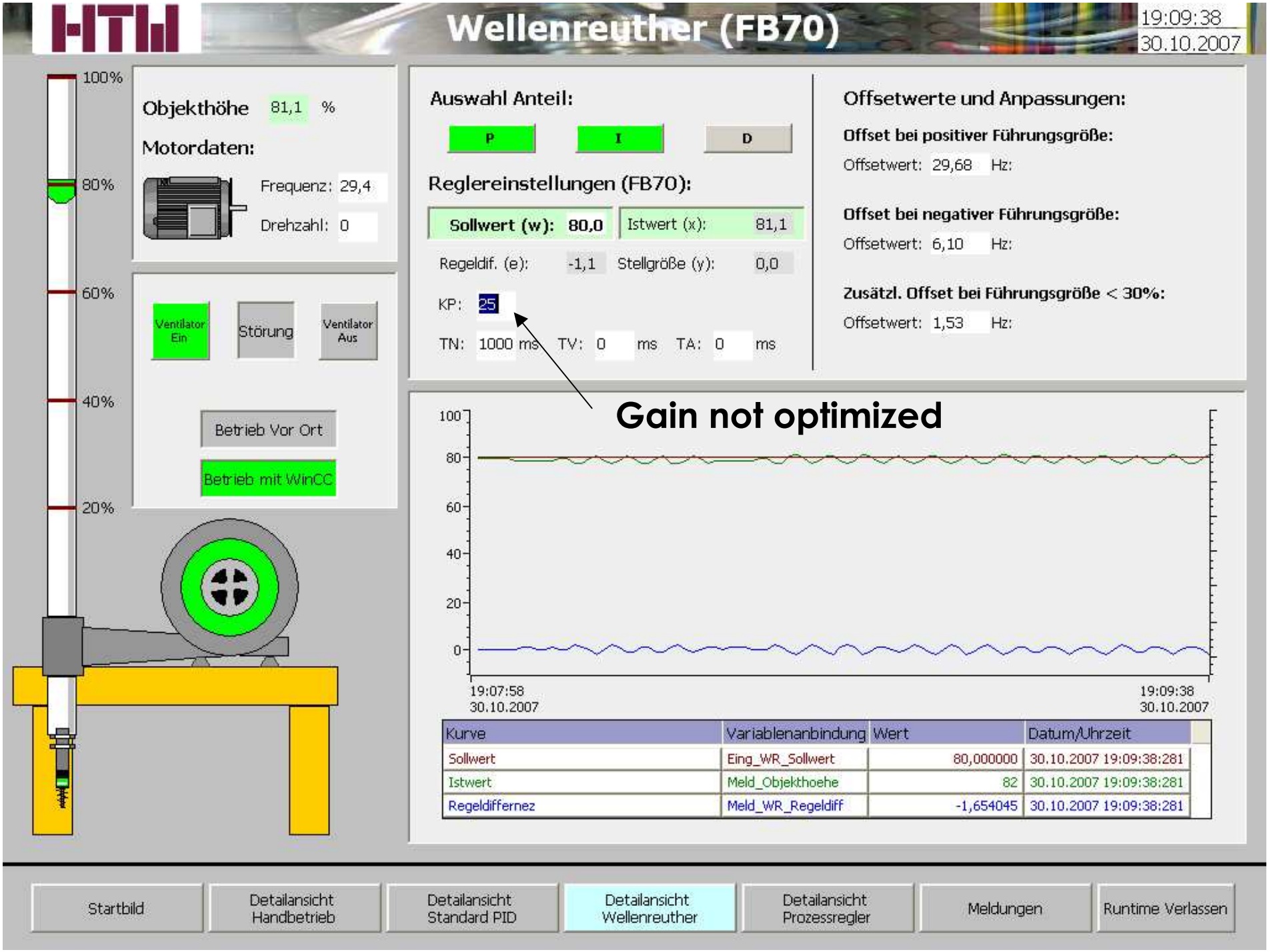
Offsetwert: 6,10 Hz:

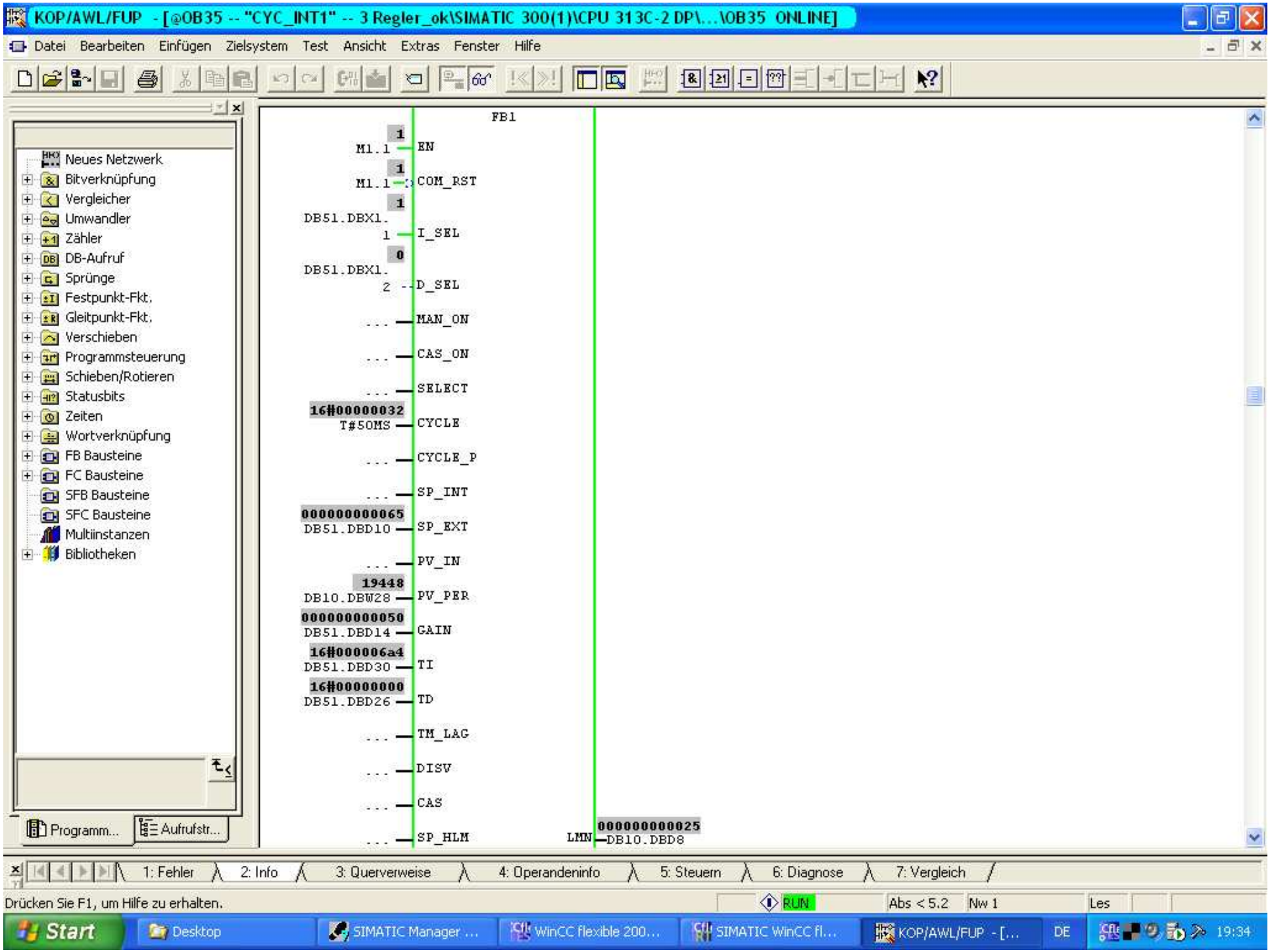
Zusätzl. Offset bei Führungsgröße < 30%:

Offsetwert: 1,53 Hz:



Kurve	Variablenanbindung	Wert	Datum/Uhrzeit
Sollwert	Eing_WR_Sollwert	80,000000	30.10.2007 19:04:58:264
Istwert	Meld_Objekthoehe	78	30.10.2007 19:04:58:264
Regeldifferenz	Meld_WR_Regeldiff	1,811302	30.10.2007 19:04:58:264


HTW
Wellenreuther (FB70)
19:09:38
30.10.2007
100%
80%
60%
40%
20%
Objekthöhe 81,1 %
Motordaten:
Frequenz: 29,4
Drehzahl: 0
Ventilator Ein
Störung
Ventilator Aus
Betrieb Vor Ort
Betrieb mit WinCC
Auswahl Anteil:
P
I
D
Reglereinstellungen (FB70):
Sollwert (w): 80,0
Istwert (x): 81,1
Regeldif. (e): -1,1
Stellgröße (y): 0,0
KP: 25
TN: 1000 ms
TV: 0 ms
TA: 0 ms
Offsetwerte und Anpassungen:
Offset bei positiver Führungsgröße:
Offsetwert: 29,68 Hz:
Offset bei negativer Führungsgröße:
Offsetwert: 6,10 Hz:
Zusätzl. Offset bei Führungsgröße < 30%:
Offsetwert: 1,53 Hz:
Gain not optimized
100
80
60
40
20
0
19:07:58
30.10.2007
19:09:38
30.10.2007
Kurve
Variablenanbindung
Wert
Datum/Uhrzeit
Sollwert
Eing_WR_Sollwert
80,000000
30.10.2007 19:09:38:281
Istwert
Meld_Objekthoehe
82
30.10.2007 19:09:38:281
Regeldifferenz
Meld_WR_Regeldiff
-1,654045
30.10.2007 19:09:38:281
Startbild
Detailansicht Handbetrieb
Detailansicht Standard PID
Detailansicht Wellenreuther
Detailansicht Prozessregler
Meldungen
Runtime Verlassen


KOP/AWL/FUP - [@OB35 -- "CYC_INT1" -- 3 Regler_ok\SIMATIC 300(1)\CPU 313C-2 DP\...\OB35 ONLINE]
Datei Bearbeiten Einfügen Zielsystem Test Ansicht Extras Fenster Hilfe
Neues Netzwerk
Bitverknüpfung
Vergleicher
Umwandler
Zähler
DB-Aufruf
Sprünge
Festpunkt-Fkt.
Gleitpunkt-Fkt.
Verschieben
Programmsteuerung
Schieben/Rotieren
Statusbits
Zeiten
Wortverknüpfung
FB Bausteine
FC Bausteine
SFB Bausteine
SFC Bausteine
Multiinstanzen
Bibliotheken
Programm...
Aufrufstr...
FB1
1
M1.1 EN
1
M1.1 COM_RST
1
DB51.DBX1.
1 I_SEL
0
DB51.DBX1.
2 D_SEL
... MAN_ON
... CAS_ON
... SELECT
16#00000032
T#50MS CYCLE
... CYCLE_P
... SP_INT
000000000065
DB51.DBD10 SP_EXT
... PV_IN
19448
DB10.DBW28 PV_PER
000000000050
DB51.DBD14 GAIN
16#000006a4
DB51.DBD30 TI
16#00000000
DB51.DBD26 TD
... TM_LAG
... DISV
... CAS
... SP_HLM
LMN 000000000025
DB10.DBD8
1: Fehler
2: Info
3: Querverweise
4: Operandeninfo
5: Steuern
6: Diagnose
7: Vergleich
Drücken Sie F1, um Hilfe zu erhalten.
RUN
Abs < 5.2
Nw 1
Les
Start
Desktop
SIMATIC Manager ...
WinCC flexible 200...
SIMATIC WinCC fl...
KOP/AWL/FUP - [...
DE
19:34

Standard PID

19:18:30
30.10.2007

100%
80%
60%
40%
20%

Objekthöhe 60,3 %

Motordaten:

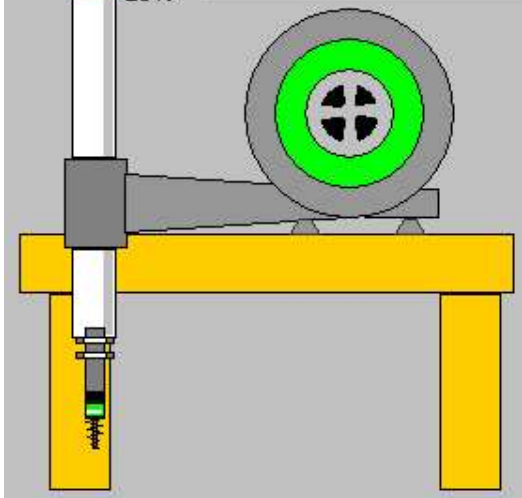
Frequenz: 31,3

Drehzahl: 0

Ventilator Ein | Störung | Ventilator Aus

Betrieb Vor Ort

Betrieb mit WinCC



Auswahl Anteil:

P | I | D

Reglereinstellungen (Standard PID):

Sollwert (w): 60,0 | Istwert (x): 60,3

Regeldif. (e): -0,3 | Stellgröße (y): 31,5

KP: 18

TD: 0 ms TI: 1700 ms

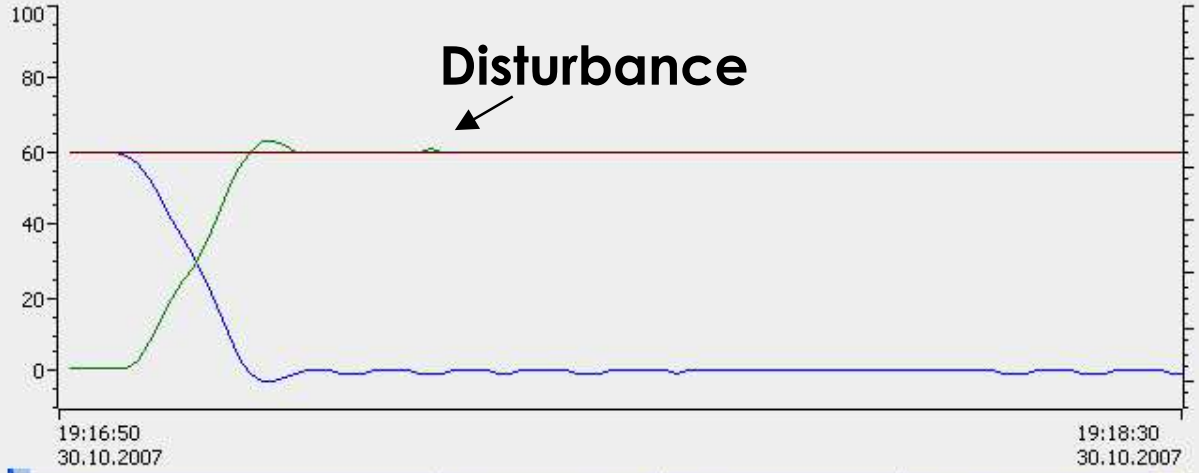
Offsetwerte und Anpassungen:

Begrenzung des Stellwertes:

obere Begrenzung: 200 untere Begrenzung: -50

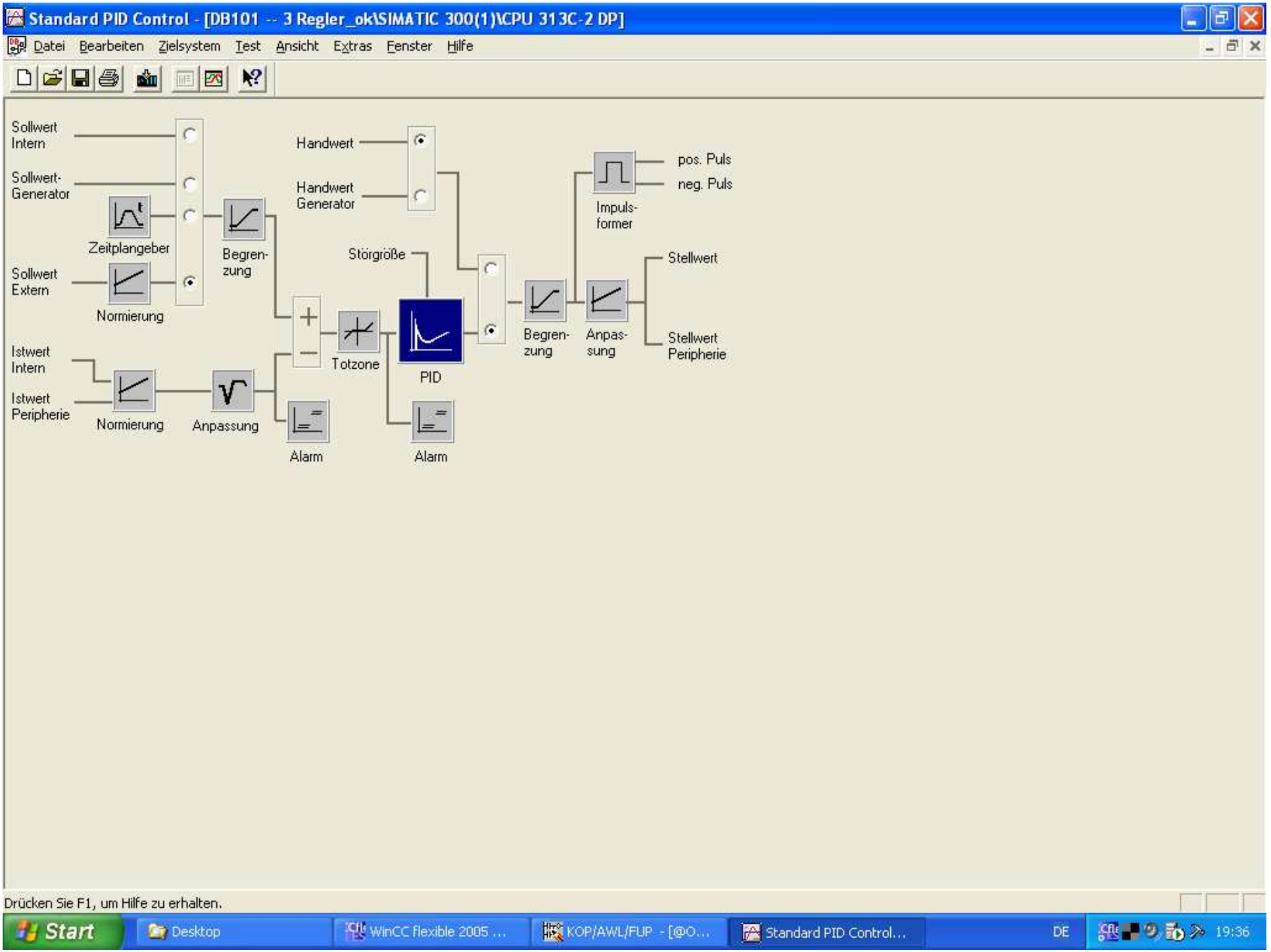
Anpassung des Stellwertes:

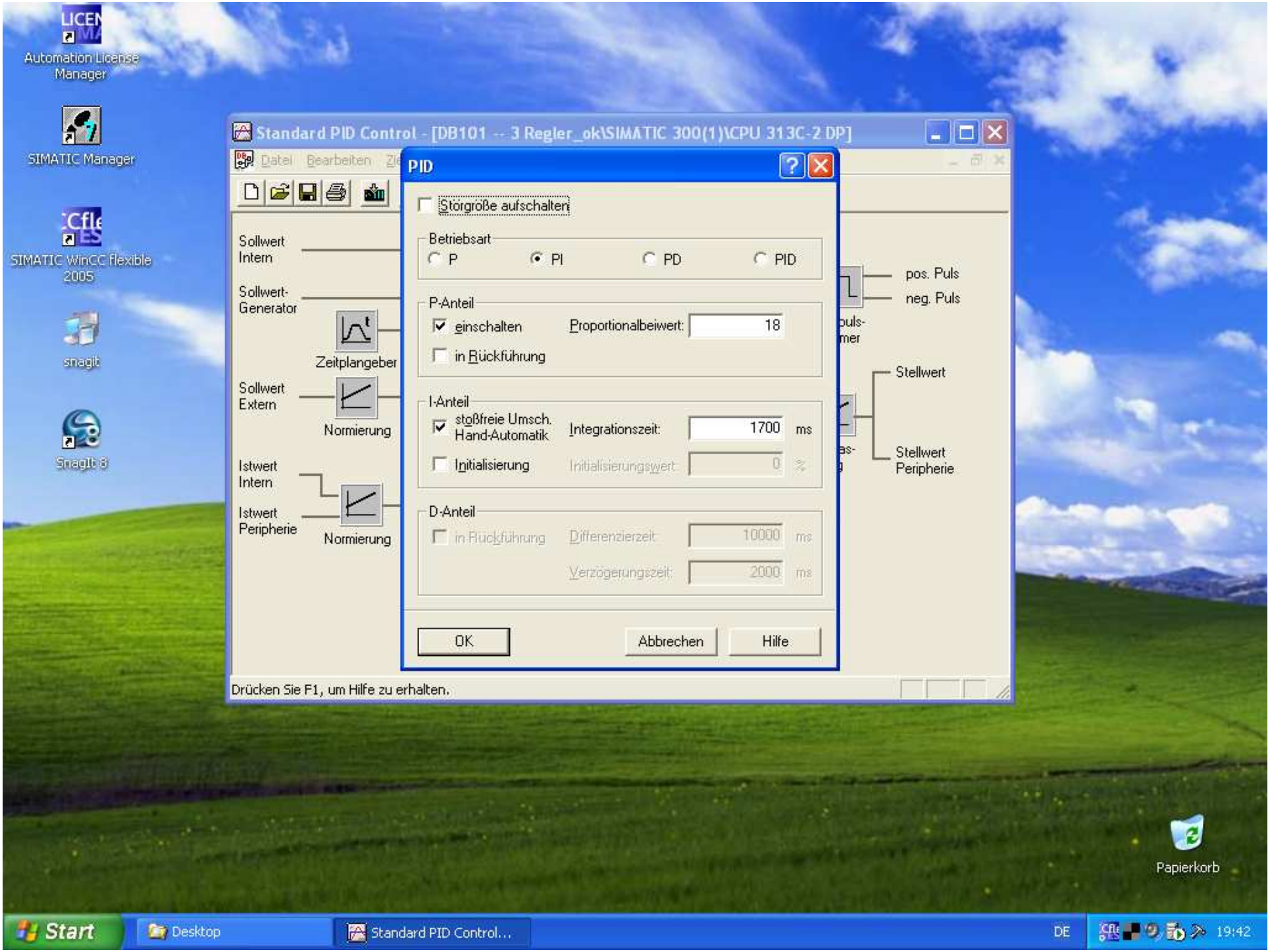
Stellwertfaktor: 0,10 Stellwertoffset: 30

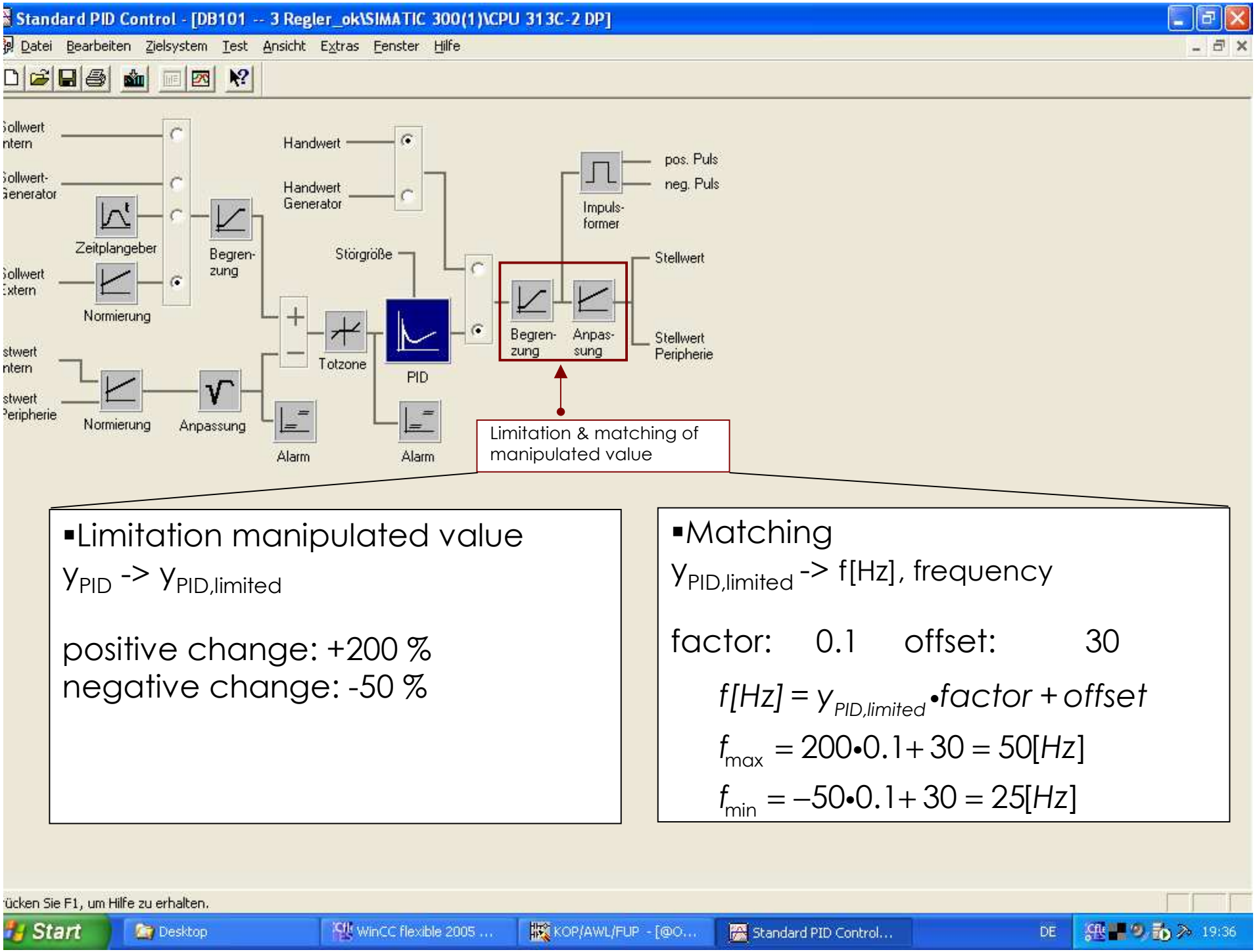


Kurve	Variablenanbindung	Wert	Datum/Uhrzeit
Sollwert	Eing_SPID_Sollwert	60,000000	30.10.2007 19:18:30:264
Istwert	Meld_Objekthoehe	60	30.10.2007 19:18:30:264
Regeldifferenz	Meld_SPID_Regeldif	-0,279556	30.10.2007 19:18:30:264

Startbild | Detailansicht Handbetrieb | Detailansicht Standard PID | Detailansicht Wellenreuther | Detailansicht Prozessregler | Meldungen | Runtime Verlassen


Standard PID Control - [DB101 -- 3 Regler_ok\SIMATIC 300(1)\CPU 313C-2 DP]
Datei Bearbeiten Zielsystem Test Ansicht Extras Fenster Hilfe
Sollwert Intern
Sollwert- Generator
Zeitplangeber
Sollwert Extern
Normierung
Begren- zung
Handwert
Handwert Generator
Störgröße
Impuls- former
pos. Puls
neg. Puls
Stellwert
Stellwert Peripherie
Begren- zung
Anpas- sung
Istwert Intern
Istwert Peripherie
Normierung
Anpassung
Totzone
PID
Alarm
Alarm
Drücken Sie F1, um Hilfe zu erhalten.
Start
Desktop
WinCC flexible 2005 ...
KOP/AWL/FUP - [@O...
Standard PID Control...
DE
19:36


Automation License Manager
SIMATIC Manager
SIMATIC WinCC flexible 2005
snagit
SnagIt 8
Standard PID Control - [DB101 -- 3 Regler_ok\SIMATIC 300(1)\CPU 313C-2 DP]
Datei Bearbeiten
Sollwert Intern
Sollwert-Generator
Zeitplangeber
Sollwert Extern
Normierung
Istwert Intern
Istwert Peripherie
Normierung
pos. Puls
neg. Puls
Stellwert
Stellwert Peripherie
Drücken Sie F1, um Hilfe zu erhalten.
PID
Störgröße aufschalten
Betriebsart
P
PI
PD
PID
P-Anteil
einschalten
Proportionalbeiwert: 18
in Rückführung
I-Anteil
stoßfreie Umsch. Hand-Automatik
Integrationszeit: 1700 ms
Initialisierung
Initialisierungswert: 0 %
D-Anteil
in Rückführung
Differenzierzeit: 10000 ms
Verzögerungszeit: 2000 ms
OK
Abbrechen
Hilfe
Papierkorb
Start
Desktop
Standard PID Control...
DE
19:42



▪Limitation manipulated value

y_{PID} -> $y_{PID,limited}$

positive change: +200 %
negative change: -50 %

▪Matching

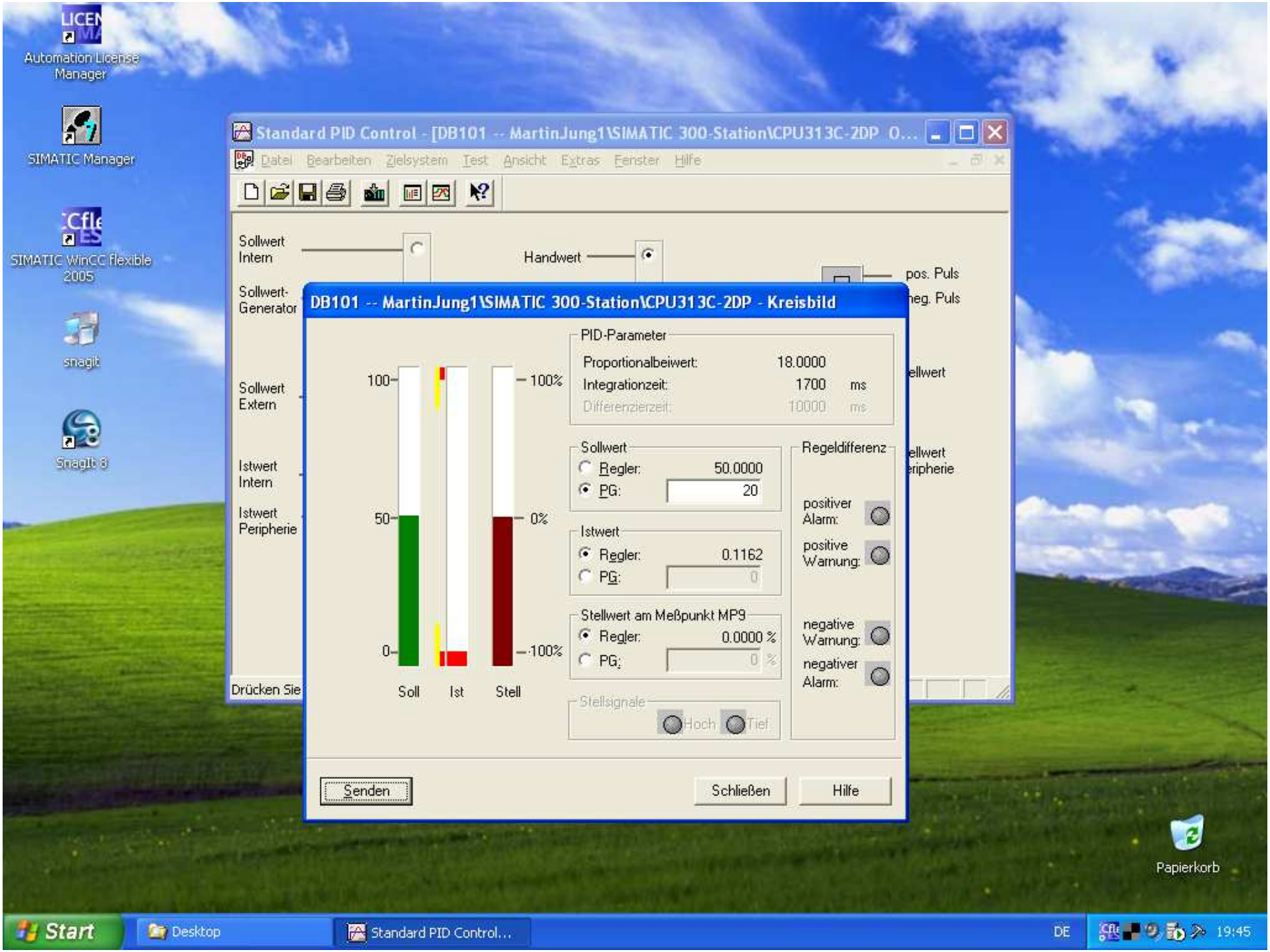
$y_{PID,limited}$ -> f[Hz], frequency

factor: 0.1 offset: 30

$$f[Hz] = y_{PID,limited} \cdot factor + offset$$

$$f_{max} = 200 \cdot 0.1 + 30 = 50[Hz]$$

$$f_{min} = -50 \cdot 0.1 + 30 = 25[Hz]$$


Automation License Manager
SIMATIC Manager
SIMATIC WinCC flexible 2005
snagit
SnagIt 8
Papierkorb
Standard PID Control - [DB101 -- MartinJung1\SIMATIC 300-Station\CPU313C-2DP O...
Datei Bearbeiten Zielsystem Test Ansicht Extras Fenster Hilfe
Sollwert Intern
Handwert
Sollwert-Generator
pos. Puls
neg. Puls
Sollwert Extern
Istwert Intern
Istwert Peripherie
Drücken Sie
DB101 -- MartinJung1\SIMATIC 300-Station\CPU313C-2DP - Kreisbild
PID-Parameter
Proportionalbeiwert: 18.0000
Integrationzeit: 1700 ms
Differenzierzeit: 10000 ms
100
50
0
100%
0%
-100%
Soll
Ist
Stell
Sollwert
Regler: 50.0000
PG: 20
Istwert
Regler: 0.1162
PG: 0
Stellwert am Meßpunkt MP9
Regler: 0.0000 %
PG: 0 %
Stellsignale
Hoch
Tief
Regeldifferenz
positiver Alarm:
positive Warnung:
negative Warnung:
negativer Alarm:
Senden
Schließen
Hilfe
Start
Desktop
Standard PID Control...
DE
19:45

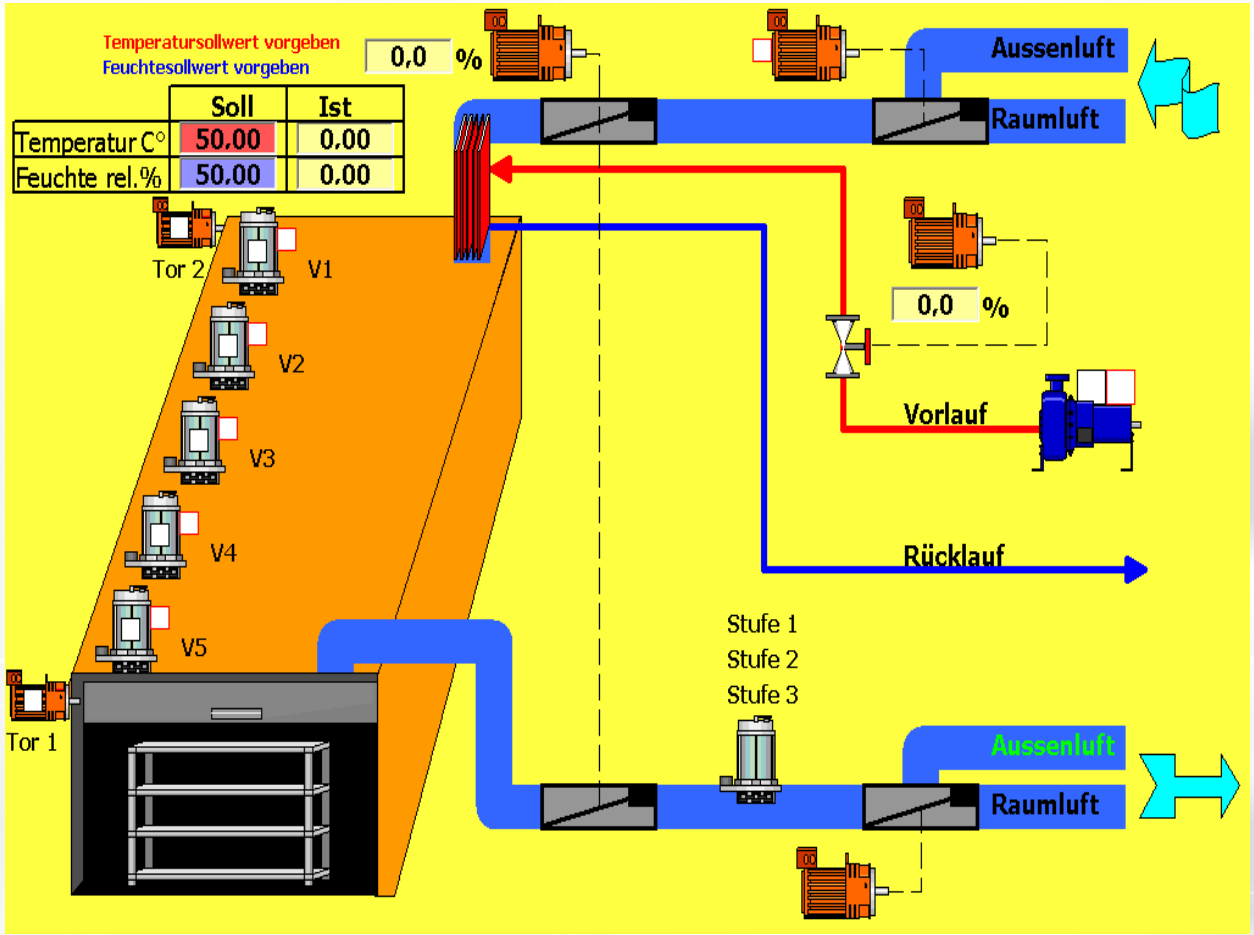
Industrial application (2007)

Process Control Design for
Heat treatment process
(3 Chambers)

Job list:

- PLC-Substitution
- New design of Temperature and Moisture Control
- Process-Optimization
- Vizualization
- Implementation
- Test

Process

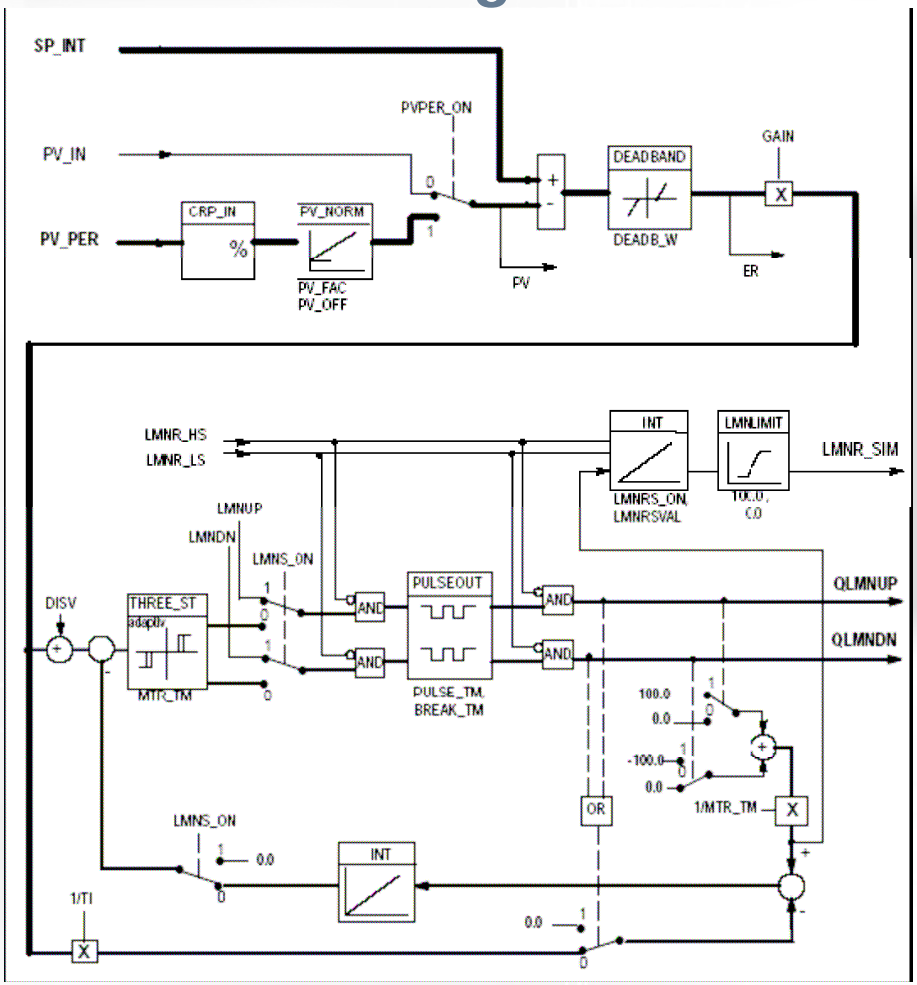


Process Equipment

Control Loop Design

Process value:	temperature, PT100 moisture measuremet device
Control actuators:	valve, powered, no position feedback, integrative actuator airflap, powered, no position feedback integrative actuator
Medium:	heating: heated water
Medium:	moisture: outside air / inside air

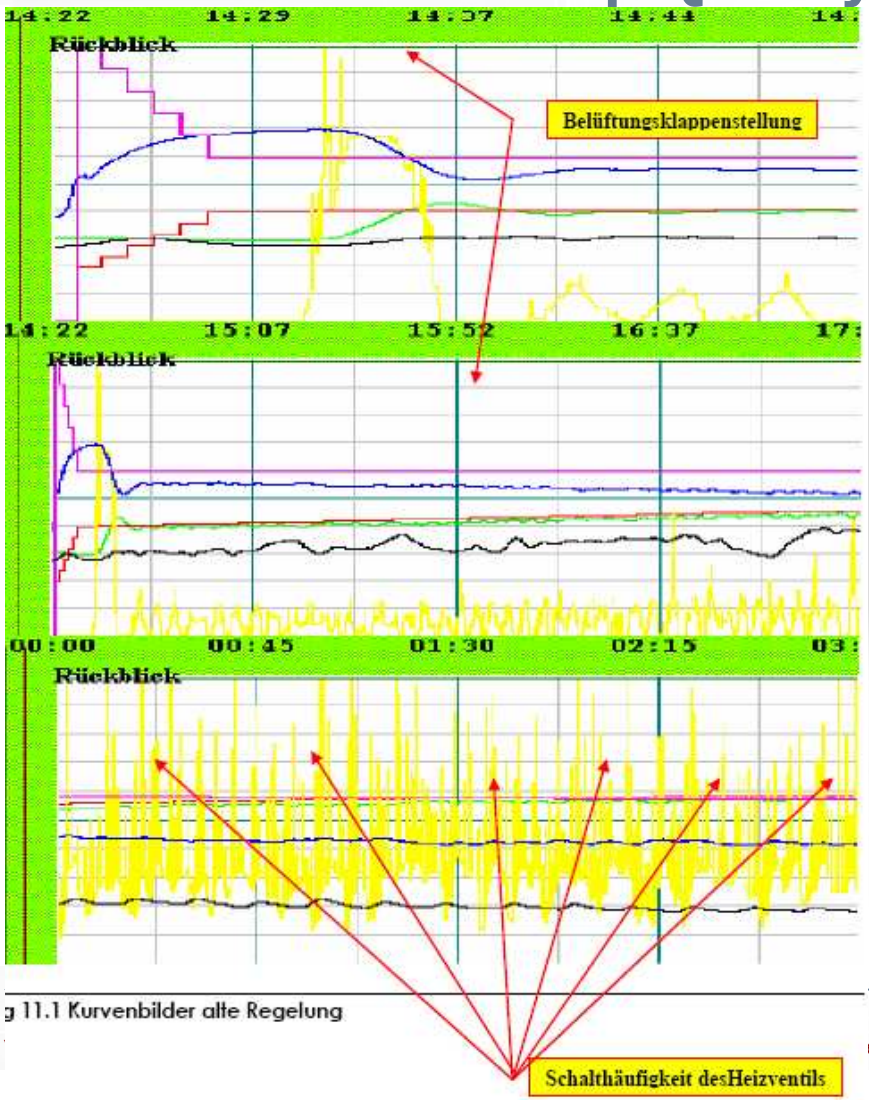
Controller Design



Adapted Controller

- controller FB 42 Step-Controller
- Integrated PI-controller
- Pulse-Modulation

Former Control Loop Quality



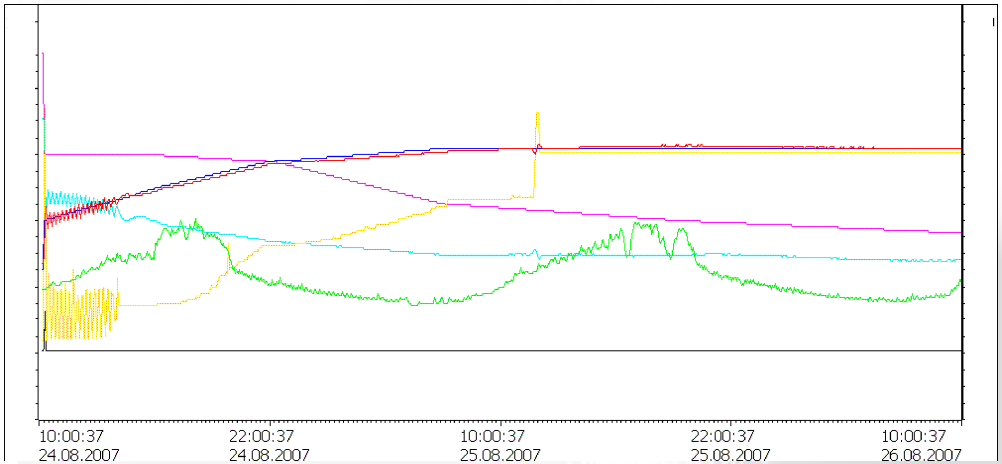
g 11.1 Kurvenbilder alte Regelung

green: temperature process value
red: temperature desired value
blue: moisture process value
lilac: moisture desired value
yellow: valve position (temperature)

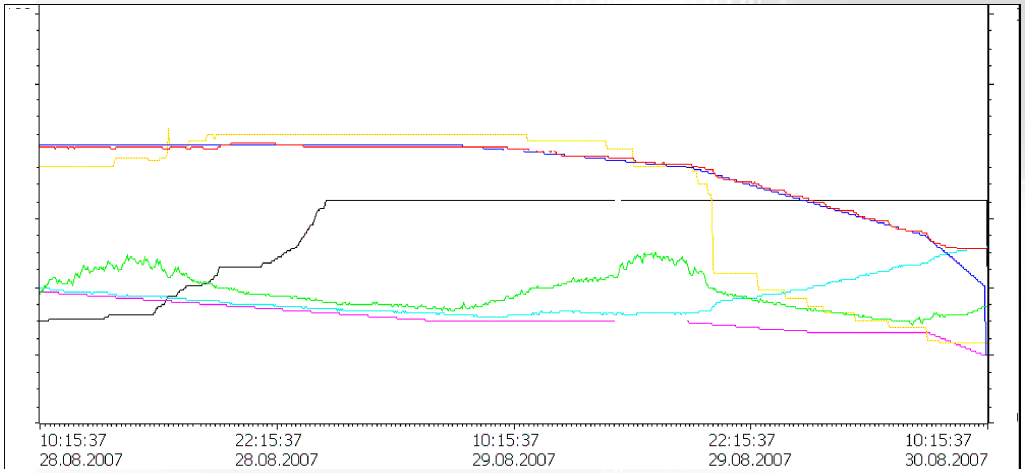
Analysis of controller design:

- No function of moisture control
- High switching rate of actuator (valve for temperature contol)
- Not optimized settings
- No monitoring of temperature limits
- Not complete visualization

New Control Loop Quality



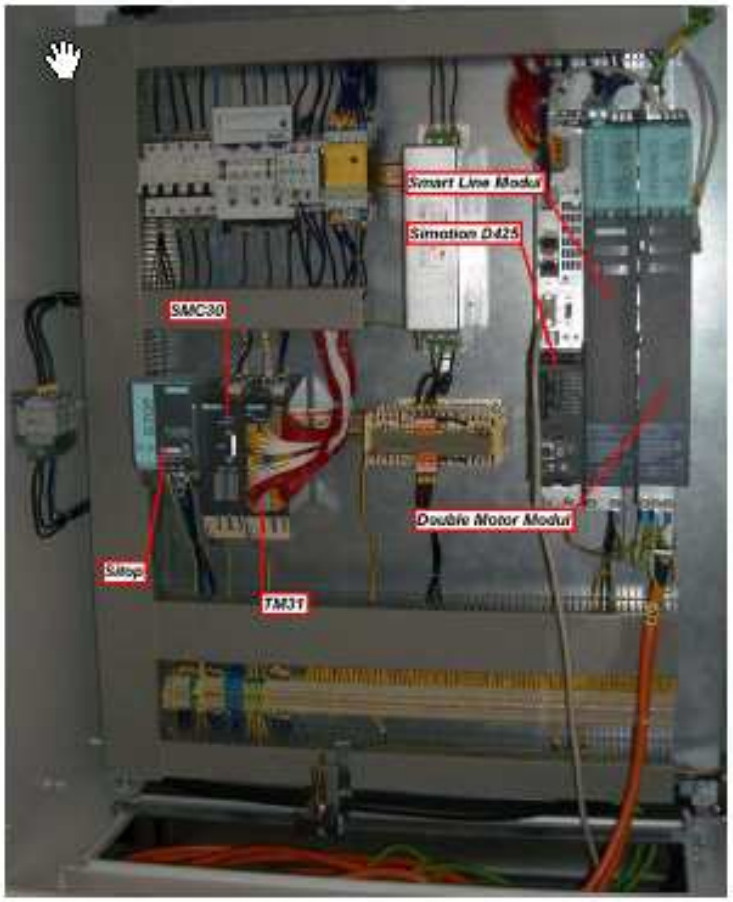
red: temperature desired value
blue: temperature process value
lilac: moisture desired value
cyan: moisture process value
yellow: valve position (temperature)
black: position airflap



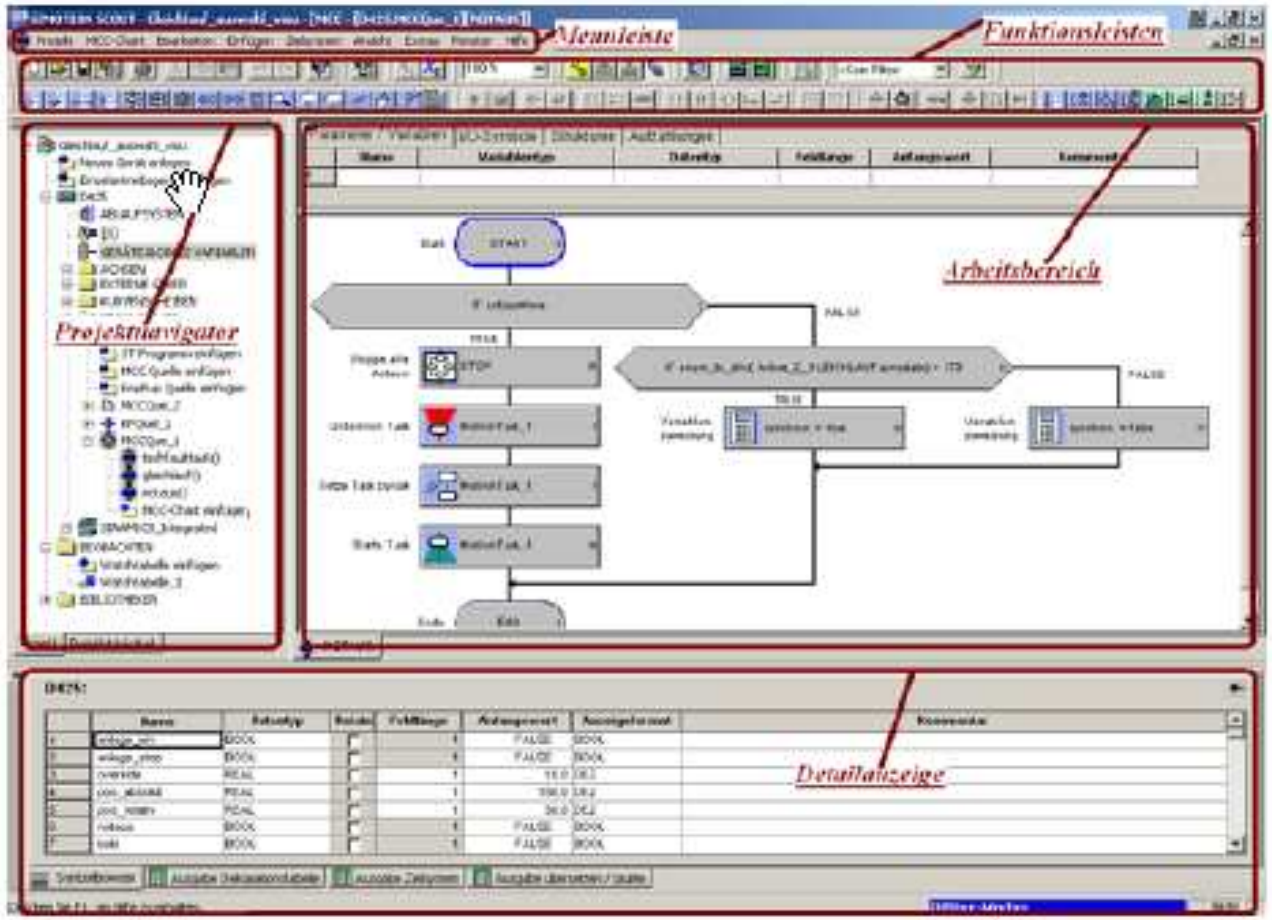
Analysis of controller design:

- active moisture control
- No oscillation of acuatores
- Optimized settings
- Monitoring of process limits

Drive Control Application (1)

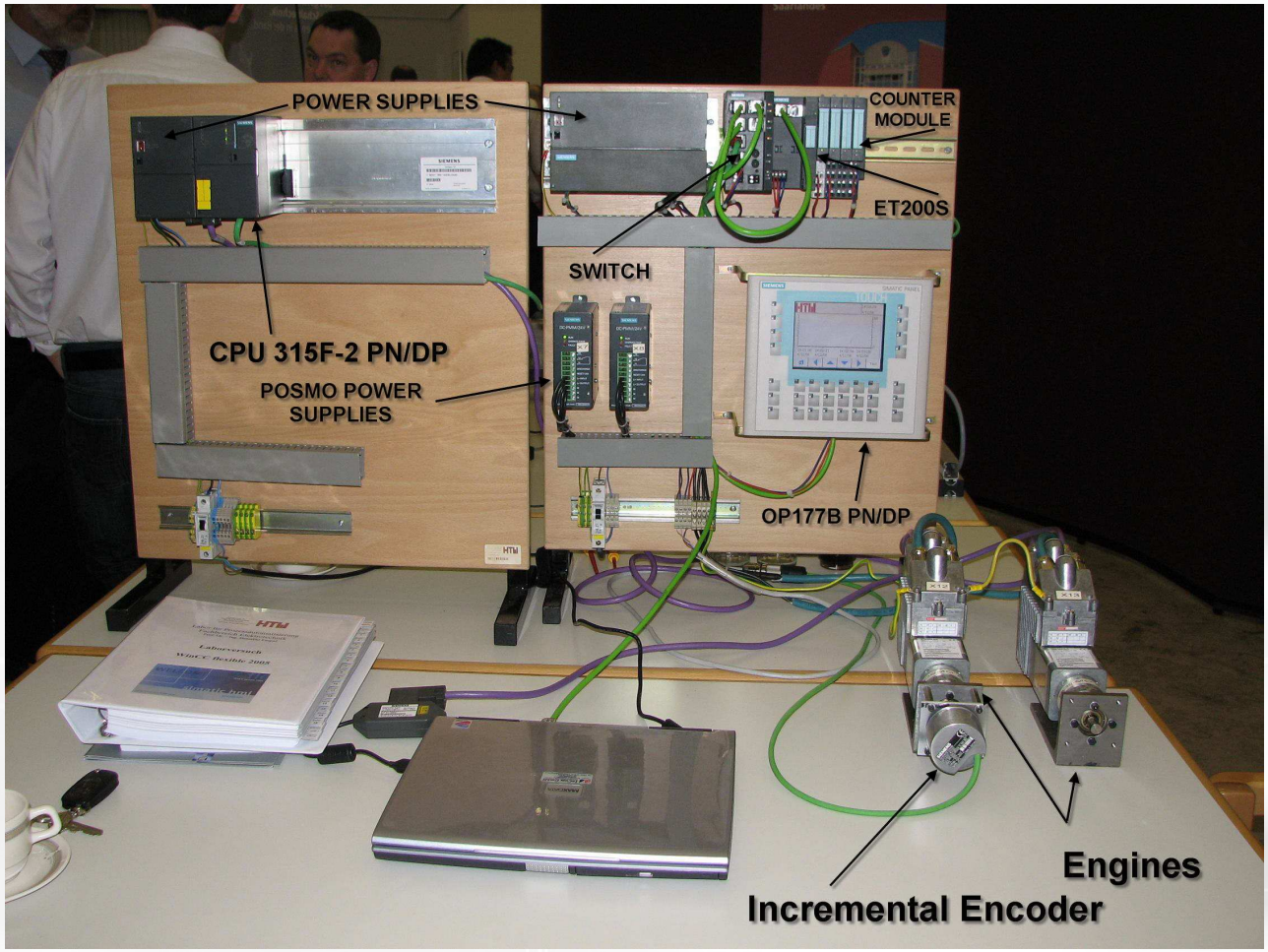


Drive Control Application (1)

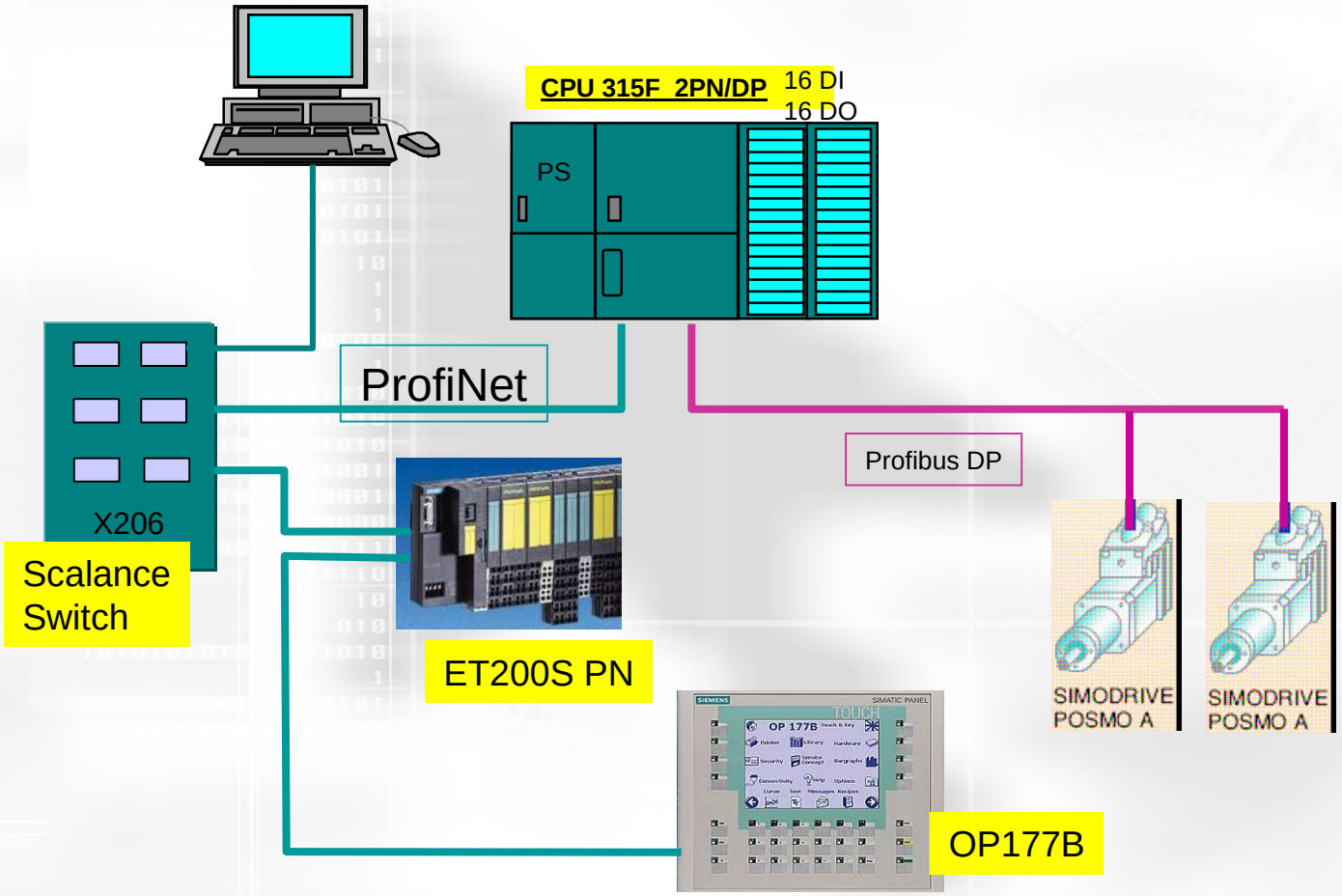


Drive Control Application (1)

Drive Control Application (2)



Drive Control Application (2)



Projects of HTW-Students

- Hoffmann Carsten: Concept and Realization of a PLC-monitoring system to detect manipulation in production plants
- Bui, Y-Khoa & Fardilla Mohd Zaihidee: Concept and Realizsation of Drive Control Lab by using Soft-PLC-System
- Schwarz Christian: Concept, Realization and Integration of a RFID-System in a gearing production plant
- Huwig Gunnar: Concept and Design of Heat-Treatment Control Device in a gypsum production plant
- Koundi & Chimbo: Modelling and Simulation of Material Handling System in a steel production plant with SIMIT
- Brosta, Marx: Control of a test station in a MPS-Training Device
- Scipio, Holger: Concept of Profi-Safe Test Lab

Contact

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Questions?