inheco

Incubator
Firmware Command Set

FCS

for

INHECO

Incubator MP
Incubator Shaker MP
Incubator DWP
Incubator Shaker DWP

Document Version: V1.5

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1.0 Document History

Version	Date	Author	Description of document changes	Corresponding Firmware
0.1	21.02.07	TTH/RPU	First Draft	V3.10
0.2	08.03.07	TTH	Device ID -=1 Watchdog Reset ASE0 in Tower not 100% correct USB specific	V3.15
0.3	20.04.07	TTH	Adjustment moved to Chapter 7 Error codes corrected ASEND added SIS, RWC, RWJ added Pure Incubator included	V3.23
0.4	21.02.08 16.07.08	TTH TTH	RLW added Device ID Reply added Up to 6 Stackable RLW with SEP 10	V3.30 V3.33
0.5	09.12.09	TTH	Inter device bus improved, Inc DWP added New Telephone Numbers INHECO	V3.39
0.6	24.11.10	TTH	Report Maximum Temperature; RMT1 Set proportionality Factor additional DWP heart foil; SPF	V3.44
0.7	17.05.2011	TTH	New Errorbyte for DWP ; Type Ink Shak DWP added; RAV extended	V3.46
0.8	21.12.2011	TTH	Communication during action commands enabled. error handling corrected. Error Code 13: “Drawer DWP not perfectly closed” added	V3.49
1.0	12.03.2012 28.03.2012 28.03.2012	MST TTH	Document ID Adjustment chapter deleted RPF/SPF added	V3.49
1.1	13.04.2012	MST	FW-Version Type Inc Shak DWP added	V3.50
1.2	28.04.2020	AWA	Fehlerbeschreibung Error 09 genauer erklärt	V3.50
1.3	28.07.2022	MZE	Added Note for workaround for faulty response to 7.2.2	V3.xx
1.4	22.09.2022	GMA	Correction: hex code at 7.2.2. (page 47) P=0x50 (wrong 0x52)	V3.xx
1.5	14.08.2024	GMA	Correction: Error number for AOD and ACD	V3.xx

2.0 Firmware Update History

FW-Version	Description of functional changes
V3.10	First version
V3.15	Watchdog Reset enabled, USB Communication stabilized (reset communication after timeout), Bug in the reply to AQS eliminated
V3.19	USB stabilised
V3.22	ASEND added USB CRC8 added
V3.23	Floor ID error implemented Pure Incubator settings (SIS,KEY,0) checked and AQS etc corrected SIS, RWC and RWJ implemented
V3.33	Up to 6 Stackable RLW with SEP 10
V3.39	Inc DWP is Type 2 (STS/RTS)
V3.49	Serial release version for all devices (tested revision) with corrected error handling.
V3.50	Serial release version for all devices with corrected AQS.

3.0 Introduction

3.1 Purpose

This document contains detailed information about all firmware commands implemented in the firmware of INHECO's incubators (4 models listed on the title page of this FCS). Topics concerning the shaking are not valid for incubators without shaking function.

3.2 Scope

This document is intended for software engineers in order to write service and setup tools or application software. It is not part of the end-user documentation.

3.3 Abbreviations

The document uses the following terms:

Controller: Microprocessor with on chip peripheral.
PWM: Pulse-Width Modulation
DWP: Deep Well Plate
MP: Micro Plate

3.4 Document Conventions

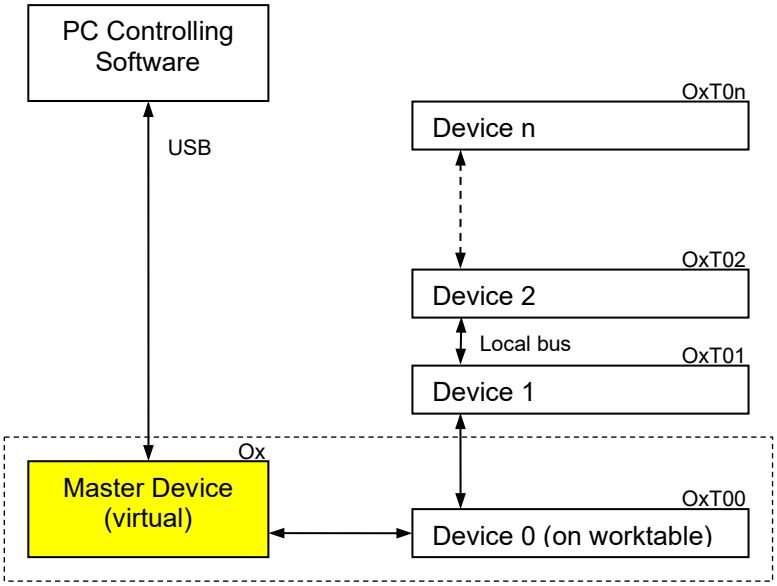
The following conventions are used in this document:

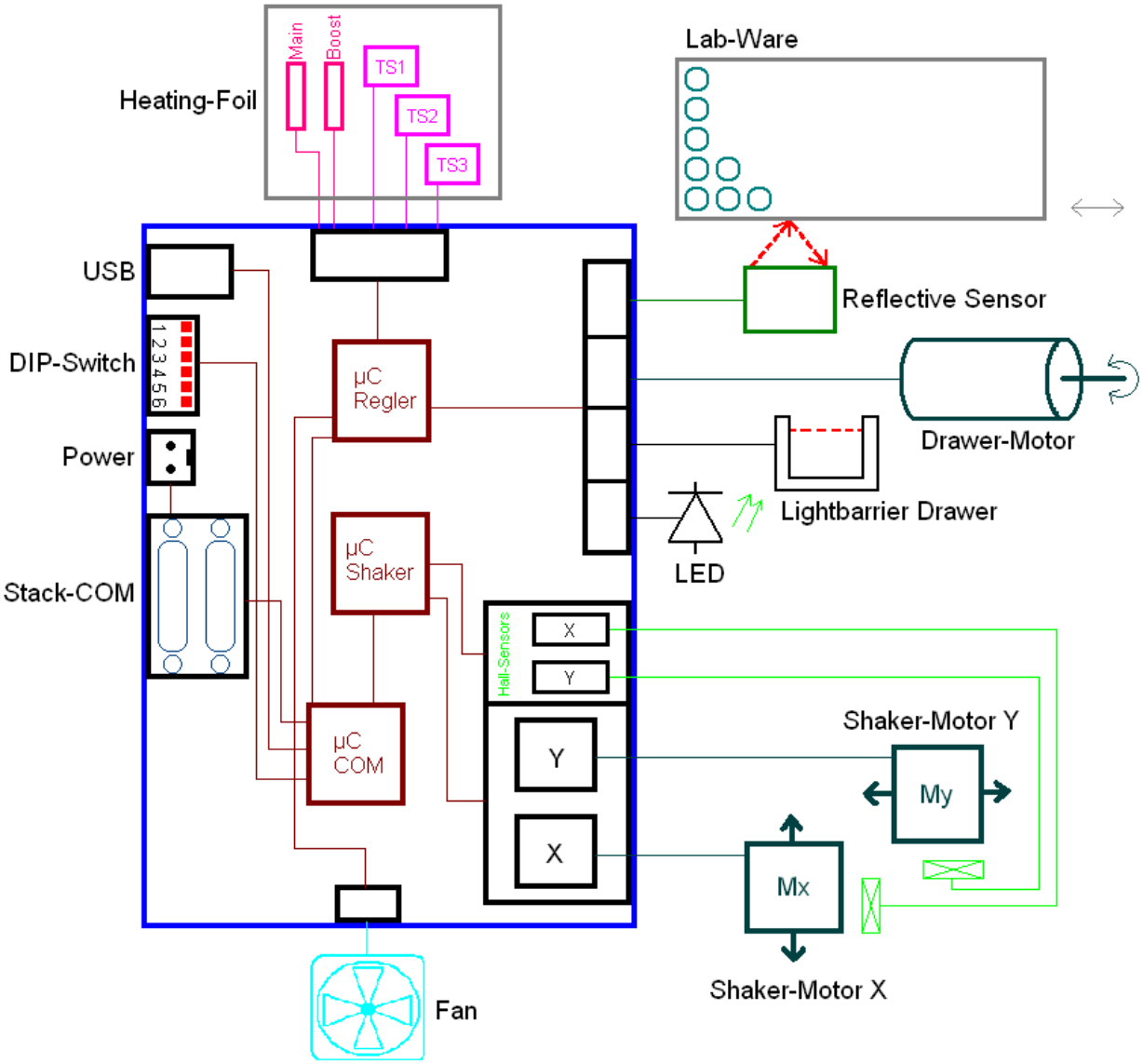
- Parameters marked with an asterisk (*) denote parameters that may be omitted. Such omitted parameters retain the current setting or position.

3.5 Device Overview

The 4 INHECO incubator models, listed on the title page of this FCS are: Incubator MP, Incubator DWP, Incubator Shaker MP, and Incubator Shaker DWP. In this document the word “incubator” stands for all 4 models.

The Incubator control unit must be connected to the PC via USB. The USB transfers transparent information to the incubators and vice versa. The incubator master device appears to the USB as a slave device.
A maximum of six incubators can be used in a stack.
The Incubator Shaker at the bottom is the master of the other incubators in the stack. Each incubator module appears as a sub device of the master.
Action, set and report commands to the sub devices have to be send with the transfer command (T0x-Cmd – with x as sub device number between 0 and 5. The master device has the sub device- or floor- “address” “T00”.
For every Incubator Shaker module stacked on top, the sub device address is incremented. The address assignment is performed during the power up procedure.
To connect several devices in a stack, you have to use the 15 pin SUB-D-Connectors. These connectors confect the communication lines and the power supply (24 V) to the slaves. Only the master device is connected to USB and power supply (24 V) directly. To chain the master device to device 1, you have to use the upper socket contact (female) of the master to connect it to the lower pin contact (male) of the slave and so on. The shielded cable can have a length of up to 22 cm. Electrical and mechanical details are described in the document *TD_P0307_07-03-15_IncubatorShakerUSB_FirstSteps_01.pdf*.

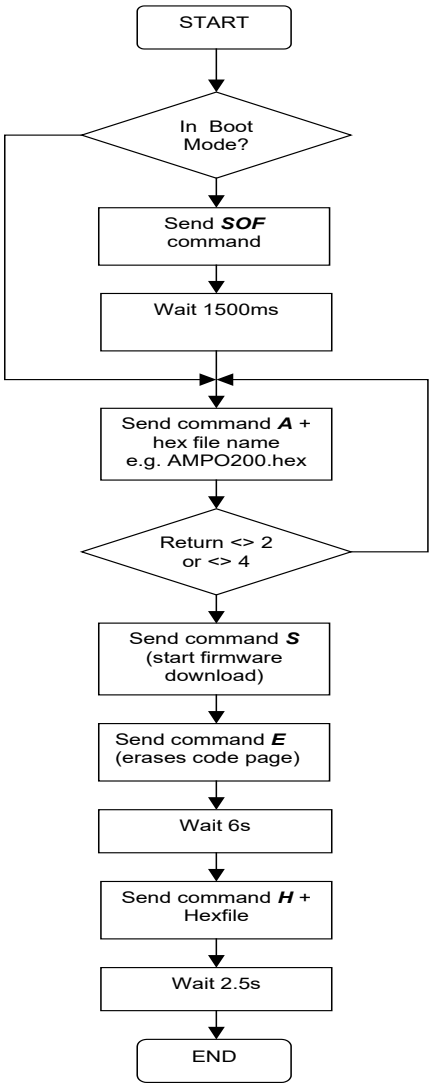


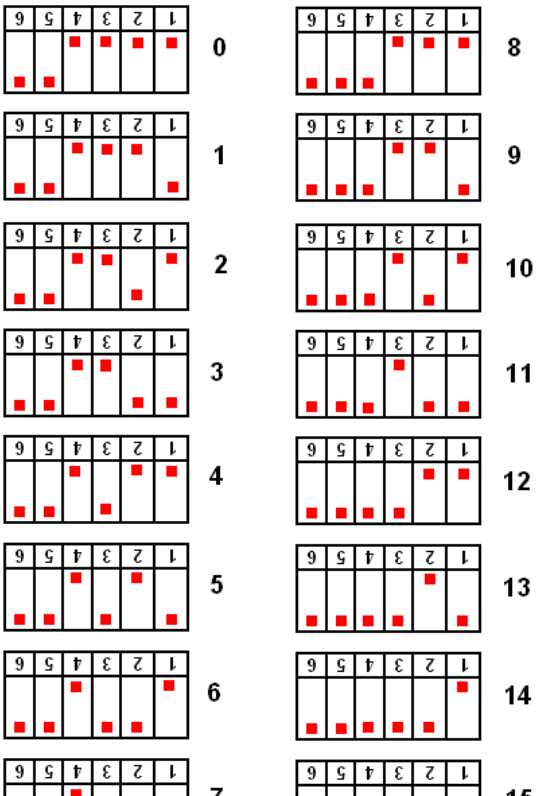

Heating-Foil
Main
Boost
TS1
TS2
TS3
Lab-Ware
USB
DIP-Switch
1 2 3 4 5 6
Power
Stack-COM
µC Regler
µC Shaker
µC COM
Hall-Sensors
X
Y
Reflective Sensor
Drawer-Motor
Lightbarrier Drawer
LED
Shaker-Motor Y
My
Mx
Shaker-Motor X
Fan

3.6 Device ID via DIP-Switch

The DIP-Switches 1-4 configures the address of the master device and its slaves. Below is shown the significance of the DIP-Switch position (the dip switch is turned upside down intentionally).

firmware download sequence





Important Note: To address a Master and its slave the header of every command must include the Device ID of the master (see below at USB Protocol). The device ID setting of the slave is unimportant. On the other hand, the reply to every message, which also includes the device ID, includes the device ID of every slave. The device ID setting of the slaves can be used to identify the origin of the reply.

3.7 Operation & Setup

Preliminary actions have to be performed in order to operate the module.

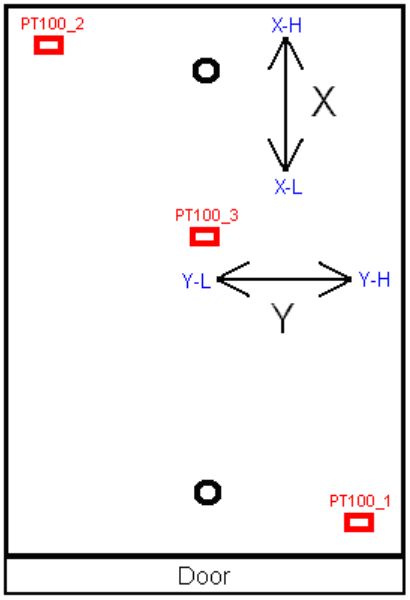
- Installation of boot ware
- Set address switch to the correct address with DIP-Switch 1-4
- Installation of firmware
- Hardware configuration
- Thermal adjustment (Incubator Shaker: also mechanical adjustment)

Boot loading

The boot itself cannot be loaded via the USB interface. It has to be programmed on a dedicated flash programmer before the assembly or with a flash adapter.

3.8 Shaking direction and temperature sensors

The following picture shows the X and Y axes of the shaking direction. The blue letters (X-H, X-L, Y-H and Y-L) shows the moving direction for the shaker adjustment (see chapter 7.2).



PT100_1, PT100_2, and PT100_3 in the above picture are the positions of the 3 temperature sensors in the incubator. Temperature sensor PT100_1 is the main sensor and PT100_3 is for the boost heating foil. Sensor PT100_2 is for validation measurements of sensor PT100_1. The validation carries on until the incubator has reached the stable phase (t_1 – t_3 in diagram chapter 6.2). When the heater reaches the stable phase (target temperature), measurements of all three sensors are averaged and used for the control (t_4 in diagram chapter 6.2).

The temperature offset (Command SHO) for different plate types is handled by the PC controlling software. The controlling PC measures the room temperature. Depending on the used plate and temperature difference between target and ambient temperature, the offset for the device must be calculated and set.

3.9 Handling Configuration Parameter

All Configuration Parameter are stored at the non-versatile EEPROM.
Parameters, which are reset to default after a power-up are:

STT; SBO; SBT; SAX; SAY; SFX; SFY; SPS and all Error Flags

3.10 Reset Behaviour

The green LED at the front of the Incubator Shaker is blinking after power on. It changes from blinking to shining after the master device has synchronized to the USB. Simultaneously the slave devices register at the master and stop blinking their LEDs too. The Incubator Shaker master device synchronizes usually after receipt of the first correct message from the USB.
The Incubator Shaker replies to the first command after this synchronisation / registration procedure with the error code 1 (Reset detected, see chapter 6), i.e. always after power on. This Error must not occur without a hardware reset. Please contact INHECO in that case. There is one exception: after the software reset command SRS this error code is even mandatory.
In case the Incubator receives a message that violates its USB protocol it may need a timeout of less than one second after it is able to receive and execute the next (valid) message.

4.0 COMMANDS

T0y Pipeline to Slave Device

T0y Cmd		
Send transparent command to the sub-device. NOTE! No comma or space characters are allowed. EXAMPLE: T01RFV2 Send the command RFV2 (Report Serial number) to the device 2. The command goes via 2 to T01 (second sub device) and reports the serial number.		
Parameter	***Validity***	***Description***
y	0…5	Sub device number
Cmd		Command of sub device
Error	(14) Device not implemented.	

4.1 Base Functionality

Report-Commands

RDA Report Device Allocation Array of Sub devices:

RDA Layer, Type			
Reports the number of devices connected to the system in binary or decimal format. The system is divided in to eight layers, where each of them containing sixteen device nodes.			
Parameter	***Validity***	***Default***	***Description***
Layer	0...7	0	Report system devices of selected layer.
Type	0	0	Report value in binary format. (= slot sub address) Ex.: Resp.: 7 → slots 2,1,0 are available
	1		Report value in decimal format. (= slot count) Ex.: Resp.: 3 → 3 slots are available
Response	***if***		***Range***
Type	0		0...65535
	1		0...16
Error	(3) Invalid operand.		

RDM Report Drawer Maximum:

RDM			
During drawer open and drawer close (after AOD/ACD) the Incubator (Shaker) counts a labware up to 100 times. RDM reports the value where the algorithm sets the border between: labware detected and labware not detected. This flexible border becomes necessary due to two reasons: 1. The pure Incubator always counts, even when there is no labware. 2. Dull white plates can be better detected than black reflecting plates. This value becomes set by the keyword secured command SEP_key_,10,value			
Parameter	***Validity***	***Default***	***Description***
Response	***if***		***Range***
Number			0...255 // 255 means not set
Error	(3) Invalid operand.		

RFV Report Firmware Version:

RFV Selector			
This command reports several systems depending information about the actual loaded firmware or hardware. This information can be used to identify the characteristics of the selected device.			
Parameter	***Validity***	***Default***	***Description***
Selector	0...25	0	Report selected system information.
Response	***if***		***Range***
Selector	0		Report current CAN application firmware version. Structure: IVD-Inc-C-Vx.xx-MM/YYYY'
	1		Report bootstrap version of the CAN-processor. Structure: 'BOOT-C-Vx.xx-MM/YYYY'
	2		Report serial number.
	3		Report actual hardware version.
	5		Report TECAN / Inheco copyright.
	7		Number of node addresses of this device
	10		Report expected HEX file name for firmware download. Structure: 'IVD-Inc'
	15		Report application CAN firmware as integer, V1.00 = 100.
	20		Report application Regler firmware as integer, V1.00 = 100.
	21		Report application Shaker firmware as integer, V1.00 = 100.
	22		Report current Regler application firmware version. Structure: 'IVD-Inc -R-Vx.xx-MM/YYYY'
	23		Report bootstrap version of the Regler-processor. Structure: 'BOOT-R-Vx.xx-MM/YYYY'
	24		Report current Shaker application firmware version. Structure: 'IVD-Inc -S-Vx.xx-MM/YYYY'
	25		Report bootstrap version of the Shaker-processor. Structure: 'BOOT-S-Vx.xx-MM/YYYY'
Error	(3) Invalid operand.		

RTS Report Type Shaker:

RTS		
This command reads the type of the device functionality. With the read command a device can be identified as Incubator with or without Shaker.		
Response	***if***	***Range***
	0	Incubator without Shaker
	1	Incubator with Shaker
	2	Incubator Deep Well Plate
	3	Incubator Shaker Deep Well Plate
	255	Undefined
Error	(3) Invalid operand.	

RAV Report Analog Values:

RAV Selector			
Report Analog Values of the A/D-Converter.			
Parameter	***Validity***	***Default***	***Description***
Selector	1..3	1	Select the sensor
Response	***if***		***Range***
Selector	1		PT100_1
	2		PT100_2
	3		PT100_3
	4		Door sensor (NTC resistor)
	5		Oven heat foil sensor 1 (NTC resistor)
	6		Oven heat foil sensor 2 (NTC resistor)
	7		Oven heat foil sensor 3 (NTC resistor)
	8		Oven heat foil sensor 4 (NTC resistor)
	9		free
Error	(3) Invalid operand.		

RLW Report Lab-Ware:

RLW		
Reports presence of Lab-Ware After a power-up with closed drawer and Lab-Ware inside, the device replies with error code 7. If it is open it replies with error code 8. If it has been closed it replies with:		
Response	***if***	***Range***
On / Off	0,1	1 = Lab-Ware present, 0 = Lab-Ware not present
Error	(8) if drawer is open, (7) after reset and drawer is closed	

RDC Report Diagnostic Counters:

RDC Selector			
Reports the operation time in hours and the drawer cycles			
Parameter	***Validity***	***Default***	***Description***
Selector	1	1	Report the overall operation time in hours
	2		Report drawer cycles performed.
Error	(3) Invalid operand.		

REF Report Error Flags:

REF		
Reports the Error Flags of the Device. NOTE: After a power-down all Error Flags are cleared. The Flag code is reported as a **32-Bit-Code**. A set bit (1) represents a set Flag. The Flag Code means for example: 16(d) = 0001 0000(b) → Flag at Bit 4.		
Response	***if***	***Range***
	Bit 0…2^{32} = '1'	**See description chapter 6.0**
Error	-	

REP Report Error Flag Parameter:

REP Selector			
Reports the Parameter of the Heater Error Flags of the Device. For detailed information's about the Error Bits, see chapter 6.0 Description Command REF			
Parameter	***Validity***	***Default***	***Description***
Selector	0…8, 13, 14, 15	0	Select the Error Flag
Response	***if***		***Description***
Selector	0		Bit 0: EFLAG_H_**WARN**_WarmUp_TIME
	1		Bit 1: EFLAG_H_**WARN**_BoostCoolDown_TIME
	2		Bit 2: EFLAG_H_**WARN**_StartState_LIMIT_Up_TEMP_S2
	3		Bit 3: EFLAG_H_**WARN**_StartState_LIMIT_Up_TEMP_S3
	4		Bit 4: EFLAG_H_**WARN**_StartStateBoost_LIMIT_UpDown_TEMP_S3
	5		Bit 5: EFLAG_H_**WARN**_StableState_LIMIT_UpDown_TEMP_S2
	6		Bit 6: EFLAG_H_**WARN**_StableState_LIMIT_UpDown_TEMP_S3
	7		Bit 7: EFLAG_H_**WARN**_DELTA_TEMP_S1_S2
	8		Bit 8: EFLAG_H_**ERR**_DELTA_TEMP_S1_S2
	13		Bit 13: EFLAG_H_**ERR**_S2
	14		Bit 14: EFLAG_H_**ERR**_S3
	15		Bit 15: EFLAG_H_**WARN**_DELTA_TEMP_S1_S3
Error	(3) Invalid operand.		

REE Report Extended Error Code:

REE		
Reports the status of the initialisation of the device and the status of the Lab-Ware detection.		
Parameter	***Validity***	***Description***
Response	0, 1, 2, 3	
Response	***if***	***Range***
	0	Device initialised
	1	Device not initialised
	2	Lab-Ware status unknown
	3	Device not initialised and Lab-Ware status unknown
Error	-	

RCM Report Calibration Mark:

RCM		
Reports the date and an alphanumeric string (e.g. operator) of the last calibration for the device. The Data is reported in the Format YYYY-MM-DD,xxxxx (Example: 2005-09-28,xxxxx). The five xs are alphanumeric wildcards.		
Response	***if***	***Range***
Date		YYYY-MM-DD,xxxxx
Error	-	

Set-Commands

SFV Set Serial Number:

SFV Key, Number			
This command sets the device serial number. A total of sixteen characters can be stored. If the given string is longer than sixteen characters or the first character is not a number, an invalid operand error will be generated. This data will be stored definitely in non-volatile memory (Flash-Memory) either when power-down the instrument or while using the AWE command.			
Parameter	***Validity***	***Default***	***Description***
Key	xxxxx	-	Secret
Number	Up to 16 ASCII characters	0	Serial number value stored as string.
Error	(3) Invalid operand.		

STS Set Type Shaker:

STS, Key, Number			
This command sets the Shaker functionality for the device (no key necessary for the first time). With the read command RTS a device can be identified as Incubator with or without Shaker. An error code (2) is send if you try to set a shaker command for a device without shaker functionality. An error message (20) appears if an already specified device has to be changed! The device type can be reset to default (255) by using the Key (Syntax: STSxxxxx,255).			
Parameter	***Validity***	***Default***	***Description***
Number	0, 1, 2, 3	255	0 = without Shaker, 1 = with Shaker, 2 Incubator Deep Well Plate, 3 Incubator Shaker DWP
Key	xxxxx	-	Secret
Number	255		Reset the specification of the device to default
Error	(3) Invalid operand. (20) Device already set.		

SEF Set Error Flags:

SEF		
Resets the Error Flags of the Device. NOTE: Before executing the command, stop heating and shaking of the device!		
Parameter	***Validity***	***Description***
Error	-	

SEP Set Error Flag Parameter:

SEP Key, Selector, Value			
Sets the Parameter of the Heater Error Flags of the Device. If a value is set to 0 for a selected Error Flag, the default parameter (internal formula) is used. After a power-up, **all** parameter are set to default. **TIME** bits are set in [sec.] and **TEMP** bits are set in [1/10 K]. Example: SEPx,y (x = Error bit; y = Parameter TIME or TEMP) For detailed information's about the Error Bits, see chapter 6.0 Description Command REF			
Parameter	***Validity***	***Default***	***Description***
Selector	0…8, 13, 14, 15	0	Select the Error Flag
Key	xxxxx	-	Secret
Response	***if***	***Value***	***Description***
Selector	0	$0…2^{14}$	Bit 0: EFLAG_H_WARN_WarmUp_**TIME**
	1	$0…2^{14}$	Bit 1: EFLAG_H_WARN_BoostCoolDown_**TIME**
	2	0…255	Bit 2: EFLAG_H_WARN_StartState_LIMIT_Up_**TEMP**_S2
	3	0…255	Bit 3: EFLAG_H_WARN_StartState_LIMIT_Up_**TEMP**_S3
	4	0…255	Bit 4: EFLAG_H_WARN_StartStateBoost_LIMIT_UpDown _**TEMP**_S3
	5	0…255	Bit 5: EFLAG_H_WARN_StableState_LIMIT_UpDown _**TEMP**_S2
	6	0…255	Bit 6: EFLAG_H_WARN_StableState_LIMIT_UpDown _**TEMP**_S3
	7	0…255	Bit 7: EFLAG_H_WARN_DELTA_**TEMP**_S1_S2
	8	0…255	Bit 8: EFLAG_H_ERR_DELTA_**TEMP**_S1_S2
	9		
	10	0….80	Interval for the labware detection
	13	0…255	Bit 13: EFLAG_H_ERR_S2 **TEMP**
	14	0…255	Bit 14: EFLAG_H_ERR_S3 **TEMP**
	15	0…255	Bit 15: EFLAG_H_WARN_DELTA_**TEMP**_S1_S3
Error	(3) Invalid operand.		

SRS Set Reset System:

SRS		
This command resets the slot device without loosing the USB-Connectivity. After such a command, the device FW starts like after a normal power-up. During the reset, the LED is blinking for 5 sec. @ 2 Hz.		
Parameter	***Validity***	***Description***
Error	-	

SCM Set Calibration Mark:

SCM Key, Date, Value			
Sets the date and e.g. operator of the last calibration for the device. The Data is reported in the Format YYYY-MM-DD,xxxxx (Example: 2005-09-28,xxxxx). The five xs are wildcards for an alphanumeric string.			
Parameter	***Validity***		***Description***
Date	YYYY-MM-DD,xxxxx		
Key	xxxxx	-	Secret
Response	***if***		***Range***
Error	(3) Invalid operand.		

SIS reSet Inheco Settings (Adjustment and Calibration) data:

SIS Key			
Reads all shaker adjustment data and heater calibration data from the EEPROM of the Communication µC and writes it into the EEPROMs of the shaker and heater µC, respectively. These data must be stored in the EEPROM with RWC and RWJ before SIS can be used.			
Parameter	***Validity***	***Default***	***Description***
Key	xxxxx	-	Secret
Error	(2) Invalid command. (3) Invalid operand.		

Action-Commands

AID Action Initialize Device:

AID		
Initializes the Device after power-on. All other Action-Commands of the device are prohibited before the command is executed. On command AID, the drawer will be closed. If the drawer is hold in its open position, no Error will be generated! If AID is send during operating, the shaker and heater stop immediately!		
Parameter	***Validity***	***Description***
Error	(1) Initialization failed.	

AQS Report Query Status:

AQS		
Report Query Status after a short Self-Test. Tested items are: 1.) Drawer (open/close) 2.) Shaker (Test duration: maximum 70 sec.) 3.) Temperature (Test duration: maximum 385 sec.) Normal Testing-Time: ca. 3 minutes (Beware of timeouts!) Maximum Testing-Time: 465 sec. (Beware of timeouts!) The Test must be performed without a Labware inside! The Error code is reported as an **11-Bit-Code**. A set bit (1) represents an Error. The Test stops immediately, when the Drawer-Test fails to avoid damage to the device! ***Please note the AQS was developed for the Incubator Shaker MP. This can lead assemblies to DWP Incubators that the result of the AQS, due to the design, 8 (bit2) could be.*** The Error Code means for example: 16(d) = 0001 0000(b) → Error at Bit 4. During Shaker-Test the Y-Axis doesn't reach desired Amplitude.		
Response	***if***	***Range***
	Bit 0..2047 = '1'	**Bit 0:** Drawer **Bit 1:** Homogeneity Sensor 3 versus Sensor 1 (>2 K) **Bit 2:** Homogeneity Sensor 2 versus Sensor 1 (>2 K) **Bit 3:** Sensor 1 doesn't reach Target Temperature after 130 sec. **Bit 4:** Y-Amplitude Shaker **Bit 5:** X-Amplitude Shaker **Bit 6:** Phase Shift Shaker **Bit 7:** Y-Frequency Shaker **Bit 8:** X-Frequency Shaker **Bit 9:** Line Boost-Heater broken **Bit 10:** Line Main-Heater broken
Error	-	

4.2 Temperature related Commands (Device Specific Functionality)

Read-Commands (Temperature)

RAT Report Actual Slot-Temperature:

RAT Selector			
This command reports the actual ambient or slot temperatures of the three sensors. It can be chosen whether the evaluated temperature or the sensor value should be reported. The temperatures are reported in 1/10 °C: 345 = 34,5 °C			
Parameter	***Vali.***	***Default***	
	1,2,3	1	
Response	***if***		***Range***
Selector	1	0…65535	Report evaluated ambient temperature in 1/10 °C of sensor 1 (main)
	2	0…65535	Report evaluated ambient temperature in 1/10 °C of sensor 2 (dif.)
	3	0…65535	Report evaluated ambient temperature in 1/10 °C of sensor 3 (boost)
Error	(3) Invalid operand.		

RTT Report Target Temperature:

RTT		
Reports the target temperature which is set with **STT** in integer format. The temperature is reported in 1/10 °C.		
Response		***Range***
Temperature		0...800 in 1/10 °C
Error	-	

RHE Report Heater Enable Status (heating / cooling):

RHE		
Reports the status of the heating / cooling mode.		
Response		***Range***
Status		0 = Device is off, 1 = Device is on, 2 = Device + Booster is on
Error	-	

RPC Report Set PID Controller Coefficients:

RPC Selector			
Reports the PID controller coefficients.			
Response	***if***	***Default***	***Range***
Selector	1	1	Report proportional gain.
	2		Report integration value, 0 = integration off.
Error	(3) Invalid operand.		

RHP Report Heat-Up / Cool-Down Parameters:

RHP Selector			
Report Heat-Up Parameters: The value of the Boost Over temperature is reported in 1/10 K: 345 = 34,5 K The constant for the time calculation is used for the command RNP and is set by SHK and SHH.			
Response	***if***	***Default***	***Range***
Selector	1	1	1 = Overshoot value for the boost heating foil in °C
	2		2 = Report **heat-up** time evaluation factor.
	3		3 = Report **cool-down** time evaluation factor.
Error	(3) Invalid operand.		

RMT Report maximum allowed DeviceTemperature:

RMT		
Report maximum allowed device temperature of the device. If the argument is 1 it reports the maximum measured temperature since the last reset. The temperatures are reported in 1/10 °C.		
Response	***Argument***	***Range***
Max measured Temperature	1	0...999 in 1/10 °C
Temperature	else	0...999 in 1/10 °C
Error	-	

RAP Report Actual PWM Value:

RAP		
Reports the actual PWM value of the selected slot. Value 256: Device is neither heating nor cooling Value <256: Device is cooling (only Cooling Device; Incubator will be heating) Value >256: Device is heating		
Response		***Range***
PWM		PWM 0...512
Error	-	

RBO Report Boost Offset:

RBO		
Reports Heat-Up Parameters: OFFSET Value. The Offset is reported in 1/10 °C.		
Response	***if***	***Range***
Offset		OFFSET value in 1/10 °C for boost heating foil.
Error	-	

RBT Report Boost Time:

RBT	
Reports Heat-Up Parameters: OFFSET Value. Reports the time for the Over-Temperature of the Boost in seconds.	
Response	***Range***
Time	Time OFFSET value in sec. for boost heating foil.
Error -	

RDT Report Delta Temperature:

RDT	
Reports the absolute temperature difference between target and actual plate temperature. When the actual plate temperature is above the target temperature, a minus is displayed The temperature is reported in 1/10 °C: 345 = 34,5 °C	
Response	***Range***
Delta Temp.	in 1/10 K
Error -	

RHO Report Heat-Up Offset:

RHO	
Reports the temperature offset for the used type of Disposable f(dT, Disposable) The temperature is reported in 1/10 °C: 112 = 11,2 °C	
Response	***Range***
Offset	in 1/10 K
Error -	

RCD Report Calibration Date:

RCD	
Reports the date of thermal adjustment. The Date is reported in the Format YYYY-MM-DD (Example: 2005-09-28).	
Response	***Range***
Date	YYYY-MM-DD
Error -	

RCL Report Calibration Low:

RCL Sensor Selector			
Reports the value of the low temperature adjustment points of the three sensors. Example: RCLx,y (x = number sensor (1,2,3), y = format (0 = AD-Value, 1 = temperature))			
Parameter	***Validity***	***Default***	***Description***
Sensor	1, 2, 3	1	Number of sensor
Selector	0, 1	0	Select sensor value format
Response	***if***		***Range***
Sensor	1		Temperature Sensor 1
	2		Temperature Sensor 2
	3		Temperature Sensor 3
Selector	0	0…65535	AD-Value temperature point low
	1	0…999	Value temperature point low [1/10 °C]
Error	(3) Invalid operand.		

RCH Report Calibration High:

RCH Sensor Selector			
Reports the value of the high temperature adjustment points of the three sensors. Example: RCHx,y (x = number sensor (1,2,3), y = format (0 = AD-Value, 1 = temperature))			
Parameter	***Validity***	***Default***	***Description***
Sensor	1, 2, 3	1	Number of sensor
Selector	0, 1	0	Select sensor value format
Response	***if***		***Range***
Sensor	1		Temperature Sensor 1
	2		Temperature Sensor 2
	3		Temperature Sensor 3
Selector	0	0…65535	AD-Value temperature point high
	1	0…999	Value temperature point high [1/10 °C]
Error	(3) Invalid operand.		

RWC Read Whole Calibration data:

RWC Key			
Reads all heater calibration data from the EEPROM of the heater µC and writes it into the EEPROM of the Communication µC. With SIS it can be written back.			
Parameter	***Validity***	***Default***	***Description***
Key	xxxxx	-	Secret
Response			
About 80 EEPROM Data			
Error	(2) Invalid command. (3) Invalid operand.		

RPF Report Proportionality Factor:

RPF			
Command for deep well plate incubators only. Fine adjustment of the power of the room heat foil compared to the main heat foil. The smaller this factor is the lower is the power of the room heating foil.			
Response	***Validity***	***Default***	***Description***
Proportionality factor	0…255	100	The smaller this value is the smaller is the power of the oven at DWP Incubators.
Error	(2) Invalid command		

Set-Commands (Temperature)

STT Set Target Temperature:

STT Temperature			
This command sets the temperature for each slot. The temperature is set in 1/10 °C: 345 = 34,5 °C			
Parameter	***Validity***	***Default***	***Description***
Temperature	0...*max. Temp*	220	Set target temperature. *Max. Temp* +**80 °C** Command in 1/10 °C.
Error	(3) Invalid operand.		

SAP Set PWM Value Directly:

SAP Key, Value			
The **SAP** command directly accesses the PWM value table **Important**: This influences not the boost heat foil it remains idle. Value 256: Device is neither heating nor cooling Value <256: Device is cooling (only Cooling Device; Incubator will be heating) Value >256: Device is heating CAUTION! This command is for development and test purposes only.			
Parameter	***Validity***	***Default***	***Description***
Value	0…511	256	PWM:0 – 255 cooling, 256 off, 257 – 511 heating
Key	xxxxx	-	Secret
Error	(3) Invalid operand.		

SHE Set Heater Enable Status:

SHE Status			
Switches the heating mode of the selected Device on or off.			
Parameter	***Validity***	***Default***	***Description***
Status	0,1	0	0 = off, 1 = on
Error	(3) Invalid operand.		

SMT Set Max. Allowed Device Temperature:

SMT Key, Temperature			
Sets Max. Allowed Slot Temperature: The max. temperature is set in 1/10 °C: 345 = 34,5 °C			
Parameter	***Validity***	***Default***	***Description***
Temperature	0...999	850	Set max. allowed Device Temperature in 1/10 °C
Key	xxxxx	-	Secret
Error	(3) Invalid operand.		

SPP Set PID Controller Coefficients (Proportional Gain):

SPP Key, Value			
Sets PID Controller Coefficients: proportional gain			
Parameter	***Validity***	***Default***	***Description***
Value	0...999	150	proportional gain 0...999
Key	xxxxx	-	Secret
Error	(3) Invalid operand.		

SPI Set PID Controller Coefficients (Integration Value):

SPI Key, Value			
Sets PID Controller Coefficients: integration Value			
Parameter	***Validity***	***Default***	***Description***
Value	0...999	100	integration value 0...999
Key	xxxxx	-	Secret
Error	(3) Invalid operand.		

SDC Set Delete Counter:

SDC Key, Selector			
Deletes the counter of the Operating time or Drawer counter.			
Parameter	***Validity***		***Description***
Selector	1,2		1 = Operating time, 2 = Drawer counter
Key	xxxxx	-	Secret
Error	(3) Invalid operand.		

SBO Set Boost Offset:

SBO Offset			
Sets Heat-Up Parameters: OFFSET Value. After Command AID or SHE0, SBO is reset to 0 (default)! The Over temperature for the Boost is set in 1/10 °C: 345 = 34,5 °C			
Parameter	***Validity***	***Default***	***Description***
Offset	-999…0...999	0	OFFSET value in 1/10°C for boost heating foil.
Error	(3) Invalid operand.		

SBT Set Boost Time:

SBT Time			
Sets Heat-Up Time Parameters: OFFSET Value. After Command AID or SHE0, SBT is reset to 0 (default)!			
Parameter	***Validity***	***Default***	***Description***
Time	0...999	0	Time OFFSET value in sec. for boost heating foil.
Error	(3) Invalid operand.		

SHK Set Cool-Down Time Evaluation Factor:

SHK Value			
Sets heat-up time evaluation factor.			
Parameter	***Validity***	***Default***	***Description***
Value	0...999	250	Set cool-down time evaluation factor
Error	(3) Invalid operand.		

SHH Set Heat-Up Time Evaluation Factor:

SHH Value			
Sets heat-up time evaluation factor.			
Parameter	***Validity***	***Default***	***Description***
Value	0...999	250	Set heat-up time evaluation factor
Error	(3) Invalid operand.		

SHO Set Heat-Up Offset:

SHO Offset			
Set Heat-Up temperature offset for the used plate-type (disposable): The Offset temperature for the different plate-types is set in 1/10 °C: 121 = 12,1 °C			
Parameter	***Validity***	***Default***	***Description***
Offset	0...150	0	Set heat-up temperature offset for plate type.
Error	(3) Invalid operand.		

SCL Set Calibration Low:

SCL Key, Value, Value, Value			
Set lower temperature adjustment points for the three sensors. When Command SCL is executed, the heater error flags are still stored but don't switch off the heater! The low adjustment temperatures are set in 1/10 °C: 345 = 34,5 °C Example: SCLxxx,yyy,zzz (xxx = Temperature Sensor 1 (differential), yyy = Temperature Sensor 2 (main), zzz = Temperature Sensor 3 (boost)) After setting the low calibration point, the high calibration point (SCH) must be set!			
Parameter	***Validity***		***Description***
Value	0...999		Set lower adjustment temperatures e.g. +25 °C
Key	xxxxx	-	Secret
Error	(3) Invalid operand.		

SCH Set Calibration High and Date:

SCH Key, Value, Value, Value, Date			
Set higher temperature adjustment points and date of adjustment for the three sensors. When Command SCH is executed, the heater error flags will switch off the heater (normal functionality)! The high adjustment temperatures are set in 1/10 °C: 345 = 34,5 °C The adjustment date has to be in the form: YYYY-MM-DD Example: SCHxxx,yyy,zzz,2005-09-28 (xxx = Temperature Sensor 1 (main), yyy = Temperature Sensor 2 (differential), zzz = Temperature Sensor 3 (boost), with the date 2005-09-28)			
Parameter	***Validity***		***Description***
Value	0...999, 0...999, 0...999,		Sets higher adjustment temperatures e.g. +80 °C
Key	xxxxx	-	Secret
Date	YYYY-MM-DD		Sets the adjustment date
Error	(3) Invalid operand.		

SRC Set Reset Calibration-Data:

SRC Key			
Reset Adjustment Data: Resets the temperature adjustment line between the point low and high to default. CAUTION! The device has to be readjusted afterwards.			
Parameter	***Validity***		***Description***
Key	xxxxx	-	Secret
Error	-		

SPF Set Proportionality Factor:

SPF Value			
Command for deep well plate incubators only. Fine adjustment of the power of the room heat foil compared to the main heat foil. The smaller this factor is the lower is the power of the room heating foil.			
Parameter	***Validity***	***Default***	***Description***
Value	0…255	100	The smaller this value is the smaller is the power of the oven at DWP Incubators.
Error	(3) Invalid operand.		

4.3 Drawer related Commands (Device Specific Functionality)

Read-Commands (Drawer)

RDS Report Drawer Status:

RDS		
Report Drawer Status		
Response		***Range***
Status		1 = open, 0 = closed
Error	-	

RPR Report Motor Power (clockwise):

RPR		
Report motor power (PWM) clockwise rotation (close drawer).		
Response		***Range***
Power		0...255 (255 = 100 %)
Error	-	

RPL Report Motor Power (anticlockwise):

RPL		
Report motor power (PWM) anticlockwise rotation (open drawer)		
Response		***Range***
Power		0...255 (255 = 100 %)
Error	-	

RGR Report Motor Current Limitation (clockwise):

RGR		
Reports the current limitation of the motor for clockwise rotation (close drawer)		
Response		***Range***
Current Limit		0...255 (255 = 450 mA)
Error	-	

RGL Report Motor Current Limitation (anticlockwise):

RGL		
Reports the current limitation of the motor for anticlockwise rotation (open drawer)		
Response		***Range***
Current Limit		0...255 (255 = 450 mA)
Error	-	

Set-Commands (Drawer)

SPR Set Power for clockwise rotation:

SPR Key, Power			
Sets the power for the clockwise rotation of the motor (close drawer)			
Parameter	***Validity***	***Default***	***Description***
Power	0...255	250	0 = no power, 255 = max. power
Key	xxxxx	-	Secret
Error	(3) Invalid operand.		

SPL Set Power anticlockwise rotation:

SPL Key, Power			
Sets the power for the anticlockwise rotation of the motor (open drawer)			
Parameter	***Validity***	***Default***	***Description***
Power	0…255	250	0 = no power, 255 = max. power
Key	xxxxx	-	Secret
Error	(3) Invalid operand.		

SGR Set Power Limit for clockwise rotation:

SGR Key, Current			
Sets the current limitation of the motor for clockwise rotation (close drawer)			
Parameter	***Validity***	***Default***	***Description***
Current	0...255	35	0 = min. power limit, 255 = max. power limit
Key	xxxxx	-	Secret
Error	(3) Invalid operand.		

SGL Set Power Limit for anticlockwise rotation:

SGL Key, Current			
Sets the current limitation of the motor for anticlockwise rotation (open drawer)			
Parameter	***Validity***	***Default***	***Description***
Current	0...255	35	0 = min. power limit, 255 = max. power limit
Key	xxxxx	-	Secret
Error	(3) Invalid operand.		

Action-Commands (Drawer)

AOD Action Open the Door:

AOD		
This command opens the door.		
Parameter	***Validity***	***Description***
Error	(7) Device not initialized. (9) Drawer not in end position. (10) Unexpected Labware Status.	

ACD Action Close the Door:

ACD		
This command closes the door.		
Parameter	***Validity***	***Description***
Error	(7) Device not initialized. (9) Drawer not in end position.	

4.4 Shaker related Commands (Device Specific Functionality)

The following commands are disabled at the Incubator without shaking function. They reply with error code 2, see chapter 5.0.

Read-Commands (Shaker)

RFX Read Shaker Frequency X:

RFX Selector				
Reads the set/actual shaker frequency in x-direction.				
Response	***if***	***Default***	***Range***	
Selector	0, 1	0	0 = to-be set, 1 = actual	Frequency [Hz] ·10
Error	(2) Invalid command. (3) Invalid operand.			

RFY Read Shaker Frequency Y:

RFY Selector				
Reads the set/actual shaker frequency in y-direction.				
Response	***if***	***Default***	***Range***	
Selector	0, 1	0	0 = to-be set, 1 = actual	Frequency [Hz] ·10
Error	(2) Invalid command. (3) Invalid operand.			

RAX Read Shaker Amplitude X:

RAX Selector				
Reads set/actual shaker amplitude in x-direction.				
Response	***if***	***Default***	***Range***	
Selector	0, 1, 2	0	0 = set	Amplitude in 1/10 mm
			1 = actual	Amplitude in 1/10 mm
			2 = static measure	Distance from middle in 1/10 mm
Error	(2) Invalid command. (3) Invalid operand.			

RAY Read Shaker Amplitude Y:

RAY Selector				
Reads set/actual shaker amplitude in y-direction.				
Response	***if***	***Default***	***Range***	
Selector	0, 1, 2	0	0 = set	Amplitude in 1/10 mm
			1 = actual	Amplitude in 1/10 mm
			2 = static measure	Distance from middle in 1/10 mm
Error	(2) Invalid command. (3) Invalid operand.			

RPS Read Phase Shift X/Y:

RPS Selector				
Reads the set/actual Phase Shift between x and y shaker drive. A return value of “12345” means, the shaker has not reached a stable state or the set frequency’s for both axis forbids a phase shift. If the amplitudes of the x-Axis or/and y-Axis are below 1 mm, the return value can be also “12345”.				
Response	***if***	***Default***	***Range***	
Selector	0, 1	0	0 = set, 1 = actual	Phase Shift in [°]
Error	(2) Invalid command. (3) Invalid operand.			

RSE Read Shaker Enable Status:

RSE	
Reads shaker enable status.	
Response	***Range***
Status	0 = shaker off, 1 = shaker on, 2 = shaker switched off, but still moving
Error	(2) Invalid command. (3) Invalid operand.

RSC Read Shaker Calibration Values:

RSC Position, Selector			
Reads Shaker Adjustment values of the Hall-Effect Sensors.			
Parameter	***Validity***	***Default***	***Description***
Position	0…11	0	
Selector	0,1,2	0	0 = Value Hall-Sensor, 1 = Freedom of movement [1/100 mm], 2 = Frequency of Correction-Factor [Hz] ·10
Response	***if***		***Range***
Center X	0,0		Value Hall-Sensor Center X-Position
Center X	0,1		Freedom of movement [1/100 mm] (**Always 0)**
X-H	1,0		Value Hall-Sensor X-Position high (rear)
X-H	1,1		Freedom of movement [1/100 mm]
X-L	2,0		Value Hall-Sensor X-Position low (front)
X-L	2,1		Freedom of movement [1/100 mm]
Center Y	3,0		Value Hall-Sensor Center Y-Position
Center Y	3,1		Freedom of movement [1/100 mm] (**Always 0)**
Y-H	4,0		Value Hall-Sensor Y-Position right
Y-H	4,1		Freedom of movement [1/100 mm]
Y-L	5,0		Value Hall-Sensor Y-Position left
Y-L	5,1		Freedom of movement [1/100 mm]
X-Delta	6,0		Δ of X-H and X-L
X-Delta	6,1		Freedom of movement [1/100 mm]
Y-Delta	7,0		Δ of Y-H and Y-L
Y-Delta	7,1		Freedom of movement [1/100 mm]
X-Axis	8,0		Correction-Factor low
X-Axis	8,1		Correction-Factor low [1/100 mm]
X-Axis	8,2		Correction-Factor low Frequency [Hz] ·10
Y-Axis	9,0		Correction-Factor low
Y-Axis	9,1		Correction-Factor low [1/100 mm]
Y-Axis	9,2		Correction-Factor low Frequency [Hz] ·10
X-Axis	10,0		Correction-Factor high
X-Axis	10,1		Correction-Factor high [1/100 mm]
X-Axis	10,2		Correction-Factor high Frequency [Hz] ·10
Y-Axis	11,0		Correction-Factor high
Y-Axis	11,1		Correction-Factor high [1/100 mm]
Y-Axis	11,2		Correction-Factor high Frequency [Hz] ·10
Error	(2) Invalid command. (3) Invalid operand.		

RWJ Read Whole Shaker adjustment data:

RWJ Key			
Reads all shaker adjustment data from the EEPROM of the shaker µC and writes it into the EEPROM of the Communication µC. with SIS it can be written back.			
Parameter	***Validity***	***Default***	***Description***
Key	xxxxx	-	Secret
Response	***if***	***Default***	***Range***
About 80 EEPROM Data			
Error	(2) Invalid command. (3) Invalid operand.		

Set-Commands (Shaker)

SFX Set Shaker Frequency X:

SFX Frequency			
Sets shaker frequency for the X-Direction.			
Parameter	***Validity***	***Default***	***Description***
Frequency	66…300	142	Frequency [Hz] ·10
Error	(2) Invalid command. (3) Invalid operand.		

SFY Set Shaker Frequency Y:

SFY Frequency			
Sets shaker frequency for the Y-Direction.			
Parameter	***Validity***	***Default***	***Description***
Frequency	66…300	142	Frequency [Hz] ·10
Error	(2) Invalid command. (3) Invalid operand.		

SAX Set Shaker Amplitude X:

SAX Amplitude			
Sets shaker amplitude for the X-Direction.			
Parameter	***Validity***	***Default***	***Description***
Amplitude	0...30	20	in 1/10 mm
Error	(2) Invalid command. (3) Invalid operand.		

SAY Set Shaker Amplitude Y:

SAY Amplitude			
Sets shaker amplitude for the Y-Direction.			
Parameter	***Validity***	***Default***	***Description***
Amplitude	0...30	20	in 1/10 mm
Error	(2) Invalid command. (3) Invalid operand.		

SPS Set Phase Shift X/Y:

SPS Phase Shift			
Sets phase shift between X and Y-shaker drive. The X-axis is the reference for the phase. **To use this command, X-Frequency ≤ Y-Frequency and the Frequencies of the axis must have a rate of 1:1, 1:2, 1:3…!**			
Parameter	***Validity***	***Default***	***Description***
Phase Shift	0...360	0	in °
Error	(2) Invalid command. (3) Invalid operand.		

SSP Set Shaker Parameter:

SSP Amplitude Amplitude Frequency Frequency Phase Shift			
This Command integrates the single Commands SAX, SAY, SFX, SFY and SPS to one. For detailed Information's, see the description of the single Command above. Syntax: SSPvv,ww,xxx,yyy,zzz (vv = Amplitude x-Axis, ww = Amplitude y-Axis, xxx = Frequency x-Axis, yyy = Frequency y-Axis, zzz = Phase Shift)			
Parameter	***Validity***	***Default***	***Description***
Amplitude x-Axis	0...30	20	in 1/10 mm
Amplitude y-Axis	0...30	20	in 1/10 mm
Frequency x-Axis	66…300	142	Frequency [Hz] ·10
Frequency y-Axis	66…300	142	Frequency [Hz] ·10
Phase Shift	0...360	0	in °
Error	(2) Invalid command. (3) Invalid operand.		

ASE Set Shaker Enable Status:

ASE Status			
Sets shaker enable status for the X- and Y-shaker drive.			
Parameter	***Validity***	***Default***	***Description***
Status	0, 1,ND	0	0 = off, 1 = on, ND = on without labware detection When the device is handled in a tower and more devices are shaking the whole tower oscillates a bit. In this case it is possible that ASE0 does not detect when the shaking has stopped. The reply to ASE0 is sent after the amplitude has dropped below a small value. In this case you have to wait an arbitrary long time for it. To avoid this, send ASE0 to all devices of the tower. With ASEND it is possible to shake without detected labware. This is important for the use of labware which cannot be detected by the Incubator Shaker labware detection.
Error	(2) Invalid command. (3) Invalid operand. (7) Device not initialized. (20) Command not executable.		

SSC Set Shaker Calibration values:

SSC Key, Position, Value			
Sets Shaker Adjustment values of the Hall-Effect Sensors (see chapter 4.2). When Command SSC0 is executed, the shaker error flags are still stored but don't switch off the shaker! After a power-up, the shaker error flags are able to switch off the shaker (normal functionality)! Syntax Examples: SSC1,143 → Adjusts the X-H moving direction with 1,43 mm SSC4,095 → Adjusts the Y-H moving direction with 0,95 mm			
Parameter	***Validity***		***Description***
Position	0…6, 8…11		0 = Center Position 1 = X-H 2 = X-L 4 = Y-H 5 = Y-L 6 = Adjustment delta of X- and Y-Values and store 8 = Sets the Correction-Factor for X-Axis low 9 = Sets the Correction-Factor for Y-Axis low 10 = Sets the Correction-Factor for X-Axis high 11 = Sets the Correction-Factor for Y-Axis high
Key	xxxxx	-	Secret
Value	0…400		[1/100 mm]
Error	(2) Invalid command. (3) Invalid operand.		

5.0 Error Codes

Code	*Error message*	*Caused by*
0	Msg Ok	Normal return message.
1	Reset detected	Power on, software or watchdog reset i.e. always after the first command after reset and announcement.
2	Invalid command	Command does not exist for this device.
3	Invalid operand	Parameter out of range (see command set).
4	Protocol error	USB Protocol error. Wrong message length or crc
5	Reserved	-
6	Timeout from Device	Device did not answer within the expected time frame. This error must be generated by the PC application
7	Device not initialized	Command requires prior initialization of a sub system.
8	Command not executable	Parameter or Device condition prohibits execution.
9	Drawer not in end position	The drawer is in an unknown position (generated by RDS). This should be handled as warning if it set the first time. In this case the command open or close drawer should be repeated. Only if the error is persistent even after resending the command the robotic program should be aborted.
10	Unexpected Labware Status	A Labware is detected on AOD after a power-up or after an undefined drawer status.
11	Reserved	-
12	Reserved	-
13	Drawer DWP not perfectly closed	NTC resistor not connected – check drawer
14	Floor ID error	Device is not registered in the master.
15	Timeout sub device	The error message is from this device. The sub devices, heater or shaker did not answer within the expected time frame.

6.0 Description Command REF

The error bits of the Command REF are defined as follows:

Error Flags Heater

Bit 0: EFLAG_H_**WARN**_WarmUp_TIME
Max. time (t_1) exceeded for reaching TT+BO after start.

Bit 1: EFLAG_H_**WARN**_BoostCoolDown_TIME
Max. time (t_3) exceeded for reaching TT after switching off booster.

Bit 2: EFLAG_H_**WARN**_StartState_LIMIT_Up_TEMP_S2
Over swing over warning level of sensor 2 during t_1-t_2. Additional Bit 13 will be set.

Bit 3: EFLAG_H_**WARN**_StartState_LIMIT_Up_TEMP_S3
Over swing over warning level of sensor 3 during t_1-t_2.

Bit 4: EFLAG_H_**WARN**_StartStateBoost_LIMIT_UpDown_TEMP_S3
Over- or under swing under/above warning level during stable boost phase (t_2) of sensor 3. Additional Bit 14 will be set.

Bit 5: EFLAG_H_**WARN**_StableState_LIMIT_UpDown_TEMP_S2
Over- or under swing under/above warning level during stable phase (t_4) of sensor 2. Additional Bit 13 will be set.

Bit 6: EFLAG_H_**WARN**_StableState_LIMIT_UpDown_TEMP_S3
Over- or under swing under/above warning level during stable phase (t_4) of sensor 3. Additional Bit 14 will be set.

Bit 7: EFLAG_H_**WARN**_DELTA_TEMP_S1_S2
Temperature difference between sensor 1 and 2 reaches warning level.

Bit 8: EFLAG_H_**ERR**_DELTA_TEMP_S1_S2
Temperature difference between sensor 1 and 2 reaches error level.

Bit 9: EFLAG_H_**ERR**_MAX_TEMP
Sensors 1 or 2 reach the max. allowed temperature. Depending on which sensor reaches the temperature first, additional Bit 13 or 14 will be set.

Bit 10: EFLAG_H_**ERR**_CABLE_BREAK_S1
Sensor 1 is out of range (broken line).

Bit 11: EFLAG_H_**ERR**_CABLE_BREAK_S2
Sensor 2 is out of range (broken line).

Bit 12: EFLAG_H_**ERR**_CABLE_BREAK_S3
Sensor 3 is out of range (broken line).

Bit 13: EFLAG_H_**ERR**_S2
Set additional to all warning flags regarding sensor 2, if error limit is reached.

Bit 14: EFLAG_H_**ERR**_S3
Set additional to all warning flags regarding sensor 3, if error limit is reached.

Bit 15: EFLAG_H_**WARN**_DELTA_TEMP_S1_S3
Temperature difference between sensor 1 and 3 reaches warning level (fan failure detection).

Error Flags Shaker

Bit 16: EFLAG_SH_**ERR**_LIMIT_MAX_AMPL_X
Shaker amplitude X-Axis reaches error level ten times in a row.

Bit 17: EFLAG_SH_**ERR**_LIMIT_MAX_AMPL_Y
Shaker amplitude Y-Axis reaches error level ten times in a row.

Bit 18: EFLAG_SH_**ERR**_LIMIT_NO_AMPL_X
No Shaker movement X-Axis detected.

Bit 19: EFLAG_SH_**ERR**_LIMIT_NO_AMPL_Y
No Shaker movement Y-Axis detected.

Bit 20: EFLAG_SH_**WARN**_DELTA_AMPL_X
Shaker amplitude X-Axis diverges from set value thirty times in a row.

Bit 21: EFLAG_SH_**WARN**_DELTA_AMPL_Y
Shaker amplitude Y-Axis diverges from set value thirty times in a row.

Bit 22: EFLAG_SH_**WARN**_DELTA_FREQ_X

Shaker frequency X-Axis diverges from set value fifty times in a row.
Bit 23: EFLAG_SH_**WARN**_DELTA_FREQ_Y
Shaker frequency Y-Axis diverges from set value fifty times in a row.
Bit 24: EFLAG_SH_**WARN**_DELTA_PHASE
Phase shift between X- and Y-Axis diverges from set value fifty times in a row.
Bit 25: EFLAG_SH_**ERR**_SENSOR_BREAK_X
Hall-Sensor X-Axis is out of range (broken line).
Bit 26: EFLAG_SH_**ERR**_SENSOR_BREAK_Y
Hall-Sensor Y-Axis is out of range (broken line).

6.1 Definitions

Levels Error Flags Heater

Warning levels: 0,5K (at 37 °C); Formula: $\frac{(5 \cdot TT)}{43} + 1$ [1/10 °C]

Error levels: 2K (at 37 °C); Formula: $\frac{(20 \cdot TT)}{43} + 3$ [1/10 °C]

Delta warning level S1/S2: 1K (at 37 °C); Formula: $\frac{(10 \cdot TT)}{43} + 2$ [1/10 °C]

Delta warning level S1/S3: 1K (at 37 °C); Formula: $\frac{(8 \cdot TT)}{43} + 2$ [1/10 °C]

Delta error level S1/S2: 3K (at 37 °C); Formula: $\frac{(30 \cdot TT)}{43} + 4$ [1/10 °C]

Delta warning level boost: 0,7K (at 37 °C); Formula: $\frac{(5 \cdot TT)}{43} + 3$ [1/10 °C]

Maximum time limit for t_1: $\frac{30 \cdot (TT + BO - T\_Actual)}{10} + 150 + Corr$ [s]

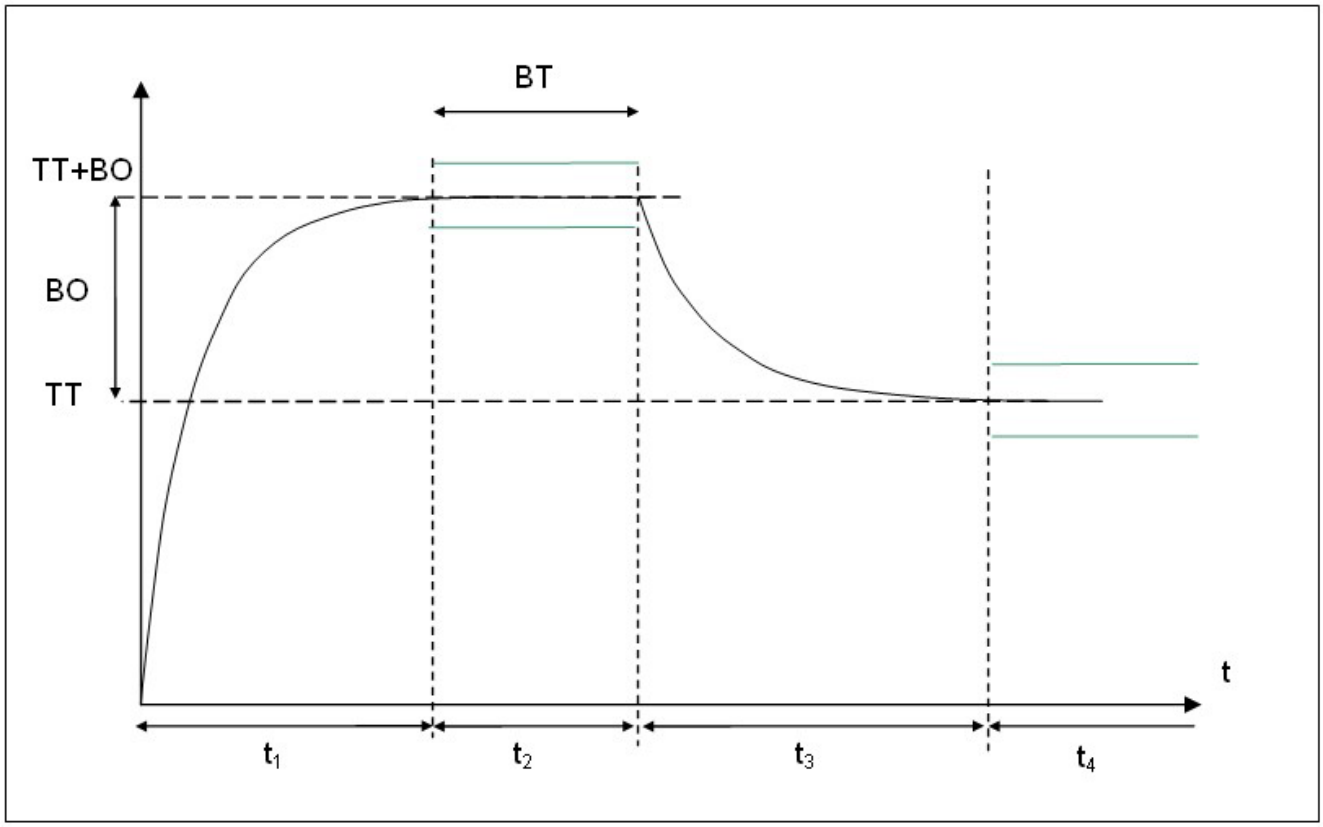
Maximum time limit for t_3: $\frac{40 \cdot BO}{10} + 180 + Corr$ [s]

Corr: $2600 - (BO \cdot 20) - (BT \cdot 50)$
If Corr < 0 → Corr = 0

Levels Error Flags Shaker
Warning level Phase shift: 11 °
Warning level frequency: 2,1 Hz
Warning level amplitude: 0,4 mm
Error level minimum amplitude: 0,1 m
Error level maximum amplitude: 4,0 m
Delay time after shaker parameter will be detected (except Bit 16 and 17): 60 sec.
Minimum set frequency for detection (Bit 22 and 23): 10 Hz

If a parameter reaches a **WARNING** Level, the Firmware sets the depending Flag. The device still works.
If a parameter reaches an **ERROR** Level, the Firmware sets the depending Flag and switches the Heater or Shaker off.
After a power-up or command SEF, all Flags will be reset. It's not advisable, to ignore Error Levels!

6.2 **Diagram**



TT = Target Temperature
BO = Booster offset
BT = Boost time

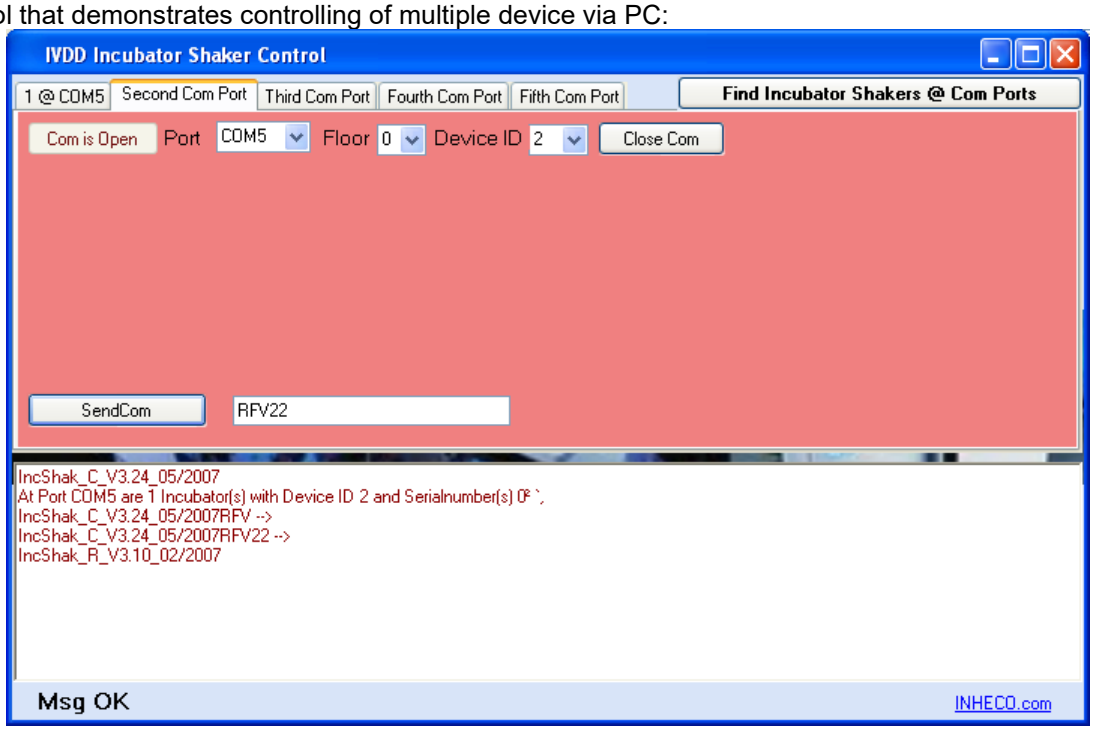
7.0 Operation

The Incubator can only be controlled via USB.

The Incubator uses a chip from the company FTDI to transform a serial signal to an USB signal. This chip is doing the registration on the USB as well. The FTDI chip is able to communicate via virtual COM (Virtual COM Port (VCP)) with the PC. The drivers that are needed are available at the homepage of the producer http://www.ftdichip.com/FTDrivers.htm. Using the virtual COM port driver, it is possible to communicate with the Incubator the same way as to serial devices. When more master devices are connected via USB to a PC, each registers to the USB with a different COM port number. Therefore one PC is able to control sixteen master devices or stacks at once.

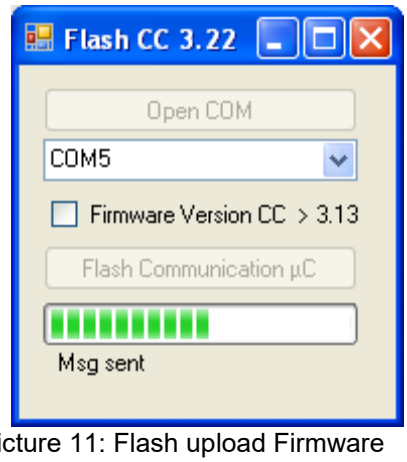
INHECO offers tools for special purposes and help for development of the automation tools.
To give the user an overview of the possibilities for controlling Incubators, the following kinds of applications has been developed at INHECO:

Example tool that demonstrates controlling of multiple device via PC:



Picture 9: PC-Tool

Tool for the flash update:



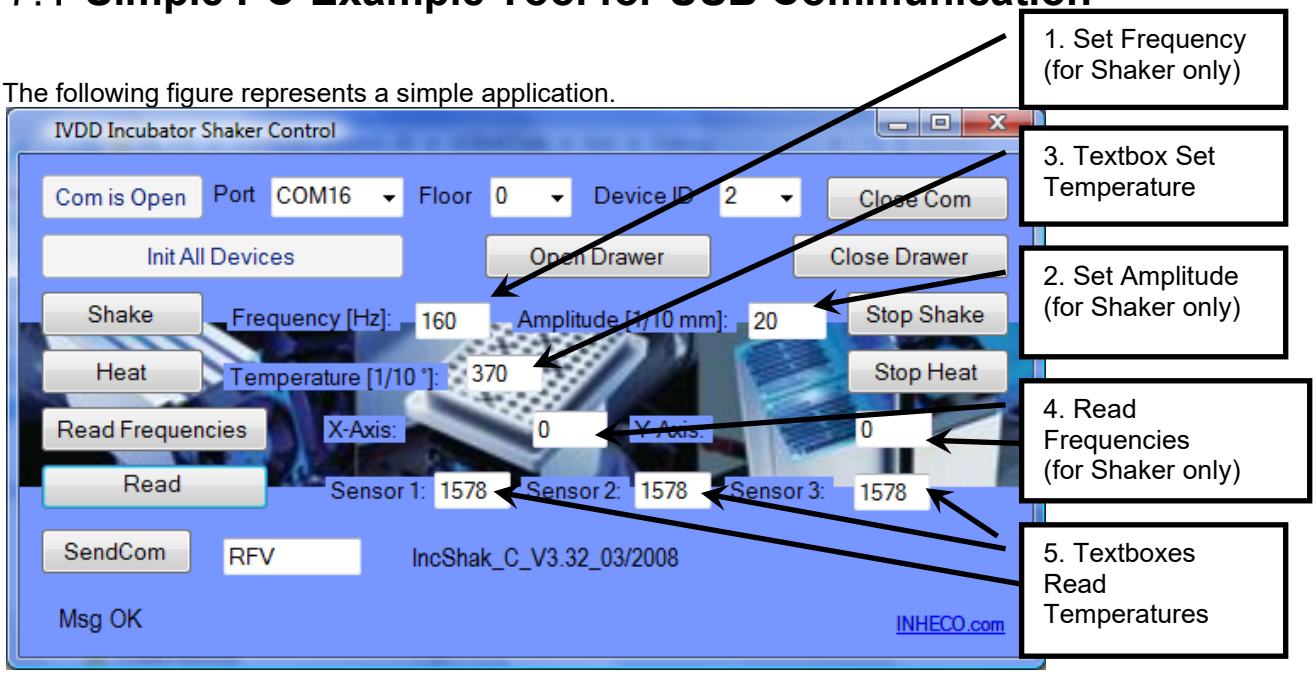
Picture 11: Flash upload Firmware

Example applications in C#, C++ and Visual Basic 2005, all .net based. To use these tools and the tools above the .Net Framework 2.0 must be installed on your system.
VEE Agilent and Labview example and automated test applications.

For detailed information's about the tools please contact the INHECO Tech hotline.

7.1 Simple PC-Example Tool for USB Communication

The following figure represents a simple application.



Picture 13: Application Example

At the virtual COM Port 16 an Incubator is connected. Its device ID is 2 (see "Address Switch", Picture 5).

- Open Com Port COM16
- Adapt Device ID, if necessary
- Click Init All Devices
- After all devices into the connected stack are initialised the control buttons became activated.
- Control the Incubator with the following actions:
  - Open: Open the drawer when closed
  - Close: Close the drawer when open
  - Shake: For Incubator Shaker only.
  - Heat: Starts heating to the temperature specified in the respective textbox (3.).
  - Stop Shake: For Incubator Shaker only.
  - Stop Heat: Stops heating, if heating was active
  - Read Frequencies For Incubator Shaker only.
  - Read Temperatures: The device returns the temperatures of its three sensors (textboxes 5.).
  - SendCom:
    - Write a desired command to the list box behind the send button (RFV at the Figure).
    - Send the command with a click on the SendCom button or Return.

Before disconnecting the device or changing the COM port, close the whole tool or the COM port by click on the CloseCom button.

Remarks:

1. Up to 6 devices (pure Incubator) can be addressed via changing the floor.
2. In general the protocol forbits to send a next command before the previous has not be answered by the devices. Therefore do not klick too fast on the buttons.

3. In the line where Msg Ok can be read in Picture 13 the error codes of **Fehler! Verweisquelle konnte nicht gefunden werden.** are interpreted.

7.2 USB Communication

Hard- and software features of the Incubator USB virtual COM port are specified in this section.

Remark: The USB is not optimized for secure real time data transfer. Therefore all communication is secured by a cyclic redundancy checksum (crc). If the communication between the PC and the MTC does often fail or results often in timeouts, the PC is responsible in most cases. Therefore we recommend for stable MTC usage:

1. Other devices connected to the USB might have an influence on the communication stability of the incubator
2. Use a simple, stable workstation PC
3. The stability of the communication has to be verified with every PC
4. Vista seems to be more stable than Windows XP
5. Do not activate the automated update from Windows

7.2.1 Settings of the Serial Interface

The hardware settings of the interface are:

- Baudrate: 19200
- Stop bits: 1
- Parity: none
- Data bits: 8

7.2.2 Protocol

The protocol from PC to the Incubator is the following:

- 1st byte: Message length (data length +3).
- 2nd byte: ASCII Coded Device ID set at the micro switch on the rear side of the Incubator. i.E. 0x30+Device ID.
- 3 rd byte: 0xC0+data length, maximum 60
- 4ff bytes: maximum 60 data. They are:
    - 4th byte (ASCII T) = 84 = 0x54 (historical inherited from CANH).
    - 5th byte = ASCII 0 = 48 = 0x30 (historical inherited from CANH).
    - 6th byte = ASCII 0, 1, 2, 3, 4 or 5. Maximum 6 incubators in a stack can be addressed by choosing the value of the position in the stack, respectively. The lowest and a single incubator are number 0. Since Firmware Version 3.24 of the CC it is possible to send Commands to the whole Stack with an X on this position
    - Bytes 7- Message length Command Set Commands, e.g. (ASCII coded) ‘AID’ initialises the device or RFV reads firmware version of the communication controller.

- Byte nr of Message length+1: Cyclic Redundancy Check (CRC). If this byte is missing or wrong the message will be ignored and the error code 4 will be reported. The CRC can be calculated with the following subroutine:
  void crc8(byte data)

```
{
    byte i = 8;
    do
    {
        if (((data ^ crc) & 1) == 1)
        {
            crc ^= 0x18;
            crc >>= 1;
            crc |= 0x80;
        }
        else
        {
             crc >>= 1;
        }
        data >>= 1;
    }
    while ((--i) > 0);
}
```

In our case the crc must be initialised with 0xA1 and the Subroutine must be called with all bytes including the header. A code that makes use of these facts is:

```
crc = 0xA1;
for (int i = 0; i < MsgLength; i++)
{
    crc8(data[i]);
}
data[MsgLength] = crc;
```

Example:

The hex string:

09 32 C6 54 30 30 52 46 56 04

has the following meaning:

- 1st byte: message length 9 byte → 0x09
- 2nd byte: device ID is two → 0x32
- 3rd byte: frame length = 6 → 0xC6
- 4th byte: T → 0x54
- 5th byte: 0 → 0x30
- 6th byte: Master device (Basement of a stack) → 0x30
- bytes 7-9: following the Command Set “Read Firmware Version Communication Controller” ‘RFV’ → 0x52 0x46 0x56
- 10th byte: CRC →0x04

The reply of the Incubator is the firmware version of the communication controller (ASCII coded), for instance:

Ack: B2 **(0xB0+device Id)**
Data:
49 56 44 49 6E 63 75 62 61 74 6F 72 2D 43 2D 56 31 2E 33 33 2D 31 32 2F 32 30 30 38
means: IVDIncubator-C-V1.33-12/2008.
Finished without error: B2 20 60

Some more examples for send messages:

SEP8,250:

No. of data				1	2	3	4	5	6	7	8	9	10	11	CRC
Dec/ASCII	14	50	11+0x C0	T	0	0	S	E	P	8	,	2	5	0	
Hex	0x0E	0x32	0xCB	0x54	0x30	0x30	0x53	0x45	0x50	0x38	0x2C	0x32	0x35	0x30	0xF2

SEP13,250:

No. of data				1	2	3	4	5	6	7	8	9	10	11	12	CRC
Dec/ASCII	15	50	12+0x C0	T	0	0	S	E	P	1	3	,	2	5	0	
Hex	0x0F	0x32	0xCC	0x54	0x30	0x30	0x53	0x45	0x50	0x31	0x33	0x2C	0x32	0x35	0x30	0x85

The protocol in direction Incubator→ PC is the following:

After receiving a command the device replies immediately its device ID plus 0xB0.

After this the data do follow. When a command is finished the device sends the two data bytes: 0x20+error code and 0x60. However the reply to

- Set commands is always (in hex) B0+ Device Id, 20+error code, 60
- Action Commands is similar. Usually a break of one to two seconds between the first and the following bytes.
- Report commands finally embed the report data between B0 + Device Id and B0+ Device Id, 20 + error code, 60.

Note:

There is a known issue in the response (only rarely observed). Following workaround may be used:

a) If the byte in front of the reference byte is unequal to 0xA, that byte contains the error code.
b) If the byte in front of the reference byte is equal to 0xA, the error code is in the byte in front of that byte.

Example:
0xB0 0xA 0x20 0x60 0xA (case a)
0xB0 0x20 0xA 0x60 0xA (case b)

7.2.3 Timing

Do not send a second command before the two finish bytes (0x20+error code; 0x60) have been received. The Communication Controller (CC) is unable to process two commands at once. This is similar for Slave/Master Commands (T01/T00). Since firmware version 3.24 of the CC the possibility exists to send commands to the whole stack with T0X.

In addition the controller may have problems, when the length of a message is longer than it was given by the message length byte (byte 0). In some cases a hardware reset is necessary.

The time, when a reply is expected depends on the kind of command that has been sent.

- Report Commands, maximum allowed 100 ms, typically is:
    - from the Master CC 20 ms
    - from Slave CC 30 ms,
    - from Temperature Controller or Shaker µC 40 ms
- Action commands maximum 5 Sec
- Set Commands maximum 1 Sec
- Flash download, maximum 200ms typically for reply time to one line of the hexfile (length 27 byte):

    CC 30 ms (→ expected download time of approximately 35 Sec)

    - Temperature Controller/Shaker 50 ms (→ expected download time of approximately 1 Min 10 Sec)

7.2.4 Dll

A Dll for easier handling of our USB device is available. HW settings of the COM, the header and the crc of the messages are handled by the Dll functions. They are:

- `public int openCom(string PortName):`
  Opens the COM Port at which the device is connected at windows you can find out the name at the device manager. Returns 77 at success and 0xAA if it was not possible to open that port. Example: res = openCom(“COM8”);

- `public string[] GetPortNames():`
  Returns the available port names at your PC using the .Net Framework 2.0 function SerialPort.GetPortNames();

- `public int closeCom():`
  Closes the COM that has been opend before. Returns 99. Example: `res=closeCom();`
- public int sendMsg(byte[] instruction, byte MsgLength, byte DeviceID, byte StackFloor):
  Sends the instruction of length MsgLength to a device with ID DeviceID to the StackFloor’th floor of the Stack. Returns 88. Example:

```
string str = "AID";
MsgLength = Convert.ToByte(sendstr.Length);
char[] tmp = new char[128];
sendstr.CopyTo(0, tmp, 0, sendstr.Length);
for (int i = 0; i < sendstr.Length; i++)
{
```

```
            instruction[i] = Convert.ToByte(tmp[i]);
        }
        comport.sendMsg(instruction, MsgLength, 3, 1);
```

- public string readCom(): Returns a string that contains all the data that has been received from the COM. Example: `string str = comport.readComAll();`

The following header is suitable to give C++ programs access to the DLL functions:

```
namespace USBCom
{
    class Com
    {
        public:
        virtual int openCom(char *c);
        virtual int closeCom(void);
        virtual int sendMsg(char *instruction, char MsgLength, char DeviceID, char
StackFloor);
        virtual char **GetPortNames(void)
        virtual char *readCom(void);
    };
}
```

To use our DLL the .Net Framework 2.0 must be installed on your system.

8.0 Index of Commands

A

R

S