Multi/Single TEC Control (MTC/STC)

Firmware Command Set

Document Status (Draft / Released / Replaced / Invalid):	Draft
Filename:	TD_P0325_07-07-07_FWCommandSet_0.9.docx
Author:	TTH/RPU
Document Version:	V0.9
Document Release Date:	………………………………….
Document Release Signature:	………………………………….

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1.0 Document History

Version	Date	Author	Description of document changes	Corresponding Firmware
0.0	07.07.07	TTH/RPU	**First Draft**	V0.10
0.1	11.11.07	TTH	**First run able firmware exists**	V0.11
0.2	10.03.08	TTH	**Alpha Test Version**	V1.07
0.3	16.04.08	TTH/RPU	**Beta Test Version**	V1.20
0.4	31.08.08	TTH/RPU	**Pre Series Version**	V1.39
0.5	13.10.08	TTH/RPU	**Pre Series Version**	V1.50
0.6	12.12.08	TTH	**Commands corrected and added (ADE). Error code table separated.**	V1.66
0.7	19.01.09	TTH/CGE/ RPU	**Improved description of Offsets and calibration. Adapted to FW**	V1.70
0.8	07.07.09	TTH/MST	**Change Requests Included New: Errors 13/16/26-32; Commands: SLT/RLT/RCF/SCF**	V1.78 V1.80
0.9	19.10.09	TTH	**REC + details; Syntax Errors Erased**	V1.85

2.0   Firmware Update History

FW-Version	Description of functional changes
V0.10	First version
V0.11	First version with full functionality
V1.07	03/08 alpha test version
V1.20	04/08 beta test version
V1.50	Pre series version. New: Comma separated parameters and external EEPROM handling, Error Codes extended.
V1.66	Improved error and device EEPROM handling, Startup implemented, Two Temp sensors per slot module realised
V1.70	Series freeze candidate: Display errors vanished, endurance test proved version. SCO added
V1.75	Boost Offset and Boost Time re enabled, ext EEPROM Handling improved
V1.78	Hologic FDA Freeze. Since 5 Month stable version with unimportant bugs
V1.80	Display appearance improved
V1.85	INHECO Series Start FW: REC details; More ext EEPROM Values (RLT, RLO5/7)

3.0   Introduction

The INHECO Multi TEC Control (MTC/STC) announces itself as a HID to the USB Host. The USB Host is usually a PC or a Notebook. The drivers for communication with a HID includes the PC Operation System e.g. Windows XP. In addition to those HID drivers a driver is needed that knows the protocol of the INHECO MTC/STC Commands. This is for example the *InhecoMTCdll.dll* (Description see chapter 8.0). In contrary to previous INHECO products the MTC/STC does not use a virtual com for communication. We recommend the customer to use the dll and not to write a driver themselves.

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/STC does often fail or results in timeouts, the PC is responsible in most cases. Therefore we recommend for stable MTC/STC usage:
1. No (or not too much) other devices should be connected to the USB because they might have an influence on the communication stability of the MTC/STC
2. Use a simple, stable workstation PC. Front USB Ports are usually worse than back side USB Ports.
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

3.1 Purpose

This document contains detailed information about all firmware commands implemented in the firmware of the MTC/STC.

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:

Abbreviation	Description
Controller	Microprocessor with on chip peripheral.
PWM	Pulse-Width Modulation
USB	Universal Serial Bus
SSB	Serial Slot Bus
HID	Human Interface Device
MB	Mainboard of the MTC/STC
Slot	Slot-Module of the MTC/STC
MTC	Multi TEC Control
ms	Millisecond
crc	Cyclic redundancy check
TEC	Thermo Electric Cooler
STC	Single TEC Control

3.4 Device Overview

The Multi/Single TEC Control unit can be connected to the PC via USB or be used as a stand-alone device via Touch-Screen. The Touch Screen enables access to MTC/STC basic features only. The USB transfers transparent information to the device and vice versa. The Multi/Single TEC Control Mainboard appears to the USB as a HID slave device. A maximum of six Slot-Modules can be plugged into the Mainboard.
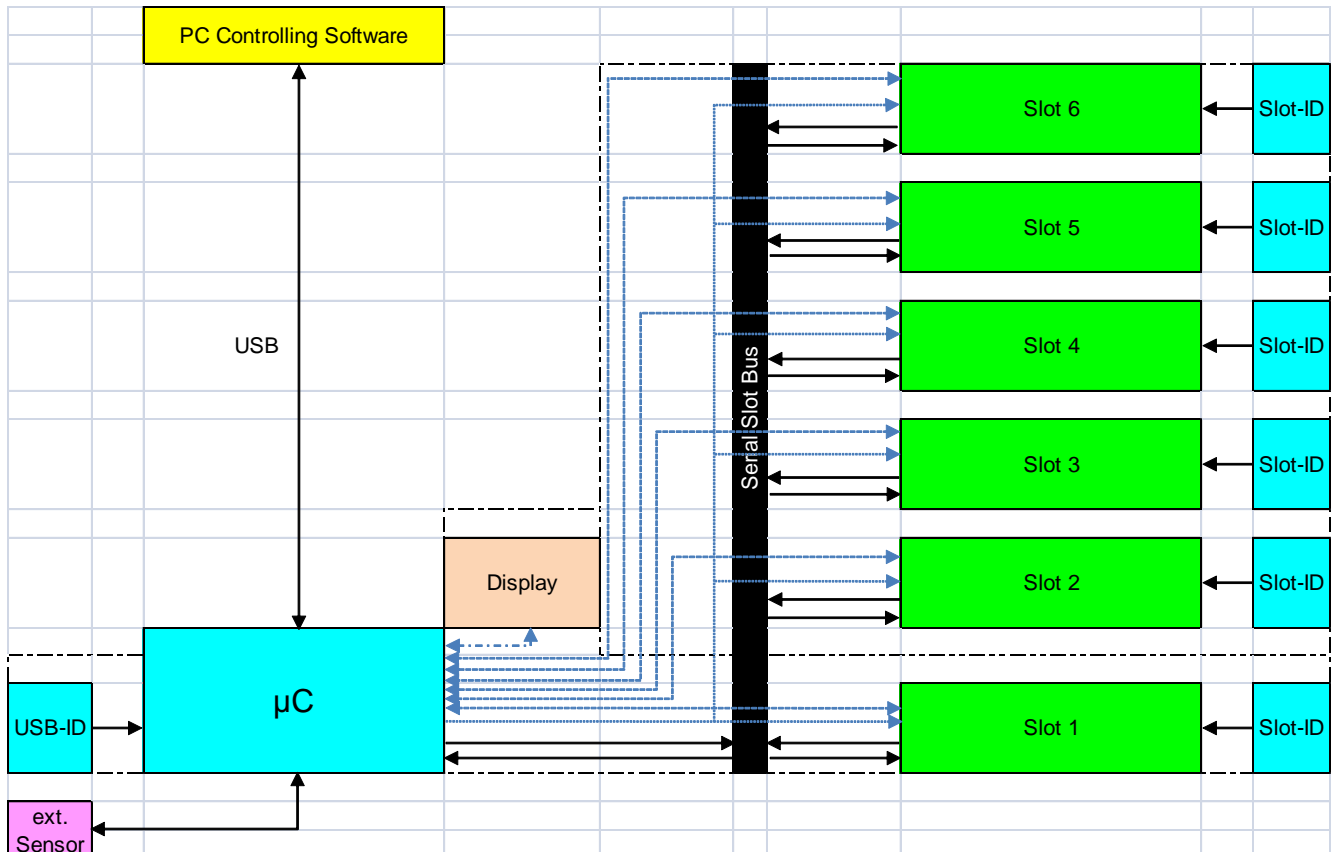
Figure 1: Communication lines at the MTC/STC

3.5 Operation & Setup

Preliminary actions have to be performed in order to operate the MTC/STC.

- Set address switch to the correct address with DIP-Switch 1-3
- Hardware configuration – if necessary:
  - Set Limits for the Error Codes,
  - Set Limits Online Diagnosis: Command SLO
  - Erase Errors: Command SEC
- Set origin of control parameters, internal or external EEPROM: Command SPO (default is external EEPROM usage)
- Set control parameters: Commands SRT, SPP, SPI, SPD, SDO, SDX…

3.6 USB-ID via DIP-Switches

The DIP-Switches 1-3 configures the address of the device. Below is shown the significance of the DIP-Switch position. → Up to 8 MTC/STCs can be controlled by one PC, also combined.
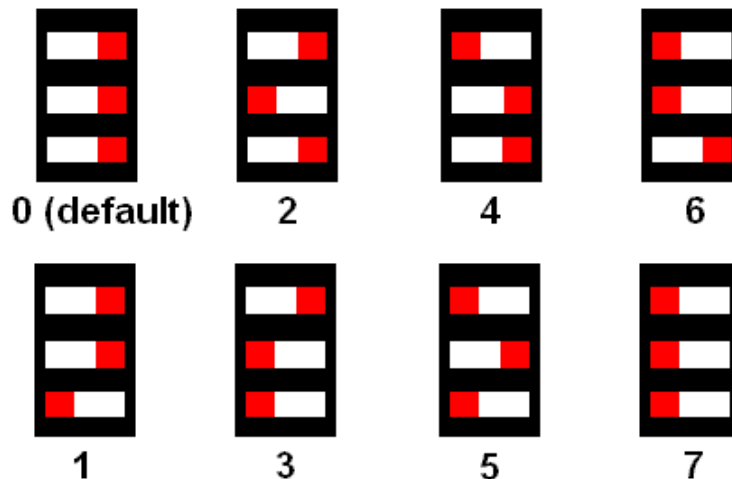
3.7 Temperature sensors

The temperature offset (command SHO & SCO) for the different plate-types will be handled by the device EEPROM. The Controlling PC measures the room temperature and relative humidity via an internal sensor on the Mainboard or external sensor (optional). Depending on the temperature difference between target and ambient temperature, the offset for the device can be calculated and set (command SRT).

3.8 Reset behaviour

The MTC/STC replies to the first command after this synchronisation-registration procedure with the error code 6 (Reset detected, see chapter 5.1) i.e. always after power on. This error must not occur without a hardware reset. Please contact INHECO if a reset is detected frequently. There is one exception from this. After the software reset command SRS this error code is even mandatory.

At power on the MTC/STC is doing a self test and reads out the memory of the devices which are plugged into the slot modules. During this procedure the fans of the devices are running and the MTC/STC displays a boot screen. It is very important that the values read from the devices memories are correct. Therefore they are secured by a cyclic redundancy check. The MTC/STC tries up to three times to read out the memories. In such a case the Start Up lasts around 20 seconds. Some error entries are connected with problems during that procedure. I.E. if the LEDs become red after start up, problems with the device memory are most probably. Heating and cooling activities are disabled if such an error occurs. Do not unplug devices after the start up. Always switch off the MTC/STC before connect/disconnect a device.

4.0   COMMANDS

The MTC/STC consists of multiple components, Mainboard and Slots. As a consequence the commands need to be addressed to the respective component. A message starting with "0" addresses the Mainboard and starting with "1-6" addresses the Slot Modules 1-6. For example the command Report Firmware Version is 0RFV for the Mainboard and 3RFV for Slot-Module 3.
There exist three types of commands: **Action** commands, **Set** commands and **Report** commands.

Lots of commands like the maximum allowed MTC/STC housing temperature are secured by a keyword (factory setting). This keyword depends on the serial number of the MTC/STC-Mainboard. If a customer needs special settings, INHECO can provide this keyword to change the parameter. Guaranty vanishes in that case.

The MTC/STC replies to the first four signs of every command with a modified echo. The modification changes the capitals of the commands to small letters. I.e. The reply to 5ASE1 is 5ase. Therefore it is easy to identify correct answers to the commands. This feature may increase integrity of the communication.

The concept for commands with multiple parameters like 0SHOkey,5,1,20 is the following: The first parameter (key) do follow immediately after the command, whereas the next parameters (5,1,20) are separated with commas. Only **S**et commands can have multiple parameters. **R**eport and **A**ction commands have one or none parameter.

4.1 Common Commands

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.		
Response	*if*	*Description*
Selector	0	Bootstrap Version
	1	Application Version
	2	Report serial number
	3	Report actual hardware version
	4	Report Inheco copyright
Error	(5) Invalid operand.	

SFV   Set Serial number:

SFV_Key,_**SN**		
This command sets the device and Mainboard serial number.		
Parameter	*Validity*	*Description*
Key	xxxxxx	Secret
SN	4 Numbers	Serial number value
Error	(5) Invalid operand, (8) wrong keyword.	

RDC   Report Diagnostic Counters:

RDC_Selector_		
Reports the current (since last power-on) and the overall operation time.		
Parameter	*Validity*	*Description*
Selector	1	Report current operation time [s]
	2	Report overall operation time [s]
Error	(5) Invalid operand.	

SDC   Set Delete Counter:

SDC*Key*			
Deletes the counter of the operating times.			
Parameter	***Validity***		***Description***
Key	xxxxxx	-	Secret
Error	(5) Invalid operand.		

RCF   Report CRC16 Flash Memory:

RCF*Selector*		
Reports checksum or number of lines into the µCs flash memory.		
Parameter	***Validity***	***Description***
Selector	0	Report the crc16 the µC has calculated in the first 30 seconds after startup
	1	Report number of full lines of the flash memory
Error	(5) Invalid operand.	

SCF   Set CRC16 Flash Memory:

SCF*Key,***Selector***,Value*		
In the first minute the µCs calculate a cyclic redundant checksum of their flash memory. When they have finished they compare it with that values that become set here. If they are identical the flash is ok if not error code 26 becomes set.		
Parameter	***Validity***	***Description***
Key	xxxxxx -	Secret
Selector	0/1	0:Set the crc16 for the flash memory 1:Set number of lines the flash code has got
Value		Either crc16 or nr of lines
Error	(5) Invalid operand.	

REC   Report Error Code:

REC*Selector*		
Reports the Error Code of the Devices. Up to 7 errors can be stored into the error memory. When the *Selector* is an error code and this error has occurred the reply includes detailed information about the specific code: Number of occurrences and time at the last occurrence (reply to RDC2 at that moment). The device specific Error codes are described in Table 2 in Chapter 5.2 In all other cases and if REC is called without *Selector* the reply includes all error codes delimited by "_".		
Response	***Code***	***Description***
Code	1-32	Codes have different meaning in Slot module and Mainboard. For details see Table 2 in Chapter 5.2.
Error	-	

SEC   Set Error Code:

SEC*Key*		
Resets the Error Codes of the device and erases the red LED at the Slot-Module.		
Parameter	***Validity***	***Description***
Key	xxxxxx	Secret
Error	(5) Invalid operand.	

SRS   Set Reset System:

SRS*Key,***Parameter**			
This command resets the Mainboard and the Slot-Device without losing the USB-Connectivity. After such a command, the device FW starts like after a normal power-up.			
Parameter	*Validity*		*Description*
Key	xxxxxx		Secret
Parameter	1,0		1: generates Watchdog Reset, 0: jumps to Bootloader
Error	(5) Invalid operand. (8) Wrong keyword.		

4.2 Mainboard Specific Commands

RAV   Report Analog Values:

RAV*Selector*		
Reports Analog Values from the AD Converter.		
Response	*if*	*Range*
Selector	0 - 31	AD Port 0 - 31
Error	(4) Invalid command. (5) Invalid operand.	

RCI   Report Calibration Inclination:

RCI		
Reports the inclination of the PT100 calibration curve of the Slot-Modules. The value is stored on EEPROM of the Slot-Module.		
Response	*if*	*Range*
0-9999		Inclination of the calibration curve
Error	(4) Invalid command. (5) Invalid operand.	

SCI   Set Calibration Inclination:

SCI*Key,***Value**		
Sets the inclination of the PT100 calibration curve of the Slot-Module. See Chapter 6.1. The value is stored on EEPROM of the Slot-Module.		
Parameter	*Validity*	*Range*
Key	xxxxxx	Secret
Value		Value between 0 & 9999
Error	(4) Invalid command. (5) Invalid operand (8) wrong keyword.	

RCT   Report Calibration Offset Temperature:

RCT		
Reports the offset of the PT100 calibration curve of the Slot-Modules. The value is stored on EEPROM of the Slot-Module.		
Response	*if*	*Range*
0-9999		Offset value of the calibration curve
Error	(4) Invalid command. (5) Invalid operand.	

SCT   Set Calibration Offset Temperature:

SCT*Key,***Date,***user,***Value**		
Sets the offset of the PT100 calibration curve of the slot-Module. See Chapter 6.1. The value is stored on EEPROM of the Slot-Module.		
Parameter	*Validity*	*Range*
Key	xxxxxx	Secret
Date	YYYY-MM-DD	-
User	xxx	AAA - ZZZ
Value	0-9999	Offset value of the calibration curve
Error		(4) Invalid command. (5) Invalid operand, (8) wrong keyword.

RHV   Report Housing Values:

RHV*Selector*		
Reports the MTC/STC the actual status values listed below.		
Response	*if*	*Range*
Selector	0	Value Power Supply [1/10 V]
	1	Housing Fan [on / off]
	2	Temperature Sensor 1 (Housing) [1/10 °C]
	3	relative Humidity Sensor 1 (Housing) [1/10 %]
	4	Temperature Sensor 2 (Housing) [1/10 °C]
(Without the external sensor	5	Temperature Sensor 1 (External) [1/10 °C]
accessory the reply to	6	relative Humidity Sensor (External) [%]
0RHV5/6 is invalid.)		
	7	Analogue Sensor 1 (External) [1/10 °C]
	8	Analogue Sensor 2 (External) [1/10 °C]
	9	Maximum measured temperature [1/10 °C] to be erased with 1
Error		(4) Invalid command. (5) Invalid operand.

RLO   Report Limits On Board Diag:

RLO*Selector*		
Reports the limits for specific values that are controlled every second from the Mainboard		
Response	*if*	*Range*
Selector	1	Max allowed Voltage Power Supply [1/10 V]
	2	Min allowed Voltage Power Supply [1/10 V]
	3	Min allowed housing temperature [1/10 °C]
	4	Max allowed housing temperature [1/10 °C]
	5	Maximum allowed temperature difference front and rear sensor [1/10 °C]
	6	Maximum allowed humidity [1/10 % rel. humid.]
Error		(4) Invalid command. (5) Invalid operand.

SLO   Set Limits On Board Diag:

SLO*Key,***Selector,***Value*		
Sets the limits for specific values that are controlled every second from the Mainboard.		
Parameter	*Validity*	*Range*
Selector	1	Max allowed Voltage Power Supply [1/10 V]
	2	Min allowed Voltage Power Supply [1/10 V]
	3	Min allowed housing temperature [1/10 °C]
	4	Max allowed housing temperature [1/10 °C]
	5	Maximum allowed temperature difference front and rear sensor [1/10 °C]
	6	Maximum allowed humidity [1/10 % rel. humid.]
Error		(4) Invalid command. (5) Invalid operand. (8) Wrong keyword.

RMA   Report AD-Channels:

RMA		
Reports bit coded the AD-Channels that need to be measured. A multiplexer on the Mainboard will work respective and guide its coded channels only to the 16-bit AD-Converter of the Mainboard.		
Response	*default*	*Range*
CNTR	3766624803	0-0xFFFFFFFF at MTC
	65535	0-0xFFFF at STC
Error		

SMA   Set AD-Channels:

SMA*Key,*CNTR		
Sets bit coded the AD-Channels that need to be measured. A multiplexer on the Mainboard will work respective and guide its coded channels only to the 16-bit AD-Converter of the Mainboard. If one channel per Slot should be measured (Channels 5, 9, 13, 17, 23 and 29 of the MUX), the voltage of the power supply and the PT100 sensor onto the Mainboard should be converted (Channels 0 and 1) and in addition values of the external sensor that may be plugged into the Mainboard should be converted (Channels 30 and 31). In the 32-bit (long) variable CNTR the respective bits must be set. Consequently its value must be in hex: 0xE0822223. Unfortunately the communication allows us to send decimal values only. Therefore for the default, described above, 0SMAKey,3766624803 must be sent to the Mainboard. Remark: To enable all 32 Channels 0xFFFFFFFF i.e. 4294967295 must be sent to the MTC Mainboard. The STC has 16 channels only. Therefore the maximum and the default setting is 0xFFFF i.e. 65535.		
Parameter	*Validity*	*Description*
Key	xxxxxx	Secret
CNTR		Bit coded activated channels for AD conversion. 0 off 1 on
Error	(5) Invalid operand. (8) Wrong keyword.	

RSN   Report Serial number external Device:

RSN*SlotID*		
Reports the serial number of a device that is connected to the selected slot module. The slot is selected with the SlotID (1-6). It replies 0 if no slot module is mounted and it reports 65535 if no device was connected to the module at start up or if the device has no external EEPROM.		
Response	*SlotID*	*Range*
SN	1-6	0-9999 Serial number of the selected device
Error	(5) Invalid operand.	

SSN   Set Serial number external Device:

SSN*Key* **SlotID,***SN*		
Sets Serial number of the device which is connected to the respective slot module, if it has a device EEPROM.		
Parameter	*Validity*	*Description*
Key	xxxxxx	Secret
SlotID		Slot ID at which the respective device is connected
SN		Serial number the device should get
Error	(5) Invalid operand. (8) Wrong keyword.	

RTD   Report Type (external) Device:

RTD *Selector*		
Selector in 1…6: Reports the type of the external device that is connected to the selected slot. Selector = 0: Reports the type of the Mainboard (STC, MTC).		
Selector	*Response*	Slot ID at which the respective device is connected
1…6	*If*	*Type of the (external) device*
	0	Thermoshake
	1	CPAC
	2	Teleshake
	3	-
	4	CPAC Ultraflat 2TEC
	Tbc	CPAC Ultraflat HT + 2TEC ….
0	0	STC
	1	MTC
	255	Not set: acts as MTC
Error	(5) Invalid operand.	

STD   Set Type (external) Device:

STD *Key,* **Selector,** *Type*		
Selector in 1…6: Sets the type of the external device that is connected to the selected Slot Module. Selector = 0: Sets the type of the Mainboard (STC, MTC).		
Parameter	*Validity*	*Description*
Key	xxxxxx	Secret
Selector	1…6	Slot ID at which the respective device is connected
Type		Type of the external device: 0 Thermoshake 1 CPAC 2 Teleshake 3 – 4 CPAC Ultraflat 2TEC tbc. CPAC Ultraflat HT + 2TEC
Selector	0	Mainboard
Type		0: STC 1: MTC
Error	(5) Invalid operand. (8) Wrong keyword.	

RRD   Report Runtime Device:

RRD *SlotID*		
Reports the runtime of the external device that is connected to the selected slot. The slot is selected with the SlotID (1-6).		
SlotID		Slot ID at which the respective device is connected
Response	*if*	*Range*
	1-6	0-65335 [minutes]
Error	(5) Invalid operand.	

SRD   Set Runtime Device:

SRD *Key,* **SlotID**		
Runtime is set to zero.		
Parameter	*Validity*	*Description*
Key	xxxxxx	Secret
SlotID	1-6	Slot ID at which the respective device is connected
Error	(5) Invalid operand. (8) Wrong keyword.	

SPP   Set PID Controller Coefficients (Proportional Gain):

The Mainboard must be addressed to change the PID Parameters, when the MTC/STC should use the external EEPROM values (default). Alternatively internal EEPROM values of each slot module can be used. The Command SPO (Set PID Origin) changes between internal Slot EEPROM and external Device EEPROM as origin of the PID parameters. The PID values can only be read from the Slot-Device after the start up of the MTC/STC.

SPP_SlotID_**,Heat/Cool**_,Value_		
Sets PID Controller Coefficients: proportional gain		
Parameter	*Validity*	*Description*
SlotID	1-6	ID of the Slot
Heat/Cool	0/1	0: PID Values for Heating; 1: Cooling
Value	0...255	proportional gain 0...255
Error	(5) Invalid operand.	

SPI   Set PID Controller Coefficients (Integration Value):

SPI_SlotID_**,Heat/Cool**_,Value_		
Sets PID Controller Coefficients: integration part		
Parameter	*Validity*	*Description*
SlotID	1-6	ID of the Slot
Heat/Cool	0/1	0: PID Values for Heating; 1: Cooling
Value	0...255	Integration value gain 0...255
Error	(5) Invalid operand.	

SPD   Set PID Controller Coefficients (Differential Part):

SPD_SlotID_**,Heat/Cool**_,Value_		
Sets PID Controller Coefficients: differential part		
Parameter	*Validity*	*Description*
SlotID	1-6	ID of the Slot
Heat/Cool	0/1	0: PID Values for Heating; 1: Cooling
Value	0...255	Differential part 0...255
Error	(5) Invalid operand.	

SRT   Set Room Temperature:

SRT_SlotId_**,**_Value_		
Sets the ambient temperature for the offset compensation curves in 1/10 °C. For details see chapter 6.1.		
Parameter	*Validity*	*Description*
Value	0...510	Set room temperature close to device in 1/10 °C
SlotID	1-6	ID of the Slot Module
Error	(5) Invalid operand.	

SHO   Set Heat-Up/Cool Down Offset:

SHOkey**,SlotID**_,Value_		
Set Heat-Up temperature offset for the device: Defines the offset temperature line for the different devices in 1/10 °C: 121 = 12.1 °C. See chapter 6.1. Set by INHECO.		
Parameter	*Validity*	*Description*
Key	xxxxx	Secret key
SlotID	1-6	ID of the Slot
Value	0...255	Set heat-up temperature offset for devices in 1/10 °C
Error	(5) Invalid operand.	

SCO   Set Constant Offset:

SCOkey,**SlotID***, Value*

Set Constant Offset at calibration of the devices is a constant offset e.g. due to varying cable length must be added or subtracted. Value is set in 1/100 °C. Set by INHECO.

Parameter	*Validity*		*Description*
Key	xxxxx		Secret key
SlotID	1-6		ID of the Slot
Value	-999…999	In 1/100 °C	Offset, e.g at std CPAC it is approx. -60 i.e. 0.6 °C
Error	(5) Invalid operand.		

RCM Report Calibration Mark:

RCM*ID*

Reports the date and an alphanumeric string (e.g. operator) of the last calibration for the Mainboard and the devices connected to the slot module.
The Data is reported in the Format YYYY-MM-DD,xxx (Example: 2005-09-28,xxx).
The "xxx" are alphanumeric wildcards.
Up to ten Calibration Marks can be written into the MAINBOARD EEPROM or the device EEPROM respectively.
Usually the last written Calibration Mark is read by this command. Previous Calibration Marks can be read with the following procedure:

- 0RCPi reports the Calibration Counter
- 0SCP_key,I,cnt sets the Calibration Counter to the desired value. E.g. cnt=0.
- Reset Mainboard either via power off/on or via 0SRS
- 0RCMi reports the desired "old" Calibration Mark
- Reset the counter to the value of step 1.

Parameter	*Validity*	*Description*
ID	0-6	0, Mainboard 1-6 Slot
Response	*if*	*Range*
Date		YYYY-MM-DD,xxx
Error	(5) Invalid operand.	

SCM   Set Calibration Mark:

SCM*Key,***SlotID***,Date,***USR**

Sets the date and e.g. operator of the last calibration for the Mainboard and the Devices.
The Data is reported in the Format YYYY-MM-DD,xxx (Example: 2008-09-28,xxx).
The "xxx" are wildcards for an alphanumeric string.
Up to ten Calibration Marks can be written into the Mainboard EEPROM or the device EEPROM respectively. Set by INHECO.

Parameter	*Validity*		*Description*
Key	xxxxxx	-	Secret
SlotID	0-6		0, Mainboard 1-6 Slot
Date	YYYY-MM-DD	-	
USR	xxx		Operator (three characters)
Error	(5) Invalid operand.		

SDO   Set Disposable Offset:

SDOSlotID,Selector,*Value*		
Sets specific disposable offset (for details see section 6.1.3.2 Linear disposable Offset (Commands SDO and SDX). Influences only the external Device EEPROM. Internal Slot EEPROM is changed with the respective slot command.		
Parameter	*Validity*	*Description*
SlotID	*1-6*	*Slot ID*
Selector	*0…8*	*Offset place*
Value	0...255	Temperature in 1/10 °C 0...255
Error	(5) Invalid operand.	

SDX   Set Disposable X-Axis Temp:

SDXSlotID,Selector,*Value*		
Sets specific disposable offset (for details see section 6.1.3.2 Linear disposable Offset (Commands SDO and SDX). Influences only the external Device EEPROM. Internal Slot EEPROM is changed with the respective Slot Command.		
Parameter	*Validity*	*Description*
Selector	*0…8*	*Place*
SlotID	*1-6*	*Slot ID*
Value	0...2550	Temperature in 1/10 °C 0...2550
Error	(5) Invalid operand.	

SRE   Set Reset External EEPROM:

SRE*SlotID*		
Writes the default parameter (see command SDP) back to the external EEPROM.		
Parameter	*Validity*	*Description*
SlotID	1-6	ID of the Slot
Error	(5) Invalid operand. (3) Command not Possible (if ext EEPROM is unreachable)	

SDP   Set Default Parameter:

SDPKey,**SlotID***,Selector,***Value**		
Sets Default Parameter ext EEPROM (Calibration values, set by INHECO)		
Parameter	*Validity*	*Description*
Key	xxxxxx	Secret, serial number dependent Keyword
SlotID	1-6	ID of the Slot
Selector	1-13	1: P-Part 0 (heating) 2: P-Part 1 (cooling) 3: I-Part 0 (heating) 4: I-Part 1 (cooling) 5: D-Part 0 (heating) 6: D-Part 1 (cooling) 7: Room Temp 8: Heat Offset device 9: Max allowed Temperature 10: Value for SDO0 (typical 0) 11: Value for SDO1 (typical 0) 12: Value for SDX0 (typical 700) 13: Value for SDX1 (typical 2550)
Value	0...255	0...255
Error	(5) Invalid operand. (8) Wrong keyword.	

RMT   Report maximum allowed Device Temperature:

RMT *SlotID*		
Report maximum allowed Temperature of the device connected to Slot with ID given in the Selector. The temperature is reported in 1/10 °C.		
Parameter	*Validity*	*Description*
SlotID	1-6	Slot ID
Response		*Range*
Temperature		0...1999 in 1/10 °C
Error	(5) Invalid operand.	

SMT   Set maximum allowed Device Temperature:

SMT *Key,* **ID** *,Selector,* **Value**		
Writes the maximum allowed device temperature to the devices EEPROM. To be read with the Slot command RMT1 (see below) and not with the Mainboard command RMT above.		
Parameter	*Validity*	*Range*
Key	xxxxxx	Secret
ID	0-6	0 Mainboard, 1-6 Slots
Selector	0,1	If Selector == 0 erase max logged temp, if Selector ==1 (only at Slots possible) Set max allowed Temp to **Value**
Value	0-2000	Max allowed Temp in 1/10 °C, only if Selector ==1 & ID>0.
Error	(4) Invalid command. (5) Invalid operand (8) wrong keyword.	

SLT   Set lowest allowed Device Temperature:

SLT *Key,* **SlotID** *,Value*		
Writes the minimum allowed device temperature to the devices EEPROM. To be read with the Slot Command RLT.		
Parameter	*Validity*	*Range*
Key	xxxxxx	Secret
SlotID	1-6	1-6 Slot ID
Value	-127-127	Minimum allowed Temp in 1/10 °C
Error	(4) Invalid command. (5) Invalid operand (8) wrong keyword.	

AEO   Action Emergency OFF:

AEO		
This command switches all Power Outputs of the Slots immediately off. The command is intended as an emergency off.		
Parameter	*Validity*	*Description*
Error	-	

AVE   Action Voltage Enable:

AVE *Selector*		
Enables/disables the 24V supply for the slot power-periphery (the Slot µC has additional 5V power).		
Parameter	*Validity*	*Description*
Selector	0,1	0 off, 1 on
Error	(5) Invalid operand.	

ADD   Action Disable Display-Touchscreen:

ADD*Selector*		
Enables/disables the touch panel of the display. Please use ASD to reactivate it.		
Parameter	*Validity*	*Description*
Selector	0	0 disabled
Error	(5) Invalid operand.	

ASD   Action Setup Display:

ASD		
Reset Display and reactivates touch panel. Display needs about 8 seconds to get refreshed.		
Parameter	*Validity*	*Description*
Error		

AUM   Action Upload Mode:

AUM*Selector*		
Activate upload mode (no internal messages are exchanged during firmware upload of one slot).		
Parameter	*Validity*	*Description*
Selector	0,1	0 disabled, 1 enabled
Error	(5) Invalid operand.	

4.3 Slot Specific Commands

RTD   Report Type Device:

RTD		
This command reads the type of the device functionality. With the read command a device can be identified. If no device is connected it reports the type of the last connected device		
Response	*if*	*Range*
	0	24 V Slot Module (black) Thermoshake
	1	12/14 V Slot Module (blue) CPAC
	2	24 V Slot Module (black) Teleshake
	4	24 V Slot Module (black) CPAC 2 TEC
	255	Undefined
Error	(5) Invalid operand.	

STD   Set Type Device:

STD*Key,***Type**		
This command sets the functionality for the device.		
Parameter	*Validity*	*Range*
Key	xxxxx	Secret
Type	0	24 V Slot Module (black) Thermoshake
	1	12/14 V Slot Module (blue) CPAC
	2	24 V Slot Module (black) Teleshake
	4	24 V Slot Module (black) CPAC 2 TEC
	255	Undefined
Error	(5) Invalid operand (8) wrong keyword.	

RRS   Report Reservoir Status (Thermoshake):

RRS		
Reads the status of the Thermoshake reservoir.		
Response	*if*	*Range*
Status		0 Reservoir is below 1/3 (please refill reservoir)
		1 Reservoir is at least 2/3 Full
Error	(5) Invalid operand.	

RLO   Report Limits On Board Diag:

RLO_Selector_			
Reports the limits for specific values that are controlled every second from the Slot-Module.			
Response	*if*		*Range*
Selector	*1*		Min allowed Voltage 14 [1/10 V]
	2	CPAC	Max allowed Voltage 14 [1/10 V]
	3	only	Min allowed Voltage 12 [1/10 V]
	4		Max allowed Voltage 12 [1/10 V]
	5	TS only	Max RPM Shaker [rpm]
	6		Max Device Temp [1/10 °C.]
	7		Max allowed delta Temp Sensor 1 and Sensor 2 [1/10 °C]
Error	(4) Invalid command. (5) Invalid operand.		

SLO   Set Limits On Board Diag:

SLO_Key,_**Selector,**_Value_			
Sets the limits for specific values that are controlled every second from the Slot-Module.			
Parameter	*Validity*		*Description*
Key	xxxxx		Secret
Selector	1		Min allowed Voltage 14 [1/10 V]
	2	CPAC only	Max allowed Voltage 14 [1/10 V]
	3		Min allowed Voltage 12 [1/10 V]
	4		Max allowed Voltage 12 [1/10 V]
	5	TS only	Max RPM Shaker [rpm]
	6		Max Device Temp [1/10 °C.]
	7		Max allowed delta Temp Sensor 1 and Sensor 2 [1/10 °C]
Error	(4) Invalid command. (5) Invalid operand. (8) Wrong keyword.		

SBM   Set Boot Mode:

SBM_Mode_		
This command changes the startup behavior of the Slot-Module. To start with the Boot Application after the next reset choose SBMB (for firmware upload e.g.). To start the main application (default) choose SBMM (default). If the slot module starts in the bootcode it can be changed back to the application with the command **M**		
Parameter	*Validity*	*Description*
Mode	B,M	Start Boot/Main Application after next reset
Error	-	

ADE   Action Display Enable:

ADE*Selection*		
Configured the slot module to react to display commands		
Parameter	*Validity*	*Description*
Selection	0/1	**0:** With activated Touch screen it is possible to scroll to menus, but changing settings, e.g. target temperature is impossible **1:** Reacts on USB commands and display input.
Error	(5) Invalid operand.	

4.3.1 Heating and Cooling (Cooling restricted to CPAC and Thermoshake)

RAT   Report Actual Device-Temperature:

RAT*Selector*		
This command reports the actual averaged temperature of the devices. The temperatures are reported in 1/10 °C: 345 = 34,5 °C		
Parameter	*Validity*	*Description*
Selector	1	Report temperature measured at the main PT100 sensor directly, without any offset compensation
	2	Report temperature measured at the redundant PT100 Sensor directly, without any offset compensation
	Else or blank	Report full compensated temperature, i.e. the temperature into the liquid in the disposable. This temperature is shown on the display either.
Response	*Validity*	*Range*
Temperature		0...1999 in 1/10 °C
Error	(5) Invalid operand.	

RTT   Report Target Temperature:

RTT		
Reports the target temperature of the device which is set with **STT** in integer format. The temperature is reported in 1/10 °C: 345 = 34,5 °C.		
Response	*Validity*	*Range*
Temperature		0...1999 in 1/10 °C
Error	(5) Invalid operand.	

STT   Set Target Temperature:

STT*Temperature*		
This command sets the temperature for each device. The temperature is set in 1/10 °C: 345 = 34,5 °C		
Parameter	*Validity*	*Description*
Temperature	min...*max. Temp*	Set target temperature. [1/10 °C]
Error	(5) Invalid operand.	

RHE   Report Heater Enable Status (heating/cooling):

RHE*Selector*		
Reports the status of the heating / cooling mode. (If selector==1, the status of the output is reported directly i.e. it is 1 during full power heating or cooling, 0 if off and it fluctuates between 0 and 1 during controlled operation).		
Parameter	*Validity*	*Description*
Selector	-	1: Reports what the controller is really doing i.e. it toggles when the MTC/STC PID controller toggles power.
		Else: It toggles not i.e.it tells, what the previous customer request was.
Response		*Range*
Status		0 = Device is heating, 1 = Device is cooling, 2 = Device is off
Error	(5) Invalid operand.	

RMT Report maximum allowed Device Temperature:

RMT*Selector*		
Report maximum allowed temperature of the device. The temperature is reported in 1/10 °C: 345 = 34,5 °C.		
Parameter	*Validity*	*Description*
Selector	0 / 1	0: Maximum Temp that has been measured since last restart
		1: Maximum allowed temperature (Depending from SMT setting stored on Slot Module or device).
Response		*Range*
Temperature		0: 0...2000 in 1/10 °C
		1: 0...2000 in 1/10 °C
Error	(5) Invalid operand.	

SMT   Set maximum allowed Device Temperature:

SMT*Key,***Selector***,Temperature*		
Sets max. allowed Device Temperature for the device which the Slot is controlling. The max. temperature is set in 1/10 °C: 340 = 34,0 °C		
Parameter	*Validity*	*Description*
Key	xxxxx	Secret
Selector	0/1	0: Erases max measured Temperature.
		1: Sets maximum allowed Temperature.
Temperature	0...1999	. Maximum allowed Slot Temperature in 1/10 °C only if Selector =1
Error	(5) Invalid operand. (8) Wrong keyword.	

RLT Report lowest allowed Device Temperature:

RLT	
Report minimum allowed temperature of the device. The temperature is reported in 1/10 °C: 345 = 34,5 °C.	
Response	*Range*
Temperature	0: -127…127 in 1/10 °C
Error	(5) Invalid operand.

SLT Set lowest allowed Device Temperature:

SLT*Key,***Temperature**		
Sets minimum allowed Device Temperature for the device which the Slot is controlling. The minimum temperature is set in 1/10 °C: 40 = 4,0 °C		
Parameter	*Validity*	*Description*
Key	xxxxx	Secret
Temperature	-127…127	. Minimum allowed Temperature in 1/10 °C
Error	(5) Invalid operand. (8) Wrong keyword.	

RVC Report Voltage CPAC:

RVC	
The CPAC Slot-Module is able to indicate the Voltage of its TEC and Fan supply. This is reported as reply to this command [1/10 V]. Only available for 12V/14V devices.	
Response	*Range*
Voltage	0...999 in 1/10 C

RTC Report TEC Current:

RTC	
The Slot-Module is able to measure the current of the TEC / Heating foil. This is reported as reply to this command [1/10 A].	
Response	*Range*
Current	0...99 in 1/10 A

RAP Report Actual PWM Value:

RAP	
Reports the actual PWM value of the selected Device. Value 0: Device is neither heating nor cooling. Else: Value gives percentage of the high interval time.	
Response	*Range*
PWM	PWM 0...1000 in 1/10 %
Error	(5) Invalid operand.

SAP Set PWM Value Directly:

SAP*Value*		
The command directly sets the PWM value in % of maximum power. **CAUTION! This command is for development and test purposes only.** Value 100: Full Power mode Value 0: SAP is off → ordinary temperature (PID) is able to work Value >0: PID is off and PWM relation is set. The command does not influence if the device is cooling or heating. When it is cooling before SAP is used the device will still cool after the usage of SAP. SAP changes only the cooling power. To switch to heating use first STT and ATE and then SAP.		
Parameter	*Validity*	*Description*
Value	0…100	PWM relation high interval time in %
Error	(5) Invalid operand. (8) Wrong keyword.	

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: +0345 = 34,5 °C

Response	*Range*
Delta Temperature	in 1/10 °C
Error	(5) Invalid operand.

RHO   Report Heat-Up/Cool down Offset:

RHO		
Report Heat Up offset of the plate at 70 °C in 1/10 °C: 121 = 12,1°C. For details see chapter 6.1.		

Response	*Validity*	*Range*
Offset Temp		-255…255 [1/10 °C]
Error	(5) Invalid operand.	

SHO   Set Heat-Up/Cool-Down Offset:

SHOkey,**Value**		
Set Heat-Up temperature offset for the used plate-type (disposable):		
Defines the offset temperature line for the different disposables offset is set		
in 1/10 °C: 121 = 12.1 °C. Origin of the straight line is set in 1/10 °C. This value is set by INHECO		

Parameter	*Validity*	*Description*
key		*Secret key*
Value	-255...255	Set heat-up temperature offset for plate type at 70 °C. in 1/10 °C
Error	(5) Invalid operand.	

RCO   Report Constant Offset:

RCO		
Report Constant Offset.		

Response	*Validity*	*Range*
Offset Temp		-999…1000 [1/100 °C]
Error	(5) Invalid operand.	

SCO   Set Constant Offset:

SCOkey,**Value**		
Set constant Offset at calibration of the devices a constant offset e.g. due to varying cable length must be added or subtracted. Value is set in 1/100 °C. This value is set by INHECO		

Parameter	*Validity*	*Description*
key		*Secret key*
Value	-999...999	Set Constant Offset. As this is a very sensitive setting the value is in 1/100 °C
Error	(5) Invalid operand.	

RRT   Report (set) Room Temperature:

RRT		
Report the Temperature that has been set with SRT in 1/10 °C: 121 = 12,1°C. For details see chapter 6.1.		

Response	*Validity*	*Range*
Offset Temp		0…510 [1/10 °C]
Error	(5) Invalid operand.	

SRT   Set Room Temperature:

SRT*Value*		
Sets the temperature for the offset compensation curves which is intended to be close to room temperature in vicinity of the devices in 1/10 °C. For details see chapter 6.1.		
Parameter	*Validity*	*Description*
Value	0...510	Set room Temperature close to device in 1/10 °C
Error	(5) Invalid operand.	

RBO   Report Boost Offset:

RBO		
Report Boost temperature offset in 1/10 °C: 121 = 12,1°C. For details see Figure 5.		
Response	*Validity*	*Range*
Offset		0…300 [1/10 °C]
Error	(5) Invalid operand.	

SBO   *Set Boost Offset:*

SBO*Offset*		
Set Boost temperature offset in 1/10 °C: 121 = 12,1°C. For details see Figure 5.		
Parameter	*Validity*	*Description*
Offset	0...300	Set heat-up temperature offset for boost. Range depends also from the maximum allowed temperature (see SMT) and the Target Temperature (see STT).
Error	(5) Invalid operand.	

RBT   Report Boost Time:

RBT		
Reports Boost Time. For details see Figure 5 in chapter 6.1.		
Response		*Range*
Offset		0…30000 [Sec]
Error	(5) Invalid operand.	

SBT   Set Boost Time:

SBT*Time*		
Set Boost Time in seconds. For details see Figure 5 in chapter 6.1.		
Parameter	*Validity*	*Description*
Time	0...30000	Set Boost Time [Sec]
Error	(5) Invalid operand.	

RCD   Report Calibration Date:

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

RCI   Report Calibration Inclination:

RCISensor		
Reports the value of the inclination of the PT100 calibration line. In connection with RCT the calibration line can be presented. Offset temperature T and inclination I are set automatically after the commands SCL and SCH has been used to calibrate the device. Example: RCI0		
Parameter	*Validity*	*Description*
Sensor	0,1	Number of sensor
Response	*if*	*Range*
Sensor	0	Inclination of Calibration line Sensor 1 (main)
	1	Inclination of Calibration line Sensor 2 (redundant)
Error	(5) Invalid operand.	

RCT   Report Calibration Offset Temperature:

RCTSensor		
Reports the value of the temperature offset of the PT100 calibration line. In connection with RCI the calibration line can be presented. Offset T and inclination I are set automatically after the commands SCL and SCH has been used to calibrate the device. Example: RCT)		
Parameter	*Validity*	*Description*
Sensor	0,1	Number of sensor
Response	*if*	*Range*
Sensor	0	Offset of Calibration line Sensor 1 (main)
	1	Offset of Calibration line Sensor 2 (redundant)
Error	(5) Invalid operand.	

SCL   Set Calibration Low:

SCL		
Set lower temperature adjustment points for the sensors.		
Parameter	*Validity*	*Description*
Error	(5) Invalid operand.	

SCH   Set Calibration High and Date:

SCHKey,**Date,Operator**		
Set higher temperature adjustment points and date with operator of adjustment for the sensors. Set by INHECO.		
Parameter	*Validity*	*Description*
Key	xxxxxx -	Secret
Date,Operator	YYYY-MM-DD,xxx	Sets the adjustment date, Operator
Error	(5) Invalid operand. (8) Wrong keyword.	

RCM Report Calibration Mark:

RCM		
Reports the date and an alphanumeric string (e.g. operator) of the last calibration for the Slots. The Data is reported in the Format YYYY-MM-DD,xxx (Example: 2005-09-28,xxx). The "xxx" are alphanumeric wildcards.		
Response	*if*	*Range*
Date		YYYY-MM-DD,xxx
Error	(5) Invalid operand.	

SCM   Set Calibration Mark:

SCMKey,**Date,**Value			
Sets the date and e.g. operator of the last calibration for the Mainboard and the Devices. The Data is reported in the Format YYYY-MM-DD,xxx (Example: 2008-09-28,xxx). The "xxx" are wildcards for an alphanumeric string. Set by INHECO.			
Parameter	**Validity**		**Description**
Key	xxxxxx	-	Secret
Date	YYYY-MM-DD	-	
Value	xxx		Operator
Error	(5) Invalid operand. (8) Wrong keyword.		

RPO   Report Parameter Origin:

RPO		
Reports origin of the PID Parameters, max allowed temperature and type device.		
Response	**if**	**Range**
		0: Origin is internal Slot EEPROM 1: Origin is external device EEPROM (default). 255: Not set yet, device tries to use external EEPROM
Error	(5) Invalid operand.	

SPO   Set Parameter Origin:

SPOSelector		
Sets Origin of the calibration and PID Values, max allowed temperature, type device, etc.		
Parameter	**Validity**	**Description**
Selector	0/1/255	0: Internal Slot EEPROM is used 1: External device EEPROM is used (default). 255: Not specified
Error	(5) Invalid operand.	

RPP   Report PID Controller Coefficients (Proportional Gain):

RPPSelector		
Reports the PID controller coefficients proportional gain.		
Parameter	**Validity**	**Description**
Selector	*0,1*	*0: heating, 1: cooling*
Response	**if**	**Range**
		0-255
Error	(5) Invalid operand.	

SPP   Set PID Controller Coefficients (Proportional Gain):

SPPSelector,Value		
Sets PID Controller Coefficients: proportional gain Influences only the internal Slot EEPROM. Device specific external EEPROM is changed with the respective Mainboard command (default).		
Parameter	**Validity**	**Description**
Selector	*0,1*	*0: heating, 1: cooling*
Value	0...255	proportional gain 0...255
Error	(5) Invalid operand.	

RPI   Report PID Controller Coefficients (Integration Value):

RPISelector		
Reports the PID controller coefficients integration value.		
Parameter	*Validity*	*Description*
Selector	*0,1*	*0: heating, 1: cooling*
Response	*if*	*Range*
		0-255
Error	(5) Invalid operand.	

SPI   Set PID Controller Coefficients (Integration Value):

SPISelector, *Value*		
Sets PID Controller Coefficients: integration value Influences only the internal Slot EEPROM. Device specific external EEPROM is changed with the respective Mainboard command (default).		
Parameter	*Validity*	*Description*
Value	0...255	integration value 0...255
Selector	*0,1*	*0: heating, 1: cooling*
Error	(5) Invalid operand.	

RPD   Report PID Controller Coefficients (Differential Part):

RPDSelector		
Reports the PID controller coefficients differential part.		
Parameter	*Validity*	*Description*
Selector	*0,1*	*0: heating, 1: cooling*
Response	*if*	*Range*
		0-255
Error	(5) Invalid operand.	

SPD   Set PID Controller Coefficients (Differential Part):

SPDSelector, *Value*		
Sets PID controller coefficients: differential part Influences only the internal Slot EEPROM. Device specific external EEPROM is changed with the respective Mainboard command (default).		
Parameter	*Validity*	*Description*
Value	0...255	Differential part 0...255
Selector	*0,1*	*0: heating, 1: cooling*
Error	(5) Invalid operand.	

RDO   Report Disposable Offset:

RDOSelector		
Reports the disposable specific offset (for details see section 6.1.3.2 Linear disposable Offset (Commands SDO and SDX).		
Parameter	*Validity*	*Description*
Selector	*0…8*	*Offset place*
Response	*if*	*Range*
		0-255
Error	(5) Invalid operand.	

SDO   Set Disposable Offset:

SDOSelector, *Value*		
Sets disposable specific offset (for details see section 6.1.3.2 Linear disposable Offset (Commands SDO and SDX). It influences only the internal Slot EEPROM. Device specific external EEPROM is changed with the respective Mainboard command (default).		
Parameter	*Validity*	*Description*
Value	0...255	Differential part 0...255
Selector	*0…8*	*Offset place*
Error	(5) Invalid operand.	

RDX   Report Disposable X-Axis Temperature:

RDXSelector		
Reports the disposable specific offset (for details see section 6.1.3.2 Linear disposable Offset (Commands SDO and SDX).		
Parameter	*Validity*	*Description*
Selector	*0…8*	*Offset place*
Response	*if*	*Range*
		0, 10, 20, 30, … 2550 in 1/10 °C
Error	(5) Invalid operand.	

SDX   Set Disposable X-Axis Temperature:

SDXSelector, *Value*		
Sets disposable specific offset (for details see section 6.1.3.2 Linear disposable Offset (Commands SDO and SDX). Influences only the internal Slot EEPROM.Device specific external EEPROM is changed with the respective Mainboard command (default).		
Parameter	*Validity*	*Description*
Value	0...2550	Temp in 1/10 °C 0, 10, 20, 30, ….2550
Selector	*0…8*	*Place*
Error	(5) Invalid operand.	

SHV   Set High Voltage:

SHV*Selector*		
Sets the Supply Voltage for the TEC of the Device. CPAC Specific Command that has no effect on 24V Slot Modules.		
Parameter	*Validity*	*Description*
Selector	0,1	0: Lower Voltage → 12V Supply at the TEC (optimum for cooling performance) 1: Higher Voltage → 14V Supply at the TEC (optimum for heating performance)
Error	(4) Invalid command. (5) Invalid operand.	

ATE   Action Temperature Enable:

ATE*Selection*	
Starts heating or cooling until the temperature previously set by STT has been reached. After the STT Temperature has been reached it will be stabilised.	
Parameter	*Description*
Selection	0 off, 1 on
Error	(5) Invalid operand.

4.3.1 Shaking (Thermoshake and Teleshake only)

RSR   Read Shaker Revolutions:

RSR			
Reads the set shaker frequency (revolution). As the MTC/STC devices have no shaker surveillance yet this command replies only the value that has been set previously with the SSR command.			
Response	*if*	*Range*	
Revolutions		0…9999	Shaker frequency [rpm]
Error	(5) Invalid operand.		

SSR   Set Shaker Revolutions:

SSR *Revolutions*		
Sets the shaker frequency (revolution).		
Parameter	*Validity*	*Description*
Revolutions	60…2000	Shaker frequency [rpm] / no leading zero
Error	(4) Invalid command. (5) Invalid operand.	

RSS   Read Shaker Shape:

RSS		
Reads the shape of the figure that should be shaked.		
Response	*if*	*Description*
Figure	0	Circle anticlockwise
	1	Circle clockwise
	2	Up left down right
	3	Up right down left
	4	Up-down
	5	Left-right
Error	(5) Invalid operand.	

SSS   Set Shaker Shape:

SSS *Figure*		
Sets the shape of the figure that should be shaked.		
Parameter	*Validity*	*Description*
Figure	0	Circle anticlockwise
	1	Circle clockwise
	2	Up left down right
	3	Up right down left
	4	Up-down
	5	Left-right
Error	(4) Invalid command. (5) Invalid operand.	

RSE   Report Shaker Enable Status:

RSE		
Reads shaker enable status.		
Response		*Range*
Status		0 = shaker off, 1 = shaker on
Error	(4) Invalid command. (5) Invalid operand.	

ASE   Action Shaker Enable:

ASE_Selection_	
Starts/Stops Shaking with the number of revolutions set by SSR.	
Parameter	*Description*
Selection	0 off, 1 on.
Error (5) Invalid operand.	

5.0   Error Handling at the MTC/STC

Two kinds of errors exist at the MTC/STC. One kind is communicated immediately with the PC via USB. The 5th byte of each reply message includes that error information and the PC Application can decide how to react on that error. The second kind of error codes is non versatile stored and can be read with the command REC and erased with the command SEC

5.1 Error Byte into the reply to every command

The following table describes all Error Codes represented by the 5th byte of the reply to each message.

Table 1: Definition of the Reply Error Byte

Code	Error message	Description
0	Message O.K.	Normal return message.
1[1]	External message protocol violation	For example the crc of an external message was not correct. This error can be generated either by the dll or by the slot modules.
2[1]	Internal message protocol violation	For example the crc of an internal message was not correct. This error can be generated by the MB or the slot modules.
3	Command not executable	Condition for the command is not fulfilled e.g. CPAC should shake.
4	Command unknown	Command does not exist.
5	Wrong parameter	e.g. RFV1 exists but RFV9 not.
6	Reset detected	After Software, Power On or Watchdog reset. Please inform INHECO if this error occurs during normal operation
7[1]	Slot Id unknown	Slot Id > 6 or respective Slot is empty.
8	Wrong keyword	The serial number specific keyword was wrong.
9	Timeout from slot-module	Slot-module is/was connected but replies not. Maybe configuration changed after reset. Reset MTC/STC.
A[1]	I am busy with an action command or startup	Direct after power on (10 seconds) and in some other cases the MTC/STC cannot handle additional commands.
B	Reserved	
C	Housing temperature NOK	Housing temperature or humidity out of range
D[1]	Response time too long	Dll Error timeout from USB.
E	Voltage power supply NOK	Voltage power supply out of range.
F	Housing fan NOK	Housing fan is blocked
G	Device temp NOK	Device temperature too high.
H	RPM too high	Setting increases limit set by SLO5.
I	CPAC voltage NOK	CPAC voltage out of range.
K	TEC current too low	TEC current is below 1 A. TEC current is checked always when the Slot Module is heating or cooling
R	Cable Break or Shortcut PT100	µC reads extreme values at one of the two PT100 sensors. At Thermoshake shortcut to ground of the second PT100 sensor indicates that the reservoir is empty.
T	Delta T too high	Temperature difference between main sensor and supervisor sensor too high.
W	Wrong device connected	A 12 V device (blue) is connected to a 24 V Slot Module (black) or vice versa. Please unplug it.

5.2 Description Commands REC/SEC

Lots of different errors can be stored into the EEPROM of the µCs, one example is Error 11 when the TEC current is too low. Simultaneously to the storage of the error code, the LED of the respective slot or mainboard becomes red and blinks orange when communication is active. Whereas the red LED vanishes after a reset, the error code remains non versatile into the EEPROM and can be read with the command REC. When the

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[1] Command may not be received by the MTC please resend it after a short delay.

command REC is used without argument, into the reply string two error codes are separated by an underscore. The entry of the error codes is debounced. The limits for the values, when some error codes should be stored, are can be set by the command SLO (Set Limits Onboard diagnosis). An example is the maximum allowed voltage of the power supply.

Since FW Version 1.85 it is in addition possible to get additional information about one specific error. If you use the REC command with the error code as an argument the reply string contains information about the number of occurrences of the error and the time when the last occurrence was dated. The time is given in the runtime of the Slot Module or Mainboard, i.e. the reply to RDC2 at the moment of error occurrence. To get all information about the error codes of e.g. Slot Module 3 the following procedure is recommended:

Command	Reply
3REC	3rec0_05_26_02_06_01
3RDC2	3rdc000123682
3REC1	3rec0001:_001_00102031
3REC6	3rec0006:_003_00123646
3REC2	3rec0002:_007_00123628
3REC26	3rec0026:_031_00123671
3REC5	3rec0005:_107_00102235

- Find out all error codes (3REC)
- Find out the actual run time (3RDC)
- Report details of all errors (rest)

The result is:
- The 5 Errors: 1, 6, 2, 26 and 5 occurred.
- The Slot Module run time is 123682 seconds (i.e. this Slot Module worked since ~34 hours)
- Error 1 occurred 1 time; 123682 – 102031= 21651 seconds (~6 hours) ago.
- Error 6 occurred 3 times; 123682 – 123646= 36 seconds ago.
- Error 2 occurred 7 times; 123682 – 123628= 54 seconds ago.
- Error 26 occurred 31 times; 123682 – 123671= 11 seconds ago.
- Error 5 occurred 107 times; 123682 – 102235= 21447 seconds (~6 hours) ago.

It seems that Slot Module 3 (or the device connected to it) had problems with the TEC Voltage (errors 1 and 5, ~6 hours run time ago). And it still has problems with the checksums of either the device EEPROM (code 2 & 6) or the flash memory (code 26).

Table 2: Error Code Description Mainboard. Remark: All error entries remain until they become erased with the SEC command

Code	Error Code Description Mainboard	Reaction of the MTC/STC and/or Recommendation
1	Voltage power supply out of range	Warning; Check if message reply byte "E" is set frequently if not this error entry was erroneous.
2	Digital housing temp out of range	Warning; Check if message reply byte "C" is set frequently if not this error entry was erroneous.
3	Analogue housing temp out of range	Warning; Check if message reply byte "C" is set frequently if not this error entry was erroneous.
4	Humidity out of range	Warning; Check if message reply byte "C" is set frequently if not this error entry was erroneous.
5	MUX or AD converter not ok	MTC/STC disables all heating/cooling facilities
6	Power switch NOK	Warning.
7	Housing fan NOK	Warning; Housing fan should run when at least one device is heating or cooling. Check if message reply byte "F" is set frequently if not this error entry was erroneous
8	Temp difference between digital and analogue sensor too high	Warning; Check if message reply byte "I" is set frequently if not this error entry was erroneous.
9	Free	
10	RAM test failed	Warning. Please inform INHECO
11	Free	
12	Cannot read external EEPROM device 1.	Warning. Check cable or use the command SPO. Slot Module must use internal EEPROM.
13	Cannot read external EEPROM device 2.	
14	Cannot read external EEPROM device 3.	
15	Cannot read external EEPROM device 4.	
16	Cannot read external EEPROM device 5.	
17	Cannot read external EEPROM device 6.	
18	Free	
19	Free	
20	CRC error external EEPROM device 1	Warning. The CRC of the external EEPROM is rewritten with every command that writes to the external EEPROM like 0SPP1,0,100
21	CRC error external EEPROM device 2	
22	CRC error external EEPROM device 3	
23	CRC error external EEPROM device 4	
24	CRC error external EEPROM device 5	
25	CRC error external EEPROM device 6	
26	CRC Error Flash Memory	Memory of the Mainboard µC is probably out of order → exchange MTC/STC
27	Device at Slot Module 1 has been unplugged during Power up or loose connection.	Warning! Runtime and maximum temperature into device EEPROM becomes no longer updated
28	Device at Slot Module 2 has been unplugged during Power up or loose connection.	Warning! Runtime and maximum temperature into device EEPROM becomes no longer updated
29	Device at Slot Module 3 has been unplugged during Power up or loose connection.	Warning! Runtime and maximum temperature into device EEPROM becomes no longer updated
30	Device at Slot Module 4 has been unplugged during Power up or loose connection.	Warning! Runtime and maximum temperature into device EEPROM becomes no longer updated
31	Device at Slot Module 5 has been unplugged during Power up or loose connection.	Warning! Runtime and maximum temperature into device EEPROM becomes no longer updated
32	Device at Slot Module 6 has been unplugged during Power up or loose connection.	Warning! Runtime and maximum temperature into device EEPROM becomes no longer updated

Table 3: Error Code Description Slot Modules. Remark: All error entries remain until they become erased with the SEC command

Code	Error Code Description Slot Module	Reaction of the MTC/STC and/or Recommendation
1	Temp control NOK. Device is heating or cooling but nothing seems to happen.	Warning; Is checked at start up only.
2	CRC Error into external EEPROM. The external EEPROM seems to be NOK or the device is not correctly connected. Check cable and send a external EEPROM write Command to the respective device (e.g. 0SDO3,5,0). Then the CRC is rewritten and everything may be corrected. If not the EEPROM is out of order.	MTC/STC disables all heating/cooling facilities. If the customer likes to use the device with probably sub-optimum offsets etc. please use the SPO0 command to switch to internal EEPROM usage, restart the MTC/STC and set the Offsets, PID parameter etc. to the desired value. Otherwise send the device to INHECO.
3	RPM shaker too high	Warning
4	CPAC voltage too high, check or exchange slot module	MTC/STC disables all heating/cooling facilities
5	CPAC voltage too low, check or exchange slot module	Warning; Check if message reply byte "I" is set frequently if not this error entry was erroneous.
6	Fan runs not correct	Warning
7	Reservoir Thermoshake almost empty or shortcut to ground PT100 sensor 2. Refill reservoir or check connection to the device	Warning; Check if message reply byte "R" is set frequently. If not, this error entry was erroneous. And can be ignored.
8	Device temp much too high	MTC/STC stops heating
9	Could not read device EEPROM. Replace device or check the connection or switch to internal EEPROM usage via command SPO0.	MTC/STC disables all heating/cooling facilities
10	RAM test failed. Please inform INHECO. Probably Slot Module must be exchanged.	Warning. Please inform INHECO
11	TEC current too low.	Warning; Check if message reply byte "K" is set frequently. If not, this error entry was erroneous.
12	Temperature difference between main sensor and supervisor sensor too high	Warning. This error occurs especially when the load is high. Max allowed difference can be changed with the SLO command.
13	Temperature too low	E.g. for the Thermoshake exists a temperature which should not be under shoot. This is just a warning.
14	Unknown device connected	MTC/STC disables all heating/cooling facilities
15	Wrong device is connected. I.E. a 12 V device is connected to a 24V Slot module or vice versa	MTC/STC disables all heating/cooling facilities
16	STC: Power switching operator out of order	Warning. Please inform INHECO
17	Shortcut to ground PT100 sensor 1	MTC/STC disables all heating/cooling facilities
18	Cable break PT100 sensor 1	MTC/STC disables all heating/cooling facilities
19	Cable break PT100 sensor 2	Warning; Check if message reply byte "R" is set frequently. If not, this error entry was erroneous.
20	CRC Error external EEPROM via SSB. We recommend changing of the origin for parameters with SPO0 to internal EEPROM usage or check the connection.	After a couple of tries of reading out the device EEPROM the MTC/STC switches automatically to usage of the internal EEPROM. To speed up the boot processes use the SPO command.
21	The device is heating instead of cooling. Please check type of the device and the cable pin out.	MTC/STC stops heating. Maybe a Teleshake is connected and its EEPROM could not be read.
26	CRC Error Flash Memory	Memory of the Slot Modul µC is probably out of order → exchange Slot Module

The whole error-memory can be erased with the command SEC.

5.3 Status LEDs

The Slot Modules and the Mainboard have LEDs, which can shine red, green or yellow. The Mainboard LED cannot be seen when the housing is closed, whereas the Slot Module LEDs are located on the backside of the MTC/STC.

The green light is toggled when a SSB Message has been received.
The red light is switched on when an error has been detected.
The red light blinks slowly during the firmware upload.

Therefore the following states are possible:

Table 4: Description of the Slot Modules status LEDs

Mode	LED behavior	Comment
Normal Mode without errors	LEDs are blinking green with same frequency of about 5 Hz	Every 30 ms a cyclic Message is send by the MAINBOARD. Therefore each Slot receives every 180 ms a new internal message. This determines the blinking frequency of the LEDs of all connected Slot Modules.
Normal mode with high communication rate and without errors	LEDs are blinking green with different frequency	The blinking frequency of the LED of that Slot Module which is addressed by the USB command blinks faster. All other blink slower than without external communication.
Normal Mode with error	The LED of the Slot Module with error blinks red/yellow. All other blink green	-
FW upload mode	The LED of the Slot Module which becomes updated blinks slowly red. All other LEDs stop blinking	During upload the internal communication is stopped with the command 0AUM1. The passive LEDs remain in that state they had when the Mainboard received that command.

5.4 Display

Since FW 1.85 the codes of actual errors become displayed on the STC/MTC screen, until the customer presses ok on the touch screen. This happens once for every different error code after each power on. Slot Module error codes are displayed only when the respective slot is selected on the touch screen (MTC only).

6.0   Adjustment

6.1 Thermal Adjustment

This manual thermal adjustment procedure should only be used, if it's impossible to use the automated INHECO Thermal-Adjustment-Measuring-System!

6.1.1 Slot

To adjust the temperature sensors on the heating plate for the device on Slot Module 1 in this example, the following step-by-step instruction has to be proceeded:

1. Plug in INHECO Calibrator into the Slot-Device 1
2. Choose low position of the switch (0°C)
3. Send 1SCL
4. Choose high position of the switch (50°C)
5. Send 1SCH**Keyword,***Date,***USR** (Date is 20YY-MM-DD, User are three signs like MST)

The thermal calibration of Slot 1 is completed. All other Slot Modules are adjusted the same way.

6.1.2 Mainboard

At the Mainboard the calibration parameters are set directly and not values at two temperatures are used for calibration. Especially the value of the inclination is taken from the PT100 of the Slot-Devices. It is usually 466 or 465 (Command *xSCIkey466*). Therefore only one value at one temperature must be used to set the offset. For that value the already calibrated digital sensor value can be used (use *0RHV2* to get the digital sensors temperature). The value "123", set by xSCTkey123 is subtracted from the temperature. For example if you have the following situation:

Calibration Inclination: *0RCI* → *466*
Calibration Offset: *0RCT* → *300*
Digital Sensor Temperature: *0RHV2* → *233* (23.3°C)
Analogue Sensor reply: *0RHV4* → 133 (not correct calibrated)

Use:
SCTkey,200
To calibrate the Mainboard PT100.

Now the reply is:
Analogue sensor reply: *0RHV4* → 233 (correct calibrated)

6.1.3 Devices

For the devices at least two different origins for temperature offsets exist. The MTC/STC has the possibility to handle two offsets. The first is based on the position of the PT100 sensor inside the device. The second is due to the labware (disposable) and the load. The first is set by INHECO and key word protected whereas the second can be set by the customer.

6.1.3.1 Heater Offset (Command SHO)

In all INHECO devices, which the MTC/STC can handle, two PT100 sensors are present. Different positions of the sensors in different devices and different cable length may lead to errors at the temperature calculation. These errors can be compensated by the help of the heater offset curve. The heater offset curve is a straight line which should intercept zero at room temperature. The two commands:

iSRT250
iSHO_*key_*,90
generates the offset line shown in Figure 2.
The value behind SRT is the 0°C interception temperature divided by two.
The value behind SHO_*key_*, is the offset temperature (in 1/10 °C) at a specific target temperature. Setting this offset to 9°C, as in this example, determines automatically an offset of 5°C at 50 °C or -3 °C at 10 °C.
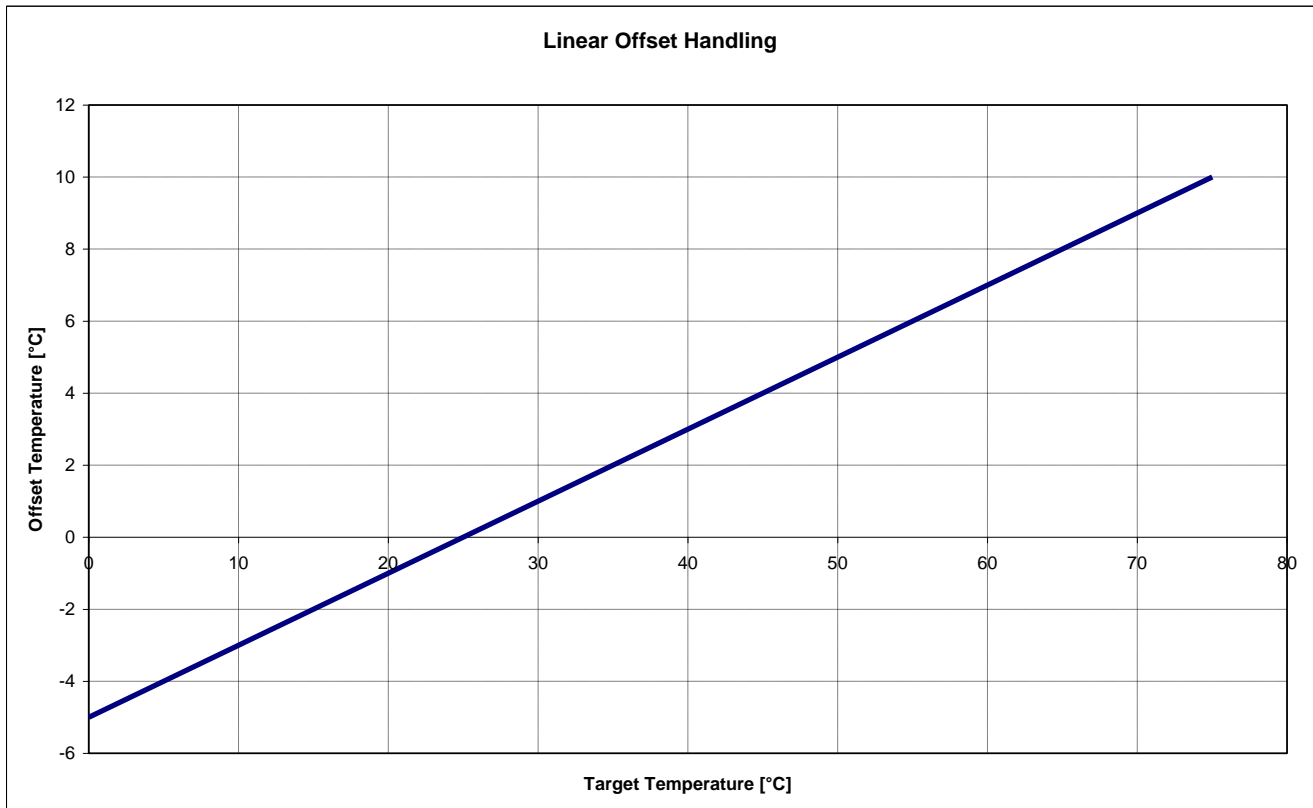
Figure 2: Linear Offset handling, device specific and disposable specific

INHECO CPAC Devices are adjusted with flat bottom adapters.

6.1.3.2 Linear disposable Offset (Commands SDO and SDX)

Table 5: Commands for a linear offset

Command to store in internal EEPROM of slot module 1	Command to store in device EEPROM of device connected to slot module 1
1SRT250	0SRT1,250
1SDO0,90	0SDO1,0,90
1SDX0,700	0SDX1,0,700
1SDX1,2550	0SDX1,1,2550

The commands of Table 5 generates the offset curve given in Figure 2 for the disposable offset at the device connected to the Slot Module 1. Using the command SRT adapts the line to the ambient temperature.

At heating activities typically the temperature into the liquid, which shall be heated, is lower than on the surface of the heating device. Therefore the MTC/STC has the possibility to add an offset to the target temperature. The higher the difference between ambient- and target temperature is, the bigger this offset should be. The MTC/STC calculates this automatically, if the target temperature is changed. But what can we do, if the ambient temperature changes?
For this task an external temperature sensor (see Figure 3) can be connected to the MTC/STC. It can be plugged in the back side of the MTC/STC and can easily be read out with 0RHV5 (Temperature) and 0RHV6 (Humidity).

To adjust the offset to the ambient temperature the following steps are recommended:

1. Put the sensor in vicinity of the heating/cooling devices
2. Read out the temperature frequently (e.g. every hour 0RHV5 … Reply is e.g. 0rhv00280)
3. Send this temperature to all devices (e.g. to device connected with Slot module 3: 0SRT3,280)
4. Repeat 2&3 till the end of the session

Figure 3: External temperature and relative humidity sensor

6.1.3.3 Non linear disposable Offset (Commands SDO and SDX)

If the DX1 is not 2550 (Use 1RDX1 to check this) a stairway offset is used:
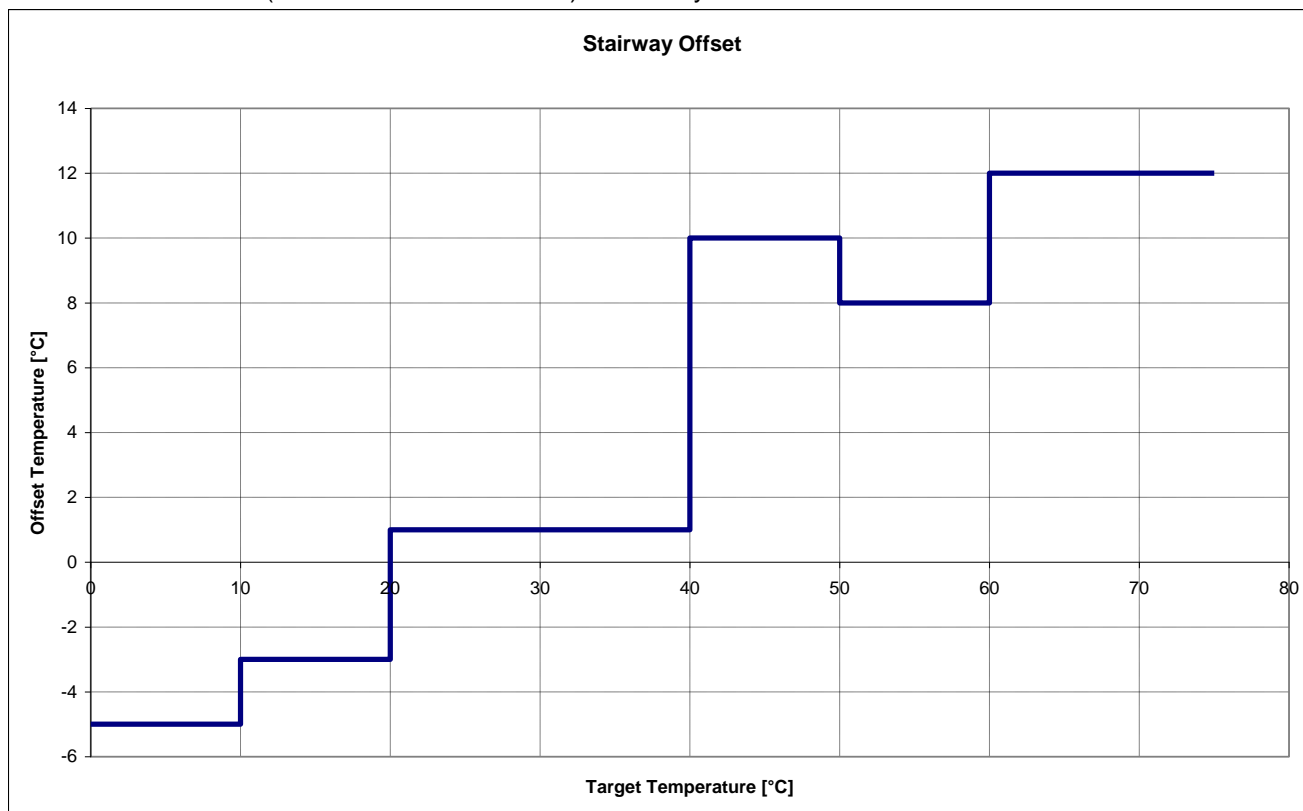
Figure 4: Advanced stairway offset handling at disposable offset

The following commands will lead to the offset stairway for the device connected to Slot Module 1 presented in Figure 4:

Table 6: Commands for a stairway offset

Command to store in internal EEPROM of slot module 1	Command to store in device EEPROM of device connected to slot module 1
1SRT250	0SRT1,250
1SDX0,0	0SDX1,0,0
1SDX1,100	0SDX1,1,100
1SDX2,200	0SDX1,2,200
1SDX3,400	0SDX1,3,400
1SDX4,500	0SDX1,4,500
1SDX5,600	0SDX1,5,600
1SDX6,750	0SDX1,6,750
1SDO0,-50	0SDO1,0,-50
1SDO1,-30	0SDO1,1,-30
1SDO2,10	0SDO1,2,10
1SDO3,100	0SDO1,3,100
1SDO4,80	0SDO1,4,80
1SDO5,120	0SDO1,5,120

The customer has the possibility to put up to 9 different offset values to the different temperatures he wants to control.

Remark: 1SDX0,100; 1SDX1,1000; SDO0,10; SDO1,10 leads to a constant offset for all temperatures < 100 °C.

6.2 Boost Time and Boost Offset

The PID Controller of the Slot-Devices can be used in different ways. For example the PID parameters can be chosen that way, that the target temperature will be reached fast but without overshoot (the aperiodic case). In that case the adequate parameters differ for every different situation. Therefore we recommend the usage of boost time and boost offset. First, in that case the setting of the PID parameters is less critical and second, the offset is needed anyway to bring the liquid into the disposables faster and more precisely to the target temperature. Boost Time and Boost Offset can be set with the commands SBT and SBO, respectively.
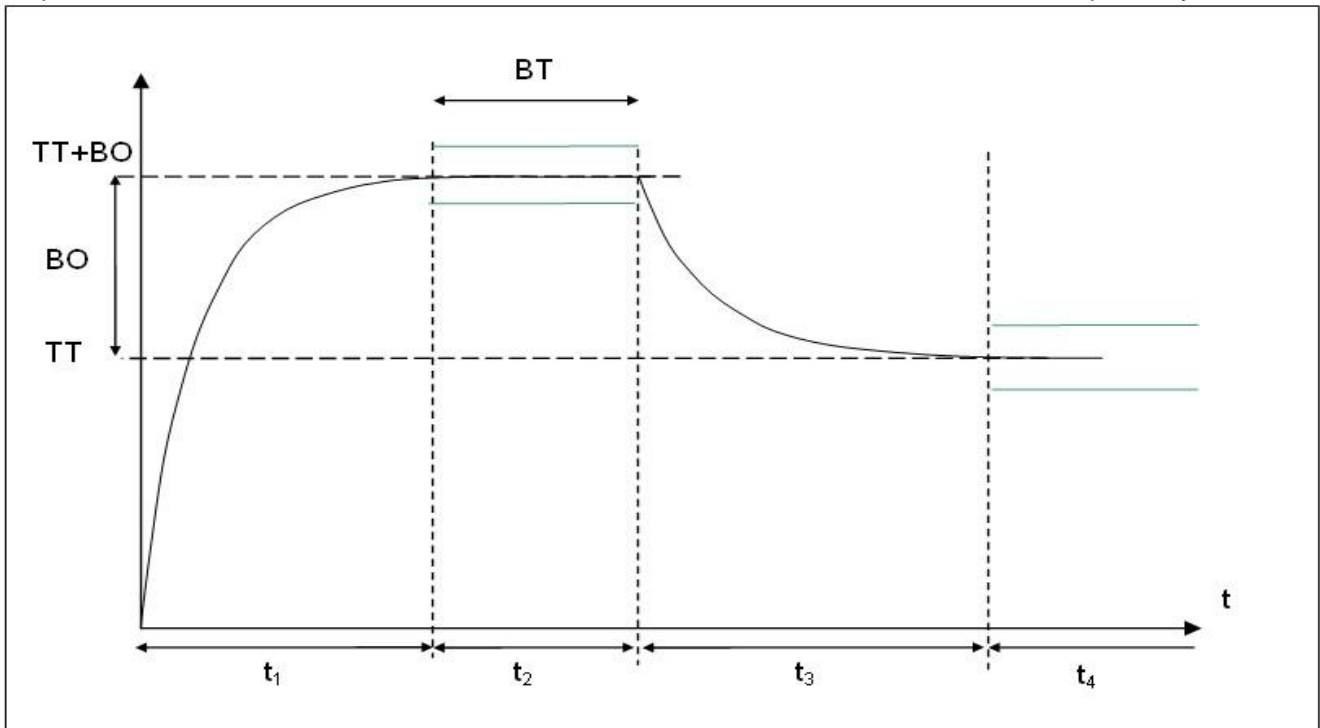
Figure 5: Definition of Boost Offset and Boost Time

TT = Target Temperature
BO = Booster offset
BT = Boost time (t_2)

The times t_1 and t_3 may be controlled and an error code can be stored if the time increases a specified value.

7.0 Handling Configuration Parameter

All Configuration Parameter are stored in the non-versatile EEPROM. Some very important parameter can either be stored into the Slot Modul EEPROM or into the external EEPROM. To change internal values the Slot commands must be used (e.g. 3SPP0xy). To change external parameter Mainboard commands must be used (e.g. 0SPP3,0,xy).
The following tables contain an overview over the EEPROMs contents.

7.1 Mainboard

Table 7:EEPROM Content of the Mainboard

Name	Commands connected to the value	Position into the EEPROM	Description
Serial number	SFV	6	
Awake time	RDC/SDC	8	
Calibration Year	SCH	12	
Calibration Month	SCH	14	
Calibration Day	SCH	16	
Max Power Supply Voltage	SLO1	32	
Min Power Supply Voltage	SLO2	18	
Max Housing Temperature	SLO3	20	
Max Humidity	SLO6	26	
Max Fan RPM	SLO7	28	
Min Fan RPM	SLO8	30	
Difference Temperature Sensor 1/2	SLO5	24	
Calibration Inclination M	SCI	36	Calibration data for the analog sensor located at the front side of the MAINBOARD
Calibration Offset T	SCT	38	Calibration data for the analog sensor located at the front side of the MAINBOARD
Error Codes	REC/SEC	50ff	
Shadow Error Codes	REC_KEY_	62ff	
Calibration Data	SCM/SCP	131-179	One Set has 9 Byte
CRC Cecksum for Flash	SCF/RCF	180	4 Bytes length and CRC16
Type Device	STD	252	STC or MTC
Error occurrence time	REC	256	
Error occurrence counter	REC	296	

7.2 Slot Modul

Table 8: EEPROM Content of the Slot

Name	Commands connected to the value	Position into the EEPROM	Description
Calibration Value M	SCH/SCL/RCI0	2	1st Sensor
Calibration Value T	SCH/SCL/RCT0	4	1st Sensor
Serial number	SFV	6	
Awake time	RDC/SDC	10	
Calibration Date	SCH	12	6 Byte
Max allowed Temp*	SMT/RMT	18	
Min allowed Temp*	SLT/RLT	184	
Offset Temperature*	SHO/RHO	20	
Room Temperature*	SRT/RRT	22	
Device Type*	STD/RTD	24	0--> Thermoshake; 1--> CPAC; 2--> Teleshake; 4 CPAC 2 TEC
P-Part of PID ctrl*	SPP/RPP	26-32 & 76-82	SPI/RPI SPD/RPD 2*6 Byte
Disposable Offset*	SDO/RDO	106	Up to 9 offset values, For details see chapter 6.1.3.2 Linear disposable Offset (Commands SDO and SDX).
Disposable X-Axis*	SDX/RDX	116	At which Temperature is the offset valid
Target Temperature	STT	34	
Min Voltage 14	SLO1	36	
Max Voltage 14	SLO2	38	
Min Voltage 12	SLO3	40	
Max Voltage 12	SLO4	42	
RPM Shaker	SSR/RSR	44	
Max Temperature Device Measured	SMT/RMT1	46	SMT0 sets measured temp to 0
Max Temperature Device Allowed	SLO6	48	
Max RPM Device allowed*	SLO5	50	
Max Delta Temp Sensor 1 & 2*	SLO7	90	Maximum allowed temperature difference between the two PT100 sensors in a "steady state"
Calibration Value M	SCH/SCL/RCI1	102	2nd sensor
Calibration Value T	SCH/SCL/RCT1	104	2nd sensor
Error Codes	REC/SEC	52ff	
Shadow Error Codes	REC_KEY_	62ff	INHECO Internal Error Codes
Calibration Data	SCM/SCP	131-179	Up to 5 Sets One Set has 9 Byte
CRC Cecksum for Flash	SCF/RCF	180	4 Bytes length and CRC16
Error occurrence time	REC	256	

| Error occurrence counter | REC | 296 | |

Device dependent values for the temperature control algorithm (which is implemented in the Slot Module) are stored into external EEPROM and into the Slot Modul EEPROM. They are marked with an asterisk '*'.

7.3 External EEPROM

One big advantage of the MTC/STC is that there exists the possibility to store the settings not only into the MTC/STC itself but also in the device which is connected to it, namely CPAC, Thermoshake or Teleshake devices. In the device EEPROM, the MTC/STC can store device specific parameters like the PID parameters and temperature offsets. With the command xSPOi (Set PID Origin) all slots can be configured to either use the internal slot EEPROM or the external device-EEPROM as origin for the parameters. Default setting will be that the MTC/STC uses the device EEPROM. The following table shows which parameters are stored in the external EEPROM:

Table 9: Content of the external device EEPROM; Slot is the Slot ID

Name	Commands connected to the value	Position in ext EEPROM	Description
PID Parameter	0SPPSlot,0/1,DATA; 0SPISlot,0/1,DATA, 0SPDSlot,0/1,DATA	1 2/3 4/5	2 times 3 bytes, one for P, one for I and one for D (Heating and Cooling); Values can be read at respective Slot 4 Seconds after Set e.g. via 3RPP0
Heater offset	0SHOkey,Slot,DATA	6	Offset at 70 °C 2 byte
Room Temperature	0SRT,Slot,DATA	8	Room Temperature 1 byte
SPP0	0SPPSlot,0/1,DATA	9	P Value0
Type Device	0STDkey,Slot	10	CPAC, Thermoshake, Teleshake, CPAC Ultraflat …
Disposable Offset	0SDO/0SDX	11-28	18 byte
Constant Offset	0SCOkey,Slot,DATA	29	2 byte
Maximum Allowed Temperature	0SMTkey, Slot,1,DATA	31	1 byte, to be set from INHECO [1/10 °C] Read at Slot only
CRC	-	32	Checked by Slot Module
		33-39	empty
Run Time	0RRDSlot	40	2 byte read via 0RRDi
Minimum Temperature	0RLTSlot	44	2 byte; can only be read
Maximum Temperature	0RMTSlot	46	2 byte; can only be read
Serial number	0SSNKey,Slot,DATA	51	Devices Serial number (two byte)
Calibration Mark	0SCMSlot	53-112	10 times 6 byte (3 Date + 3 Name)
		113-120	empty
Default Parameter	0SRESlot, 0SDPkey,Slot,,j,	121-134	14 byte
Article Number	0SANSlot,Number	137	last three digits of article number are stored
		140-194	empty
Calibration Mark count	0SCP	195	Set Calibration Date Position Counter
		196-209	Internal Data (Calibrator Settings)
Minimum Allowed	0SLTkey,Slot,DATA	210	1 Byte

Temperature			
Max Delta T PT100 1-2	0SDT	211	
Max RPM	0SMR	212	
		213-229	empty
CRCII		230	Second crc checked by MB

As the Mainboard handles the external EEPROM whereas the Slots need most of its content (e.g. for the temperature control) lots of communication between MAINBOARD and Slots must take place when the commands of the second column are used. If something went wrong at the usage of the external EEPROM configuration commands, please restart the MTC/STC. Then check if the values are correct.
If e.g. device 3 behaves unexpected use 0SRE3 to set its external EEPROM back to the default settings.

8.0   Description of the MTC/STC dll

The Name of the dll is InhecoMTCdll.dll. In addition the HID.dll is needed, where the last one is content of every Windows System since at least Y2K. As it has been mentioned above the MTC/STC behaves like a Human Interface Device (HID) on the USB. To communicate with the MTC/STC, we wrote a small dll that includes the following three functions only:

```
public int FindTheUniversalControl(int ID);
public void WriteOnly(string msg);
public string ReadSync();
```

FindTheUniversalControl(int ID) must be called with the dip switch settings of the MTC/STC as ID to find the respective MTC/STC. It replies 1 if the MTC/STC could be found and 0 if not. The three dip switches allow 8 unique MTC/STC IDs. Therefore eight MTC/STC can be controlled by one PC at once.

WriteOnly(string msg) sends the commands as msg to the MTC/STC, that are described in this Firmware Command Set document.

string ReadSync() reads the reply of the MTC/STC again, as described in this Firmware Command Set document.

It is strongly recommended to use ReadSync() immediately after WriteOnly(msg).

The delay between command (write) and reply (read) is usually less than 100 miliseconds (ms). Anyhow we recommend sending commands not more frequent than every 100 ms.

Timeouts and CRC errors are handled by the Dll automatically.

Some of the Error Codes described in Table 1 are generated by the Dll.

When more than one MTC/STC is connected to the PC always that MTC/STC is addressed, which ID was operand of the last call of FindTheUniversalControl(ID).

Remark: When you connect two MTC/STC with the same IDs (Dip Switch settings) and use the subroutine FindTheUniversaControl(ID); you get a blue screen!

The following example application uses the dll:
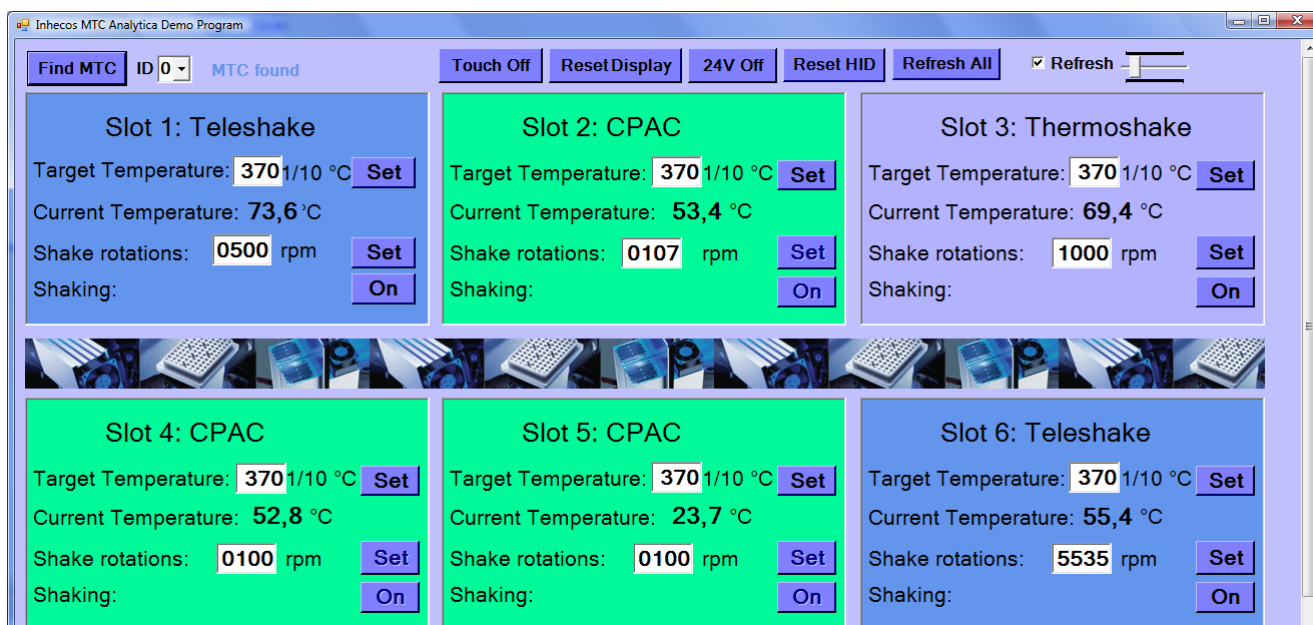
Figure 6: Screenshot of an example application

9.0   Firmware upload

The Flash memory of both different devices, the Mainboard and the Slot-Modules, can be updated via USB. To update the firmware of the MAINBOARD mainly a tool from Atmel, the µC supplier, can be used. To update the firmware of the Slot-Modules an INHECO tool is needed.

9.1 Mainboard

Install the FLexible In system Programmer (FLIP) Tool from Atmel.

Send 0SRS1 (Software Reset Mainboard) to the MTC/STC --> The HID Device MTC/STC disappears from the USB

A device called AT90USB128 appears on the USB. At the first time windows will ask for a driver for this device. The driver is located into a FLIP subdirectory, usually at: /Programs/Atmel/Flip330/usb/.

Install the driver

Start FLIP --> FLIP needs the Java Virtual Machine. Please install this if it is not already installed on your PC and start FLIP again.

The following screen will occur:
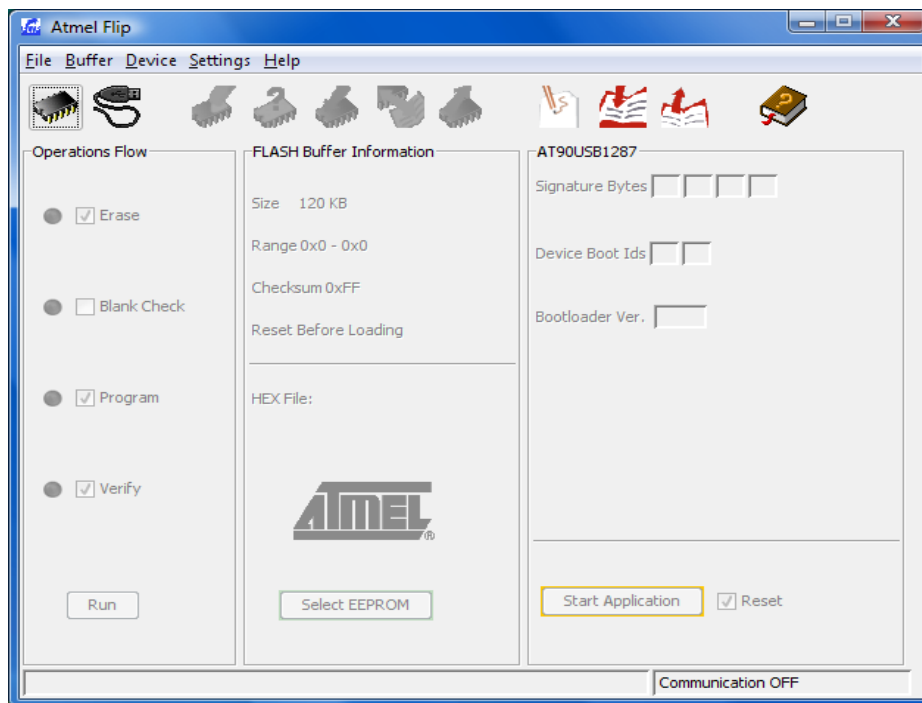
Click the most upper left button and choose the respective µC (AT90USB1287)

Click the button next to this and connect to the Mainboard Boot Program (FLIP changes its outfit, see next screenshot):
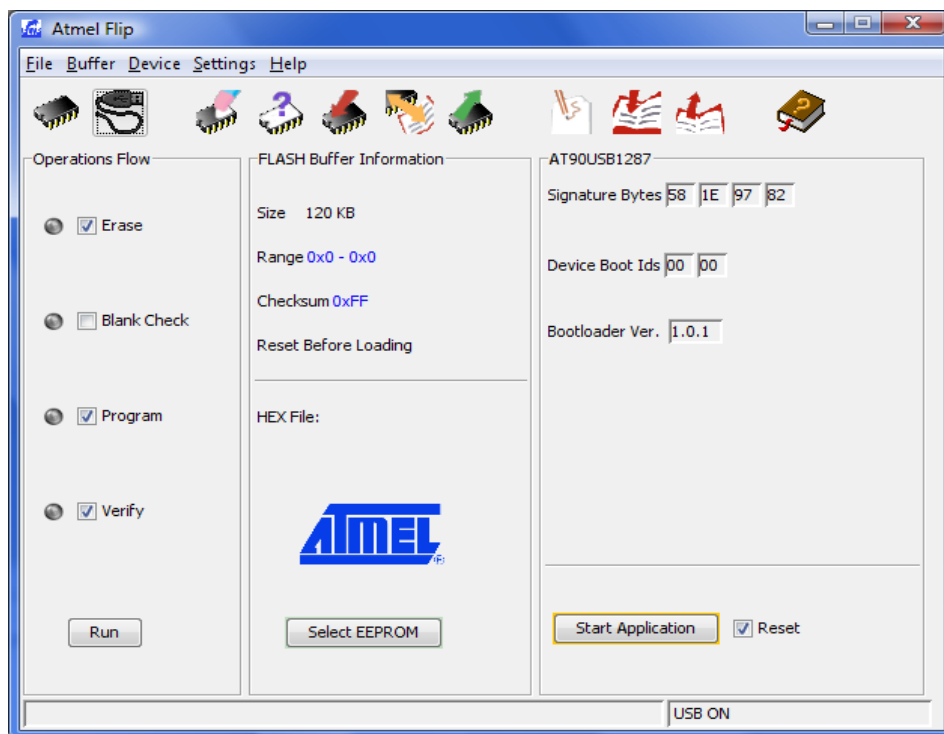
Chose with the file dialogue the respective Mainboard file

Click the "**Run**" Button and wait about three seconds

Click the "**Start Application**" Button

Exit FLIP

Probably it is necessary to restart the MTC/STC.

Check the Firmware Version after the upload.

9.2 Slot-Modules

The Firmware of the Slot-Modules always starts with the Boot Program. The User does not realise this because it immediately branches to the main program, if the main program is valid. This ensures that a firmware update is always possible, even if no main program was installed or if the upload failed.

To switch Slot-Module 3 between Main Program and Boot Program, the following commands can be used:

Main --> Boot: 3SBMB (Set Boot Mode Boot) followed by 3SRS1 (Software Reset).

Boot --> Main: 3M (Main) followed by 3S (Software Reset). In both cases the software reset can be replaced by a hardware reset.

Of course the upload tool does this automatically. The user has to choose the respective Slot-Module address and has to click "Upload Slot". The Upload needs about four minutes. It is slow because all data must be gated through the Mainboard.

Via: PC--USB—HID--MAINBOARD--SSB--Slot and the reply Slot-- SSB—MAINBOARD--HID--USB--PC
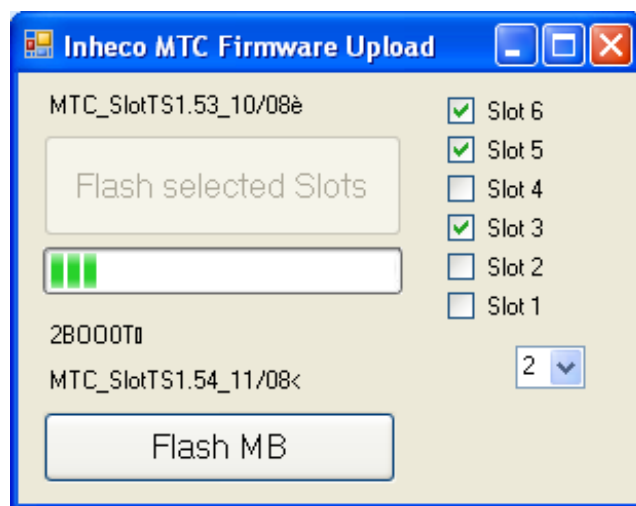
Figure 7: Firmware Upload Tool MTC

Check the Firmware Versions after the upload.

10.0 Index of Commands