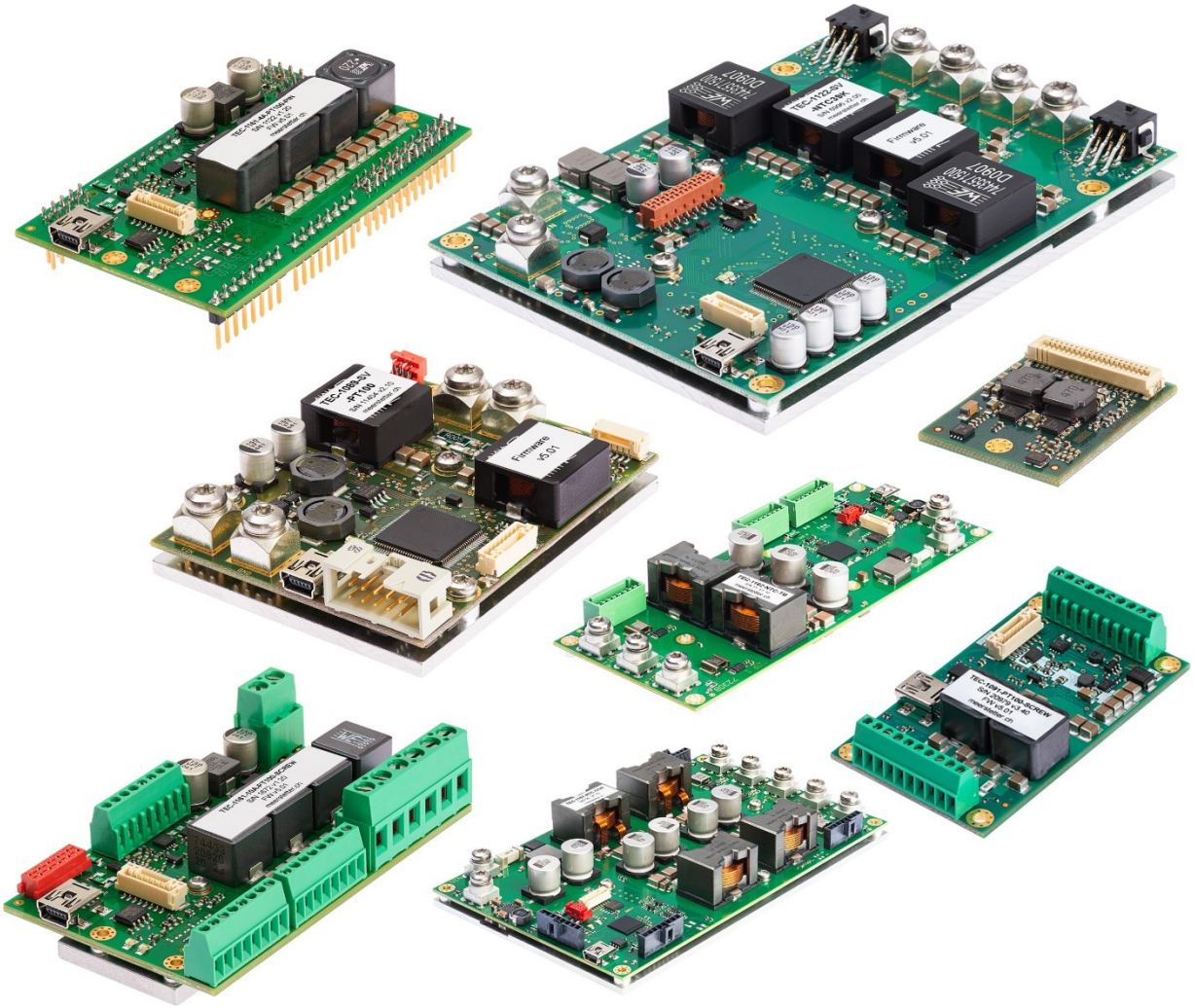
Communication Protocol
TEC Controller



TEC-Family

TEC-1092	TEC-1089	TEC-1122	TEC-1162
TEC-1091	TEC-1090	TEC-1123	TEC-1163
		TEC-1161	TEC-1166
			TEC-1167

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1 General Description

If you have any questions, please do not hesitate to contact us.

This document mainly describes the proprietary MeCom Protocol. Details about each parameter can be found in this document and in the User Manual.

1.1 Protocol Specifications

- General serial interface specs: 8 Data bits; no Parity; 1 Stop bit; no Handshaking.
- The used communication protocol is based on the "MeCom Protocol Specification" Document me5117D.
- Some Demo Applications could help to implement this specification. Please also check the Example Communication Strings at the end of this document.
    - The **MeComAPI** with demo Application shows the fully implementation of this protocol for C and C++ applications. Tested on Windows, Linux, and Microcontrollers.
    - The **MeComAPI for .Net** is a C# based library that enables communication over RS232/RS485, direct FTDI driver access or Ethernet.
    - The **LDD-TEC-Sample Application** shows only the Query Strings for getting the Configuration Software Parameters.
    - **LabVIEW VI** Sample Application.
    - **Python** Sample Application.

1.2 Addressing

The package format contains an address field, to address up to 254 devices on the same bus. The device reacts in the following cases:

- The device receives a package that matches to the user configurable device address.
    - The device address can be configured and is nonvolatile.
    - An offset to the configured address can be added by using the GPIO pins. This allows the user to have the same configuration on more than one device on a bus. The individual address is then set by hardware bridged pins on the GPIO pins.
- The device receives a package with the address 0. (broadcast)
- The device receives a package with the address 255. Similar like 0, but it does not send an answer back to the host. This can for example be used to change the serial speed on each device connected to the bus.

1.3 Connecting the TEC Configuration Software

- By default, the TEC Configuration Software always sends to each FTDI USB interface the "?IF" command with 57600 Baud and checks if it gets the correct answer.
- If an answer has been received, then it checks the firmware version.
- If the firmware version matches, then it uses the CS (Change Speed) command to temporarily change the speed from 57600 to 1M Baud. Please have a look at the 2 tables on the next page.
- Using the factory default settings, it is possible to connect the TEC Configuration Software on each interface (USB, RS232 TTL, RS485).
- If the Base Baud Rate has been changed to n different value, it is possible to change the TEC Configuration Software behavior by passing some additional startup parameters. It is recommended to create a shortcut to the .exe file and then modify the shortcut parameters. Startup parameters:
    - … `.exe /Ftdi -LowSpeed=115200`
      Sets the initial speed to a certain Baud Rate. By default, this value is 57600.
    - … `.exe /Ftdi -HighSpeed=921600`
      Sets the high-speed value to a certain Baud Rate. By default, this value is 1000000.
    - … `.exe /Ftdi -Speed=115200`
      Changes both the `Connecting Speed` and the `High Speed Rate` to a certain Baud Rate.
    - … `.exe /Connection -IP=192.168.1.191 -DevAddr=3`
      Sets the Mode to Ethernet and uses the given IP Address and Device Address to connect.
- To use RS485 we recommend the following interface cable: www.ftdichip.com/Products/Cables/USBRS485.htm
- To use RS232 TTL, we recommend the 3.3V versions of the following interface cable: www.ftdichip.com/Products/Cables/USBTTLSerial.htm

1.3.1 All Startup Arguments

Please review the settings of the "Connection Criteria" window of the TEC Configuration Software first. Use it like this: `.exe /Connection -DevAddr=7 -DevSerialNr=10568 /Ftdi -Speed=115200`

Main Command	Argument	Description
/Connection	-DevAddr=X	Sets the Device Address criteria to X. X can be a value from 0 to 255
	-DevSerialNr=X	Sets the Device Serial Number criteria to X.
	-IP=X	Switches to "Use Ethernet (TCP) Connection". Pass the IP like 192.168.234.88
/Ftdi	-SerialNr=X	Only connects to a device with the given FTDI Chip Serial Number like DK0FPV09. This value is shown in the "Connection Criteria" window.
	-LowSpeed=X	Sets the Connection Speed to X. X can be 4800 … 1000000
	-HighSpeed=X	Sets the High Speed Rate to X. X can be 4800 … 1000000
	-Speed=X	Same as LowSpeed and HighSpeed. Sets both values to the same value.

1.4 Interfaces, Baud Rate

The following table shows the available interfaces for the different product categories. All interfaces support the same commands. It is also possible to use several interfaces simultaneously, for example one interface to connect the TEC Configuration Software and a second one to connect a custom application.

1.4.1 Interfaces

Interface	TEC- 1089, 1090, 1122, 1123	TEC-1091	TEC-1092	TEC-1161	TEC- 1162, 1163, 1166, 1167
1	USB UART MODE 1	USB HW < v3.00: UART MODE 1 HW >= v3.00 UART MODE 3	RS232 TTL Together with EVL-1093: USB UART MODE 3	USB UART MODE 3	USB UART MODE 3
2	RS485 Channel 1 UART MODE 2	RS232 TTL HW < v3.00: UART MODE 2 HW >= v3.00 UART MODE 3	RS485 UART MODE 3	RS485 UART MODE 3	RS485 1 UART MODE 2
3	RS485 Channel 2 UART MODE 2	RS485 HW < v3.00: UART MODE 2 HW >= v3.00 UART MODE 3	Not available	RS485 UART MODE 3	RS232 TTL UART MODE 2

1.4.2 UART Modes

UART Mode	Primary Base Baud Rate	Secondary Baud Rate	Description
UART MODE 1	Fixed to 57600	None	Fixed to 57600 but can temporarily be changed with the CS command to a different value. Falls back to 57600 if no data has been received for more than 5s. Is always compatible with the TEC Configuration Software.
UART MODE 2	Configurable	None	Configurable Primary Base Baud Rate but can temporarily be changed with the CS command to a different value. Falls back to Primary Base Baud Rate if no data has been received for more than 5s. Is only compatible with the TEC Configuration Software when the Primary Base Baud Rate is set to 57600 or Startup Parameters are used.
UART MODE 3	Configurable	57600	Configurable Primary Base Baud Rate but can temporarily be changed with the CS command to a different value. Falls back to Primary Base Baud Rate if no data has been received for more than 5s. A secondary UART is always listening on this interface with 57600 and therefore it is always compatible with the TEC Configuration Software.

1.5 Flash Parameters (nonvolatile) / RAM Parameters (volatile)

This controller does not save any parameters automatically to the flash (nonvolatile memory). If the parameters should be saved to the nonvolatile memory, then send the "Save Parameter to Flash" command. This command is described in the Document "MeCom Protocol Specification 5117".

The TEC Configuration Software does automatically send the save command after clicking to "Write Config".

The flash can only be re written about 100'000 times. Therefore, we recommend not sending the "Save Parameter to Flash" command automatically and periodically to the TEC Controller.

2 TEC-Family Commands

2.1 Set Commands

Only the specialized commands are specified in this table. The standard commands are specified in the document 5117.

Command	**Mnemonic**	**Arguments / Description**			
		Type	**Min**	**Max**	**Description**
Emergency Stop	ES	-	-	-	Disables all Power Outputs immediately and the Error 11 is thrown.
Change Speed	CS	INT32	4800	1M	Changes the speed of the communication interface where this command was received. If no communication is recognized on the changed interface for more than 5s, the speed is changed back to the Base Baud Rate. The address is ignored to detect communication on the interface, just a valid package frame is necessary.
Set Address	SA	This command is used to set the address of a device to a specific address. It can be sent to the device as broadcast command. The device will only recognize this command if the "Device Type" and the "Serial Number" is correct.			
		INT32	0	+INT32	Device Type of the device to be addressed. (e.g., 1089, 1090, 1091, 1122, 1123) If the Device Type is sent as 0, the Device Type is ignored.
		INT32	0	+INT32	Serial Number of the device to be addressed. If the Serial Number is sent as 0, the Serial Number is ignored.
		UINT8	-	-	0: Set to the address given by the "Address Field". 1: Set to the CH1 Rack Terminal Output (do not use!)
		UINT8	0	254	Address Field.

2.2 Query Commands

Only the specialized commands are specified in this table. The standard commands are specified in the document 5117.

The Firmware Identification (?IF) is: "8065-TEC SW G01 " (20 chars)

Request	Mnemonic	Description	Server Response	
			Type	**Description**
Bootloader Control	?BC	For Controlling the Bootloader	UINT32	See 4 Bootloader for Details
Bootloader Stream	?BS	Bootloader Data Stream		See 4 Bootloader for Details
Download Lookup Table Page 256 Byte	?LT UINT4 1 x UINT32 256 x UINT8	Command 0: Status Query 1: Program 2: Do Analyze Data Lookup Table Page Offset 32 x 8 Byte Commands	UINT4	0: Idle 1: Erasing or Writing (Sent Data is ignored) 2: New Data accepted 3: Error
Settings Download	?SD	Can be used to download the exported Settings Dump (*.mepar) of the Service Software. (The Configuration Software does currently not support this feature)		
		One Line of the Settings Dump File (*.mepar)	UINT4	0: Parameter Accepted 1: CRC wrong: Possible causes: • The *.mepar File has been modified • The firmware version is not exactly the same as it was while the *.mepar file has been created • The *.mepar File was created for another device.

3 Configuration Software Parameters

3.1 Payload Format description

The Parameter Instance is usually used to control the TEC Output Channel 1 - 4. In case the Instance does not refer to the Channel (e.g., GPIO or Display Parameters) it is noted in this document.

If there is only one instance available, Parameter Instance must be set to 1 (e.g., Firmware Version).

All standard commands have been transferred to document 5117.

3.2 General Value Range Description

Name	Min	Max	Description
RNG_TEMP	-273°C	1000°C	General Temperature Range

3.3 Parameter List

This capture contains all parameters which can also be accessed by the TEC Configuration Software. The order is the same as in the TEC Configuration Software. Please refer to the TEC-Family User Manual (5216) for detailed parameter descriptions.

R after the Format information means Read-Only.

3.3.1 Common Product Parameters

3.3.1.1 Device Identification

ID	Name	Format	Value Range	Description
100	Device Type	INT32 R	..	1122 → TEC-1122
101	Hardware Version	INT32 R	..	123 → 1.23
102	Serial Number	INT32 R	..	
103	Firmware Version	INT32 R	..	123 → 1.23
104	Device Status	INT32 R	..	0: Init 1: Ready 2: Run 3: Error 4: Bootloader 5: Device will Reset within next 200ms
105	Error Number	INT32 R	..	
106	Error Instance	INT32 R		
107	Error Parameter	INT32 R		
109	Parameter System: Flash Status	INT32 R	..	0: All Parameters are saved to Flash 1: Save to flash pending or in progress. (Please do not power off the device now)
110	Error Text	LATIN1 R		Use the ?VB command to query the error text.
111	Device Reset	INT32	0 … 1	Write 1 to this parameter, to trigger a reset.
112	Firmware Version	FLOAT32 R		Same as parameter 103, but as float. Round it to two decimal places.
115	Random Startup Value	INT32 R	..	Random value, which gets updated at each system start. Might be used to detect an unexpected reboot.

3.3.2 General

3.3.2.1 General Operating Mode

ID	Name	Format	Value Range	Description
2040	General Operating Mode	INT32	..	0: Bipolar 1: Parallel Bipolar Individual 2: Parallel Bipolar Common 3: Unipolar 4: Mixed 5: Do not use: Just for tests

3.3.2.2 TEC Channel Source Selection

ID	Name	Format	Value Range	Description
6300	Object Source Selection	INT32	..	0: HR 1 1: HR 2 2: LR 1 3: LR 2 4: LR 3 5: LR 4 6: Device 7: External (From ID 52200)
6304	Sink Source Selection	INT32	..	0: HR 1 1: HR 2 2: LR 1 3: LR 2 4: LR 3 5: LR 4 6: Device 7: Fixed (From ID 52201)
52200	Object External Temperature	FLOAT32	*RNG_TEMP*	Initial Value will be NAN. NAN causes the temperature controller to Stop. This Value should be set every 100ms or faster. To enable this feature use Parameter 6300. If this Parameter doesn't get refreshed for longer than 5s, the value will automatically be set to NAN. This stops the temperature controller.
52201	Sink Fixed Temperature	FLOAT32	*RNG_TEMP*	

3.3.2.3 Fan Channel Source Selection

ID	Name	Format	Value Range	Description
6210	Fan Temperature Source	INT32	..	0: HR 1 1: HR 2 2: LR 1 3: LR 2 4: LR 3 5: LR 4 6: Device

3.3.3 System

3.3.3.1 System Parameters

ID	Name	Format	Value Range	Description
1051	Firmware Build Number	INT32 R	..	
1054	Min Version for Firmware Downgrade	INT32 R	..	123 → 1.23
1065	Unique ID	LATIN1 R		This is the UniqueID of the processor on the device.

3.3.3.2 Supplies

ID	Name	Format	Value Range	Description
1060	Driver Input Voltage	FLOAT32 R	V	
1061	Medium Internal Supply	FLOAT32 R	V	
1062	3.3V Internal Supply	FLOAT32 R	V	
1064	Calculated Input Current	FLOAT32 R	A	The 'Calculated Input Current' is calculated by dividing the total output power by the 'Driver Input Voltage'.
1071	Input Protection: Actual Output Limit	FLOAT32 R	A	The maximum output current limitation that serves as input protection for the output stage.
1072	Input Protection: Device Limitation	FLOAT32 R	A	The maximum input current limitation defined by the power stage.

3.3.3.3 Device Temperature Management

ID	Name	Format	Value Range	Description
1063	Device Temperature	FLOAT32 R	°C	Temperature of the TEC Controller itself
1110	Maximum Device Temperature	FLOAT32 R	°C	
1111	Maximum Output Current	FLOAT32 R	A	

3.3.4 Temperature Controller

3.3.4.1 Main Input Temperatures

ID	Name	Format	Value Range	Description
3000	Target Object Temp	FLOAT32	*RNG_TEMP*	
1000	Object Temperature	FLOAT32 R	°C	
1001	Sink Temperature	FLOAT32 R	°C	

3.3.4.2 Nominal Temperature Ramp (not Peltier, Heat/Cool Only Mode)

ID	Name	Format	Value Range	Description
3003	Coarse Temp Ramp	FLOAT32	1E-6°C/s … 50°C/s	
3002	Proximity Width	FLOAT32	0°C … 200°C	
3004	Sine Ramp Start Point	INT32	..	0: On a new Target Value, the actually measured Temperature is taken as Start Temperature. 1: On a new Target Value, the current Target Temperature is taken as Start Temperature
1011	(Ramp) Nominal Object Temperature	FLOAT32 R	°C	

3.3.4.3 Peltier, Heat/Cool Only Boundaries

ID	Name	Format	Value Range	Description
3051	Upper Boundary	FLOAT32	*RNG_TEMP*	
3050	Lower Boundary	FLOAT32	*RNG_TEMP*	

3.3.4.4 Temperature Control

ID	Name	Format	Value Range	Description
3010	Kp	FLOAT32	0%/°C … 10000%/°C	
3011	Ti	FLOAT32	0s … 10000s	0s disables the integral term
3012	Td	FLOAT32	0s … 10000s	
3013	D Part Damping PT1	FLOAT32	0 … 1	
1032	PID Control Variable	FLOAT32 R	%	

3.3.4.5 Thermal Model

3.3.4.5.1 Mode

ID	Name	Format	Value Range	Description
3020	Mode	INT32	0 … 2	0: Peltier, Full Control 1: Peltier, Heat Only - Cool Only 2: Resistor, Heat Only

3.3.4.5.2 Thermal Model Mode: Peltier, Full Control or Peltier, Heat/Cool Only

ID	Name	Format	Value Range	Description
3034	Polarity	INT32	..	0: Cooling (Positive current is cooling) 1: Heating (Positive current is heating)
3030	Imax	FLOAT32	0.1A … 1000A	From the Peltier Datasheet
3033	dTmax	FLOAT32	1°C … 200°C	From the Peltier Datasheet

3.3.4.5.3 Thermal Model Mode: Resistor, Heat Only

ID	Name	Format	Value Range	Description
3040	Resistance	FLOAT32	0.001Ohm … 10k Ohm	
3041	Maximum Current	FLOAT32	0.01A … 1000A	

3.3.4.5.4 Thermal Model Outputs

ID	Name	Format	Value Range	Description
1012	Thermal Power Model Current	FLOAT32 R	A	
1030	PID Lower Limitation	FLOAT32 R	%	
1031	PID Upper Limitation	FLOAT32 R	%	
1033	PID 0A Limitation	FLOAT32 R	%	Only active in Mode Peltier Heat/Cool Only

3.3.4.6 Stability Indicator

ID	Name	Format	Value Range	Description
4040	Temperature Deviation	FLOAT32	0°C … 50°C	
4041	Min Time in Window	FLOAT32	0s … 86400s	
4042	Max Stabilization Time	FLOAT32	0s … 86400s	
1200	Temperature is Stable	INT32 R	..	0: Temperature regulation is not active 1: Is not stable 2: Is stable

3.3.4.7 Output Stage

3.3.4.7.1 Output Enable

ID	Name	Format	Value Range	Description
2010	Status	INT32	..	0: OFF 1: ON

3.3.4.7.2 Output Stage Monitoring

ID	Name	Format	Value Range	Description
1020	Actual Output Current	FLOAT32 R	A	
1021	Actual Output Voltage	FLOAT32 R	V	

3.3.4.7.3 Output Stage Input Selection

ID	Name	Format	Value Range	Description
2000	Input Selection	INT32	..	0: Fixed Current/Voltage (Uses ID 2020…) 1: Temperature Controller

3.3.4.7.4 Fixed Output Values (Temperature Controller not active)

ID	Name	Format	Value Range	Description
2020	Set Current	FLOAT32	1092: -1.2A … 1.2A 1091 / 1161-4A: -4A … 4A 1089 / 1122 / 1161-10A: -10A … 10A 1090 / 1123: -16A … 16A 1162 / 1166: -5A … 5A 1163 / 1167: -25A … 25A	
2021	Set Voltage	FLOAT32	1092: 0V … 9.6V -SV Version and 1091 / 1161: 0V … 21V -HV Version: 0V … 30V 1162 / 1163 / 1166 / 1167: 0V … 57V	

Value Range hints:

- For channels in "Unipolar" mode, there are no negative values.
- In the "Parallel Bipolar Common" mode, the current [Ampere] values are doubled.

3.3.4.7.5 CHx Output Stage Limits

ID	Name	Format	Value Range	Description
2030	Current Limitation	FLOAT32	See parameter ID: 2020	
2031	Voltage Limitation	FLOAT32	See parameter ID: 2021	
2032	Current Error Threshold	FLOAT32	1092: 0A … 1.4A 1091 / 1161-4A: 0A … 5.6A 1089 / 1122 / 1161-10A: 0A … 14A 1090 / 1123: 0A … 20A 1162 / 1166: -7A … 7A 1163 / 1167: -35A … 35A	
2033	Voltage Error Threshold	FLOAT32	1092: 0A … 13V -SV Version and 1091 / 1161: 0V … 25V -HV Version: 0V … 34V 1162 / 1163 / 1166 / 1167: 0V … 60V	
1073	Final Output Limitation	FLOAT32 R	...	Shows the final output current limitation, as min value of the parameters 1111, 1071, 2030

3.3.5 HR Input (High Resolution Measurement)

3.3.5.1 Analog Digital Converter

3.3.5.1.1 ADC Configuration

ID	Name	Format	Value Range	Description	
6000	PGA Gain	INT32	..	0: Gain = 1 1: Gain = 2 2: Gain = 4 3: Gain = 8 4: Gain = 16 5: Gain = 32 6: Gain = 64 7: Gain = 128 8: Auto Gain 1 or 8 9: Auto Gain 1 or 8 or 32	
6007	PGA Bypass	INT32	..	0: Disabled 1: Enabled	
6001	Current Source	INT32	..	TEC-1091, 1092, 116x: 0: OFF 1: 10uA 2: 50uA 3: 100uA 4: 250uA 5: 500uA 6: 1000uA 7: 1500uA	Others: 0: OFF 1: 50uA 2: 100uA 3: 250uA 4: 500uA 5: 750uA 6: 1000uA 7: 1500uA
6008	Current Source 2 Out	INT32	..	TEC-1091, 1092, 116x: 0: OFF 1: AIN0 (UB) 2: AIN1 (UA) 3: AIN2 4: AIN3 (IA) 5: REFP0 (IB) 6: REFN0	Others: 0: OFF 1: AIN0 (UB) 2: AIN1 (UA) 3: AIN2 (IA) 4: AIN3
6009	Measurement Type	INT32	..	0: Resistance 1: Voltage	
6301	Sampling Frequency	INT32	..	0: 10Hz 1: 80Hz/90Hz 2: 1Hz	
6002	ADC Rs	FLOAT32	10Ohm … 1MOhm		
6006	ADC Rp	FLOAT32	0Ohm … 1MOhm	0 Ohm means not assembled.	

3.3.5.1.2 ADC Calibration

ID	Name	Format	Value Range	Description
6003	Offset	FLOAT32	-100000 ... 100000	
6004	Gain	FLOAT32	0.1 ... 2	

3.3.5.1.3 ADC Outputs

ID	Name	Format	Value Range	Description
1042	Resistance	FLOAT32 R	Ohm	
1046	Differential Voltage	FLOAT32 R	V	
1040	HR Measurement: Raw ADC Value	FLOAT32 R	..	

3.3.5.2 Temperature Conversion

3.3.5.2.1 Conversion Type

ID	Name	Format	Value Range	Description
6005	Conversion Type	INT32	..	0: NTC 1: PT100 2: PT1000 3: Voltage

3.3.5.2.2 Temperature Calibration

ID	Name	Format	Value Range	Description
4001	Offset	FLOAT32	-1E4°C … 1E4°C	
4002	Gain	FLOAT32	0.1°C/°C … 2.0°C/°C	

3.3.5.2.3 NTC Sensor Characteristics

ID	Name	Format	Value Range	Description
4024	T High	FLOAT32	*RNG_TEMP*	
4025	R High	FLOAT32	1Ohm … 1MOhm	
4022	T Middle	FLOAT32	*RNG_TEMP*	
4023	R Middle	FLOAT32	1Ohm … 1MOhm	
4020	T Low	FLOAT32	*RNG_TEMP*	
4021	R Low	FLOAT32	1Ohm … 1MOhm	

3.3.5.2.4 Voltage to Temperature Conversion

ID	Name	Format	Value Range	Description
6400	Reference Temp	FLOAT32	*RNG_TEMP*	Reference Temperature in °C
6401	Reference Voltage	FLOAT32	-5V … 5V	Voltage output at the Reference Temperature
6402	Temperature Slope	FLOAT32	-100V/°C … 100V/°C	Voltage change per temperature change

3.3.5.2.5 Conversion Output

ID	Name	Format	Value Range	Description
1045	Measured Temperature	FLOAT32 R	°C	

3.3.5.3 Measurement Limits

ID	Name	Format	Value Range	Description
4035	Highest Voltage	FLOAT32 R	V	
4036	Lowest Voltage	FLOAT32 R	V	
4030	Lowest Resistance	FLOAT32 R	Ohm	
4031	Highest Resistance	FLOAT32 R	Ohm	
4032	Temperature at Lowest Resistance	FLOAT32 R	°C	
4033	Temperature at Highest Resistance	FLOAT32 R	°C	

3.3.5.4 Surveillance

ID	Name	Format	Value Range	Description
6302	ADC Limit Errors	INT32	..	0: None 1: Upper Only 2: Lower Only 3: Both
6303	Temp Limit Errors	INT32	..	Same as ID 6302
4011	Upper Error Threshold	FLOAT32	*RNG_TEMP*	
4010	Lower Error Threshold	FLOAT32	*RNG_TEMP*	
4012	Max Temp Change	FLOAT32	1°C/s … 200°C/s	

3.3.5.5 Detected Sensor Type

ID	Name	Format	Value Range	Description
4034	Sensor Type	INT32 R	..	0: Unknown Type 1: PT100 2: PT1000 3: NTC18K 4: NTC39K 5: NTC56K 6: NTC1M/NTC 7: VIN1 8: VIN2

3.3.5.6 ADC Self Check

3.3.5.6.1 Configuration

ID	Name	Format	Value Range	Description
6050	Self-Check Period	INT32	0s … 2147483647s	Self-check Period in s. 0 disables the periodic self-check.
6051	Self-Check Trigger	INT32	0 … 1	Writing a 1 to this parameter triggers the automatic self-check. The parameter is automatically set to 0 after the check is finished.
6052	IRs Error Enable	INT32	0 … 1	If this parameter is set to 1 an error is thrown when the measured IRs is out of boundaries.

3.3.5.6.2 Results

ID	Name	Format	Value Range	Description
6053	AVDD	FLOAT32 R	V	Analog Supply Voltage measured by the ADC TEC 1091, 1092, 116x: 5V Other TEC-Controllers: 3.3V
6054	IRs	FLOAT32 R	I	Current through the reference Resistor See parameter 6001 for nominal value.
6055	VRef	FLOAT32 R	V	Voltage at the reference voltage input of the AD-Converter

3.3.6 LR Input (Low Resolution Measurement)

3.3.6.1 Analog Digital Converter

3.3.6.1.1 Configuration

ID	Name	Format	Value Range	Description
6010	ADC Rv	FLOAT32	10Ohm … 1MOhm	
6013	ADC Vps	FLOAT32	0V … 100V	

3.3.6.1.2 Calibration

ID	Name	Format	Value Range	Description
6011	ADC Calibration Offset	FLOAT32	-100000 ... 100000	
6012	ADC Calibration Gain	FLOAT32	0.1 ... 2	

3.3.6.1.3 Outputs

ID	Name	Format	Value Range	Description
1041	LR Measurement: Sensor Raw ADC Value	FLOAT32 R	..	
1043	LR Measurement: Sensor Resistance	FLOAT32 R	Ohm	

3.3.6.2 Temperature Conversion

3.3.6.2.1 NTC Sensor Characteristics

ID	Name	Format	Value Range	Description
5024	Upper Point: Temperature	FLOAT32	*RNG_TEMP*	
5025	Upper Point: Resistance	FLOAT32	1Ohm … 1MOhm	
5022	Middle Point: Temperature	FLOAT32	*RNG_TEMP*	
5023	Middle Point: Resistance	FLOAT32	1Ohm … 1MOhm	
5020	Lower Point: Temperature	FLOAT32	*RNG_TEMP*	
5021	Lower Point: Resistance	FLOAT32	1Ohm … 1MOhm	

3.3.6.2.2 Temperature Calibration

ID	Name	Format	Value Range	Description
5001	Temperature Offset	FLOAT32	-1E4°C … 1E4°C	
5002	Temperature Gain	FLOAT32	0.1°C/°C … 2.0°C/°C	

3.3.6.2.3 Conversion Output

ID	Name	Format	Value Range	Description
1044	LR Measurement: Measured Temperature	FLOAT32 R	°C	

3.3.6.3 Measurement Limits

ID	Name	Format	Value Range	Description
5040	Lowest Resistance	FLOAT32 R	Ohm	
5041	Highest Resistance	FLOAT32 R	Ohm	
5042	Temperature at Lowest Resistance	FLOAT32 R	°C	
5043	Temperature at Highest Resistance	FLOAT32 R	°C	

3.3.6.4 Surveillance

ID	Name	Format	Value Range	Description
6014	ADC Limit Errors	INT32	*0 … 3*	0: None 1: Upper Only 2: Lower Only 3: Both
5013	Temp. Limit Errors	INT32	*0 … 3*	Same as ID 6014
5011	Upper Error Threshold	FLOAT32	*RNG_TEMP*	
5010	Lower Error Threshold	FLOAT32	*RNG_TEMP*	
5012	Max Temp Change	FLOAT32	1°C/s … 200°C/s	

3.3.7 Fan

ID	Name	Format	Value Range	Description
6200	Fan Control Enable	INT32	..	0: Disabled 1: Enabled

3.3.7.1 Fan General Settings

ID	Name	Format	Value Range	Description
6230	Fan PWM Frequency	INT32	..	0: 25kHz 1: 1kHz

3.3.7.2 Fan Temperature Controller

ID	Name	Format	Value Range	Description
6211	Target Temperature	FLOAT32	*RNG_TEMP*	
6212	Kp	FLOAT32	0%/°C … 10000%/°C	Temperature Controller
6213	Ti	FLOAT32	0s … 10000s	Temperature Controller, 0s disables the integral term
6214	Td	FLOAT32	0s … 10000s	Temperature Controller

3.3.7.3 Fan Speed Controller

ID	Name	Format	Value Range	Description
6220	0% Speed	FLOAT32	0 … 100000	Fan Speed when no cooling is required
6221	100% Speed	FLOAT32	0 … 100000	Fan Speed when maximum cooling is required
6227	Fan Min Speed Start	FLOAT32	0 … 100000	Speed above which the Fan starts
6228	Fan Min Speed Stop	FLOAT32	0 … 100000	Speed below which the Fan stops
6222	Kp	FLOAT32	0%/°C … 10000%/°C	Speed Controller
6223	Ti	FLOAT32	0s … 10000s	Speed Controller 0s disables the integral term
6224	Td	FLOAT32	0s … 10000s	Speed Controller
6225	Bypassing Speed Controller	INT32	..	0: No 1: Yes
6226	Fan Surveillance	INT32	..	0: Enabled 1: Disabled

3.3.7.4 Fan Controller Monitoring

ID	Name	Format	Value Range	Description
1100	Relative Cooling Power	FLOAT32 R	%	
1101	Nominal Fan Speed	FLOAT32 R	rpm	
1102	Actual Fan Speed	FLOAT32 R	rpm	
1103	Fan PWM Level	FLOAT32 R	%	

3.3.8 Communication

ID	Name	Format	Value Range	Description
2051	Device Address	INT32	0 … 254	

3.3.8.1 UART Interface Settings

ID	Name	Format	Value Range	Description
2050	Base Baud Rate	INT32	4800 … 1M	Instance 1 = Interface 1…
2052	Response Delay	INT32	0us … 1E6us	Instance 1 = Interface 1…

3.3.8.2 Communication Watchdog

ID	Name	Format	Value Range	Description
2060	Timeout	FLOAT32	0; 0.1 … 60s	0 disables the Watchdog

3.3.8.3 CANopen Interface

ID	Name	Format	Value Range	Description
2070	Node ID	INT32	1 … 127	
2071	Bit Rate	INT32	10 kbit/s … 1000kbit/s	
2072	CAN1	INT32	0 … 1	0: CAN 1 Disabled 1: CAN 1 Enabled

3.3.9 Tab: Auto Tuning

3.3.9.1 Presettings

ID	Name	Format	Value Range	Description
51002	Thermal Model Speed	INT32	0-1	0: Fast Model 1: Slow Model

3.3.9.2 Status

ID	Name	Format	Value Range	Description
51000	Auto Tuning Start	INT32	1	Writing 1 to this parameter initiates the Auto Tuning process.
51001	Auto Tuning Cancel	INT32	1	Writing 1 to this parameter cancels the Auto Tuning process.
51020	Tuning Status	INT32 R	..	0: Idle 1: Ramping to Target Temperature... 2: Preparing for Acquisition... 3: Acquiring Data... 4: Success. Tuning Complete! 10: Error. Check Error Number!
51021	Tuning Progress	FLOAT32 R	0 … 100%	

3.3.9.3 Tuning Results

3.3.9.3.1 Results for PID Controller

ID	Name	Format	Value Range	Description
51014	PID Parameter Kp	FLOAT32 R	%/°C	Returns the optimized Proportional Gain for the PID Controller.
51015	PID Parameter Ti	FLOAT32 R	s	Returns the optimized Integral Time for the PID Controller.
51016	PID Parameter Td	FLOAT32 R	s	Returns the optimized Derivative Time for the PID Controller.

3.3.9.3.2 Results for PI Controller

ID	Name	Format	Value Range	Description
51022	Slow PI Parameter Kp	FLOAT32 R	%/°C	Returns the optimized Proportional Gain for the PID Controller.
51023	Slow PI Parameter Ti	FLOAT32 R	s	Returns the optimized Integral Time for the PID Controller.

3.3.9.3.3 Nominal Temperature Ramping Recommendation

ID	Name	Format	Value Range	Description
51017	Coarse Temp Ramp	FLOAT32 R	°C/s	Returns a recommendation value for the Target Temperature Ramp function.
51018	Proximity Width	FLOAT32 R	°C	Returns a recommendation value for the Target Temperature Ramp function.

3.3.9.3.4 PID D Part Damping PT1 Recommendation

ID	Name	Format	Value Range	Description
51024	PID D Part Damping PT1 Recommendation	FLOAT32 R	..	Returns a recommendation value for the PID D Part Damping.

3.3.9.3.5 Raw Auto Tuning Results

ID	Name	Format	Value Range	Description
51010	Tuning Parameter 2A (Temperature peak-peak value)	FLOAT32 R	°C	Returns the Temperature peak-peak value recorded while the Tuning Process was running.
51011	Tuning Parameter 2D (Control Variable peak-peak value)	FLOAT32 R	%	Returns the Control Variable peak-peak value recorded while the Tuning Process was running.
51012	Tuning Parameter Ku (Ultimate gain)	FLOAT32 R	%/°C	Returns the Ultimate Gain calculated based upon the 2A and 2D values.
51013	Tuning Parameter Tu (Ultimate period)	FLOAT32 R	s	Returns the recorded Ultimate Period.

3.3.10 Lookup Table

ID	Name	Format	Value Range	Description
52000	Lookup Table Start	INT32	1	Writing 1 to this parameter initiates the Lookup process.
52001	Lookup Table Stop	INT32	1	Writing 1 to this parameter cancels the Lookup progress process.
52002	Lookup Table Status	INT32 R	..	0: Not initialized 1: Table Data not valid 2: Analyzing Data Table 3: Ready (Data Table OK) 4: Executing… 5: Max nr of Tables exceeded 6: Sub Table not found
52003	Lookup Table Status Current Table Line	INT32 R	INT32	Only valid if "Lookup Table Status" is "Executing…". Information about the currently executed Data Table Line.
52010	Lookup Table ID Selection	INT32	INT32	Selection of the Lookup Table part to be executed
52012	Nr Of Repetitions	INT32	0 … +INT	Nr Of Executions of the REPEAT_MARK Elements

3.3.11 Display

Instance 1 is Display Line 1 and Instance 2 is Display Line 2.

ID	Name	Format	Value Range	Description
6020	Display Type	INT32	..	0: OFF 1: OLED 2x16 (DPY-1113) 2: OLED 4x20 (DPY-1114) 3: Small OLED 2x16 (DPY-1115)
6023	Display Line 1 - 4 Alternative Mode	INT32	..	0: None 1: On Error 2: Toggle on Error 3: Toggle
6024	Display Line 1 - 4 Default Text	LATIN1	..	See TEC-Family User Manual
6025	Display Line 1 - 4 Alternative Text	LATIN1	..	See TEC-Family User Manual
6026	Display Line 1 - 4 Startup Text	LATIN1	..	See TEC-Family User Manual

3.3.12 I/O

3.3.12.1 GPIO Configuration

Instance 1 is GPIO1. Instance 2 is GPIO2…

ID	Name	Format	Value Range	Description
6100	GPIO Function	INT32	..	0: No Function 1: Data Interface (See 3.3.13.4) 2: TEC OK (1 when Ready or Running) 3: Stable 4: HW Enable 5: Fan PWM 6: Fan Tacho 7: Rmp/Stable 8: Run 9: TempUp 10: TempDown 11: Pump 12: Lookup Start 13: Adr +1 (Device Address) 14: Adr +2 (Device Address) 15: Adr +4 (Device Address) 16: Fan Stop 17: Alt Target T1 18: Alt Target T2 19: PowerSt 0A 20: Encoder A 21: Encoder B 22: Ramp 23: Fix 0 24: HW Enable Toggle
6101	GPIO Level Assignment	INT32	..	0: Positive 1: Negative
6102	GPIO Hardware Configuration	INT32	..	0: IN WeakNo 1: IN WeakUp 2: IN WeakDown 3: OUT PushPull 4: OUT OD NoPull 5: OUT OD WeakUp
6103	GPIO Channel	INT32	..	1: Channel 1 2: Channel 2 3: Channel 3 4: Channel 4 For example, Temperature Control Channel

3.3.12.2 Change Target Temperature Buttons

ID	Name	Format	Value Range	Description
6111	Upper Temp Limit	FLOAT32	*RNG_TEMP*	
6110	Lower Temp Limit	FLOAT32	*RNG_TEMP*	
6112	Step Size	FLOAT32	0°C … 1000°C	

3.3.12.3 Alternative Target Temperature over GPIO Pin

ID	Name	Format	Value Range	Description
6133	Temperature 0	FLOAT32	*RNG_TEMP*	
6130	Temperature 1	FLOAT32	*RNG_TEMP*	
6131	Temperature 2	FLOAT32	*RNG_TEMP*	
6132	Temperature 3	FLOAT32	*RNG_TEMP*	

3.3.12.4 Pump Control

ID	Name	Format	Value Range	Description
6120	Actual Temperature Source	INT32	..	0: HR 1 1: HR 2 2: LR 1 3: LR 2 4: LR 3 5: LR 4 6: Device
6121	ON Threshold	FLOAT32	*RNG_TEMP*	
6122	OFF Threshold	FLOAT32	*RNG_TEMP*	

3.3.13 Advanced Misc Settings

3.3.13.1 Output Stage Controller Limit (Error 108)

ID	Name	Format	Value Range	Description
6320	Error Delay	INT32	-1 … 20000000ms	-1: fully disable the Error 108 (not recommended) 0: set the delay to 1ms automatically

3.3.13.2 Error State Auto Reset Delay

ID	Name	Format	Value Range	Description
6310	Delay till Restart	FLOAT32	0s … 86400s	If the system is in an error state, it restarts after this specified time. This feature is disabled if a time of 0 seconds is specified. Note: The auto reset is delayed for a fixed time of 20 seconds after starting up.

3.3.13.3 Device Temperature Mode (Output Stage)

ID	Name	Format	Value Range	Description
6330	Mode	INT32	..	0: Standard 1: Extended

3.3.13.4 GPIO (General Purpose Input Output) GPIO1 … GPIO10 Signal Control

The following parameters are volatile parameters.

This feature can be used to manually control the GPIO1 through GPIO10 signals.

The respective GPIOs must be set to the "Data Interface" function to allow these parameters to control them.

The pins are addressed by a bit field.

Bit Field Description:

Bit Number	Output Signal
0	GPIO 1
1	GPIO 2
2	GPIO 3
3	GPIO 4
4	GPIO 5
5	GPIO 6
6	GPIO 7
7	GPIO 8
8	GPIO 9
9	GPIO 10

Example:

To configure GPIO3 / GPIO4 as output pins, and to set GPIO3 to high level and GPIO4 to Low Level, use the following commands:

Set ID 52102 to 4 (Set Bit Number 2 to '1')

Set ID 52101 to 12 (Set Bit Numbers 2 and 3 to '1')

Set ID 52100 to 1 (Enable the Function)

This command order has been chosen to avoid spikes. After Reset, all values are set to 0.

ID	Name	Format	Value Range	Description
52100	Enable Function	INT32	0 … 1	Enables the Output Signal control function.
52101	Set Output to Push-Pull	INT32	0 … 1023	If a Bit is set to '1', the Output Signal is driven. Note: By default, the GPIOs use the Hardware Configuration defined by Parameter 6102. This setting will override the Hardware Configuration and set it to "OUT PushPull".
52102	Set Output States	INT32	0 … 1023	Sets the output states of driven signals.
52103	Read Input States	INT32	0 … 1023	Reads the (input) states of all signals back.

4 Bootloader

- The new application can be downloaded using all (not CANopen) communication interfaces.
- The Bootloader can be controlled over a Control and Stream command.
- The whole new application will be cached and verified onboard, before the old application gets erased.
- Do not interrupt the power after the ReBoot command, till the device is answering to your queries again. Interrupting the power after the ReBoot command can cause irreversible memory errors.
- Do not worry about communication failures, wrong command sequences or downloading the wrong firmware using this bootloader. Everything is verified, before the bootloader enters the critical process. If the power is not being interrupted after the ReBoot command, no irreversible errors are possible.

It is important to have the correct command sequence:

1. Activate Bootloader using Command **BootloaderActivate**.
2. Query the status using **NoOperation** and wait till it reports the status activated.
3. Clear the update memory using the command **ClearMemory.**
4. Query the status using **NoOperation** and wait till it reports the status memory is cleared.
5. Send the whole .hex file using the Bootloader Stream command.
6. Query the status using **NoOperation** and wait till it reports the status Valid Application.
7. Start replacing the running application. Send the command **ReBoot**. Attention:
    a. The device will not answer your queries for typically 10s. (May take longer)
    b. Do not interrupt the power during this process!
    c. Continuously send queries (e.g., ?IF) to the device, to see if the new application is already running. If the device is answering to your queries again, the critical process is finished.
8. Verify the expected firmware version.

4.1 Bootloader Control (BC?)

Type	Mnemonic	Field 1
Query	?BC	UINT32 Bootloader Command

Type	Field 1
Response	UINT32 Bootloader Status or Server Error Code

4.1.1 Bootloader Command

Bit	Value	Description
NoBit	0x00	(No bit set) **NoOperation**. Can be used to read only the Bootloader Status.
0	0x01	**BootloaderActivate**. Starts enabling the update memory.
1	0x02	**ClearMemory**. Starts clearing the update memory.
2	0x04	**ReBoot**. Starts replacing the running application. Will only be accepted if the Bootloader Status reports "Valid Application".

4.1.2 Bootloader Status

Bit	Value	Description
0	0x0001	Bootloader is activated.
1	0x0002	Memory is cleared.
2	0x0004	Valid Application. There is a Valid Application in the Update Memory.
3	0x0008	Bootloader Error. This flag will always be set if an error occurs. See additional flags below (FW >= v5.00).
4	0x0010	Error: CRC error detected in the downloaded file.
5	0x0020	Error: The Firmware Identification String does not match. The downloaded firmware is not intended for this device.
6	0x0040	Error: This firmware is not made for this firmware branch.
7	0x0080	Error: The firmware is too old for this device.
8	0x0100	Error: AES decryption failure. The code was encrypted with a different key.
9	0x0200	Error: This firmware is too new for the currently installed firmware version. Please check the Software Release Notes. An intermediate firmware might be needed.
10	0x0400	Error: Unencrypted firmware file detected. It is not possible to install this firmware anymore. Please contact the manufacturer.
11	0x0800	Error: Feature Firmware Update Limit reached. The downloaded file contains a firmware that is too old for the device.
12	0x1000	Error: Feature Firmware Update Limit reached. The downloaded file contains a firmware that is too new for the device.

4.2 Bootloader Stream (BS?)

Type	Mnemonic	Field 1	Field 2
Query	?BS	UINT32 Length in bytes of field 2	Data Stream Part of the Hex File

Type	Field 1
Response	UINT32 Bootloader Status or Server Error Code

4.2.1 Data Stream

The Data Stream command is used to send the Hex File content to the microcontroller.

Add a few Hex File lines to the Payload Filed of the communication protocol frame and remove all '\n' and '\r' from the stream. (The Hex File lines are then only separated by the double dot).

The maximum size of the Payload Field is 512Bytes.

It is recommended to send 10 Hex File Lines in one package. This will not exceed the 512Byte limit.

4.2.2 Bootloader Status

See chapter 4 Bootloader.

5 Example Communication Strings

- If you have any questions, please do not hesitate to contact us via email: contact@meerstetter.ch or via our website: www.meerstetter.ch.
- The following Example Communication Strings have been captured with the MeComAPI trace log file.
- It shows the Serial Communication Data as it would appear on a normal Serial Terminal Program. Only the "OUT:" and "IN:" tags have been added by the MeComAPI. The End-of-Frame Byte is not shown, because it is an ASCII <CR> (Carriage Return, 0x0D).
- The Checksum is calculated using the CRC16-CCITT (XMODEM) algorithm over the previous frame data as ASCII String.
- To easily assemble command strings for our protocol we have a small tool on our website that you can make use of: www.meerstetter.ch/MeCom.
- All the Frame data is colored to better understand what is going on:
  - Control
  - Address (Using address 0, the device will always answer independent from its address)
  - Sequence Number
  - Payload / Other Payload part
  - Checksum

Get Firmware Identification String

OUT: #0015AA?IF62AE

IN: !0015AA8065-TEC SW G01 7199

→ Result is "8065-TEC SW G01 "

Get Device Type (Using Parameter Value Read)

Parameter ID: 100 (0x0064); Instance 1

OUT: #0015AB?VR00640180 00

IN: !0015AB00000044 11DBD

→ Result is 0x00000441 → 1089

Get Serial Number (Using Parameter Value Read)

Parameter ID: 102 (0x0066); Instance 1

OUT: #0015AC?VR00660180 125

IN: !0015AC00000070 6F2C

→ Result is 0x00000070 → Interpreted as an INT32: Decimal Value 112

Set TEC Output Stage Enable Status (Using Parameter Value Set Command)

Parameter ID: 2010 (0x07DA); Instance 1; New value is 2 (Live OFF/ON) as INT32

OUT: #0015AEVS07DA0100000002 8F97

IN: !0015AE8F97

→ As Result we get a ACK. The ACK sends the Checksum of the Set Command back.

Get TEC Object Temperature (Using Parameter Value Read)

Parameter ID: 1000 (0x03E8); Instance 1

OUT: #0015AB?VR03E801C21A

IN: !0015AB41CD2F28D5C2

→ The Result is 0x41CD2F28 → Interpreted as an FLOAT32: 25.648026°C

You may use the tool: www.h-schmidt.net/FloatConverter for tests.

Usually, Microcontrollers do support float according to IEEE754 by a Hardware or Software FPU.

Set TEC Target Object Temperature (Using Parameter Value Set)

Parameter ID: 3000 (0x0BB8); Instance 1; New Value 21.750°C AS FLOAT32 according to IEEE754

The new Value 21.75 is being transmitted as Hexadecimal Representation 0x41AE0000.

OUT: #0015B0VS0BB80141AE0000C482

IN: !0015B0C482

→ As Result we get a ACK. The ACK sends the Checksum of the Set Command back.

Querying a not available Parameter ID (Using Parameter Value Read)

Parameter ID: 1234 (0x04D2); Instance 1

OUT: #0015AC?VR04D2017BFE

IN: !0015AC+0532DA

→ As Result we get the Server Error Code 0x05 which means that this Parameter is not available.

6 CANopen

Please consider that this is the first implementation of CANopen. We gladly accept suggestions for improvement (support@meerstetter.ch).

Supported Features:

- All mandatory functions of CiA 301
- 1 SDO Server
- EMCY
- Producer Heartbeat
- 16 RPDO and 16 TPDO with dynamic object mapping
- Store Parameter and Restore Default Parameters

General Information:

- The CAN ID and Bitrate can be set using the Configuration Software and will be saved in the non-volatile memory.
- All the CAN Objects in the Communication Segment are only saved in the volatile memory, so they need to be re-configured after every reset.
- Except for the "Monitor" Objects, most of the Objects in the "Manufacturer Segment" are saved in the non-volatile memory.
- The device has its own parameter system, which is used to handle all the parameters for the device operation. This parameter system only supports INT32 and FLOAT32 (REAL32) values. Therefore, every parameter in the Manufacturer Segment have always a size of 4 bytes.
- Most of the parameters have only 1 instance, but some have several instances. For example, the External Temperature Measurement. For simplification, all objects in the Manufacturer Segment are always arrays. The subindex 0 is always the "Highest sub-index supported" or in other words, maximal number of instances. Subindex 1 … n represent the parameter instances 1 … n.
- The name of the objects in the EDS file are closely linked to the TEC Configuration Software.

6.1 Feature Details

6.1.1 EMCY

The error reporting only reports a few CANopen stack specific error messages. All other error messages are manufacturer specific.

For manufacturer specific errors the EEC Field shows 0xFF00 + <Meerstetter Specific Error Number>. This number can be found in the User Manual.

Usage of the MEF bytes:

- Byte 0: Instance (Channel): For example, if the External Temperature Sensor on channel 2 has a problem, then this byte is set to 2. Usually, it is 1 for this device.
- Byte 1 … 4: Additional information for support purposes. Please provide this number if you contact our support.

6.1.2 PDO

- The mapping tables have always 2 Mapping Entries, because the "Manufacturer Segment" Objects always have a size of 4 bytes.
- Some parameters have a very high update rate internally, so be careful, when using TPDOs with should automatically transmit if the value has changed.

6.1.3 Store Parameter

- Only "Save all Parameters" is available.
- Saves the following CANopen parameters from the Communication Segment:
    - 0x1005 – COB-ID SYNC
    - 0x1015 – Inhibit Time Emergency
    - 0x1017 – Producer Heartbeat Time
    - 0x1400 – Receive PDO Communication Parameters
    - 0x1600 – Receive PDO Mapping Parameters
    - 0x1800 – Transmit PDO Communication Parameters
    - 0x1A00 – Transmit PDO Mapping Parameters
- Saves all Manufacturer Segment parameters, except for the Monitor parameters.

6.1.4 Restore Default Parameters

- Only "Restore all Default Parameters" is available.
- Restores only the CANopen Communication Segment parameters to its default value, not the Manufacturer Parameters.

A Change Log

Date of change	Doc Version	Changed/ Approved	STM32 SW Version	Changes
2 Feb 2015	W	ML	2.20	• Add: Command ?TT • Add: Description about Flash and RAM parameters • Add: Parameter 6320 (CHx Output Stage Controller Limit Error Delay)
16 March 2015	X	ML	2.30	• Mod: Parameter ID 1061: New Name: Medium Internal Supply • Add: Parameter ID 1044: Sink Sensor Temperature
15 July 2015	Y	ML	2.40	• Add: Parameter ID 6120 – 6122 (Pump Control) • Mod: Parameter ID 6100 (Add Pump selection)
16 Sep 2015	Z	ML	2.41	• Bug: Parameter ID 52101 Example: Bug fixed
29 Dec 2015	AA	ML	2.50	• Add: Parameter ID 1045 (Object Temperature Measurement) • Mod Parameter ID 6300 (Take Temp of CH2 for CH1) • Mod: TEC maximum output voltages modified • Add: Parameter ID 1110 (Maximum Device Temperature) • Add: Parameter ID 1111 (Maximum Output Current) • Add: Parameter ID 6330 (Device Temperature Mode)
21 April 2016	AB	ML	2.60	• Add: Parameter ID 6226 (Fan Surveillance Disable option) • Mod: ?VL command documentation optimized
3 June 2016	AC	ML	2.70	• Add. Parameter ID 5032 (Sink Upper ADC Limit Error) • Add: Parameter ID 6006 (Object Measurement Rp)
5 Sept 2016	AD	ML	2.72	• Add: Parameter ID 4034 (Object Sensor Type) • Mod: Examples address changed to 0

Date of change	Doc Version	Changed/ Approved	STM32 SW Version	Changes
2 Feb 2017	AE	ML	3.00	• Add: CS command (change speed) • Mod: Parameter ID 1040, 1041 Object and Sink ADC values Format changed from INT32 to FLOAT32 • Mod: Parameter ID 2050, 2052 UART Baud Rate and RS485 Replay delay settings are now available for all 3 interfaces • Del: Legacy Commands removed (also from firmware) • Mod: Parameter ID 6100 options extended • Del: Peltier Umax and Qmax removed • Add: Parameter ID 6130 Alternative Target Temperature over GPIO Pin • Add: Parameter 6302 Object Temperature Observe Mode • Add: Parameter 6301 Control Speed (Temperature Controller) • Mod: Parameter 3020 Mode Generalized • Add: Parameter 3050, 3051 Heat Only – Cool Only Boundaries
28 June 2018	AF	HS	3.11	• Del: All standard commands moved to document 5117C • Del: Parameter 1046 because it was doubled. See ID 4034 • Add: Temperature Measurement Parameters: 6007, 6008, 6009 • Add: Temperature Conversion Parameters: 6400, 6401, 6402 • Add: Voltage option to the Sensor Type Selection parameter 6005 • Add: Monitor Value 1046 Object Differential Voltage • Add: Object Temperature Parameter 4035 Highest Voltage and 4036 Lowest Voltage • Add: Fan Control Parameters 6227 and 6228 • Add: Fan Control Parameter 6210 more options • Mod: GPIO Parameter 6100 changed options • Add: Display Parameters 6024, 6025 and 6026 • Del: Display Parameters 6021 and 6022 • Add: GPIO Parameters 6101, 6102 and 6103
15 Oct 2018	AH	HS	3.11	• Bug: Communication Example ACK example was wrong • Add: Hint for Python example
15 Jan 2019	AI	HS	3.20	• Add: ADS Self Check Parameter 6050 – 6055 • Mod: Parameter 3002 range modified

Date of change	Doc Version	Changed/ Approved	STM32 SW Version	Changes
30 August 2019	AJ	ML	4.10	• Add: Parameter 1054: Min firmware version • Bug: Parameter 6227 - 6228 was documented as INT32 instead of FLOAT32 • Bug: 4.1 Interfaces, Baud Rate documentation relating TEC-1091 HW version was wrong
11 March 2020	AK	HS	4.20	• Add: Pump Control Parameter 6120 more options • Add: TEC-1161 to Interfaces/Baudrate
30 July 2020	AL	ML / HS	5.00	• Add: Bootloader Flags (?BC) • Bug: Bootloader Stream (?BS): Length field was missing
30 July 2021	AM	XF / HS	5.00	• Add: TEC-1161 Current and Voltage range information for Parameters 2020, 2021, 2030 – 2033, 50001 and 50002 • Add: Information about Checksum algorithm
23 March 2023	AN	ML / XF	5.10	• Add: Parameter 6100 GPIO Function: Ramp • Del: Doubled Parameter Numbers: - 1081: Parameter System Flash Status - 1080: System Status - 1070, 1071, 1072: Error Registers - 1052: Hardware Version - 1053: Serial Number - 1050: Firmware Version • Add: GPIO Function Parameter: 6100: Fix 0 • Add: CANopen Interface Parameters • Add: Hint that PID Ti = 0s disables the integral term • Add: CANopen section • Add: Parameter 4034: Object Sensor Type: VIN2 • Add: Parameter limits for TEC-1162/1163/1166/1167 • Mod: Parameter 6300: Object Temperature Source Selection • Add: UART Modes for TEC-1162 based devices

Date of change	Doc Version	Changed/ Approved	STM32 SW Version	Changes
10 July 2023	AO	ML / XF	6.00	• Mod: 1.5 Flash Parameters (nonvolatile) / RAM Parameters (volatile) • Add: CANopen NonVolatile Parameters • Del: Par 108: Disable save to flash • Mod: Par 109: Delete status “Save to flash disabled” • Add: Par 110: Error Text • Add: Par 111: Device Reset • Add: Par 112: Firmware Version as FLOAT32 • Del: Par 50011: Target Temp Source Sel. • Del: Par 50012: Volatile Target Temp • Mod: Par 50010 new 3004: Sin Ramp Start Point • Del: Par 50000: Live Enable • Del: Par 50001: Live Set I • Del: Par 50002: Live Set U

Date of change	Doc Version	Changed/ Approved	STM32 SW Version	Changes
20 September 2024	AO	ML / XF	6.00	• Add: Par 115: Random Startup Value • Del: Par 1010: Target Object Temperature (Monitor) • Add: Par 1033: PID 0A Limitation • Add: Par 1064: Calculated Input Current • Add: Par 1071: Input Protection: Actual Output Limit • Add: Par 1072: Input Protection: Device Limitation • Add: Par 1065: Unique ID • Add: Par 6304: Sink Source Selection • Add: Par: 52201: Sink Fixed Temperature • Add: Par: 6303: HR Temp. Limit Errors • Add: Par: 6014: ADC Limit Errors • Add: Par: 5013: Temp. Limit Errors • Del: Par: 1090: Actual Output Current (CH1 + CH2) • Add: Par 6133: Alternative Target Temperature over GPIO Pin: Temperature 0 • Add: Par 1073: Final Output Limitation • Mod: Configuration Software Startup Arguments • Mod: HR/LR ADC and Temp Gain lower limit changed from 0.5 to 0.1 • Mod: GPIO Data Interface is also capable to use GPIO9 and 10. Clarification about the push-pull feature. • Bug: Par 52012: Nr Of Repetitions: Range: 0 … +INT • Del: ?TT Custom command documentation removed