Manual for DSP OAS Demonstrator

"DSP*check*"

developed and realized for ATI Korea Co., Ltd.

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ICT/IMM Ref. Nr.:	**AN 107255 A2**
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Content

1 SAFETY ADVICES 4

2 GENERAL INFORMATION 5

2.1 Scope of Delivery 5

2.2 Specifications of the DSP*check* 6

2.3 Requirements for operators and operating environment 7

3 OPERATION 7

3.1 Transport 7

3.2 Commissioning 7

3.3 Warm-up sequence 9

3.4 System status verification 10

3.5 Measuring H_2O_2 and H_2SO_4 10

3.6 Saving data 11

3.7 Stop measurements 13

3.8 Decommissioning 13

4 INTERFACE DESCRIPTION 14

4.1 Analogue ports, 4-20mA 14

4.2 RS232 14

4.3 RS485 15

4.4 LAN 15

4.5 USB 15

5 SERIAL COMMUNICATION 15

5.1 Setup 15

5.2 Protocol 15

5.3 Command list 16

6 REPAIR & MAINTENENCE 16

6.1 General 16

6.2 Error Codes 18

6.3 Installation of Firmware Updates 19

6.4 Calibration 19

7 DISPOSAL 20

8 CONTACT 21

1 Safety Advices

CAUTION

Instructions and prohibitions for prevention of body injury and property damage.

Body injury or property damage ***could result*** if the corresponding preventive measures are not met.

NOTE

Reference to an important issue.

The following of these notes is a relevant constraint for a proper operation of the device.

Within this document potential danger and notes for certain issues will be indicated with the above mentioned labels (red for danger and blue for notes). The user of the sensor system should take warnings and notes seriously.

2 General Information

2.1 Scope of Delivery

- Device DSP*check* with software version 1.0
- Measures: height: 250 mm, width: 360 mm, length: 295 mm
- Weight: 8.8 kg
- Power supply: 24 VDC, min. 30 W, DC-plug with diameter 2.5 mm
- Operating manual, Version 4.0

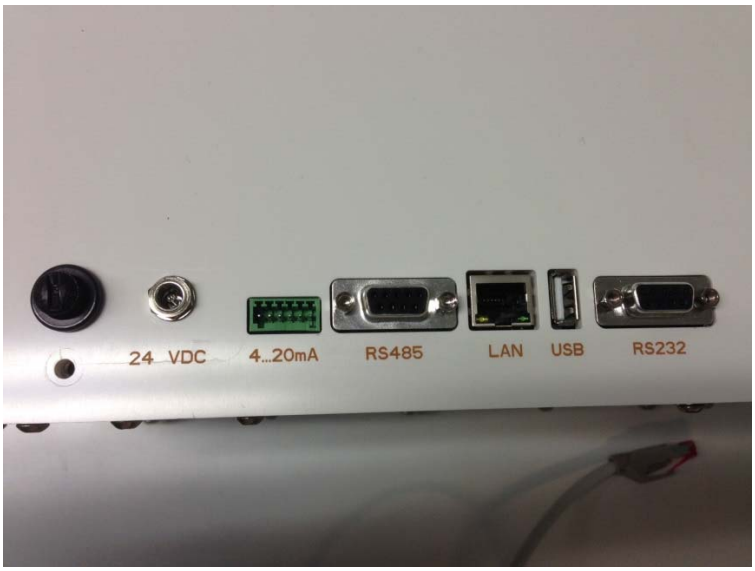


Figure 1: Photography of the electrical interfaces (top side). From left to right: micro-fuse, 24V power supply, 4-20mA analogue output, RS485 interface, LAN connector, USB port, RS232 interface. See chapter 4 for description.

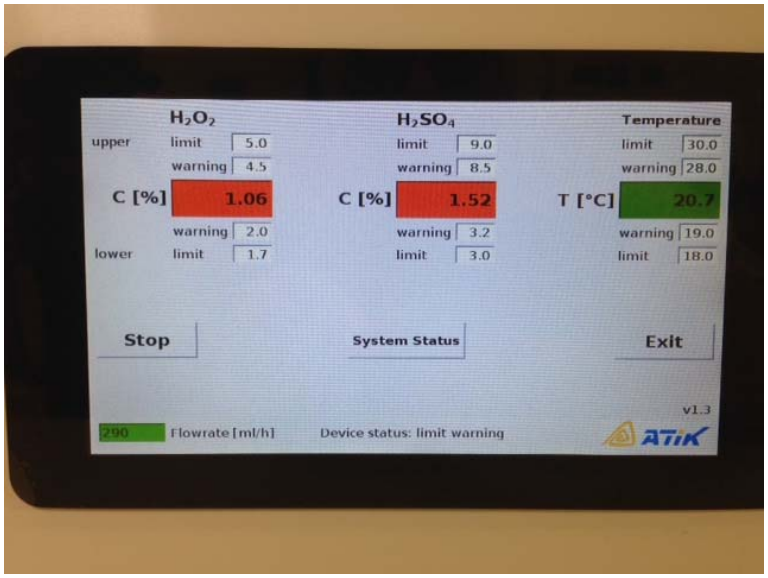


Figure 2: Photography of the user interface on touch-screen display (front side). See chapter 3 for description.

Figure 3: Photography of the der fluidic connections (left side), consisting of standard FPT connectors (inlet, outlet) and manual valve (open/close). See chapter 3 for description.

Figure 4: Photography of the emergency stop button (front side). See chapter 3.7 for description.

2.2 Specifications of the DSP*check*

The intended use of the DSP*Check* device is the continuous measurement of the hydrogen peroxide (H_2O_2) and sulfuric acid (H_2SO_4) concentrations in dilute sulfuric peroxide (DSP) solution. The mentioned concentrations are measured by optical absorption spectroscopy in selected spectral ranges. The measuring ranges are:
H_2O_2 → 0-5 % with an accuracy of 2% (1-4% concentration),
H_2SO_4 → 0-10 % with an accuracy of 2% (2-8% concentration).

The device serves solely for the concentration determination of the above mentioned substances in DSP solution in flow through mode, with 5ml/min flow rate and in a temperature range between 20-30°C at a maximum pressure of 1.5bar.

NOTE

A change of the operating conditions to not specified values in general requires a recalibration of the sensor system.

Since the calibration of the sensor system has been performed under the below mentioned conditions, an operation of the sensor system outside of the specified ranges might require a recalibration of the system. Please contact ICT-IMM for that.

Operating flow: 1 inch FPT containment coupling, the connector type is flare fitting, flow rate 5ml/min.

Operating pressure: 20-30 Psi (1.4-2.1bar) absolute pressure at the inlet.

Operating temperature: 20°-30°C, stabilized within +/-1°C.

Ulterior use is considered as reasonable foreseeable misuse and leads to the exclusion of warranty.

2.3 Requirements for operators and operating environment

The device may only be operated by instructed and skilled personnel. It was designed for operation in temperature controlled laboratory environment and may only be operated in such. The DSP*check* must be installed in horizontal position with electrical connections directing upwards. Also installation must be made so that electrical cable connections are free of tensile load. The operator has to ensure himself before operation of the device that the fluidic connections to the device (DSP solution inlet and outlet) are made properly, being tight and that operating pressure is met.

3 Operation

To ensure a safe operation of the DSP*check*, the following hints should be considered:

3.1 Transport

In case of repair required, the DSP*check* has to be sent back to ICT-IMM. The packaging must be made in a manner so that the device is protected from mechanical shock and vibrations. Therefore, we recommend keeping the original package for reuse.

3.2 Commissioning

Unwrap the DSP*check* from the packaging and mount the device at the installation site properly, so that falling down or vibrations are avoided. Then connect the flare fitting FPT containment couplings to the DSP*check*, with manual valve in **"Closed"** position.

Check that fluidic connection is made free of bubbles. The **"outlet"** connection must be properly connected to a waste containment. Check that fluidic connections are properly made and tight. Then connect all the required interface cables to the corresponding interface plugs.

CAUTION

Electric Shock

Before any activation of the DSP*check* the operator has to check the current-carrying cables and connectors on visible damage. The device is not water proof and may therefore not be operated in moist environment. DSP solution may only be filled in via the forseen fluidic connectors. Touching of unisolated cables or direct filling of the device with liquids, can cause an electric shock.

The power supply contained in the scope of delivery (after connecting to main power 235V/50Hz) must then be plugged into the 24VDC female connector of the DSP*check*. When doing so, the DSP*check* will power up, showing on the touch screen at the front end of the device. On the display appears a pop-up window (Figure 5) where the user must enter the actual date and time. This serves for setting the internal clock which is only running when power is connected to the DSP*check*, since the integrated electrical board has no internal battery.

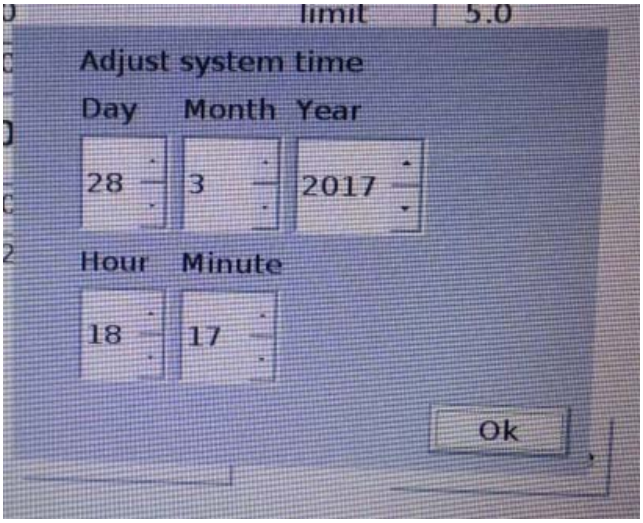


Figure 5: Pop-up window after system power up, asking for entering date and time.

After time and date have been entered into the system, the user interface appears on the touch screen, as shown in Figure 6.

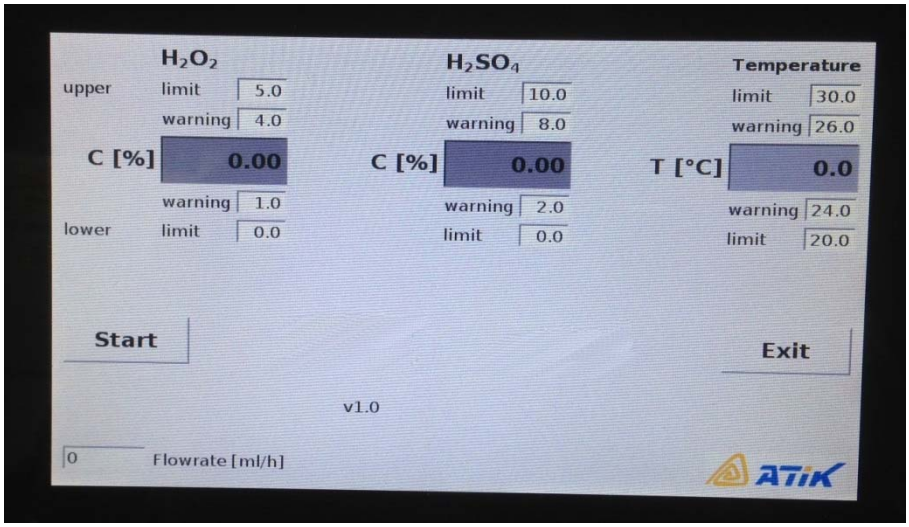


Figure 6: User interface after start-up, with set standard limit values.

Now set the limit values for the concentrations of H_2O_2 and H_2SO_4, as well as the temperature (standard values for concentrations are all set to "0" during first start-up, for temperature low value is set to 20°C and high value is set to 30°C), by pressing on the numeric fields of the corresponding value. A numeric keypad window will pop up (Figure 7) where the number can be entered and confirmed by pressing the button **"OK"**.

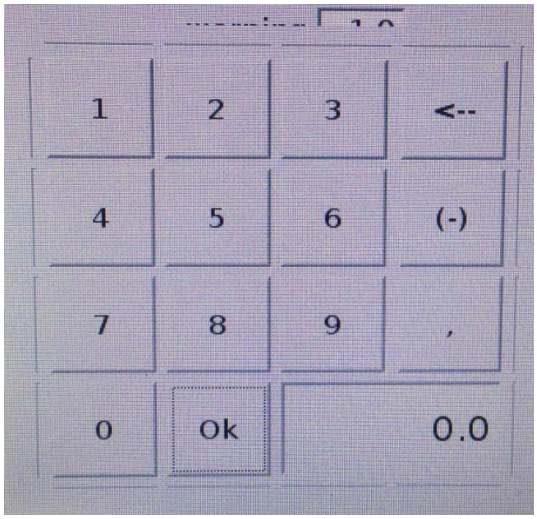


Figure 7: Numeric keypad for entering the limit values of concentrations and temperature.

After having set the limit values, open the manual valve by turning the valve handle into position **"open"**. The measuring sequence can now be started by pressing the button **"Start"**.

3.3 Warm-up sequence

Immediately after pressing the **"Start"** button a warm-up phase of 45 min. duration will be initiated, where LED's and photodetectors will be switched on to reach a stable operating temperature. During the warm-up phase no changes can be made to the

system and no values are indicated (all 0). Warm-up phase will be indicated on the touch screen by a popup-window, indicating the remaining time in count-down mode.

CAUTION

Acidly Substances

The substances passing through the DSP*check* are strongly acidly with a ph-value of about pH=2. In case of any leakages do not touch the liquids or liquid-contaminated surfaces by bare hand. Use protective rubber gloves to avoid chemical burn of your hands.

During the warm-up phase the user should control the device concerning any leakages and in case of any leakages are present, close the manual valve on the DSPcheck and the valve on the main line. After warm up the flowrate indicator should switch from 0ml/h to 300ml/h (5ml/min) and color indication of the flowrate should switch to green.

3.4 System status verification

System status verification (e.g. after the device has been shipped) can be performed by letting pure water flow through the system. For that, proceed as described within chapters 3.2 to 3.3 but with pure deionized water connected to the DSP*check* instead of DSP solution. By pressing the the **"System status"** button, the raw signal levels of the photodetectors will be compared to the values that have been measured at the site of the manufacturer. In case that no relevant deviations of the corresponding values are detected, the system status will be presented as **"OK"** (green background of the pop up window) and system can be used for DSP concentration measurements. In case that any relevant deviations of the corresponding values are detected, the system status will be presented as **"Failure"** (red background of the pop up window). In case of **"Failure"** please contact ICT-IMM for maintenance purpose.

3.5 Measuring H_2O_2 and H_2SO_4

After warm-up the DSP*check* automatically measures the concentrations of H_2O_2 and H_2SO_4, as well as the temperature. The actual measured data is shown in the upper half of the touch screen (Figure 8), with a color indication of green, yellow or red, depending on the following rules for the limits:

Green: → low high limit > value > high low limit
Yellow: → high limit > value ≥ low high limit or high low limit ≥ value > low limit
Red: → value ≥ high limit or value ≤ low limit

The visual alarm levels, indicated by different colors are accompanied by acoustic signals in the following manner:

No sound: → green status & yellow status
Beeping: → red status

In case of red status, the beeping sound is accompanied by the blinking of a red light from a tell-tale on top of the DSP*check*.

Figure 8: Touch screen with user interface.

The actual flow rate is indicated in the lower left corner on the display. The flow rate is preset within the instrument to a value of 5ml/min=300ml/h. Color indication for the flow rate is as follows:

Green → deviation from 300ml/h < +/- 5%
Yellow → deviation from 300ml/h +/-5% ≤ value ≤ +/- 10%
Red: → deviation from 300ml/h >10%

The flow rate levels are not accompanied by acoustic signals!

3.6 Saving data

The data is saved automatically on an internal memory card. For that, every 4 seconds a mean value of the last four measurement points is calculated and saved. The maximum file size of the datalog-file is limited to 2.5MB. After the maximum datalog-file size has been reached, the datalog-file will be overwritten. However, the file size of 2.5MB ensures that at least the data of the last 24 hours is available on the data storage medium for retrieval.

NOTE

No data is saved in case of power disconnection.

Is the system disconnected from the power line, no data will be saved, since the sensor unit has no internal, battery-driven power supply!

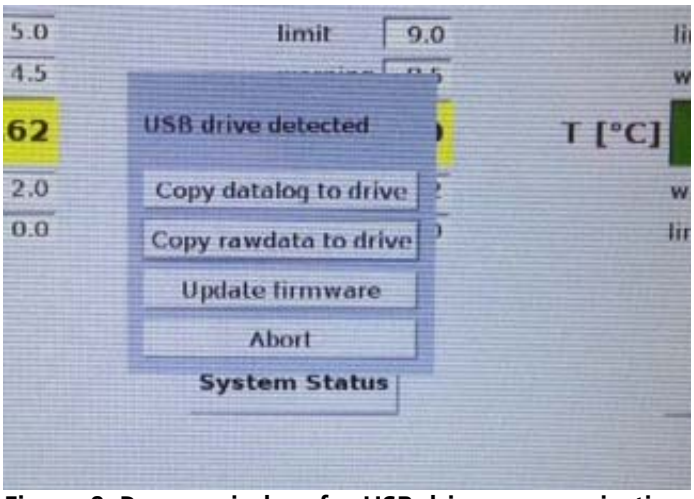


Figure 9: Popup window for USB drive communication.

Measured data is stored continuously with the time stamp based on the settings during the start-up sequence (see chapter 3.2), until the measurement is stopped. During data acquisition the flow and temperature of the DSP solution should be kept constant, to avoid any errors caused by deviations from the specified operating conditions.

The data of date/time/concentrationH2O2/concentrationH2SO4/temperature/error code is stored in the datalog-file which can be saved to a memory stick, by inserting the stick into the USB port. After insertion a pop-up window opens which allows you for several options. Chose **"Copy Datalog to Drive"** to copy the data to the USB-stick. The file structure of the datalog-file is shown in Table 1 and is given in text format.

date	time	concentration H2O2	concentration H2SO4	temperature	Error code
01.04.2017	02:13:28	0,043206	0,107853	24,4742	1
01.04.2017	02:13:32	0,0429979	0,107826	24,4664	1
01.04.2017	02:13:36	0,0430741	0,104169	24,4978	1
01.04.2017	02:13:40	0,0429533	0,108651	24,4821	1
01.04.2017	02:13:44	0,0429477	0,10633	24,49	1

Table 1: File structure of saved data (datalog).

Additional to the processed data also the raw data can be saved to the USB drive, by chosing the option **"Copy Rawdata to Drive"**. The raw data is also in text format and has the following structure: date/time/concentrationH2O2/concentrationH2SO4/ UVLEDmeas/UVLEDref/IRLEDmeas/IRLEDref/temperature1/temperature2/leakagesensor/ flow/error code. The raw data might be useful for instrument check via remote diagnosis and calibration purposes if made available to FhG ICT-IMM by the user (see chapter 6).

3.7 Stop measurements

The measurements are stopped when the button **"Stop"** is pressed. This includes the saving of data. By pressing the button **"Exit"**, the system will proceed a shut-down, after which the power of the system can be disconnected. Set limits are only saved, if the system is shut down via **"Exit"**!
The system can also be stopped by pressing the **"Emergency Exit"** knob. This should only be performed in emergency situations, since the software in that case will not close down correctly and data may not be saved anymore. To reboot the system, pull out the "emergency Exit" button and proceed as described within chapter 3.2.

NOTE

New Warm-Up phase required after system reboot!

In case of power disconnection, either by pressing the "Emergency Exit" button or removing the power connector cable, a new warm-up phase is initiated after rebooting the system.

3.8 Decommissioning

To decommission the DSP*check*, first stop the measurements and shut down the software (see chapter 3.7). After that disconnect the power supply from the device and move the manual valve in position **"closed"**. Then disconnect the device from the FPT containment couplings.

CAUTION

Acidly Substances

The substances passing through the DSP*check* are strongly acidly with a ph-value of about pH=2. After disconnection of the device, DSP solution could leak out of the FPT connectors! Remove carefully any contaminations from the connectors. Use protective rubber gloves to avoid chemical burn of your hands.

4 Interface description

Within this chapter the basic interfaces to the DSP*check* and corresponding pin assignments are described and specified (Figure 10).

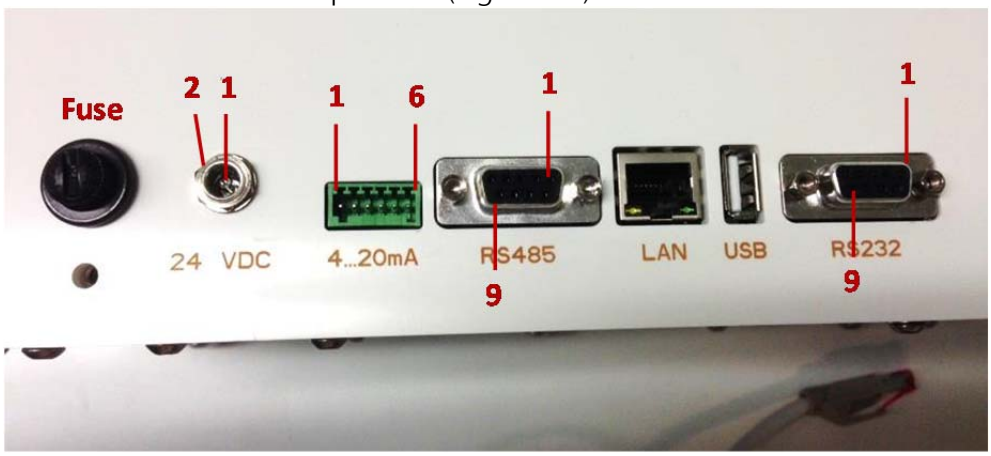


Figure 10: Fuse and interface connector description (see text for details).

The power supply is 24 VDC with a supply voltage of 24VDC, min. 30W; DC-plug with diameter 2,5mm (pin1=+24VDC, pin2=ground). The micro fuse is a cartridge fuse 2A, F. In the following the basic parameters of the communication interfaces are given.

4.1 Analogue ports, 4-20mA

There are three 4..20mA outputs on a single connector with current loop 4-20 mA, each of which is addressed to a concentration range of H_2O_2, H_2SO_4 and HF, respectively. The corresponding pin assignment is as follows:

- pin 1: sensor 1 out (range c(H_2O_2)=0-5%)
- pin 2: GND
- pin 3: sensor 2 out (range c(H_2SO_4)=0-10%)
- pin 4: GND
- pin 5: sensor 3 out (range c(HF)=0-300ppm), currently not used
- pin 6: GND

4.2 RS232

The RS232 serial interface has a D-Sub9 connector and the following pin assignment:

- pin 1: NC (not connected)
- pin 2: TxD
- pin 3: RxD
- pin 4: NC
- pin 5: GND
- pin 6: NC
- pin 7: NC
- pin 8: NC
- pin 9: NC

4.3 RS485

The RS485 serial interface has a D-Sub9 connector, using a maximum input voltage within the range -7 to +12 V. The corresponding pin assignment is as follows:

- pin 1: GND
- pin 2: NC (not connected)
- pin 3: NC
- pin 4: TxD pos.
- pin 5: TxD neg.
- pin 6: NC
- pin 7: NC
- pin 8: RxD pos.
- pin 9: RxD neg.

4.4 LAN

The LAN interface is an ethernet connector, which can be used for programming and debugging.

4.5 USB

The USB interface is a standard USB connector for a USB flash drive.

5 Serial communication

5.1 Setup

Baud rate:	9600
Data bits:	8 bits
Parity:	none
Stop bits:	1 bit
Flow control:	none

5.2 Protocol

Communication is managed with the ASCII MODBUS protocol. All messages start with a leading colon and a trailing carriage return/linefeed. The general message structure is as follows:

: ADDRESS COMMAND DATA(optional) CHECKSUM CR LF

Due to the Modbus ASCII protocol every single byte of information is encrypted as two characters (each 0..9 or A..F) equivalent to the single bytes hexadecimal value.
For example the number 163 (hexadecimal 0xA3) is encoded as two characters "A" and "3". Therefore the minimal total length of one message is 11 bytes (including zero data bytes).
Within replies from the system the address and command number are the same as within the query.

ADRESS: 0x01 (always)

COMMAND:	0x01 – 0x05 and A0 – A3
DATA:	no data = send zero data bytes 32bit-float = encoded as per IEEE 754
CHECKSUM:	Longitudinal redundancy check (0xFF minus sum of all bytes, except colon and carriage return/linefeed)
CR LF:	Carriage return and linefeed

Example:
Query concentration of sensor 1 (command: 0x02)

Query message:
:010200DD\r\n (in characters)
0x3A 0x30 0x31 0x30 0x32 0x30 0x30 0x44 0x44 0x0D 0x0A (in hexadecimal bytes)

Reply message:
:01024083EF9E65\r\n (in characters)
0x3A 0x30 0x31 0x30 0x32 0x34 0x30 0x38 0x33 0x45 0x46 0x39 0x45 0x36 0x35 0x0D 0x0A (in hexadecimal bytes)

data: 4083EF9E converted to float (IEEE754) = 4.123

5.3 Command list

Get system status:	0x01
Get concentration 1 (H2O2):	0x02
Get concentration 2 (H2SO4):	0x03
Get temperature 1:	0x04
Get temperature 2:	0x05 (not in use)
Get sensor 1 raw:	0xA0
Get sensor 2 raw:	0xA1
Get sensor 3 raw:	0xA2
Get sensor 4 raw:	0xA3

All query commands are sent without trailing data bytes

6 Repair & Maintenence

6.1 General

The DSP*check* contains two LED's as light sources for spectroscopy. The lifetime of the LED's is not specified by the manufacturers. A drop in overall performance is compensated by the system internally. However, a failure of an LED (indicated by an error code, see chapter 6.2) requires a replacement of the corresponding LED. The replacement of the LED may only be made by Fraunhofer ICT-IMM and requires a re-

calibration (see chapter 6.4) of the system. Please inform Fraunhofer ICT-IMM about foreseeable repair & maintenance schedules as soon as possible.

NOTE

Repair & Maintenance only by Fraunhofer ICT-IMM.

Repair & maintenance work may only be performed by Fraunhofer ICT-IMM.
Opening of the DSP*check* device immediately leads to the loss of warranty.

Cleaning of the flow through cells in general is not required, as long the DSP*check* device is used according to the terms of this manual. However, since later on also DSP⁺ solution is going to be used which contains up to 300 ppm of hydrofluoric acid (HF), the glass surfaces of the cuvettes may slightly be etched. Therefore, it may not be excluded that a replacement of the cuvettes after a certain time period (not foreseeable) is required. The replacement of the cuvettes also requires a re-calibration of the system and, therefore, may only be performed by Fraunhofer ICT-IMM.

CAUTION

Electric Shock

The uncovering of the device leads to exposure of current carrying parts. Touching of unisolated cables or connections as well as cleaning of the device with liquid media, can lead to electric shock.

CAUTION

Acidly Substances

The substances passing through the DSP*check* are strongly acidly with a ph-value of about pH=2. In case of any leakages do not touch the liquids or liquid-contaminated surfaces by bare hand. Use protective rubber gloves to avoid chemical burn of your hands.

CAUTION

Class 1 UV/IR radiation

The DSP*check* device contains two LED's emitting in the deep UV (0.8 mW) and the near IR (1.0 mW). Please do not remove the LED's from the cuvette holders, while the system is under operation, since eye- and skin damage could be generated.

6.2 Error Codes

In the following error codes, reasons and actions (concerning the device) are described that are attributed to hardware failure of the DSP*check* device. The number in brackets represents the error code number saved in the data log file within column 6 (Table 1). The standard error code saved is 1 for status "OK" and 2 for status "Warm Up".

Error code **"Limit Warning"** (#225)
Reasons → measured values (c(H_2O_2) or c(H_2SO_4) or T) in red range
Actions →none

Error code **"Detection Failure"** (#226)
Reasons → photodetector defect
Actions → stop device, close valve and disconnect from fluidics and change photodetector (see chapter 6)

Error code **"Leakage Warning"** (#227)
Reasons → internal leakage within the device or the leakage detector is contaminated
Actions → stop device, close valve and disconnect from fluidics and check fluidic connections inside of the device (see chapter 6)

Error code **"Flow Controller Communication Failure"** (#228)
Reasons → communication to flow controller disrupted
Actions → stop device and check cable connection between flow controller and electric board (see chapter 6)

Error code **"Temperature Sensor Failure"** (#229)
Reasons → temperature sensor defect or disconnected from the electronic board
Actions → stop device and check cable connection between flow controller and electric board or change temperature sensor (see chapter 6)

Only the error with highest priority is saved in the data log file. The sequence of priority from high to low is as follows: priority 1: Leakage Warning, priority 2: Detection Failure, priority 3: Flow Controller Communication Failure, priority 4: Temperature Sensor Failure, priority 5: Limit Warning.

6.3 Installation of Firmware Updates

For installation of firmware updates, the DSP*check* device must be connected to power supply so that the touch screen is in operation. To update the firmware, insert a USB stick, containing the firmware update file in the main folder, into the USB connector of the device. After that a tick box menu window will pop up automatically (Figure 9). Chose **"Update firmware"** and the new software will be installed automatically. Request Fraunhofer ICT-IMM for available firmware updates.

6.4 Calibration

The system has been calibrated by Fraunhofer ICT-IMM under defined conditions of temperature (25°C) and flow rate (5ml/min). The highest accuracy of the system is achieved for these conditions.

NOTE

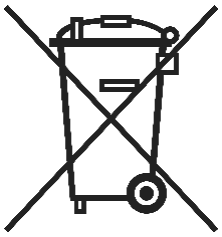
The calibration is valid only for the conditions (temperature interval and flow rate) under which the calibration has been made and free of blow holes.

Other conditions could lead to a change of signal levels on the photodetectors and, therefore, to a wrong indication of concentration levels.

Also the calibration has to be renewed in case of any movement of the LED's or photodetectors which is usually required if one of the components was changed or has been displaced by implementation of a hard shock onto the device.

For calibration, reference solutions of defined concentrations have to be fed through the DSP*check* device under typical operating conditions. These are pure H_2O_2 solutions and pure H_2SO_4 solutions of at least 5 different concentrations covering the whole concentration range of interest (0-4% H_2O_2 and 0-8% H_2SO_4). The corresponding raw data as function of concentration of the photodetectors can be used to re-calibrate the system. For that send the raw data to Fraunhofer ICT-IMM which will fit the data and prepare for a firmware update.

7 Disposal



The packaging material and the device do not represent consumer waste. Please inform yourself at your local authorities about the correct waste disposal, to ensure compliance with the regulations of your country.

8 Contact

In case of questions, please do not hesitate to contact us:

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