INNOVATIVE SENSOR TECHNOLOGY

TEMPERATURE

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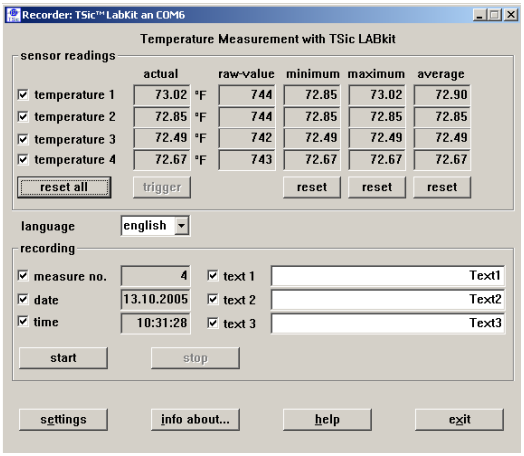
TSic LABkit™

User Manual for USB/Windows™

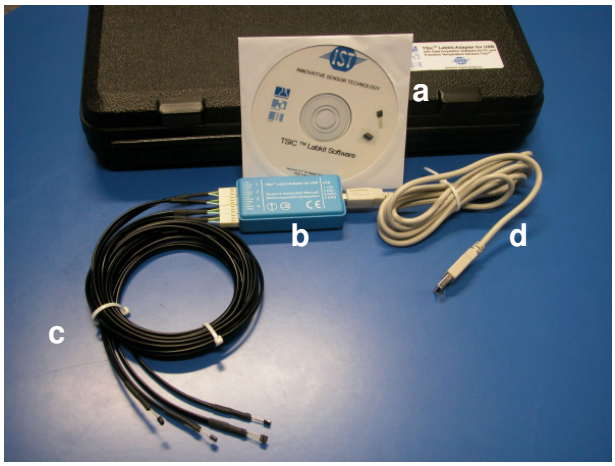
Technical Documentation

Contents



The TSic™ LABkit™ for Fast, Precise Temperature Measurement, Records and Analysis

1 TSic LABkit™ Contents



a) CD ROM with the TSic Recorder™ Software for Microsoft® Windows®
b) TSic LABkit™ Adapter for USB
c) Four TSic™306 Sensors with Cable/Connector
d) USB Cable

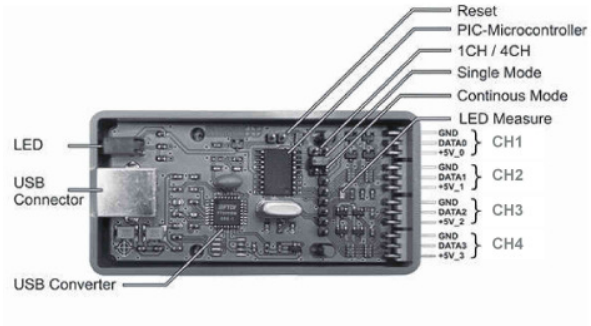


Figure 1.1 – LABkit™ PCB with Jumpers and Connectors

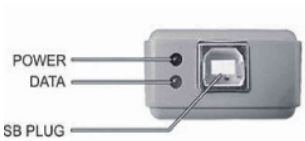


Figure 1.2 – Interface for USB Cable

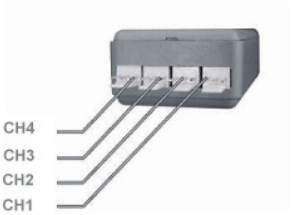


Figure 1.3 – Sensor Interfaces for the TSic™ Connections

For a description of the TSic LABkit™ Adaptor communication interface, refer to the *TSic™ Application Notes – ZACwire™ Digital Output* document.

2 General Technical Data

Temperature Measurement	
Number of Channels	1 to 4
Temperature Measurement Range (maximum depending on sensor type)	-50°C to +150°C
Resolution and Accuracy	Dependent on Sensor Type
Module	
Operating Temperature Microcontroller PCB	-10°C to +60°C
Supply Voltage	Via USB Interface
Communication	RS 232 Emulation via USB
Interface	USB
Adapter Dimensions	80 mm x 40 mm x 23 mm
EMC	89/336/EEC (European Harmonized Standards)
Noise Emission	EN 61000-6-3:2001
Noise Immunity	EN 61000-6-2:2001

Note: The technical data provided above is subject to change without notice.

3 General Description

The TSic LABkit™ enables precise measurement of up to four temperatures using a USB interface connected to a Microsoft® Windows® PC. The TSic Recorder™ software is used for data acquisition.

The TSic LABkit™ was primarily designed as an evaluation kit for the innovative TSic™ temperature sensors. It provides a reliable and multi-channel temperature measurement system that can also be used to facilitate measurements in the laboratory.

Note: For each measurement, the supply voltage for the TSic™ sensors will be turned on and turned off after the data transfer via adaptor.

4 TSic Recorder™ Software for PC/WINDOWS®

Features

- Display of actual temperature values
- Display of measurement value and raw value; minimum, maximum and average value
- Data stored on hard drive
- Option to analyze the recorded data via Microsoft® Excel®

4.1 System Requirements and Software Installation

System Requirements

- 5x86-compatible PC
- 32 MB RAM
- Hard drive with 20MB free space
- USB port
- Microsoft® W98/ME/2000/XP
- Internet Explorer 6.0™ recommended

Software Installation

a) Insert the TSic LABkit™ CD; and follow the instructions to install the TSic Recorder™ software

b) Connect the temperature sensors to the Tsic LABkit™ then connect the Tsic LABkit™ to the PC via the USB. If no USB driver is installed use the “Hardware Installation Wizard” (Control Panel → System → Add Hardware).

c) The TSic Recorder™ software automatically searches for the USB connection and adjusts it to emulate the COM port. If this is not successful, see section 4.4, Figure 4.3, for manual settings.

4.2 Measurement Steps

After opening the TSic Recorder™ software, follow the steps described below to acquire measurement data.

Step1: Connect at least one of the four temperature sensors to the TSic LABkit™ Adapter and select the connected temperature channels in the main window of the TSic Recorder™ software.

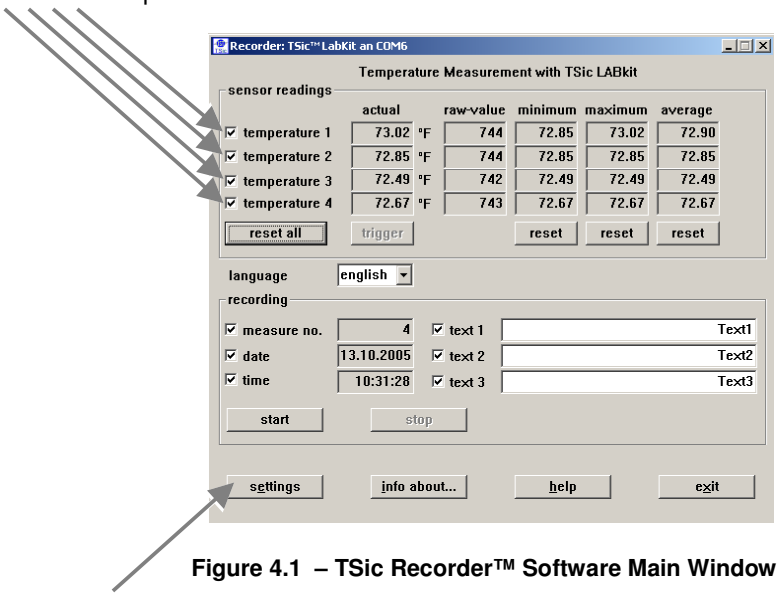


Figure 4.1 – TSic Recorder™ Software Main Window

Step 2: Correct settings if necessary using the Settings dialog window described in section 4.4. Then click OK to exit the Settings dialog window. For all enabled temperature channels, the actual measurement values are displayed in the main window (see Figure 4.1 above). The TSic LABkit™ system is now ready to read the sensors' measured temperature.

Important: The software default configuration after installation is for the TSic™ 306. If other TSic™ types are connected, see section 4.4.2 below for required sensor type configuration using the Settings dialog window.

The Settings dialog window can also be used to change settings such as temperature display refresh time and the interval of the displayed mean value.

See section 4.3 for more information on the main window settings.

Troubleshooting Note: If measurement data is missing, check the connections (USB connector, TSic LABkit™ Adapter and sensors) and ensure that the correct USB Port has been selected. You can select the USB/COM port in the Settings dialog window as described in section 4.4, Figure 4.2.

Step 3: To record temperature measurement values in a text file, click the Start button in the main window. Click the Stop button to end recording.

The default directory and filename are C:TSIC-LABKIT\DATA\tempdata.csv. To change the directory or filename, see section 4.4.7.

The information to be recorded with the sensor data in the text file can be selected on the main window. By default, the text file includes the measurement number, date, and time columns and the Text 1-3 file heading text in addition to the "Actual" (T1-4) and "Raw Value" (R1-4) data for each enabled sensor.

The Settings dialog window can also be used to specify the measurement frequency and the recording interval for the text file and to change the title.

Troubleshooting Note: If clicking the Start button has no effect, which is indicated by the Stop button remaining gray and no recording of data in the specified file, there could be a problem with access rights to the specified directory and file.

Step 4: To import temperature measurement data into Microsoft® Excel® for processing, open Excel® and from the menu, select Data → Get External Data → Import Data. Locate and select the text file. Follow the dialog boxes as needed to select the comma and semicolon as the delimiters. Then click "Finish" to display the data in an Excel® worksheet. Data for each sensor should be listed in a separate column. Data can now be analyzed in Excel®. See section 8.2 for more details.

4.3 The Main Window for TSic Recorder™

4.3.1 Measurement Values

Temperature units are °F or °C as selected in the Settings dialog window. See section 4.4.

The display interval for the minimum, maximum and average readings for the sensor measurements is selected in the Settings dialog window. See section 4.4.

The Raw Value readings are the decimal values output by the TSic™ sensors. Conversion into °C or °F values is based on the conversion table or formula (0 = min value; 2047 = max value) for the specified TSic™ sensor.

4.3.2 Trigger Button

Clicking the Trigger button triggers a single measurement of the selected channels. It is only active when "Manual" is selected in the pull-down menu for Reading Interval under the Settings dialog window.

The Trigger button is inactive for all other options in the Reading Interval pull-down menu.

4.3.3 Reset Buttons

Each Reset button resets all values for the sensor data column above it.

The Reset All button resets all values for all data columns.

4.3.4 Measurement, Date, Time, Text 1, Text 2, and Text 3 Check Boxes

Check the boxes of the information to be recorded in the text file in addition to the sensor data. For Text 1, Text 2, and Text 3, enter text up to 31 digits. This optional text will be displayed as the file heading at the beginning of the text file.

4.3.5 Start and Stop Buttons:

To record data in the designated text file, click the Start button. Click the Stop button to end recording. If Start is clicked again, data is appended to the existing text file if "Continue File" is selected in the Settings dialog window. The file is overwritten if "Overwrite File" is selected.

4.3.6 Settings Button

To change the configuration, click Settings, which opens the Settings dialog window. See section 4.4.

4.3.7 Exit

Click the Exit button to close the program. All settings changes will be saved.

4.4 The Settings Dialog Window

Open the Settings dialog window by clicking on the Settings button in the main window. To close the Settings dialog window and apply any new settings, click OK.

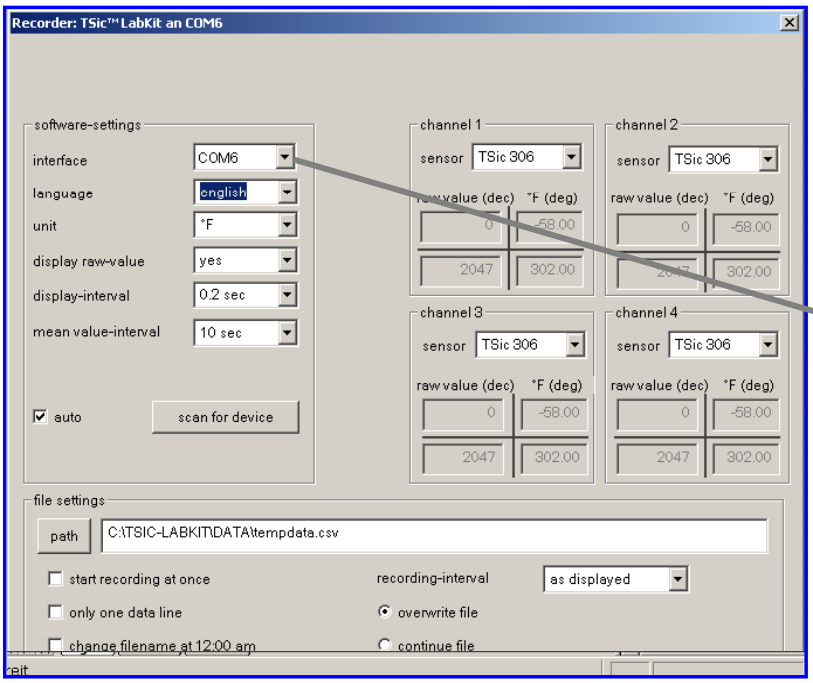


Figure 4.2 – TSic Recorder™ Settings Dialog Window

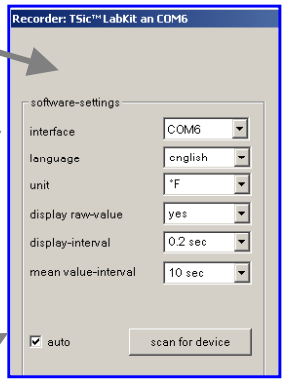


Figure 4.3 – USB / COM Port Setting

4.4.1 USB/COM Port Settings

If Auto is selected (see Figure 4.2 and Figure 4.3), the software automatically looks for the correct PC COM port when the program starts. On the Interface pull down menu, the configuration ports COM1 through COM16 can be manually selected. If Auto selects an incorrect port, try searching again by clicking “Scan for Device” or select the correct port manually in the Interface pull-down menu.

4.4.2 Sensor Channels 1 – 4

The software default configuration after installation is for the TSic™ 306. If other TSic™ types are connected, the configuration of the channel settings must be adjusted. Click the Settings button, which opens the Settings dialog window shown in Figure 4.4.

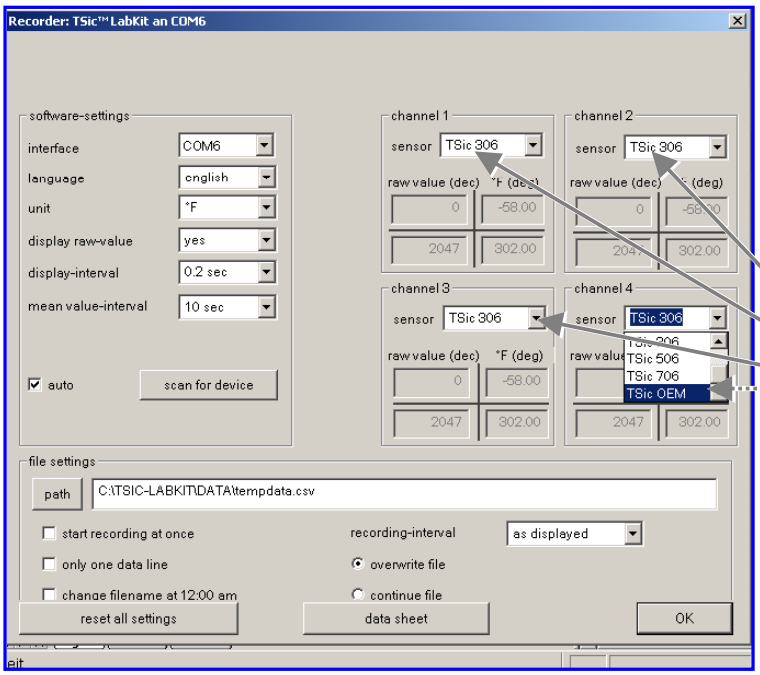


Figure 4.4 – Sensor Type Selection

For each of the four channels, select the correct sensor type in the pull-down menu. This is required for the correct scaling and display of the measurement values. With the correct sensor type selection, the scaling table will automatically configure the correct measurement range.

Note: In addition to the standard sensor products offered by IST, customized OEM sensor types are also available from IST and can be manually configured as specified. In this case, choose “TSic OEM” in the pull-down menu. The backgrounds for the “Raw Value (dec)” and “°F” fields turn white, and the field values must be edited with the required specifications. “Raw Value (dec)” is the decimal raw value, and “°F” is the measured temperature value.

4.4.3 Unit

Use the pull-down menu for “Unit” to select °C or °F for temperature measurement

4.4.4 Display Raw Value

Select “Yes” on the pull-down menu for “Display Raw Value” to display raw values for temperature measurements in the main window. The raw values are displayed in decimal. If “No” is selected, these fields are blank.

4.4.5 Display Interval

The “Display Interval” setting defines how often the temperature measurement values in the main window are refreshed. The minimum refresh time is 0.2 seconds with one sensor (5 measurement values per second) or 0.5 seconds with four sensors.

4.4.6 Mean Value Interval

Use the “Mean Value Interval” pull-down menu to configure the time base for the the floating average values as displayed in the main window.

The minimum and maximum values in the main window do not depend on this “Mean Value Interval” , they are reset by the “Reset” or “Reset All” Buttons.

4.4.7 File Settings

Path

To change the directory or filename of the comma-separated text file in which data is recorded, enter the new directory and filename, which must be write-accessible, in the Path dialog box.

Default directory and filename: C:TSIC-LABKIT\DATA\tempdata.csv.

Change Filename at 12:00 a.m

Selecting the “Change Filename at 12:00 a.m.” option causes the software to start a new file at 12:00 a.m. (i.e., midnight) and automatically add the new date to the filename

Recording Interval

Use the “Recording Interval” pull-down menu to define the interval between two temperature measurement recordings (for one channel).

Reset All Settings

Click on the “Reset All Settings” button to reset all entries on the Settings dialog window to the factory default values (i.e. TSic306™ sensors, 0.5 sec display interval, etc.)

Data Sheet

The “Data Sheet” button can be used to browse to and open any data file.

OK

To apply all settings changes, exit the Settings dialog window, and return to the main window, click the OK button.

5 TSic LABkit™ Hardware

The TSic LABkit™ temperature measurement system uses a PIC 16F628 to receive the digital measurement values of up to 4 connected temperature sensors (TSic™). The PIC 16F628 converts the digital values into a serial data string. This data string is transmitted to a serial-USB-converter FTDI232BL. The circuitry is USB 2.0 compatible. Data transmission to the PC is accomplished with a "virtual COM-Port driver," which emulates a standard COM interface to transfer the data to the application software.

The low noise design is achieved by low pass filters for all inputs and outputs. The USB connection is decoupled with an LC filter. Diodes at the sensor inputs provide ESD protection.

5.1 USB-Hardware Configuration

The jumpers on the PCB control the following settings.

Important: Connect either JP1 or JP8, not both at the same time.

Pin	Connections	Name	Settings
JP1			
1 2	GND RBO (/START)	START	When JP1 is connected, RB0 is low, which means it is sending. Do not connect JP1 at the same time as JP8.
JP7			
1 2	GND RB3 (1CH/4CH)	RX	When JP7 is connected, RB3 is low, which means the temperature values of only one channel are measured and transmitted. When JP7 is disconnected, the values of all 4 sensors are measured and transmitted.
JP8			
1 2	RB0 RB1 (RX-START)	RX	When JP8 is connected, RB0 and RB1 are connected, which means the TSic™ LABkit™ sends one data set (data line/packet) after receiving any signal. Do not connect JP8 at the same time as JP1.

Default Hardware Settings

JP1 is disconnected and JP8 is connected, which means that the TSic™ LABkit™ sends only after receiving any signal via interface.

JP7 is disconnected, which means the TSic™ LABkit™ operates with up to four sensors.

5.2 Microcontrollers In-Circuit-Programming

For further information regarding hardware and software, please contact HYGROSENS INSTRUMENTS GmbH, Germany, *www.hygrosens.com.*

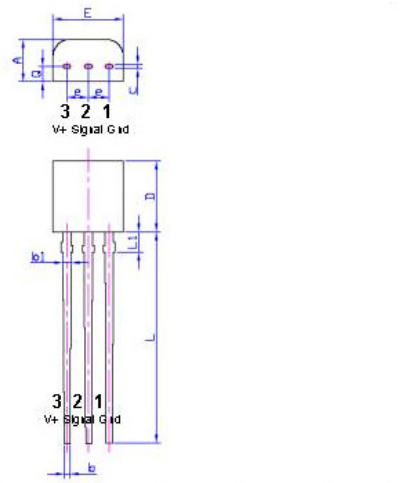
6 Sensors for the TSic LABkit™, Sensor Connection Cable and Connector

6.1 Standard Cables

- Adaptor with TSic™ 306 E-Line Sensor Type
- Length: 3 ft / 1m
- Maximum temperature: 80°C
- Blocking capacitor: 100nF connected close to the sensor between VDD and GND

Note: If the standard cable requires an extention, add it on the connector side of the cable to minimize the distance between the blocking capacitor and the sensor.

Order Number for sensor with cable	TEFÜ-TSIC306-IST
Sensor	TSic™ 306
Temperature Range with delivered cabeling	-20°C to 80°C (Short-term temperature strain: -50°C to 120°C)
Protection	Sensor enameled
Connection Cable	PVC connection wire, 3ft (1m) 4-pole, unshielded, t_{max} 80°C
Connector	3-pole, nylon connector, soldered, crimped, connectors not shrunken
Pin	V+ (VDD) yellow DATA green GND white



A	2.4	2.8	0.049	0.110
b	0.35	0.48	0.0138	0.0189
b1	0.45	0.60	0.0178	0.0240
c	0.25	0.35	0.0098	0.0138
D	4.0	4.4	0.157	0.173
E	3.8	4.4	0.150	0.173
e	2.4	2.8	0.049	0.110
Q	0.8	1.1	0.031	0.043
L	12.0	13.0	0.472	0.512
L1	1.0	1.3	0.039	0.051

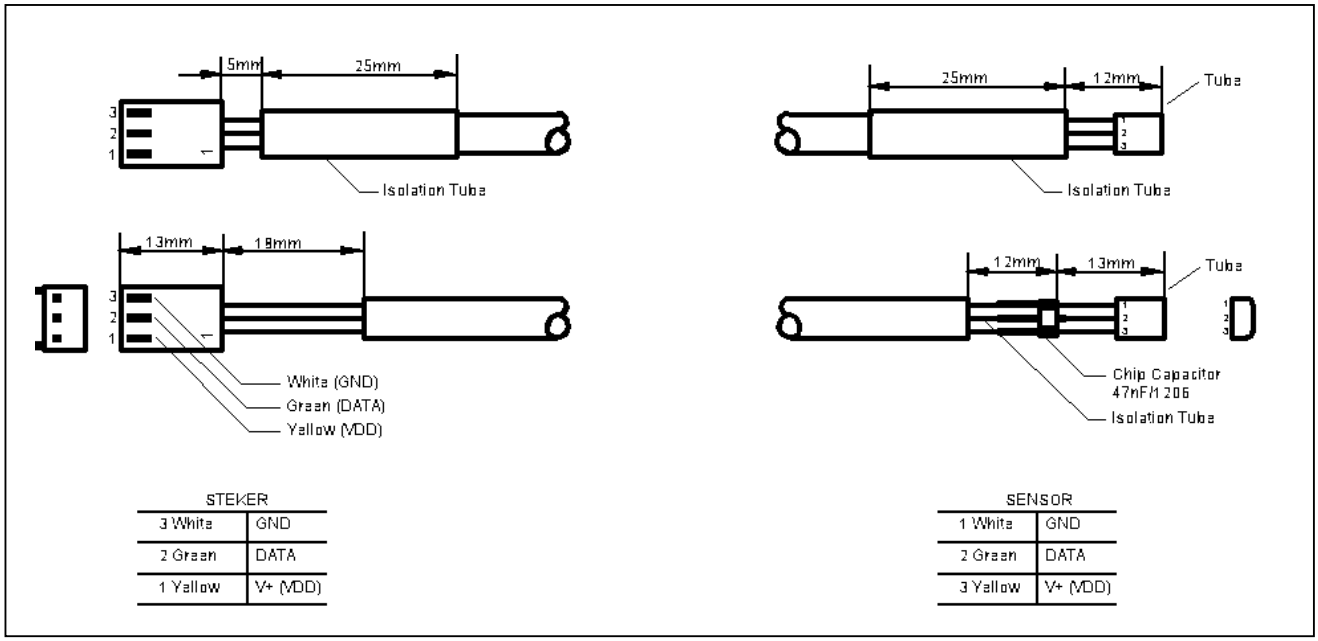


Figure 6.1 – Sensor Adaptor Overview

6.2 Requirements for Customized Cables for Other TSic™ Types

- Temperature-proof, 3-pole cable up to 90 ft / 30m
- Blocking capacitor: 100nF connected close to the sensor between VDD and GND
- 3-pole connector: Schukat Electronics, part no. NSG25-3, crimp contact NSK25-0

7 Electromagnetic Compatibility (EMC- Standard 89/336/EU)

The TSic LABKIT™ USB Adapter meets the electromagnetic compatibility requirements of the following standards:

EN 61000-6-3 (2001) Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments

EN 61000-6-1 (2001) Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments

For more detailed information, please contact the manufacturer, HYGROSENS INSTRUMENTS GmbH, Germany, www.hygrosens.com.

8 Appendix – Data Processing with Examples

8.1 Output String Format

The format of the serial data transmission (i.e., text data stream) is as follows:

The 11-bit sensor value is transferred unscaled as a 16-bit integer (ASCII code). Only the lower 11 bits are used; the 5 highest bits are 0.

The data rate is 9600 baud. There are 8 data bits, no parity bit, and one stop bit. The transmission of the binary data for one measurement set is done in a line. Information is sent continuously and separated by ";" (semicolon). The character "$" and carriage return <CR> mark the end of the transmission.

Typical data line structure example: **@;08DA;08C2;08CC;08CA;2332;$<CR>**

Characters Definitions

ASCI Characters	Description
@´	Synchronization pattern for the beginning of the data line.
08DA **08C2** **08CC** **08CA**	Measurement values of the four sensors; the data is transmitted in 4-bit groups (nibbles) in hexadecimal ASCII code. The numeric measurement values are 2 bytes (4 ASCII characters). The resolution depends on the sensor used. If the channel is not connected, FFF is sent as the measurement.
; (semicolon)	Separator between the measurement values.
2332	Check sum of all measurement values as an ASCII coded binary number. This sum adds all the binary values. It is followed by a ";" (semicolon).
$<CR>	The end of the data line.

Measurement data can be logged in a file with a terminal program that allows data to be saved and evaluated at a later point in time.

Examples (only channel 0 for reference, valid for Tsic 306):

Temperature	TSic™ 306 Raw Value	String to PC	Value on Screen
<=-50.0°C	0x000	@;0000;XXXX;XXXX;XXXX;CCCC;$<CR>	<<<
-49.9°C	0x001	@;0001;XXXX;XXXX;XXXX;CCCC;$<CR>	-49.9°C
0.0°C	0x200	@;0200;XXXX;XXXX;XXXX;CCCC;$<CR>	0.0°C
25.0°C	0x2FF	@;02FF;XXXX;XXXX;XXXX;CCCC;$<CR>	25.0°C
60.0°C	0x2FF	@;02FF;XXXX;XXXX;XXXX;CCCC;$<CR>	25.0°C
125.0°C	0x6FE	@;06FE;XXXX;XXXX;XXXX;CCCC;$<CR>	125.0°C
149.9°C	0x7FE	@;07FE;XXXX;XXXX;XXXX;CCCC;$<CR>	149.90°C
150°C	0x7FF	@;07FF;XXXX;XXXX;XXXX;CCCC;$<CR>	>>>
Not valid	0x800 to 0xFFF	@;UUUU;XXXX;XXXX;XXXX;CCCC;$<CR>	???
No response	Timeout, no sensor	@;FFFF;XXXX;XXXX;XXXX;CCCC;$<CR>	---

XXXX Other channels
CCCC Value for check sum
UUUU Value not valid, ranges from 0x800 to 0xFFF

8.2 Importing and Processing the Measurement Data with Microsoft® Excel®

Data processing can be accomplished with the measurement data saved as a text file (.txt), which can be converted into a Microsoft® Excel® file via the following steps. Open Excel® and from the menu, select Data → Get External Data → Import Data. Locate and select the text file. In the Text Import Wizard, choose as the delimiters the semicolon and comma (see Figure 8.1). Then click “Finish” to display the data in an Excel® worksheet. Data for each sensor should be listed in a separate column. See Figure 8.2 for an example of the data and Figure 8.3 for an example of a chart of the data.

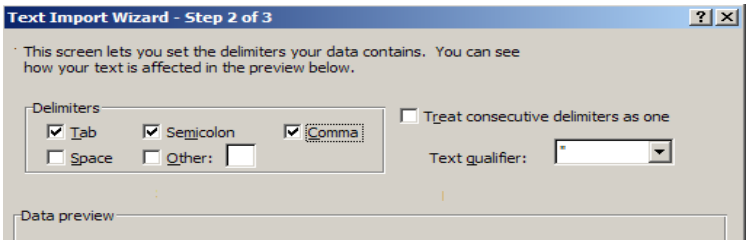


Figure 8.1 – Microsoft® Excel® Text Conversion Wizard Window

Test Messung 1	Text2	Text3		Sensoren: 4x TSic 306			
Lauf.Nr.	Date	Time		Sensor 1	Sensor 2	Sensor 3	Sensor 4
2897	08.08.2005		17:39:39	24.65	24.74	24.74	24.55
2898	08.08.2005		17:39:40	24.55	24.65	24.65	24.45
2899	08.08.2005		17:39:41	24.55	24.55	24.55	24.45
2900	08.08.2005		17:39:42	24.55	24.55	24.55	24.45
2901	08.08.2005		17:39:43	24.55	24.55	24.55	24.45
2902	08.08.2005		17:39:44	24.45	24.55	24.55	24.45
2903	08.08.2005		17:39:45	24.45	24.45	24.55	24.45
2904	08.08.2005		17:39:46	24.45	24.55	24.55	24.35
2905	08.08.2005		17:39:47	24.45	24.45	24.55	24.45
2906	08.08.2005		17:39:48	24.45	24.55	24.45	24.45
2907	08.08.2005		17:39:49	24.45	24.45	24.45	24.35
2908	08.08.2005		17:39:50	24.45	24.55	24.45	24.35
2909	08.08.2005		17:39:51	24.45	24.45	24.55	24.45
2910	08.08.2005		17:39:52	24.45	24.45	24.45	24.35
2911	08.08.2005		17:39:53	24.45	24.45	24.45	24.35
2912	08.08.2005		17:39:54	24.45	24.45	24.45	24.35
2913	08.08.2005		17:39:55	24.45	24.45	24.45	24.35
2914	08.08.2005		17:39:56	24.45	24.45	24.55	24.35
2915	08.08.2005		17:39:57	24.45	24.45	24.45	24.35
2916	08.08.2005		17:39:58	24.35	24.35	24.45	24.26
2917	08.08.2005		17:39:59	26.11	26.5	26.5	26.7
2918	08.08.2005		17:40:00	29.14	28.75	28.94	29.04
2919	08.08.2005		17:40:01	30.7	29.92	30.31	30.21

Figure 8.2 – Example of Display of Recorded Data in Microsoft® Excel®

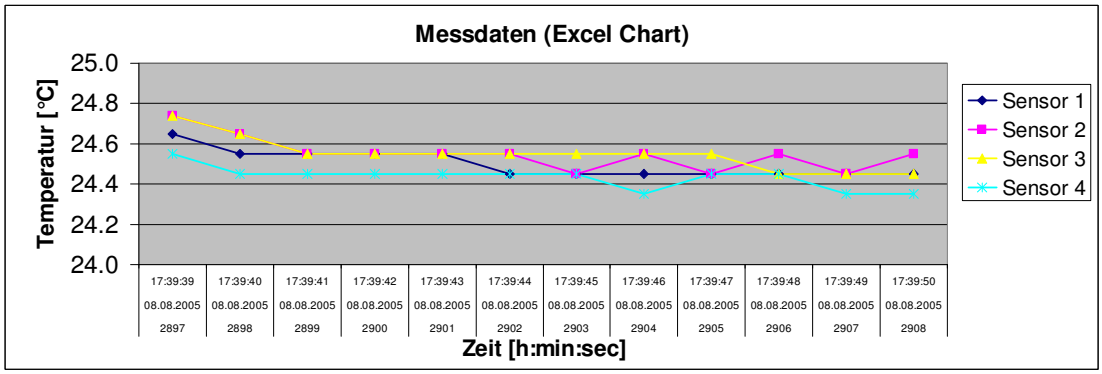


Figure 8.3 – Example of Measurement Data Display as a Chart in Microsoft® Excel®

8.3 Processing Example

In the three following examples, these sensors were used:

- T1 – T3 TSic™ 306 e-line (measurement range: –50°C to +150°C; accuracy: ±0.3°C for +10°C to +90°C)
- T4 TSic™ 506F e-line (measurement range; -10°C to 60°C; accuracy: ±0.1°C for +5°C to +45°C)

Example 1 – Processing of surface temperature measurement data for a metal surface.
This example shows the inhomogeneous temperature behavior of a continuously heated metal surface.

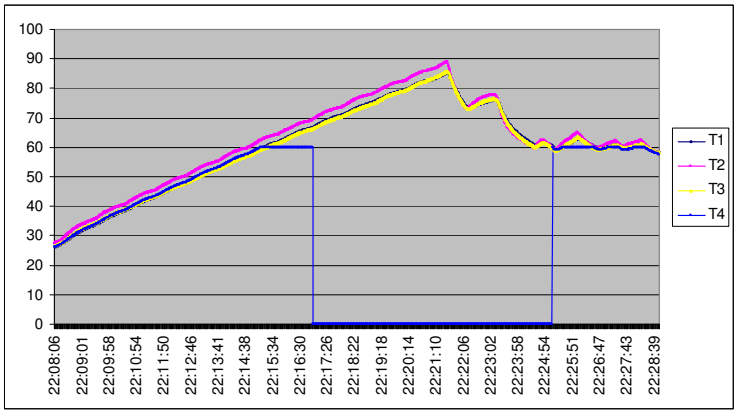


Figure 8.4 – Metal Surface Measurement Data Chart

Example 2 – Processing of surface temperature measurement for four different points on a wafer.

In this example, the temperature was continuously heated from 26°C to 80°C.

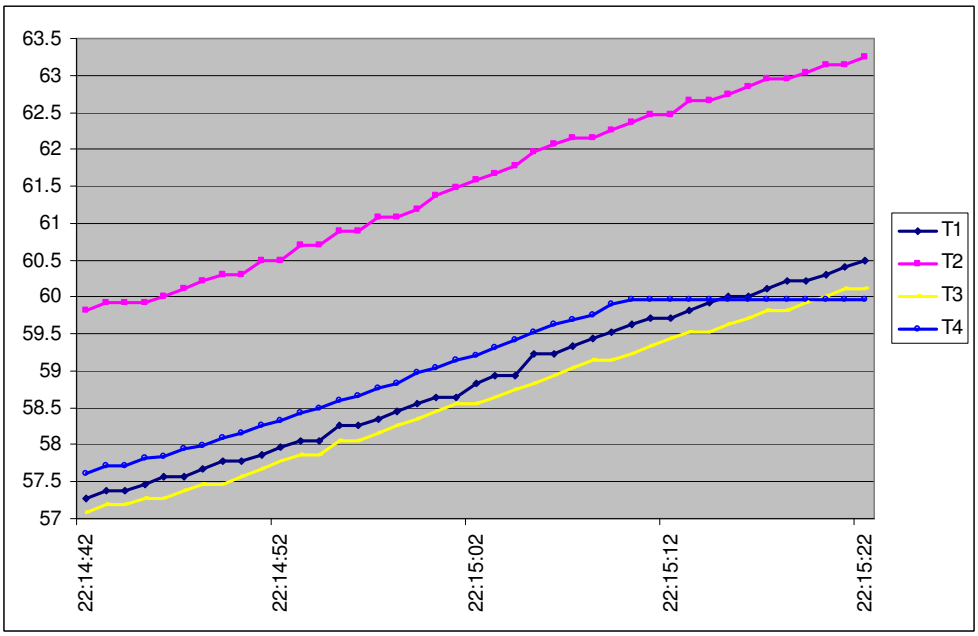


Figure 8.5 – Excerpt of Surface Temperature Measurement of 4 Different Points on a Wafer

Example 3 – Processing for surface temperature measurements before and after touching the sensors by hand.

The measurement values are stable after 10 seconds in the accuracy range. The chart shows the higher resolution of TSic™ 506F, which is shown as sensor T4.

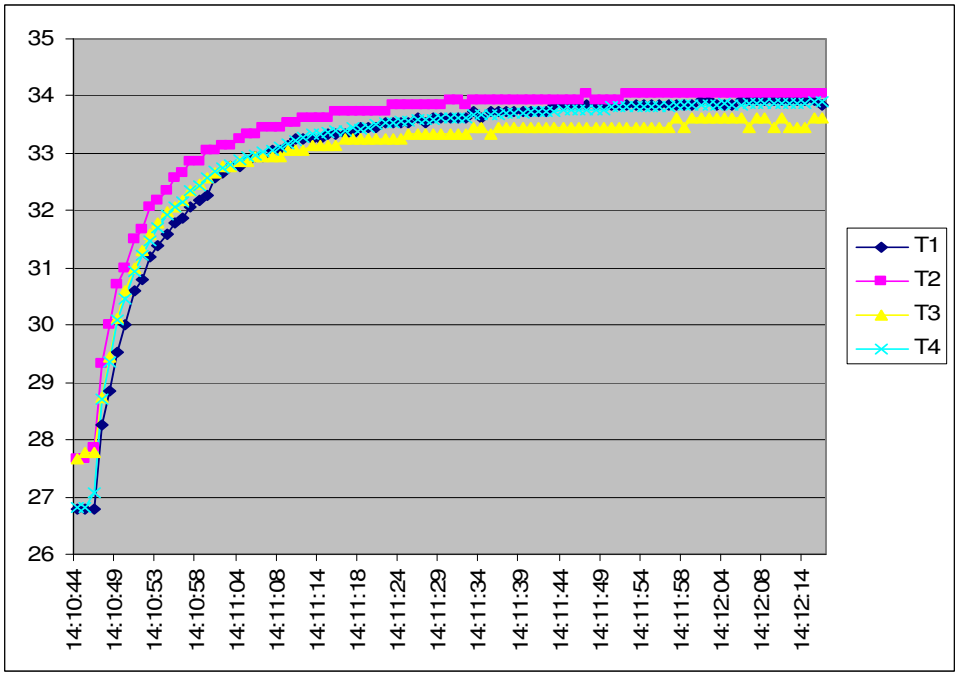


Figure 8.6 – Surface Temperature Measurement Before and After Touching the Sensors

Number	Date	Time	T1	T2	T3	T4	R1	R2	R3	R4
460	19.08.2005	14:10:49	29.53	30.7	30.12	30.08	814	826	820	1172
462	19.08.2005	14:10:49	30.02	31	30.61	30.45	819	829	825	1183
465	19.08.2005	14:10:51	30.61	31.49	31	30.93	825	834	829	1197
467	19.08.2005	14:10:51	30.8	31.68	31.29	31.21	827	836	832	1205
470	19.08.2005	14:10:53	31.19	32.07	31.58	31.48	831	840	835	1213
472	19.08.2005	14:10:53	31.39	32.17	31.78	31.69	833	841	837	1219
475	19.08.2005	14:10:55	31.58	32.36	31.97	31.92	835	843	839	1226
…										
634	19.08.2005	14:11:58	33.83	34.03	33.44	33.84	858	860	854	1282
637	19.08.2005	14:12:00	33.83	34.03	33.63	33.84	858	860	856	1282
640	19.08.2005	14:12:01	33.93	34.03	33.63	33.84	859	860	856	1282
642	19.08.2005	14:12:02	33.93	34.03	33.63	33.84	859	860	856	1282
645	19.08.2005	14:12:03	33.83	34.03	33.63	33.84	858	860	856	1282
647	19.08.2005	14:12:04	33.83	34.03	33.63	33.87	858	860	856	1283
650	19.08.2005	14:12:05	33.83	34.03	33.63	33.84	858	860	856	1282
652	19.08.2005	14:12:06	33.93	34.03	33.63	33.84	859	860	856	1282

Table 8.1 – Extract of Surface Temperature Measurement Data Before and After Touching the Sensors (T1/R1-T3/R3 = TSic™ 306, T4/R4=TSic™ 506)