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**Coverpage: AS73211-AB5 SET DK User Guide**

Please be patient while we transfer this adapted former MAZeT document to the latest ams design.

## User Guide

AS73211-AB5 SET DK

## Development Kit

Order No. AS73211-AB5 SET DK: 220810004

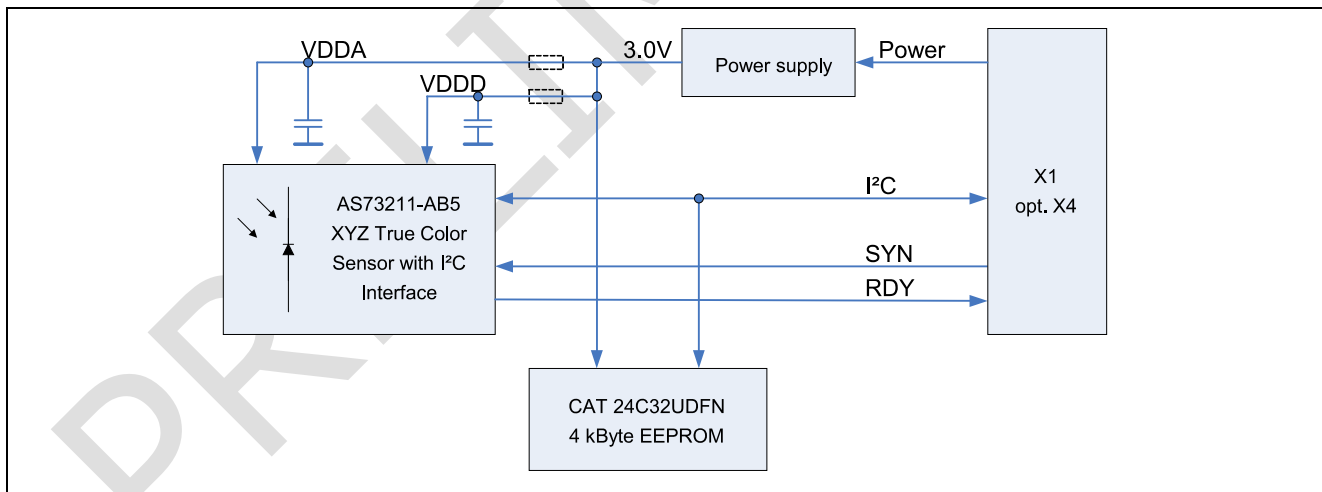
Status: certified

## INTRODUCTION

The family of AS73211-AB5<sup>1</sup> based test systems of ams Sensors Germany, their housing, adapters and further information's are described in this document. The test SETs include the OEM AS73211-AB5 sensor board [5], optional (Development Kit) fitted into a metallic housing with optical interface, a standard I<sup>2</sup>C-to-USB converter as well as Windows PC software. The test software enables to control the converter, calibrate the sensor and allows data logging options including an export out of results. Please note, the Development Kit in any form was designed to be a test system for system and application tests.

The OEM sensor board AS73211-AB5 is a small PCB for general color measurement and control applications, with a high bandwidth for light energy and handheld applications. The sensor board includes the JENCOLOR® AS73211 (see [1]) with a high dynamic range and on-chip temperature sensor, an EEPROM for sensor data (see [3]), LDO micro power regulators (see [2]) to manage the analog and digital supply voltage. I<sup>2</sup>C is used for external communication, configuration of the sensor, readout of the sensor data as well as writing and reading of the memory. The PC connection was realized via the standard I<sup>2</sup>C-to-USB converter IOW24-DG (see [4]). The standard PC software is only valid for Windows based systems.

Figure 1: Block diagram AS73211-AB5 Development Kit



The description of the sensor, OEM hardware and I<sup>2</sup>C communication is implemented in the reference documents [1], [2], [3] and [5]. For all details of the I<sup>2</sup>C-to-USB converter see [4].

The following chapters describe the Development Kit and especially the software setup and usage for a Windows PC. Please make sure to all libraries, driver and the test software before you connect the Development Kit to a PC via USB. Otherwise, the test software starts in a demonstration mode and does not make real measurements.

<sup>1</sup> And alternative deliver forms e.g. OEM AS73211-AB5 board without mechanical package

⚠ Production data information is current as of publication date. Products conform to specifications per the terms of ams Sensors Germany GmbH. The information in this document is subject of change without notice, please confirm that this is the latest version. Please check with a ams Sensors Germany sales representative for availability and further information. Full legal notices can be found on the final page.

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## 1 SCOPE OF DELIVERY

The AS73211-AB5 product family includes alternative delivery forms with the following standard elements:

- Housed sensor board DK AS73211-AB5 (or OEM PCB)
- Setup for PC test software including setup for MATLAB™ Compiler Runtime, not for OEM version
- I<sup>2</sup>C and/or USB cable with USB converter (device from [4]) , not for OEM and/or optional
- Optical cover for realize angle of incidence, not for OEM and/or optional

Defined in [4] alternative IO-Warriors and libraries are available for customers wanting to integrate the kit into own software environments. For the scope of delivery of alternatives see the following table:

Table 1: Scope of delivery for AS73211-AB5 product family (form of deliveries may be different)

	AS73211-AB5 SET DK JENCOLOR® Development Kit with USB-Interface	AS73211-AB5 JENCOLOR® OEM Sensor Board with I <sup>2</sup> C-Interface
		
Article	220810004	220810002
Sensor-IC AS73211	O	O
Interface	I <sup>2</sup> C / USB via dongle	I <sup>2</sup> C
PC Windows Test software	O	---
Housing and adapter	O / O	---
JCDK-aperture mini	O	optional
Optical cover	O	optional

The housed test system consists from a basic case which will be adapted customized and/or application specific by various parts and optical components (apertures).

The solid basic case was made of anodized aluminum, which protects the sensor board AS73211-AB5 against mechanical stress as well as ESD and EMF. The sensor AS73211 is positioned in the basic case coaxial with a 3/8"-24 UNF internal thread and ready for the application of different optical accessories.

Table 2: Basic case and adapters for the DK AS73211-AB5<sup>2</sup>

JCDK-Basic case	JCDK-Aperture mini	JCDK-Aperture- 10 <sup>3</sup>	JCDK-1/4"- Adapter	JCDK-SMA- Adapter
				

<sup>2</sup> For other adapters please contact our sales team.

<sup>3</sup> Available in alternative variants, with/without IR cut-off filter.

There are difference adapters "Aperture" available to adapt for the sensor in the package the angle of incidence and/or to fix the sensor system.

The JCDK-Mini-Aperture is designed to limit only the angle of incidence on the AS73211 to  $\pm 10^\circ$ . It is the smallest aperture of the JCDK assortment. The JCDK-Mini-Aperture belongs to the delivery contents of DK AS73211-AB5.

The JCDK-Aperture-10 is also designed to limit the angle of incidence on the AS73211 to  $\pm 10^\circ$ . It is an optional aperture of the JCDK assortment and characterized with a single groove outside. The outside diameter of 25 mm makes it compatible with JCDK-1/4"-Adapter and opto-mechanical system parts (e.g. Linos). In front of the aperture is space for mounting a filter glass with outside diameter up to 22.2 mm and thickness up to mm.

JCDK-1/4"-Adapter is used for mounting the JENCOLOR® DKs on a camera tripod or equivalent holders. On the bottom side there is a centered 1/4"-20 UNC internal thread and 20mm below the optical axis there are two M4 internal threads for mounting the JCDK-1/4"-Adapter on a flat surface. For IR sensible applications order the JCDK aperture 10 with inserted IR blocking. For using the adapter with an alternative integrated filter please ask our sales team.

Via the JCDK-SMA-Adapter a fiber optic patch cable with F-SMA 905 plug can be connected to the JENCOLOR® Development Kit. The distance between fiber end and sensor is calculated to achieve an angle of incidence of at most  $10^\circ$  with a fiber core diameter up to  $600\mu\text{m}$ . Minimum NA for illumination of the whole sensor area is 0.22 and to reduce the effect of stray light inside the adapter and the case NA should not exceed 0.39.

## 2 SYSTEM REQUIREMENTS

For start-up procedures, the following system resources are required:

- PC Pentium 1 GHz or higher
- 512 MB RAM
- 1x free USB (2.0) port
- 80 MB free hard drive memory (+ approx. 1.3 GB for MATLAB™ Compiler Runtime)
- Microsoft Windows™ 7 and above
- (optional<sup>4</sup> for import/export functions) Microsoft EXCEL™
- Internet Connection and administration right for runtime and software installation

## 3 SPECIFICATION OF AS73211-AB5 family

Table 3: Specification of (SET) (DK) AS73211-AB5<sup>5</sup>

<b>Spectral range</b>	380 nm ... 700 nm
<b>Measuring Method</b>	Based on XYZ CIE 1931 standard (user calibration necessary) <sup>6</sup>
<b>Measuring values</b>	ADC digit; ADC current; XYZ; Yxy; Yxy SDCM; Yuv
<b>Gain (reference currents)</b>	Selectable 5 nA ...1024 nA (12 stages)
<b>Integration time</b>	Selectable 1 ms ... 16 sec (15 stages)
<b>Digital electronic resolution</b>	16 Bit ADC output by using divider for 24 internal bits
<b>LSB min lux</b>	0.00043
<b>FSR min lux</b>	28.17
<b>FSR max lux</b>	115,400.68
<b>Dynamic range</b>	1 - 250,000,000
<b>Power supply</b>	USB powered
<b>PC interface</b>	USB 2.0 full speed
<b>Weight</b>	58 g plus adapter ca. 5...10 g
<b>Operating conditions</b>	Temperature 0 ... 85 °C Humidity 85 % relative humidity at 35 °C

<sup>4</sup> E.g. recommend to use some special program functions like write protocol and others

<sup>5</sup> Based on max. TINT = 1sec.

<sup>6</sup> For more details for sensor response, sensitiveness and other parameters see the AS73211 datasheet

## 4 START-UP

### 4.1 Software/Driver Installation

This section of the document describes how to install and use the AS73211-AB5 PC-software.

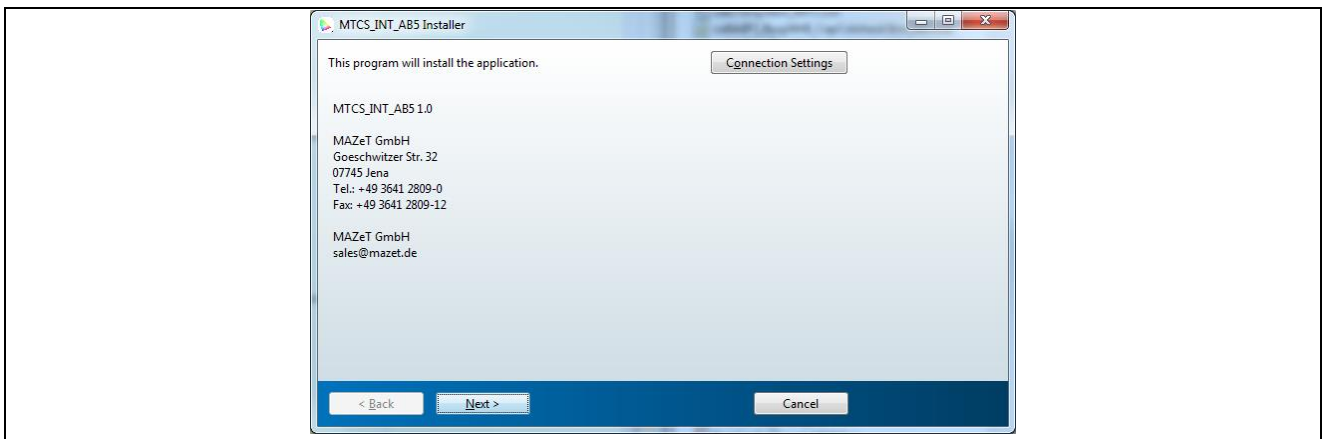
During process installation and work administration permission are needed. Note: The SETUP must be run with the special option "run with administration rights".

The installation process also requires a working internet connection to connect to MATLAB-specific system requirements. Please check your system configuration in Windows System Control for the Internet connection and right settings.

Before you start the SETUP file for the test software check whether the actual MATLAB Compiler Runtime (MCR) 8.2 version (standard installation by MCR\_R2013b\_win32\_installer.exe) is installed on your PC<sup>7</sup>. If MATLAB Compiler Runtime library was not installed then follow the special instructions in the setup process for MATLAB.

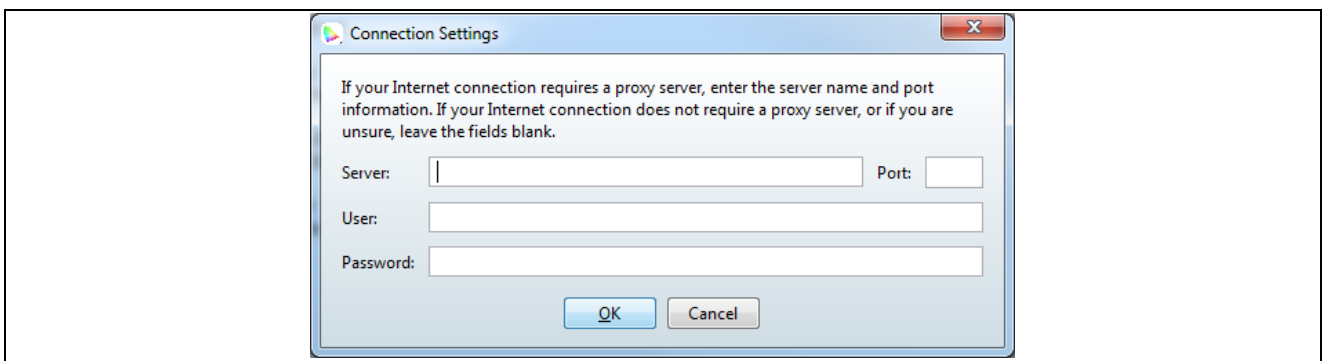
To start the installation of the DK AS73211-AB5 test software simply execute the setup.exe file from the USB stick or other memory which you got and all required files are installed automatically. The setup opens in a window which guides the user through the installation step by step.

Figure 2: Setup - Welcome windows Setup



The setup software checks the installed MCR version. If the version is incorrect the setup attempts to download the correct MCR via internet. If your internet connection requires a proxy server, configure the server using the 'Connection Settings' button.

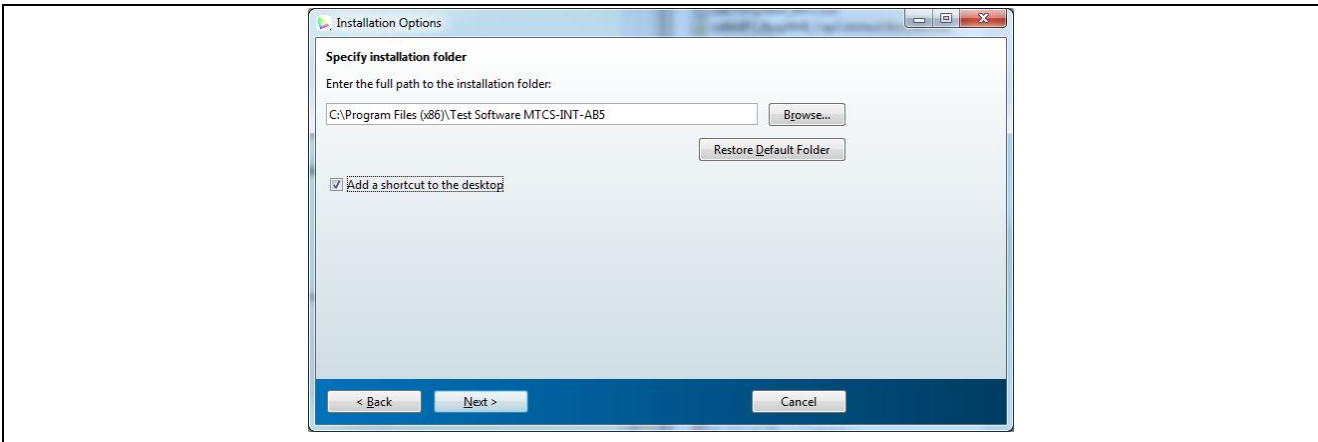
Figure 3: Setup - Connection settings



<sup>7</sup> The setup routine always check internally whether Setup Matlab was defined by the System variables \$PROGRAMFILES. Normally that is the path C:\Program Files (x86)\MATLAB\MATLAB Compiler Runtime.

Click 'Next' to specify installation options, set the installation path and add a shortcut to the desktop. The installation folder will include the program and data files in several directories.

Figure 4: Setup - Destination Folder



After clicking 'Next' setup will check the installed MCR version. If the correct version was installed just click 'Next' at the following screen. Otherwise, setup attempts to download the correct version via internet and installs it.

Figure 5: Setup - MATLAB Compiler Runtime version already installed.

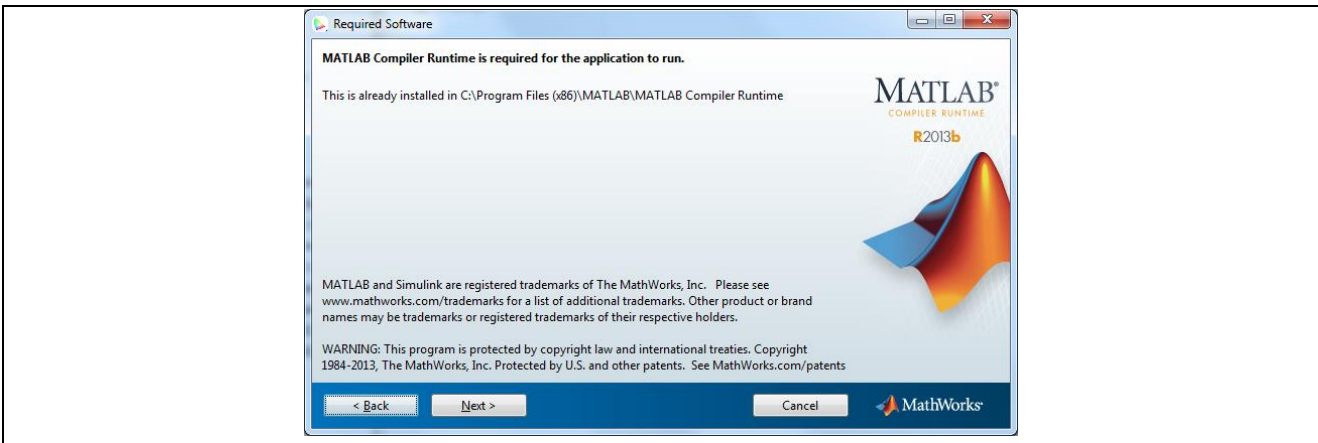
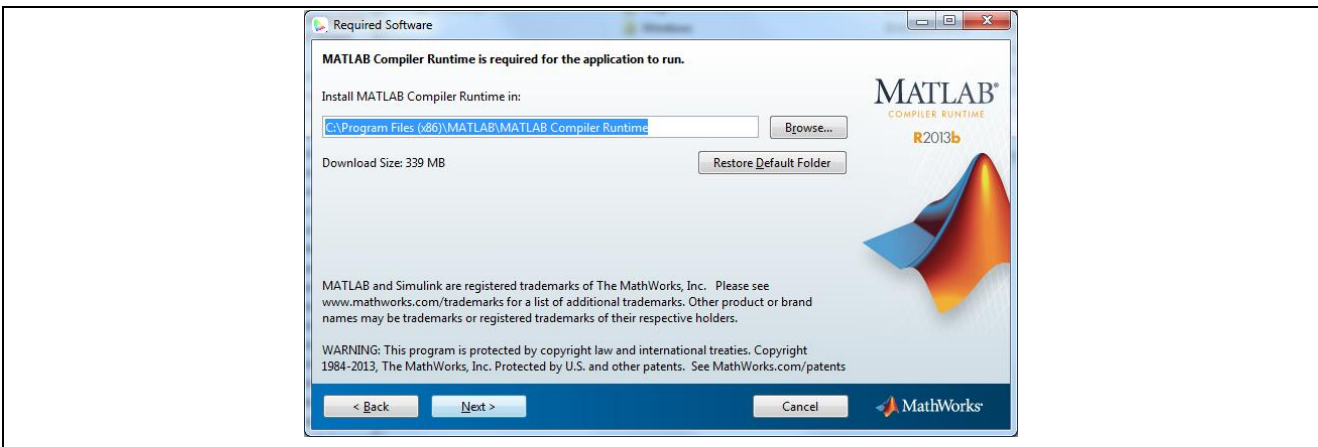
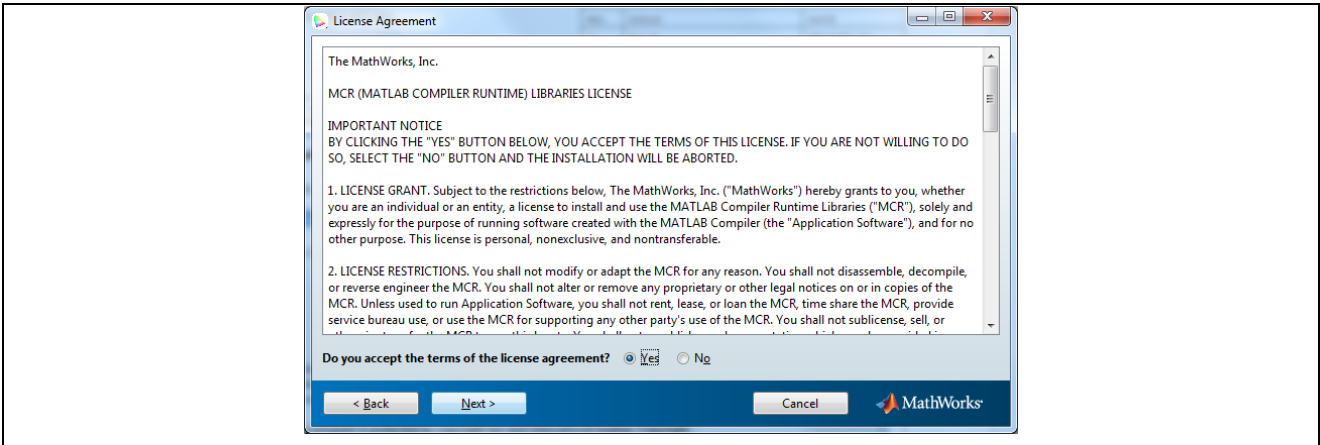


Figure 6: Setup - Download required Compiler Runtime and confirm MATLAB License Agreement

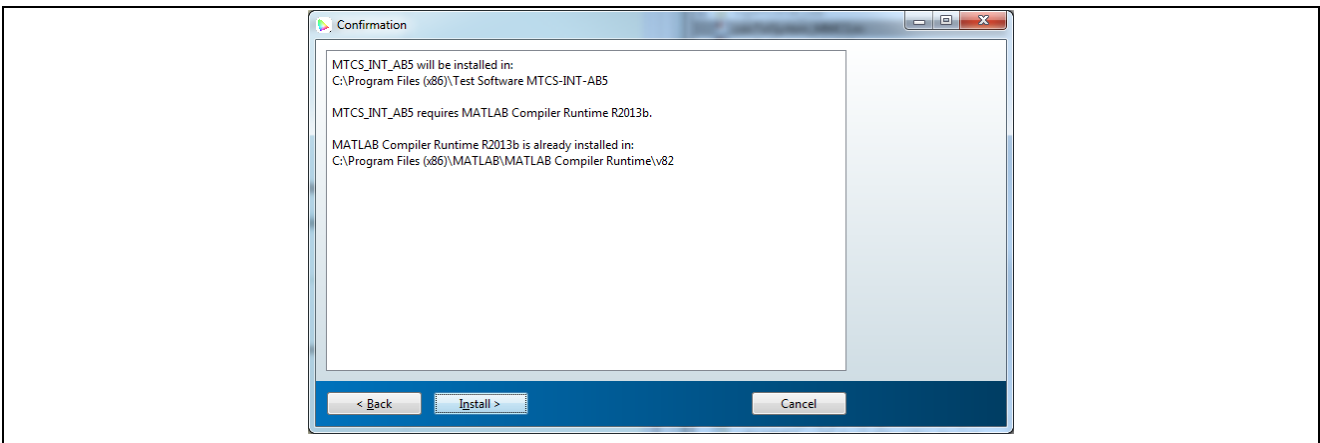






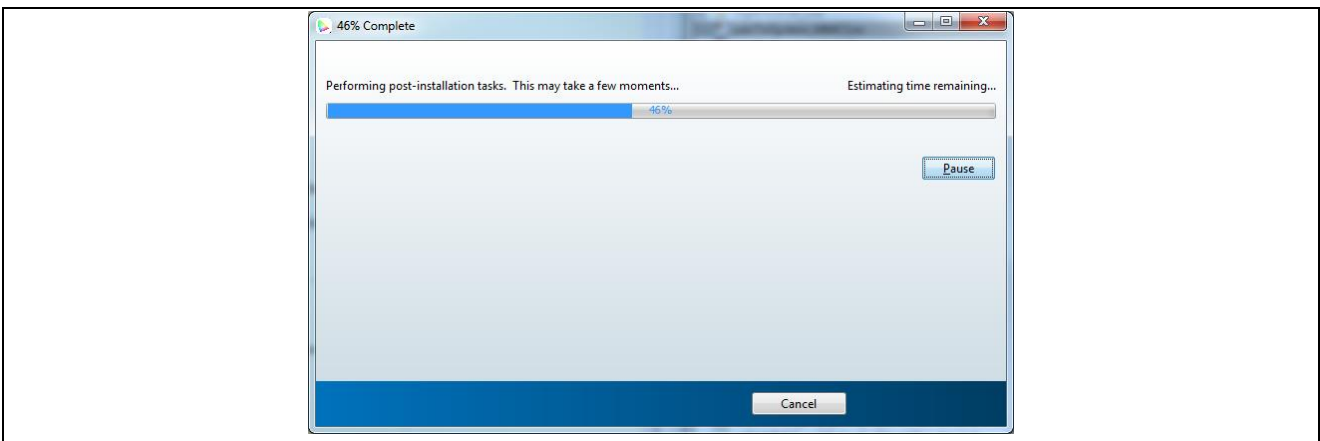
In the next screen, there is the option to confirm the MathWorks License Agreement.

Figure 7: Setup - Start installation



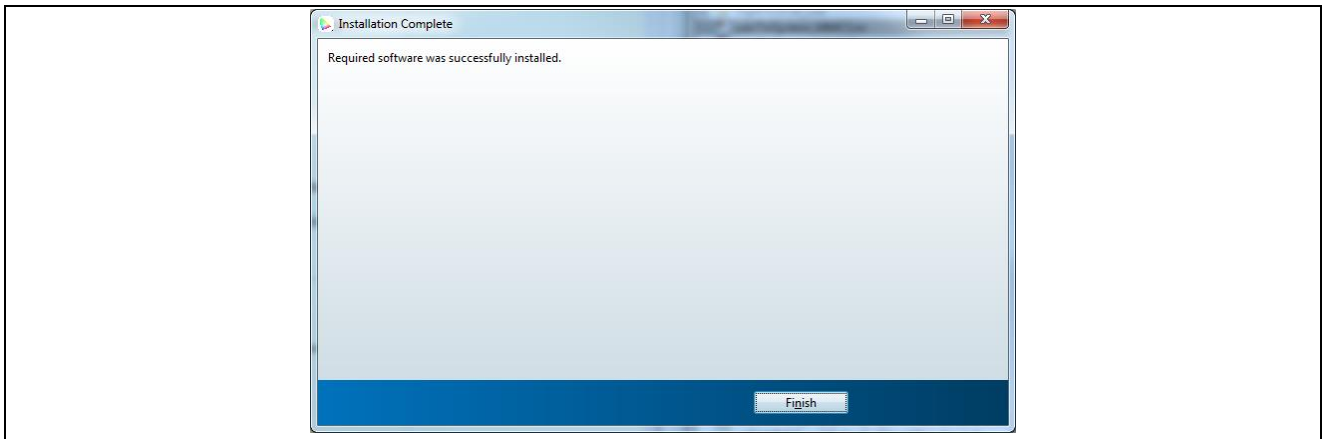
The software will be installed into the shown destination folders after confirming via 'Install' button.

Figure 8: Setup - Installing



The installation is completed after confirming via 'Finish' button.

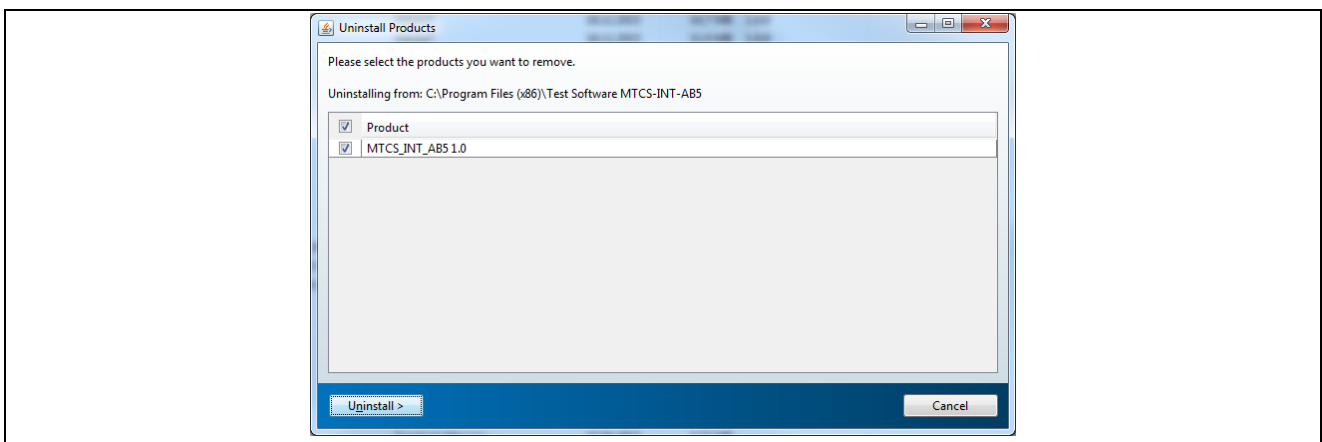
Figure 9: Setup - Installation finished



## 4.2 Remove

To uninstall the software use the Windows system setup "Add or remove programs". Choose the programs to uninstall them in the following dialog.

Figure 10: Setup - Remove program



Press 'Uninstall' to delete the complete software package. You may be required to manually remove some files remaining in the installation of the software.



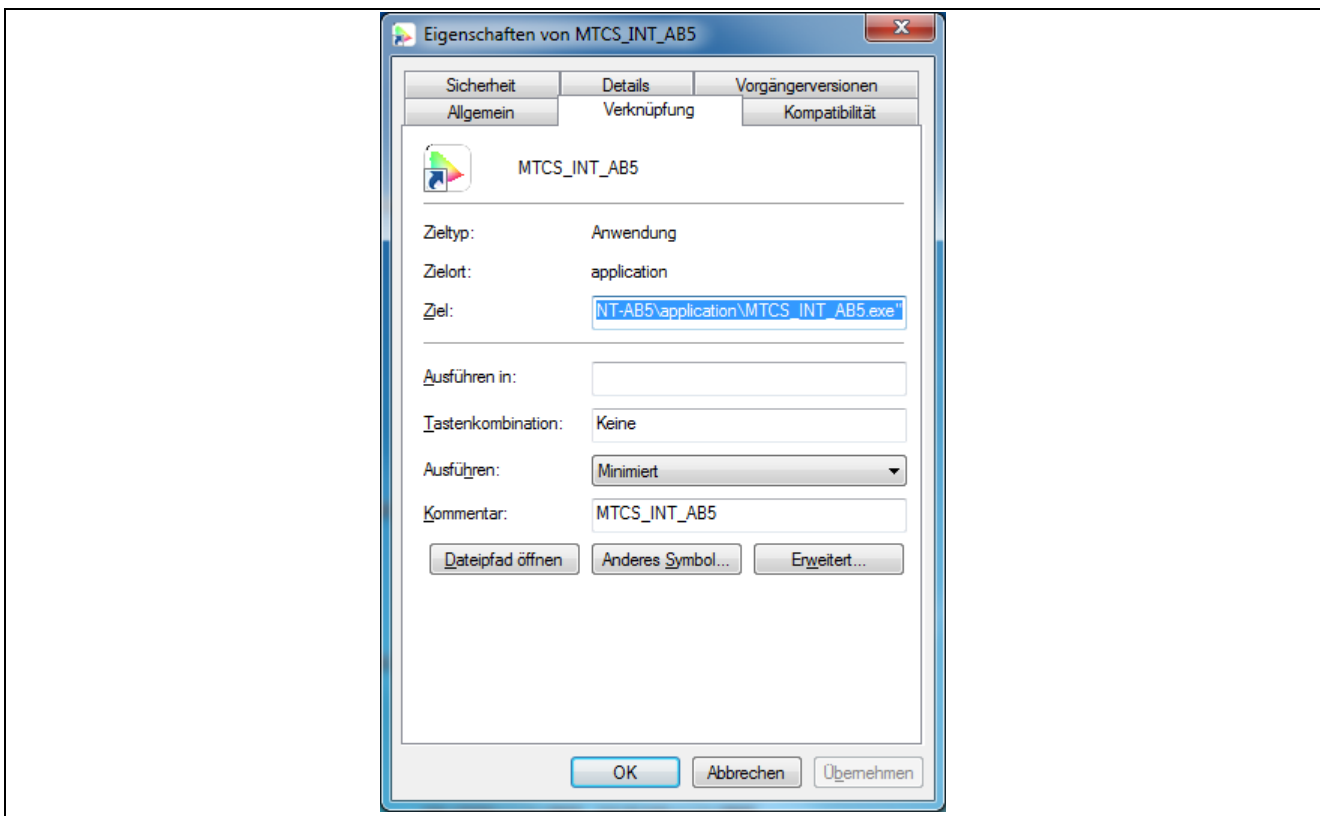
**Attention:** Create a backup of your own created files that are located within the installation folder.

## 5 SOFTWARE DESCRIPTION

### 5.1 Software start

Use the standard to start the DK AS73211-AB5 software by the installed icon MTCS\_INT\_AB5 in the program menu. In the main user interface the specification for the measurements e.g. integration time, reference currents and divider must be selected before the measurement process will be started or use the function "Load configuration file" to specify all the named parameters (see chapter 5.7). Some examples of such predefined specification files are installed in the directory "...Test Software AS73211-AB5\application" (see chapter 5.8).

Figure 11: Standard properties of the installed AS73211-AB5 software



Another variant to start the software DK AS73211-AB5 with specified parameters is to expand the start command in the property menu of the program shortcut by a pre-defined configuration file. See the following example for a complete text in the target field of the property dialog to start the software:

**"..... MTCS\_INT\_AB5.exe" "command example.csv"**

### 5.2 Main User Interface Elements

After a successful installation and running the software the user interface always starts in **Expert Mode** (see chapter 5.4) and includes different possibilities (button, menu bar, dropdown menu) to change the parameters for measurements (**Configuration**), to select form of outputs (**Diagram**), and to control the next program steps (**Measurement, Calibration**).

**Configuration:** The most important parameters can be changed direct by the user. It is possible to initialize and control the measurements direct in the main windows or by an initializing file (see also chapter 5.8).

**Integration time** determines the conversion time of the Sensor ASIC ADC. The higher this time means the better the accuracy (higher number of bits). Set and increase the Integration time based on your

application specific timing but avoid saturation. Please note, in the test system AS73211-AB5 only the internal clock frequency of 1 MHz is using although the AS73211 supports alternative frequencies [1]. So in customized designs the sensor can be adapted on application specific frequencies.

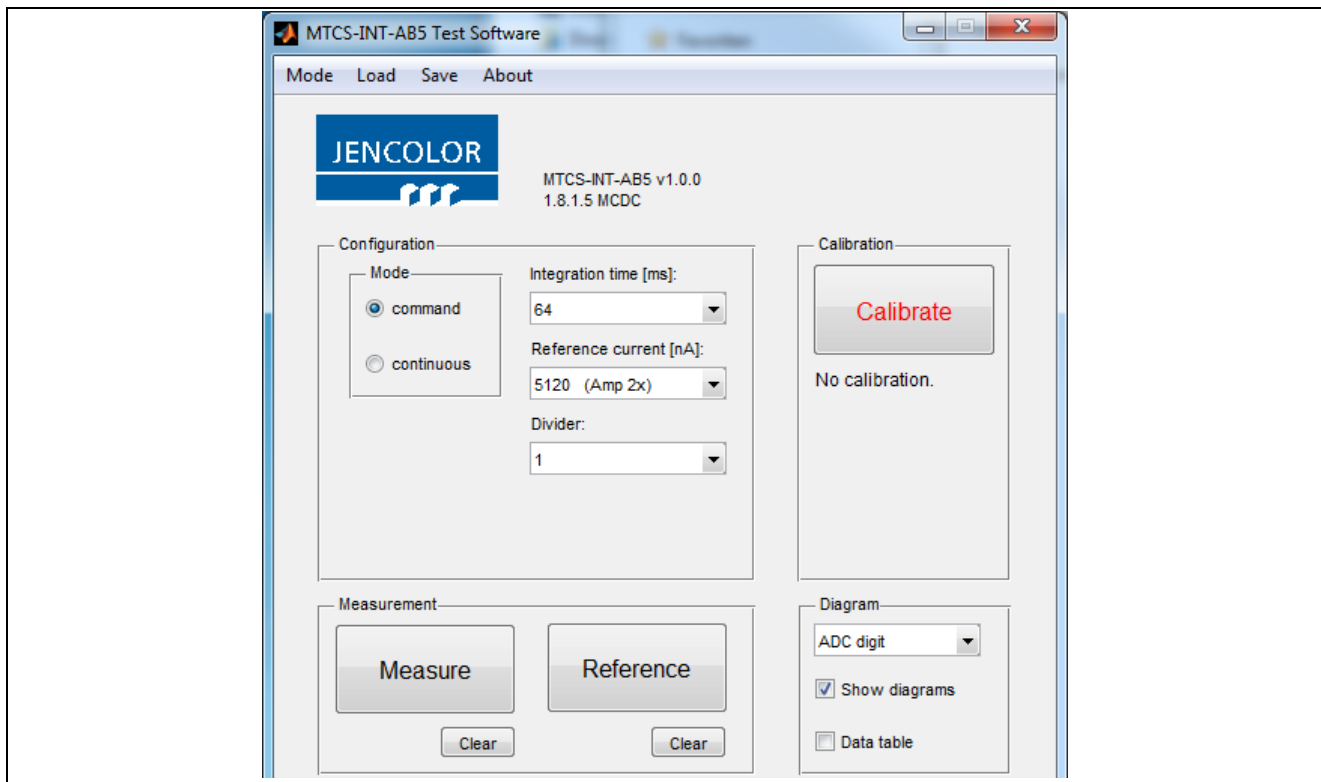
**Reference current [nA]:** Configures the amplification of the sensor board by changing the reference currents. Example: The smallest reference current results in the highest gain and increase the accuracy.

**Divider:** Is used to expand the measurement ranges and to prevent partly saturation. The AS73211 uses internal 24 bits for analog-digital-converting and transform 16 bits as sensor result via I<sup>2</sup>C. An internal implemented digital divider can be used to scale the results from 24 bits to 16 bits.

After pressing the **Measure button** the test software starts a measurement with the selected initialization. Based on the selected mode the measurement will be performed sequentially by **command** after each click and/or in **continuous** mode. For realization the software uses only the CMD/CONT modes<sup>8</sup> of the AS73211 (see [1]). By selecting the parameters of the sensors ADC converter like **Integration Time, Reference Current** and **Divider** parts of the gain of the sensor system can be directly controlled by the user. If an initialization via a \*.csv-file (see chapter 5.8) was selected then **Configuration** shows the actual selected parameters of \*.csv.

For more details and parameters of **Configuration** please see chapter 5.5 and/or the datasheet of the AS73211 [1].

Figure 12: Main User interface elements in Expert Mode



**Calibration:** Use this button to start the calibration process (see also chapter 5.6). As long as no calibration is performed, the status of calibration is invalid and the button is highlighted in red. After completing a calibration the status is valid and the button is highlighted in green. A change in the configuration parameters changes the status of the calibration back to invalid (red) if the parameters differ from the setting used for the calibration.

<sup>8</sup> In case of customized software check the alternative modes of the sensor (SYNS, SYND).

**Diagram:** The representation of the measured data and a table for the data output of the measurements can be enabled / disabled and adjusted.

**Measure / Reference:** A (reference) measurement (see chapter 5.3 and/or 5.4) is started with the selected parameters.

The **Clear** button deletes all measurement values and closes the **Color space** window. It does not delete any register settings<sup>9</sup>.

**Status:** The status window shows important steps performed by the program and I<sup>2</sup>C status is logged (see also chapter 5.4).

In the **Menu Bar** different functions for the initialization of the program, parameters and/or data input / output are listed.

**Load/Save:** In **Load** an initialization file for the gain parameters can be read ('Load Config', see chapter 5.7, 5.8). 'Load Config and measure data' will restore a saved session file (\*.dat) with all gain parameters, calibration and measured data's of a last session. In **Save** the entry 'Save Config and measure data' saves all data of the actual session in a \*.dat file and 'Export...' writes all configuration data's and the measured results in a \*.xls<sup>10</sup> or \*.csv file.

**Mode:** The **Easy Mode** (see chapter 5.3) can be activated in this selection. This options is ideal to perform measurements after a calibration has been performed.

### 5.3 Easy Mode

The **Easy** Mode is designed to be as simple as possible using only limited functions. It can be set manually in menu bar as shown in the following picture in case the expert mode is active.

Figure 13: Menu bar - Easy mode

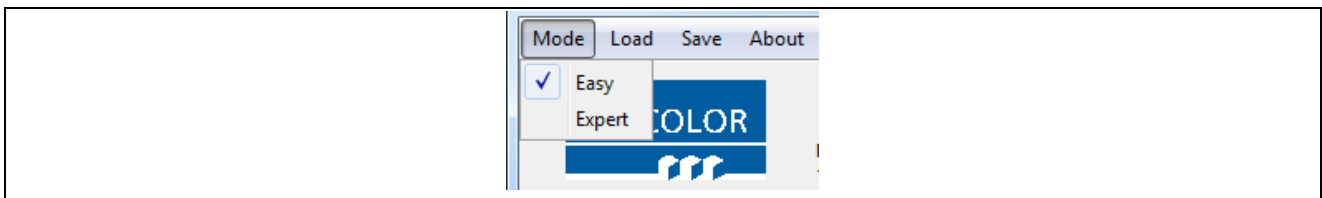
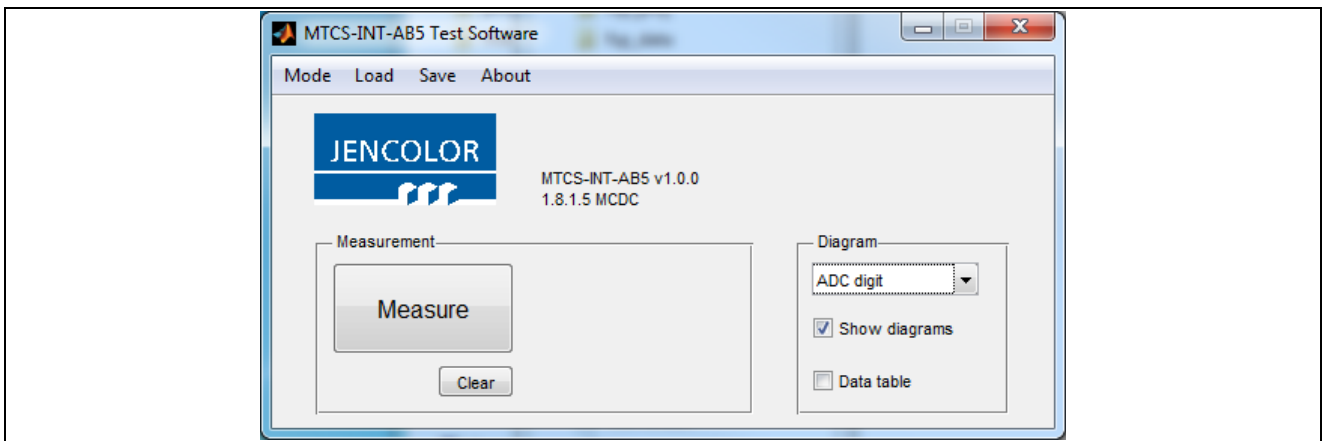


Figure 14: Main User interface elements in Easy Mode



To configure the device in the **Easy** Mode you can load a predefined configuration \*.csv file or a full session file (\*.dat) including configuration, calibration and measurements. To do this use the **Load** menu.

<sup>9</sup> Please note that register settings only could be changed by new writing or after a hardware reset to default via USB disconnection/connection.

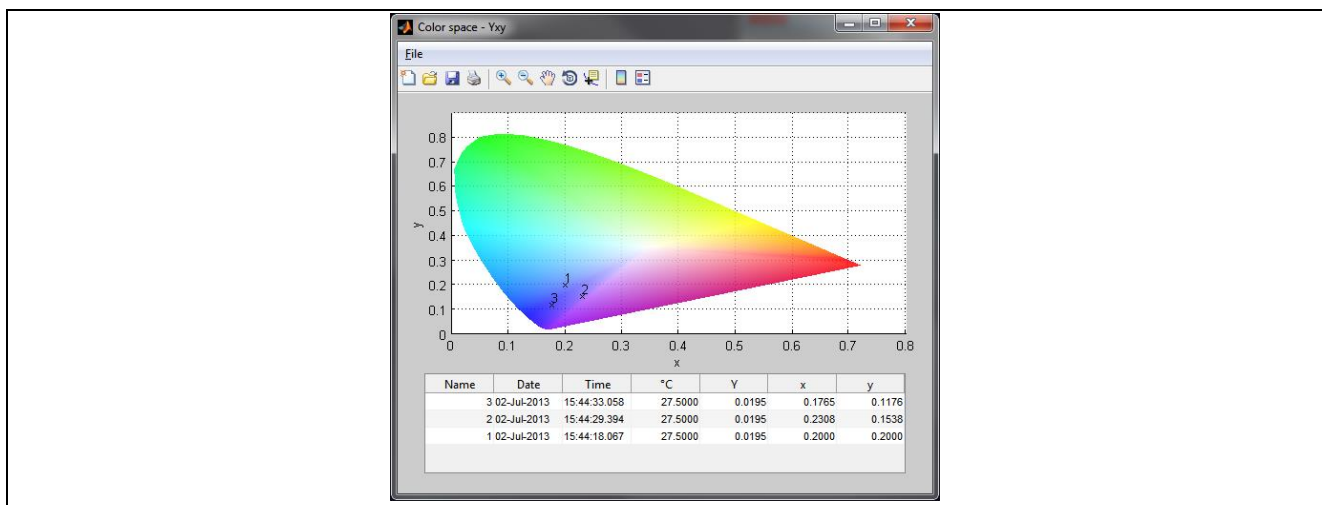
<sup>10</sup> Excel installation on PC is necessary

After pressing the **Measure** button a color chart appears with the selected diagram which shows the measured values of the sensors. Using a command based configuration file, clicking generates one new measurement value (in command mode) or continues measurements (in continues mode) until the stop button is pressed. The result(s) of the measurement(s) are shown in the selected diagram color space window as a figure, or, if activated, in a data table under the figure. The following example shows the color space Yxy (Figure 15).

After starting the program this data table is not automatically activated to increase the speed of the measurements. If **Data table** is activated, please note the final result of the measurement is always displayed in the first line.

The number of measurements is always shown in row one.

Figure 15: Measurement values – with selected Yxy diagram and selected Data table



## 5.4 Expert Mode

The **Expert** Mode offers further options like a reference measurement<sup>11</sup>, sensor calibration, and a detailed I<sup>2</sup>C status report. The Expert Mode can be activated similar to the Easy Mode via menu button **Mode**. The user interface changes automatically after choosing this option as shown in the Figure 16.

**Measure:** All features of the **Measure** button described in the above chapters are included in the Expert Mode.

**Calibrate:** The button **Calibrate** helps you to perform a sensor/application calibration to optimize the overall accuracy based on the CIE 1931 standard. Read section 5.6 for further information. If the Calibrate button is highlighted in red, it indicates that no calibration file is loaded and that the sensor only shows exact ADC values.

After the calibration has been performed and the Calibration button turns green all selected color points shown in the color space windows are shown exactly according to the calibration.

**Status:** The **Status** field provides information about the run time processes. This can be for example the ADC value, readings or settings of the configuration on the sensor board via I<sup>2</sup>C or a specific calibration status.

**Reference:** Pressing the **Reference** button while color spaces are selected in the **Diagram** dropdown performs a comparison of the reference and measured values in the selected color space. Subsequently, pressing the **Measure** button allows to view the delta values between the reference and the measured

<sup>11</sup> in case of selected diagram functions color spaces and calibrated sensor

values. To generate a new reference value, just press the **Reference** button again and the user interface will be updated with the new reference value.

Figure 16: Expert mode - User interface

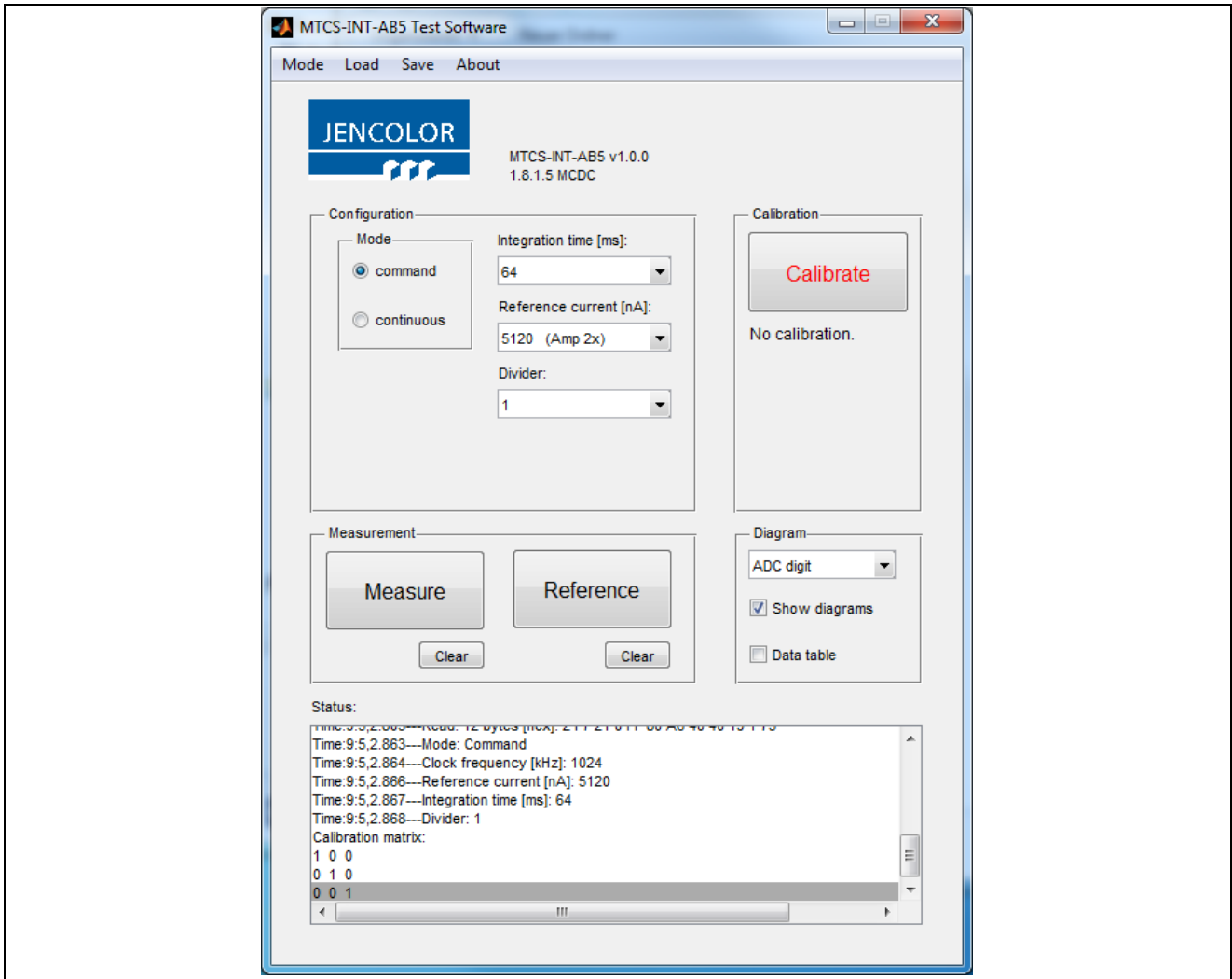
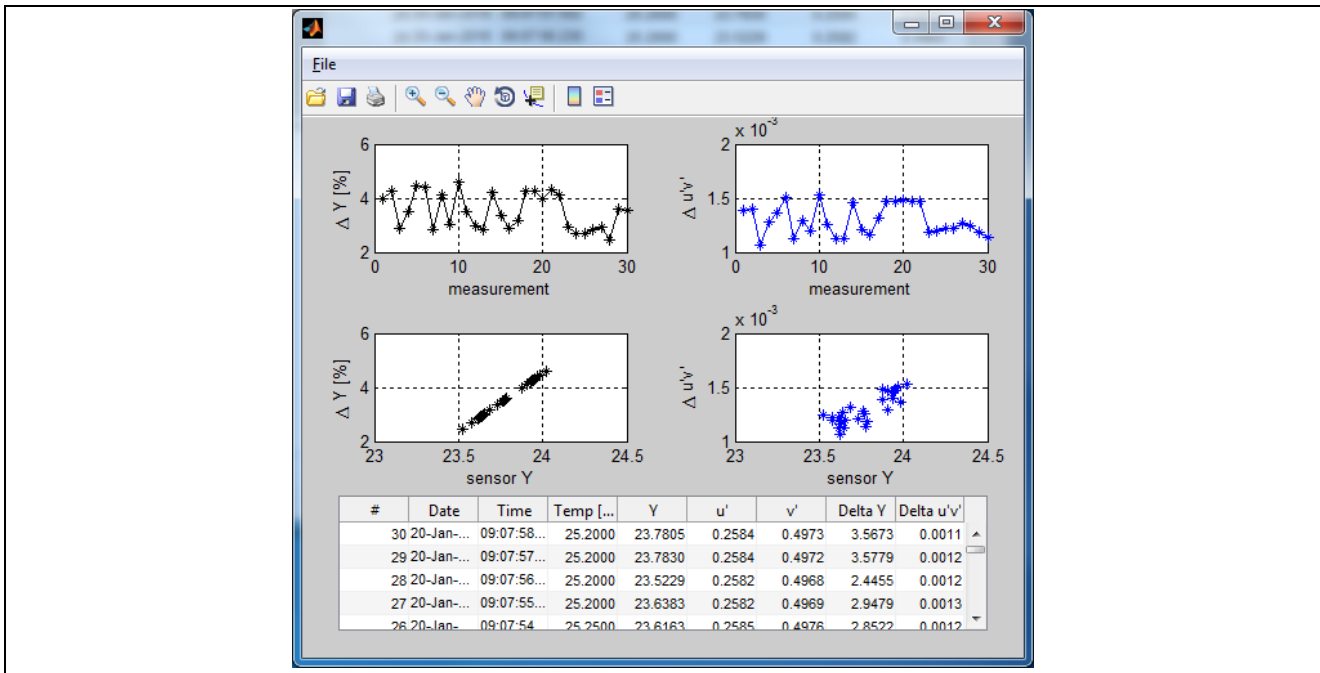


Figure 17: Measurements compared to a reference – with selected Yu'v' diagram and selected data table



## 5.5 Basics for Measurements

Each ADC value (Analog-Digital Converted value) is calculated to a photocurrent ("photocurrent\_nA") under consideration of a reference current ("refCurrent\_nA"), integration time ("nClck") and a digital divider ("divider"). These steps are performed before this value is used for any calibration or colorimetric functions. The following virtual code is used for each sensor channel value - wherein the ADC is the digital 16 bit read out value:

```
% Correction of bit shift (register CREG2)
% divider = 1 (off), 2, 4 ... 256
Adc = Adc * divider;

% Calculation of the maximum number of clocks nClck
% intTime_ms is the integration time in milliseconds (register CREG1)
% note: the following is only correct for a clock frequency of 1.024MHz (register CREG3)
bit = 10 + log2(intTime_ms);
nClck = 2^bit;

% Check of saturation
sat = nClck - 1;
if sat > 65535
    sat = 65535;
end
if Adc >= sat
    % Error! Sensor channel is saturated!
else
    % Measurement is ok.
end

% Calculation of photo current in nano ampere using the reference currents (register CREG1)
photocurrent_nA = Adc * refCurrent_nA / nClck;
```



A detailed description of the sensor signal calculation is included in the datasheets of JENCOLOR® key components, white papers or application notes. Please ask our sales team for further information.

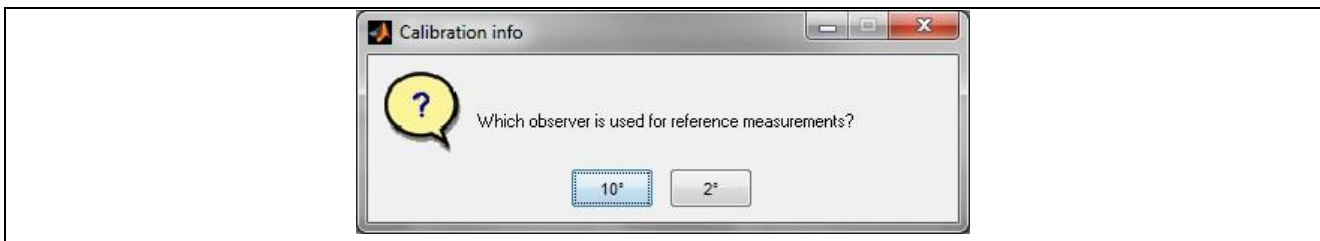
To perform absolute color measurements or for further evaluation of the results in any color space, the sensors system DK AS73211-AB5 must be calibrated to the specific application or test setup. Please ensure that all continuous processes, measurements and the calibration procedures are performed based on same conditions. These aspects refer to the DUT (device under test), distances between DUT and sensor as well as all initialization and environment conditions. The sensor, selected illumination and target are used in a closed system for calibration and measurement procedures. A new calibration is required if you change any conditions inside this closed system.

## 5.6 Calibration

The calibration option is used to create an application and sensor specific calibration via calibration targets measured by a reference device like a spectrometer. The standard calibration simply uses an identity matrix which approximates the color space values. Therefore it is recommended to calibrate the sensor/application to get accurate results and coordinates in any color spaces. This section describes how to calibrate the device.

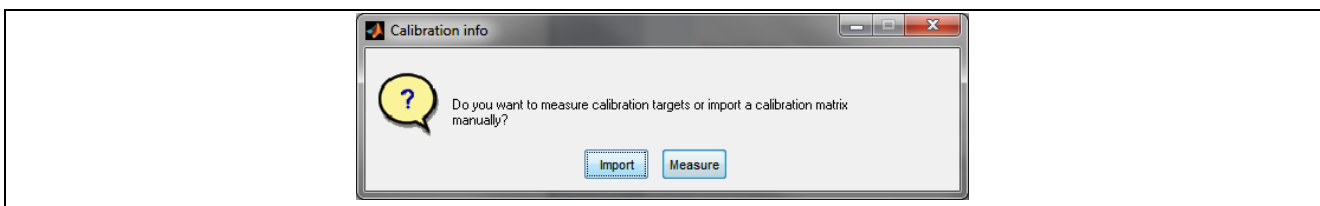
First set the observer with which the reference values are measured (see colorimetric settings of your reference device alike a spectrometer or others).

Figure 18: Calibration - Observer



Then choose whether the calibration matrix should be inserted manually or to measure it.

Figure 19: Calibration - Targets measure or manually -



After choosing **Import** the calibration matrix and offset values must be inserted e.g. from an Excel sheet like shown in the following figure. Just select the cells for import and press the button **Import from xls**.

Figure 20: Calibration - Manual, insert matrix

black-white offset XYZ Offset	X offset	0,0		
	Y offset	0,0		
	Z offset	0,0		
S'' = S' - XYZ Offset	X'' ADC	748,00	683,00	1100,00
	Y'' ADC	298,00	2272,00	708,00
	Z'' ADC	41,00	101,00	2302,00
calculation: matrix for linear transformation K	A = T * S''_trans	4167086,88	4034470,36	3085718,38
	B = [S'' * S''_trans]^ -1	9,6619E-07	-4,8091E-07	-3,9188E-07
	K = A * B	0,876753	-0,084033	-0,007160
		0,213279	0,664411	-0,123580
		-0,085213	-0,007913	2,311510

**Import Matrix**

Import a 3x3 calibration matrix:

	1	2	3
1	0.8768	-0.0840	-0.0072
2	0.2133	0.6644	-0.1236
3	-0.0852	-0.0079	2.3115

Import from xls  transpose

In the next step the dark measurement offset values for the sensor must be imported.

Figure 21: Calibration - ADC offset values

**Import Matrix**

Import ADC offset values:

ADC offset X	0
ADC offset Y	0
ADC offset Z	0

Import from xls

When choosing the **Measure** option, it is required to enter the number of calibration targets to be measured. The minimal amount of targets is the number of sensor channels. Therefore, the DK AS73211-AB5 uses at least 3 targets.

Next, the software requests to cover the sensor for an offset measurement. After this following the software performs measurements for each target and guides the user through the process step by step.

Figure 22: Calibration - Measurement steps Dark measurement and measurements of targets -

**Calibration**

Cover the sensor for offset measurement.

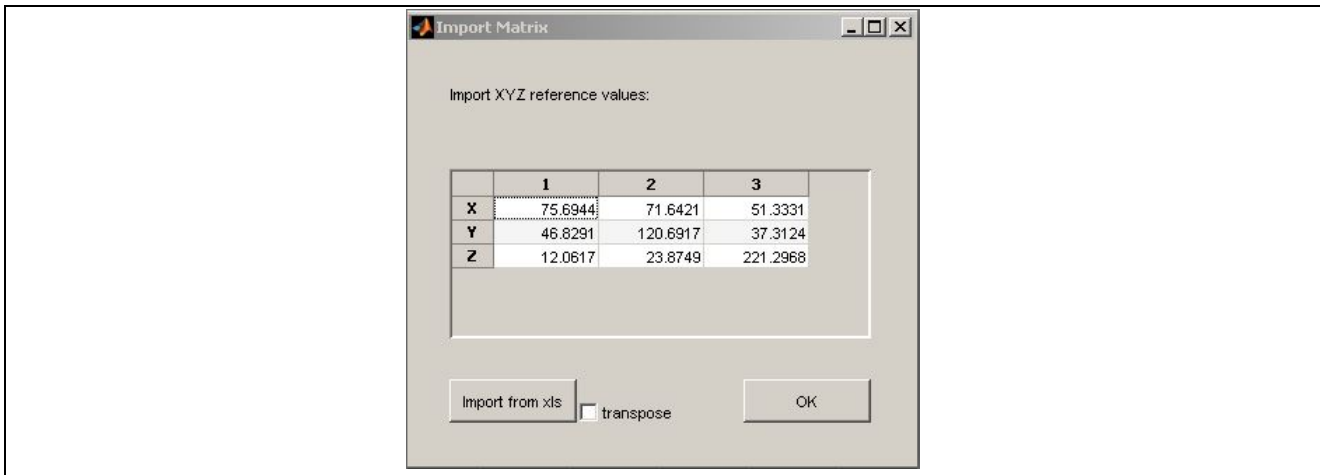
**Calibration**

Set sensor on calibration target number 1

In the final step, the software requests to insert XYZ values of the calibration targets measured by a reference device. It is possible to save the results of the calibration process into a special owner configuration file.

If any support during the sensor calibration is needed, please contact our sales team.

Figure 23: Calibration - Input XYZ reference values -



A calibration is valid for the used system. A new calibration is only required in case relevant system configurations or parameters for measurement were changed (e.g. integration time). After changing the configuration file the software always tests the specified parameters if a re-calibration is necessary and shows the message "No calibration loaded" or "Calibrated with different settings". In this case the calibration must be performed again to achieve exact results. Please note, the software only tests known parameters of the test software and cannot check if any external conditions in the test system were changed. Ask our sales team for support during the calibration process or if you do not get the intended results after calibration.

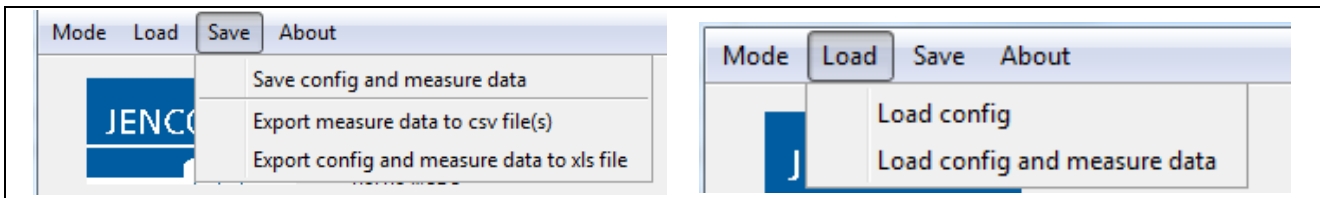
Please note also the give details for calibration in [5].

### 5.7 Load/Save menu

The **Load** and **Save** menus provide the option to load and save the configuration, calibration and measurement values in a file with the extension \*.dat ('Load config and measure data'; 'Save config and measure data'). To only load a configuration of the sensor use the **Load config** menu entry. This allows you to load a \*.csv (\*.csv – comma separated values) configuration file (see chapter 5.8).

The **Save** menu also offers an extra feature to export measurement values to \*.csv files or the actual sensor configuration and measurement values to an Excel file (\*.xls) for further usage. This data can be used for comparison or for statistical calculations. Note: The export to Excel is only available if Excel is properly installed on your local PC.

Figure 24: Menu - Load and Save



### 5.8 Configuration Files (\*.csv)

The Configuration Files (\*.csv – comma separated values) contain all important information about the measurement and configuration behavior. The files are used for application-specific adjustment of the test board AS73211-AB5 and/or compatible boards. In the installation path of the test software you find examples for a configuration file, e.g. "command example.csv".

Processing these \*.csv-files is possible with a text editor, Open Office Software or MS Excel. Please note, however compliance with the syntax and the extension \*.csv when saving. Other-wise, errors will occur during software operation. Table 4 indicates all relevant syntax, columns and register commands. All grey

highlighted columns are comments or user information with no conditions for syntax except for the use of the separation of characters like “,” or “;”. In case of using JENCOLOR® sensors a changing of the line with the keyword “ChannelOrder” is not necessary because the filter set was pre-defined. On the other side by using alternative sensor boards the ChannelOrder must be adapted based on the special configuration. Check the installation or support files like readme.txt or data sheet for more details.

To use a configuration file, select the file and load it by mouse click. Then the parameters inside the files specified will be used.

Table 4: Command example.csv - includes scenario for measurement to show structure and coding

STATE	INFO REGISTER	INFO DATA	COMMENT	R/W/X	I <sup>2</sup> C ADDRESS	REG.	DATA	
Channel Order	DO NOT REMOVE THIS ROW					1	2	3
Init	OSR	Software reset	Reset IFS to clear all registers	W	E8	0	10	
Init	OSR	Set config mode and no power down	Init configuration and wake up AS89XXX (wait 500 $\mu$ s before measurement)	W	E8	0	2	
Init	CREG1	R=320/T=64	Set R=reference current [nA] / T=integration time [ms]	W	E8	6	102	
Init	CREG2	Div=1/OUTCONV=enable	Set digital divider and OUTCONV	W	E8	7	64	
Init	CREG3	Mode=command/Clock=1024/Standby=off/readyPin=push pull	Set mode/standby/readyPin/configuration [kHz]	W	E8	8	64	
Init	OSR	Set address to register 0	Set address to first configuration register	X	E8	0		
Init	OSR	Read 12 Byte	Read all configuration registers	R	E9		12	
Measure	OSR	Start measure	Begin measurement	W	E8	0	131	
Measure	OSR	Set address to register 0	Set address to first output register	X	E8	0		
Measure	OSR	Read 10 Byte	Read OSR/STATUS/TEMP/MRES1/MRES2/MRES	R	E9		10	

All commands and data refer to the I<sup>2</sup>C communication and register settings of the sensors ADC converter. For more details please check the description in the data sheet of the AS73211 [1].

Description of \*.csv columns:

"State"	All rows containing "Init" are send to the AS73211-AB5 to initialize the AS73211 after choosing a configuration file (see chapter 5.2). Important: Do only use the commands "ChannelOrder", "Init" and "Measure" (case sensitive)! Do not mix "Init" and "Measure" rows!
"Info Register", "Info Data", "Comment"	} Columns are not relevant for a functional use.
"Read/Write"	Insert "W"/"X" for write I <sup>2</sup> C data with/without I <sup>2</sup> C-stop ("X" is used for "repeated start" functionality) or "R" for read I <sup>2</sup> C data.
"I <sup>2</sup> C Address"	Insert "E8" for write and "E9" for read I <sup>2</sup> C data.
"Register"	For write I <sup>2</sup> C: Insert the register address which should be written to. Important: Only insert decimal values 0...255! For read I <sup>2</sup> C: Leave it empty.
"Data"	For write I <sup>2</sup> C: Insert the data which should be written. Important: Only insert decimal values 0...255! For read I <sup>2</sup> C: Insert the amount of bytes which should be read.

**Attention:**

The JENCOLOR® AS73211-AB5 Evaluation Software is designed like as a simple terminal program. This means that each write and read command (each row of configuration file) is written or read via I<sup>2</sup>C without checking the validation of data. For detailed description of all registers check the data sheet of AS73211 [1]. The JENCOLOR® AS73211-AB5 Evaluation Software can only be used in Command and Continuous mode (compare register CREG3 of AS73211). After software installation in the software directory "application" some samples of \*.csv files show several examples to set the system, write/read registers and measure in different modes.

## 6 QUICK START GUIDE

STEP	ACTION	BASICS	RESULT	COMMENT / DESCRIPTION
Initializing Test system and start the software Setting / control parameters	<ul style="list-style-type: none"> <li>Install software and drivers</li> <li>Connect sensor boards via USB</li> <li>start the software</li> </ul>	Software and hardware are available, all system requirements are fulfilled	Installed software	See chapter 4.1  See chapter 5.1
	Set <b>Reference current</b>	In/Decrease until the digits are in a range with an excellent ratio between noise (digits) and brightness digits (several thousands, max. without saturation, in case of saturation consider also divider)	Optimal digits = high accuracy	Specify it as low as possible but so high as necessary (see chapter 5.2 )
	Set <b>IntegrationTime</b>	An ideal ratio between noise (digits) and brightness digits needs to be found (several thousands)	Optimal (max) digits = high accuracy	Specify it as low as possible but so high as necessary (see chapter 5.2 )
	Set <b>Divider</b>	To prevent the risk of saturation increase divider as long as the sensor is not in saturation otherwise decrease gain or IntegrationTime	Optimal (max) digits = high accuracy	If possible decrease amplification to prevent saturation, consider the divider in the signal calculation (see chapter 6.2)
Sensor calibration	<b>Dark measurement</b>	Consider electronically noise – needed to increase accuracy	$I_{Dark}$ which correct sensor result ADC digit	see chapter 5.6
	<b>Calibration - Option #1</b> Known target values	Use known XYZ values for the calibration target	Possible calibration for the existing target	see chapter 5.6
	<b>Calibration - Option #2</b> Trial & Error	Use a virtual calibration via simple calibration matrix $\begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{matrix}$	No existing reference values and spectrometer	No absolute measurement, estimation values for relative color measurement (see chapter 5.6 )

## 7 EXAMPLE FOR MEASUREMENT

The AS73211 and/or its test system is ideal to detect and measure colors, color temperatures or brightness of lighting signals<sup>12</sup>. Typical applications are LED control and measurement and/or calibration of video walls and monitors.

Please note, the results was achieved by a standard and application specific calibrated test system (by using spectrometer and sensor, measured one by one, nearly at the same position). Measurements and calibration were done with a standard display under laboratory conditions. The following tables show the calculation of the calibration matrix and the results of the spectrometer, sensor and evaluation by using the set  $i_{ref} = 1nA$ ,  $T_{int} = 1024ms$  and a RGB calibration.

Table 5: Example for calculation of the calibration matrix (calibration for RGB / target = 3)

		red	green	blue	white	yellow	magenta	cyan	black
Target data T	X	40,9	36,2	17,1	95,4	77	58,2	52,8	0,36
	Y	21,3	74,8	8,4	105,8	96,6	29,6	82,3	0,338
	Z	1,8	12,3	92,4	107,4	13,7	93	105,2	0,546
Sensor data S	X ADC	18662	19277	8520	46847	37865	27199	27615	189
	Y ADC	10136	32954	4334	47836	43284	14406	37023	177
	Z ADC	1133	6184	40141	47617	7116	40869	46508	264
electronical offset XYZ ADCOffset	X ADCOffset	44							
	Y ADCOffset	45							
	Z ADCOffset	53							
S' = S - XYZ ADCOffset	X' ADC	18618	19233	8476	46803	37821	27155	27571	145
	Y' ADC	10091	32909	4289	47791	43239	14361	36978	132
	Z' ADC	1080	6131	40088	47564	7063	40816	46455	211
S'' = S' - XYZ Offset	X'' ADC	18618,00	19233,00	8476,00	0,00	0,00	0,00	0,00	0,00
	Y'' ADC	10091,00	32909,00	4289,00	0,00	0,00	0,00	0,00	0,00
	Z'' ADC	1080,00	6131,00	40088,00	0,00	0,00	0,00	0,00	0,00
calculation: matrix for linear transformation K	A = T * S''_trans	1602650,4	1677369,6	951619					
		1906390,2	2712559,1	818342					
		1053260,7	819248,1	3781486,5					
	B = [S'' * S''_trans] <sup>-1</sup>	6,64615E-09	-4,4503E-09	-8,8954E-10					
		-4,4503E-09	3,87816E-09	3,85749E-10					
		-8,8954E-10	3,85749E-10	7,75714E-10					
	K = A * B	0,002340	-0,000260	-0,000040					
		-0,000130	0,002351	-0,000015					
		-0,000010	-0,000051	0,002312					

<sup>12</sup> Note, the accuracy is depend on the system conditions, calibration and interferences. Therefore in application specific systems the sensor system must be optimized to increase accuracy. E.g. IR lighting will reduce the signal noise ratio dramatically. An add-one IR blocking will correct that.



Table 6: Calculations and sensor results

	Target	red	green	blue	white	yellow	magenta	cyan	black
Spectrometer									
X		40,900	36,200	17,100	95,400	77,000	58,200	52,800	0,360
Y		21,300	74,800	8,400	105,800	96,600	29,600	82,300	0,338
Z		1,800	12,300	92,400	107,400	13,700	93,000	105,200	0,546
sensor ADC									
ADCx		18662	19277	8520	46847	37865	27199	27615	189
ADCy		10136	32954	4334	47836	43284	14406	37023	177
ADCz		1133	6184	40141	47617	7116	40869	46508	264
Sensor XYZ after calibration									
X		40,989	36,289	17,189	95,262	77,063	58,251	53,114	0,386
Y		21,399	74,899	8,499	105,714	96,767	29,752	82,796	0,388
Z		1,920	12,420	92,520	107,202	13,866	93,506	105,378	0,600
<b>DIFF</b>	<b>X</b>	<b>0,089</b>	<b>0,089</b>	<b>0,089</b>	<b>0,138</b>	<b>0,063</b>	<b>0,051</b>	<b>0,314</b>	<b>0,026</b>
	<b>Y</b>	<b>0,099</b>	<b>0,099</b>	<b>0,099</b>	<b>0,086</b>	<b>0,167</b>	<b>0,152</b>	<b>0,496</b>	<b>0,050</b>
	<b>Z</b>	<b>0,120</b>	<b>0,120</b>	<b>0,120</b>	<b>0,198</b>	<b>0,166</b>	<b>0,506</b>	<b>0,178</b>	<b>0,054</b>
Spectrometer									
x		0,639	0,294	0,145	0,309	0,411	0,322	0,220	0,289
y		0,333	0,607	0,071	0,343	0,516	0,164	0,342	0,272
z		0,028	0,100	0,784	0,348	0,073	0,514	0,438	0,439
Sensor									
x		0,637	0,294	0,145	0,309	0,411	0,321	0,220	0,281
y		0,333	0,606	0,072	0,343	0,516	0,164	0,343	0,282
z		0,030	0,100	0,783	0,348	0,074	0,515	0,437	0,437
<b>DIFF</b>	<b>Delta Y (%WP)</b>	<b>0,1%</b>	<b>0,1%</b>	<b>0,1%</b>	<b>0,1%</b>	<b>0,2%</b>	<b>0,1%</b>	<b>0,5%</b>	<b>0,0%</b>
	<b>Delta xy</b>	<b>0,0017</b>	<b>0,0007</b>	<b>0,0008</b>	<b>0,0002</b>	<b>0,0006</b>	<b>0,0010</b>	<b>0,0008</b>	<b>0,0138</b>
Spectrometer									
u'		0,447	0,121	0,163	0,190	0,197	0,298	0,132	0,204
v'		0,524	0,563	0,180	0,475	0,555	0,341	0,462	0,430
Sensor									
u'		0,446	0,121	0,163	0,190	0,196	0,297	0,132	0,193
v'		0,524	0,563	0,181	0,475	0,555	0,341	0,462	0,436
<b>Diff</b>	<b>Delta u'v'</b>	<b>0,00143</b>	<b>0,00019</b>	<b>0,00130</b>	<b>0,00013</b>	<b>0,00026</b>	<b>0,00120</b>	<b>0,00041</b>	<b>0,01244</b>

See the in the lines "Delta" values the results as Delta Y, Delta xy or Delta u'v' for the single colors, measured by the calibrated test system.

## 8 TROUBLE SHOOTING

You have received a tested device that works reliably. Therefore, measurement errors are generally due to the test setup, faults, system incompatibilities or incorrect operation. For example, colorimetric results from a non-calibrated test system are not useful and faulty. The results after calibration depend on the process of calibration itself, the target (color normal) and particularly by the observance of the operating and ambient conditions. So please make sure that there are no drifts or interferences during the measurements. A change or deviation will inevitably lead to errors and may require recalibration.

In case of results, with unexpected sizes, negative<sup>13,14</sup> values or similar errors please check your test system reliability and consider all external influence parameters that take effect on the calibration matrix. After optimization please test again. If you cannot solve the problem, please contact our sales team for further support.

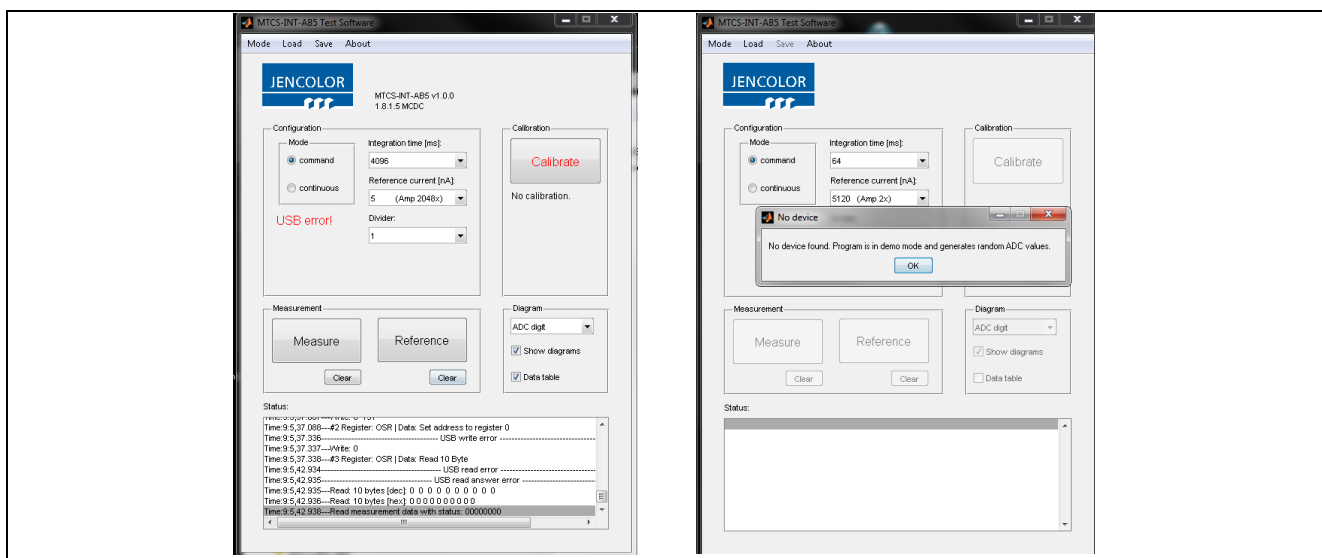
### 8.1 Out of Range

There are two different out of range errors (digits  $\geq 65535$  or Input Saturation) that can occur during measurements.

- Integration time is too long  $\rightarrow$  decrease the integration time or increase the divider
- Amplification is too high  $\rightarrow$  set the reference current to a higher value Not connected sensor or USB error

If the software cannot find a sensor at PC then it starts in a demonstration mode and does not make real measurements. Please stop the software, connect the sensor with the PC and start the software again. In case the error still exists, please check the system requirements (see chapter 2 ) and start-up (see chapter 4.1 ) or connect your system administration. The same we suggest to do in case of a sudden USB error.

Figure 25: USB connection error

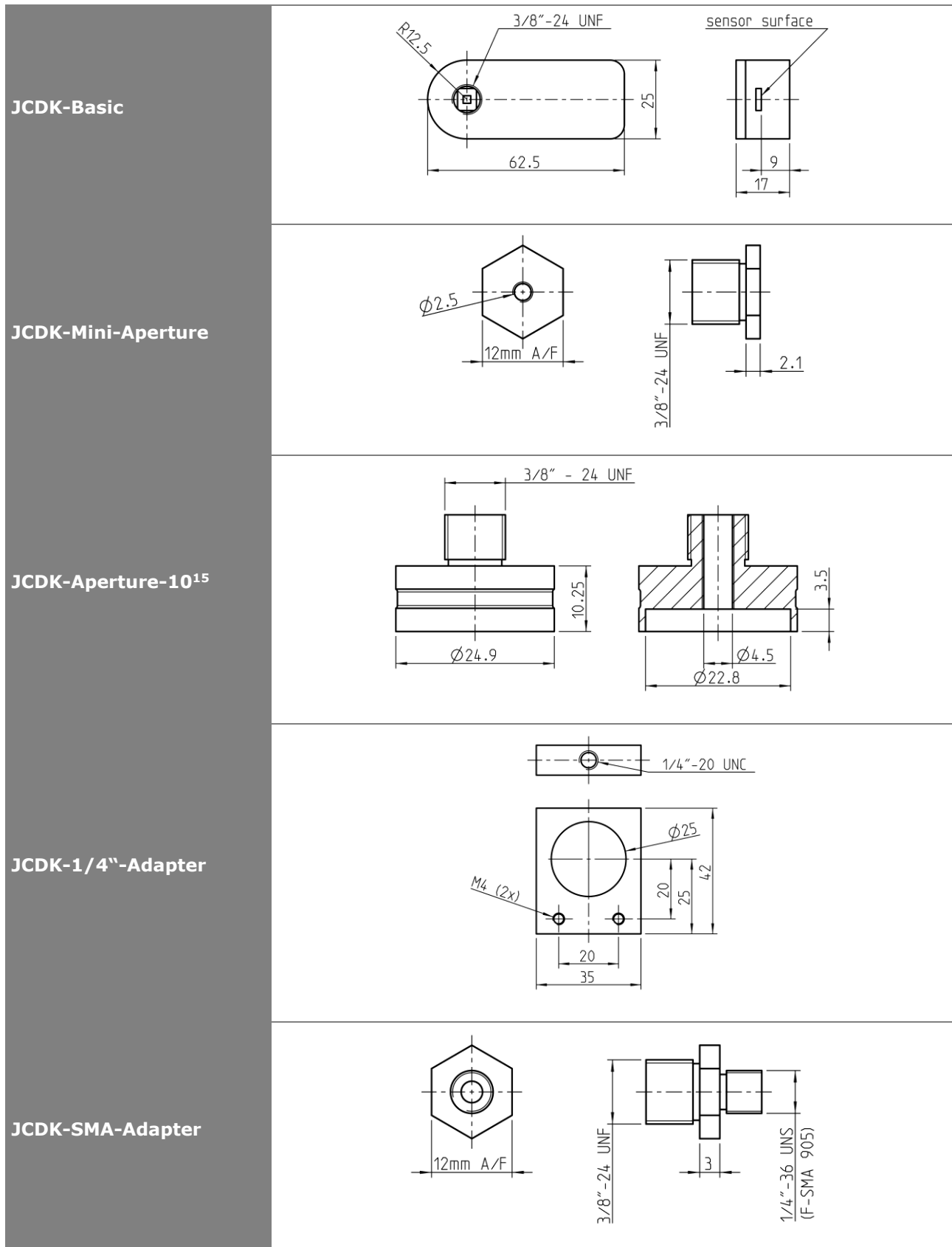


<sup>13</sup> A negative coordinate or a coordinate out of the color space indicates on errors in calibration and/or, interferences or changed conditions or measurement

<sup>14</sup> In exception negative results in photo currents are possible and indicate negative leakage currents (technological reasons) in low-energy measurements. In these cases, please use the method offset correction (see [1] OPTREG Register) and move depend on the Offset Value the workspace about the deficit balance per channel in the positive range.

**9 MECHANICAL SIZES**

Figure 26: Dimensions of the package and adapters



<sup>15</sup> Available with inserted IR cut-off filter.

## SOFTWARE LICENSE AGREEMENT

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## REFERENCE DOCUMENTS

- [1] "data sheet AS73211.pdf", data sheet, ams Sensors Germany
- [2] "LTC1844, Rev. A", data sheet, Linear Technologies
- [3] "EEPROM CAT24C32-D Rev.14, data sheet, ON Semiconductor"
- [4] "IOW24DG Converter I<sup>2</sup>C to USB", technical details, [www.codemercs.com](http://www.codemercs.com)
- [5] AS73211-AB5 OEM Sensor board, data sheet, ams Sensors Germany

## ORDERING INFORMATION

NAME	STATUS	ARTICLE
AS73211-AB5 SET DK	Development Kit	220810004
AS73211-AB	Series	220810002
JCDK-Aperture-10	Accessoires	on request
JCDK-Aperture-10 with IR-cut-off filter	Accessories (on request)	on request
JCDK-1/4"-Adapter	Accessoires	on request
JCDK-SMA-Adapter	Accessoires	on request

The Development Kits and OEM modules described here are only to be used for compatibility-, qualification tests, and verification procedures or as demonstrators. They are not designed to be used in series products.

Please note, the OEM sensors and kits were designed to be a test system for usage in laboratories only. They are not suitable for outdoor applications or to as series devices for inline measurements. Do not use the device in any process control or in any other series applications!

Before using engineering samples for anything other than system tests, please ask our sales team for status and availability of series or customized system solutions.

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**ESD Warning:** Sensor handling precautions should be observed to avoid static discharge



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