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HIGH PRECISION 7 WAVELENGTHS COATING TEST

USER MANUAL

CT-7 AND CT-7A



	NAME AND FUNCTION	DATE	SIGNATURE
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Document Change Log









Issue	Date	Modified Pages	Rationale
1	2011-04-14 	All	Document Creation Applicable for Instruments: SN : 10001, 10002, 10003, 10004, 10005, Software versions: CT7_DSP: v 1.0.2 built 2011-04-28 CT7 OLED v 1.0.2 built 2011-04-29 CT7 Console v 1.00 built 2010-05-01 and later.
2	2012-10-15 	Start-up procedure CT7-Console description New functions Battery management	New version of CT7 Console Software New version of CT7 DSP firmware Applicable for Instruments SN: 12006-and later Software versions: CT7_DSP: v 1.2.02 built 2012-09-25 CT7 OLED v 1.2.02 built 2012-09-21 CT7 Console v 1.2.01 built 2012-09-30 and later.
3	2014-07-10 	Improved performances Minor changes in menus Specification (Annex 1)	New, high precision, optical head. Applicable to instrument 120000 and later with Precision Optical Head Applicable for firmware: CT7_DSP: v 1.3.05 built 2014-05-21 CT7 OLED v 1.2.11 built 2014-05-16 CT7 Console v 1.3.00 built 2014-05-02 and later.
4	2014-08-25 	Firmware upload procedure added	Idem.
5	2015-06-15 	Introduction of Li-Ion Battery	PowerOn procedure and Battery Maintenance Chapters: CT7_DSP: v 1.5.00 built 2015-06-15 CT7 OLED v 1.2.11 built 2014-05-16 CT7 Console v 1.5.00 built 2015-06-15 and later.
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7	2019-09-11 	set of wavelengths read from CT7 instrument - screenshots update -3.1 Introduction -New: 7.2.16.1 Connecting more than one CT7	original set: 365, 404, 464, 522, 624, 760, 970 nm New set: 325, 375, 468, 523, 660, 850, 940 nm -PC console reads from CT7 list of installed LEDs CT7_DSP: v 1.8.00 built 2019-09-11 CT7 OLED v 1.2.13 built 2019-09-11 CT7 Console v 1.8.03 built 2019-09-11 and later.
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1 **Objective**

This document provides description of CT7 reflectometer/scatterometer to the depth necessary for the user to effectively work with the instrument.

2 **Scope**

This document is applicable for the instrument model manufactured since 2015 with upgrades introduced later. The operation in *Normal mode* (end-user) is described.

3 The CT7 instrument

3.1 Introduction

The CT7 is dedicated to monitoring of the coating's quality of the high grade optical surfaces. In essence, CT7 is an optical caliper that can be set to fit your laboratory measurements and repeat them at the remote telescope mirror location.

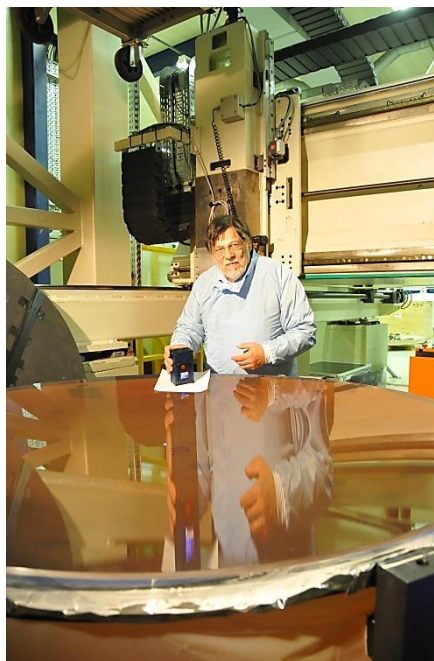
The current model takes benefit of new high precision optical head providing repeatability of 0.01% (short term).

CT7 measures the specular reflection and scattering using seven wavelengths spanning from UV to near IR.

Measurements are performed with a countdown of few seconds, enabling gently placement of the instrument on the precious mirror surface.

Configurations of the instrument and data retrieval are facilitated by PC application **CT7 Console**.

Note: Thanks to the development in LED physics, new powerful single chip LEDs have emerged and we were able to introduce in 2019 new sets of LEDs. The software of CT7-console and CT7 instrument were adapted to cope with any list of wavelengths mounted in the instrument. In this document most of examples is based on the original list of wavelengths.



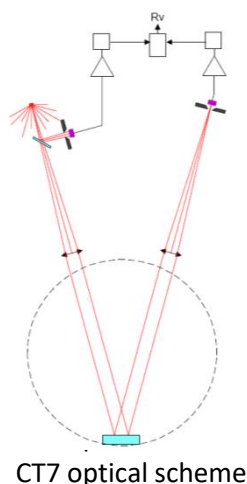
Daniel Malaise demonstrating CT7 at AMOS premises.

(Note: There is a 20mm dia. hole in the center of the tissue)

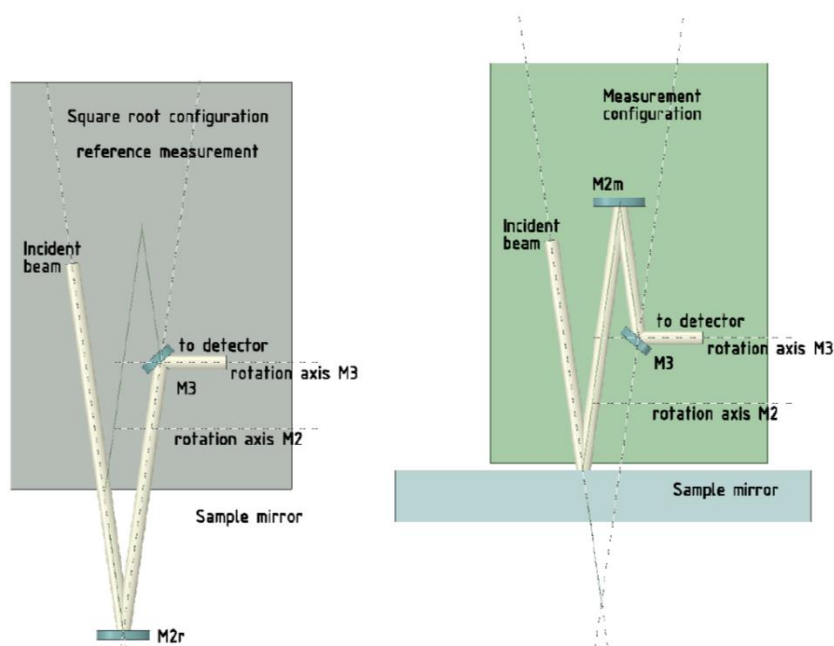
3.2 Introduction of CT7a

CT7a – “a” stands for absolute. CT7a is a CT7 instrument with added arrangement for measuring his own optical path as 100,00% reference value.

We shall recall here the principle of standard CT7 which is an *comparison reflectometer* - unknown sample reflectivity is compared to a known sample (*calibration target*, externally characterized)
CT7 is enough linear and stable to execute such measurement with excellent repeatability.



The optical path of CT7a is more complicated: by introduction of 2 additional mirrors and a rotating arm, we are able to send the incident beam to the detector either directly (reference position) or via measured mirror (measurement position). Any ageing, contamination or thermal effects can be cancelled just before the measurement.



CT7a optical scheme in position: REFERENCE and MEASUREMENT

Note: if CT-7a is used with a gauge as reference, it becomes standard CT-7.

3.3 CT7 Features

3.3.1 CT7 Instrument

1. CT7 measures optical reflection and scattering at 8° incidence from UV to NIR in 7 bands
2. The measurement is performed with instrument standing on the measured mirror.
3. The results are displayed and stored to non-volatile memory.
4. CT7 may be calibrated to user supplied reference targets
5. All measurements are time-stamped thanks to the real time clock.
6. CT7 is built to protect the measured mirror.
7. An USB connection allows for data retrieval to PC.
8. All CT7 functions are available from PC and/or from instrument front panel
9. CT7 may operate without batteries on the USB power
10. The instrument has three power modes: ACTIVE, SLEEP and CHARGE.
11. Auto OFF feature protects the batteries against accidental discharge.
12. Two parallel Li-Ion cells, 14500-size (~AA) size, power the instrument.
13. Charging of AA cells is primarily performed by built-in charger powered from USB connector of the PC , thus charge current is limited to 500mA
14. Charge is performed only when CT7 is not active

3.3.1.1 CT7a instrument

CT7a is a CT7 instrument with moving arm allowing use internal path transmission as 100.00% reference. This arrangement adds a new feature:

15. Provision for absolute calibration of the instrument at any time.

3.3.2 CT7 Console software

Small display and simple joystick as data entry interface is definitively not adequate to enter texts, names and figures necessary for user friendly options of CT7. For this reason, a PC based interface application **CT7-Console** was created.

The main purpose of this application is:

1. Data retrieval
2. CT7 configuration
3. CT7 laboratory operation

CT7-Console provides following functions:

- 1.1. USER level instrument control
 - 1.1.1. Data retrieval and handling of measurement results (export).
 - 1.1.2. Device management by user: configuration view, diagnosis, and up- and down-load of the user configuration (Measurements **Carts**: named series of measurements).
 - 1.1.3. Calibration to reference target sample values
 - 1.1.4. Firmware update
- 1.2. PROCESSING
 - 1.2.1. Sorting and saving data (*)
- 1.3. EXPERT level instrument control (*not recommended for standard user*)
 - 1.3.1. Setting and testing the device at the factory.
 - 1.3.2. Down- and up-load factory configuration.
 - 1.3.3. Manage LED driver parameters

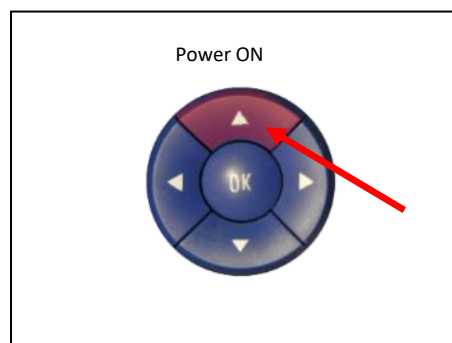
(*) the exported data are saved in .csv format (Excel compatible), so further data processing and graphical presentations can be done with specialized software

4 CT7 Concepts

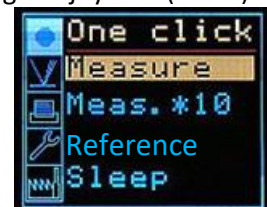
4.1 Quick Start. First measurement.

Note: CT7 is designed as instrument not requiring frequent calibration. Nevertheless, we recommend verifying the validity of calibration after delivery and when instrument is subjected to important temperature change. Simply measure the Calibration Target provided with the instrument.

- The CT7 is normally in sleep mode and can be awakened by pressing both: the ON Button on the top of the instrument and navigation switch **up**.



- At the first Power ON, if necessary, the instrument prompts for time setting. (Only when the time introduced, CT7 is ready for the measurements.)
- CT7 is ready to perform quick “One click” measurement with the active **Cart** of wavelength selection. By default, the NORMAL measurement configuration is active i.e. 7 bands in Reflectivity and Dust
- The MEASURE option is highlighted and may be triggered when pressing the joystick (**Enter**).



- Trigger the measure still keeping CT7 in your hand: you have 5 seconds to place the instrument gently on the mirror.
- After the measurement, the results are displayed and stored with the *time stamp* and *Cart ID*.

Data view		
Index :	00000128	
	2018/01/05 20:40:19	
	00 Normal	
Temp :	24.5	
	R	D
365	85.04	5.12
404	92.20	4.65
464	91.56	4.27
522	93.11	4.03
624	87.72	3.85
760	90.91	3.65
970	99.18	3.15

- Pressing joystick (ENTER) returns to the menu.

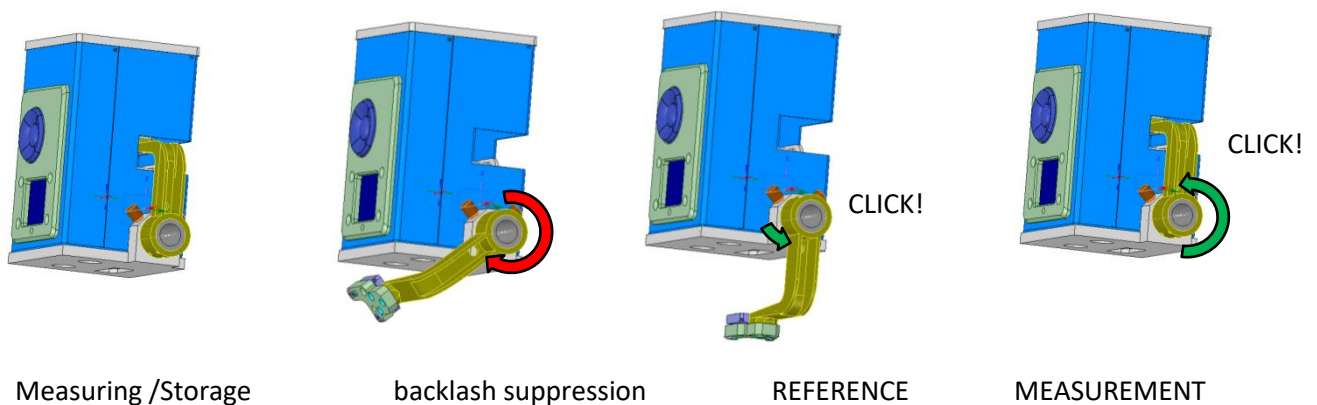
The measurements are performed as specified by a user's **Cart** indicating the wavelengths and type of measurements to be performed and bearing an identifier. The user can create and select as many **Carts** as needed(64). Carts are created or suppressed from PC application CT7-Console. The new instrument comes with a default **Cart** NORMAL that provides all measurements at all wavelengths.

4.1.1 CT7a: Taking a Reference Measurement

Note: Commands CALIBRATE and REFERENCE calls the same function from different MENUs of CT7.

CT7a is a CT7 instrument with moving arm allowing use of internal path transmission as 100.00% reference. Before starting the sequence as for a standard CT7 single measurement, a “reference” measurement shall be executed to calibrate the optical paths of the instrument. By definition the instrument parameters are tuned to obtain 100.00% measurement for all 7 wavelengths.

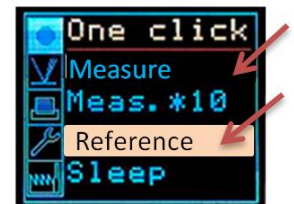
The mirror arm is locked in reference and work positions by means of spring loaded balls. Therefore for the best repeatability an elimination of backlash is necessary. This is achieved by approaching the desired position always from the same direction.



Taking CT7a reference

To execute REFERENCE measurement

- Place mirror arm in REFERENCE position
- Select REFERENCE in ONE-CLICK menu – press OK to start the measurement
- Replace mirror-arm to MEASUREMENT position
- Perform planned measurements /select MEASURE, press OK/



The REFERENCE command is exactly the same as CALIBRATE, i.e. CT7 adjusts internal parameters in function of measured reference mirror. The reference mirror for CT7 is a one with known parameters and 100% of CT7a own optical path.

Note. With exception of two additional mirrors CT7 and CT7a are identical; hence, the latter inherit of the accuracy, stability and repeatability of the former. The interface is identical also, operating with a PC console or selfstanding. In practice, a measuring session with CT7a will be as follows:

- rotate the reference mirror in the down position;
- perform one reference measurement
- rotate the reference mirror in the upper position;
- perform as many measurements as planned.

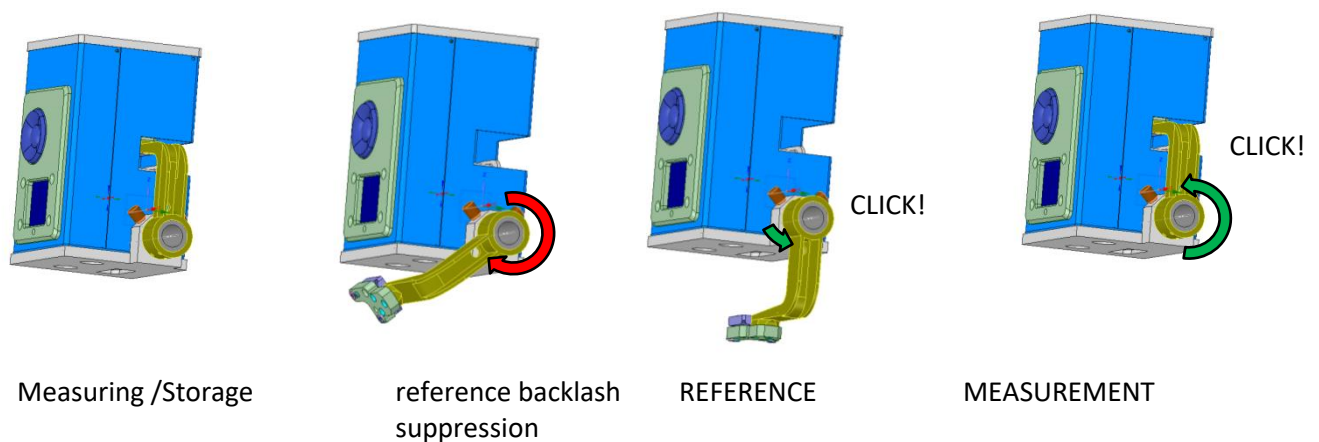
If at any time you have any doubt about the stability or if you want to do a test of stability, rotate the reference mirror back into the down position; perform one measurement; rotate the reference mirror in the upper position; perform the measurements as needed; compare the results.

4.1.2 CT-7a: Practice your rotation

CT-7a inherits accuracy, stability and repeatability of CT-7.

The measurement repeatability and accuracy depends on repeatability of mechanical positioning of the rotating arm. It is important to check how precisely you operate the rotating arm.

A good habit is to use classical backlash suppression technique: approach the desired position always in the same direction.



CT7a backlash suppression rotation movement

We recommend to train operator for the rotation movement of the reference mirror arm by practicing the sequence:

- rotate the reference mirror in the down position with backlash suppression movement;
- perform one REFERENCE measurement (i.e. calibrate to 100%) **/REFERENCE command/**;
- rotate the reference mirror in the upper position;
- rotate again the reference mirror in the down position;
- perform one measurement **while mirror is in the down position /MEASURE command/**;

You shall read a result very close to 100,0% - if not, continue the practice!

For your convenience you may work with CT-7a connected to PC-Console using “Calibration/Reference” and “Measure” buttons on the “CT7 Management” panel.

Hint: press “0.00” or “0.000” button to increase the resolution of data transferred to CT7-Console.

Hint: Before practicing, go to “Measure Configuration” panel and select “Reflection” CART - this will speed-up the measurement by skipping the scattering.

4.1.3 Single measurement in brief

In current use the measure sequence is following:

- Power up CT7 (Press ON button and joystick UP)
- [Keeping it in hand](#), go to MEASURE option and trigger it. [You have 5 seconds](#) before the measurement starts (with on-screen countdown)
- Place CT7 gently on the mirror
- When the measurement is finished, and the results show-up, pick up carefully CT7
- Perform your measurements repeating the above steps
- Once in the office, connect to PC , run [CT7-Console](#) and power-up CT7, activate [SERVICE/PC-Link](#) mode
- Retrieve data from CT7 to archive file
- Sort data by date, by cart, than export to Excel and finish your report with usual edition tools

4.1.4 Professional work-flow

By professional we understand long term tracking of reflectivity/scattering of one or more specific mirrors. Therefore CT7 has a possibility to name the measurements and easily sort the results for given mirror.

- Install CT7 Console provided on CT7 Flash Disk on your PC, and start it
- Connect CT7, awake it and activate SERVICE/ PC-Link mode
- Indicate the COM port to be used (at first connection)
- Open Measurement Configuration Management
- Read Configuration from CT7
- Edit table: selecting wavelengths to be used and give names to CARTs for specific mirrors. [The CART name will help you to sort-out the data for specific mirror.](#)
- Write Configuration to CT7
- Disconnect by closing CT7-Console
- Now you are ready to monitor the mirrors. Select the active CART in menu [MEASURE/ Sel. Cart](#). Perform your measurements following single measurement flow

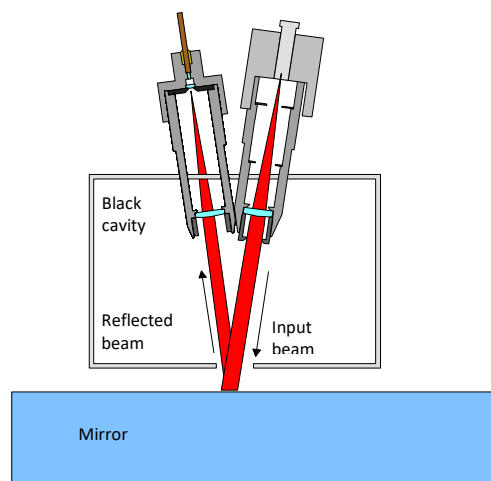
[Note: You may always review results using menu \[Report/Data\]\(#\) of CT7](#)

4.2 CT7 design protects telescope mirror

- Delayed start
- Low sensitivity to the measurement distance

4.2.1 Contact of CT7 with telescope mirror

As the instrument measures specular reflectivity, its angular position with respect to the normal to the mirror's surface must be exact, and this can only be achieved by a three point isostatic contact. The actual contact is provided by three spherical touching feet made out of white Teflon. Teflon can in no way mark the mirror's substrate, but it can mark the coating especially if rubbed. The **delayed start** allows the operator to lay gently the CT7 on the mirror after starting the measurement and remove it after measurement without the need to touch it while it sits on the coating. Moreover, the small incidence angle of the measuring beams makes the result little sensitive to the measurement distance so that **the instrument can stand on an optical tissue**. This tissue (paper or cloth) must provide an opening for the beam (25 mm hole) and should be of equal thickness (± 0.05 mm) under the three feet.



Optical scheme of CT7



Taking a measurement with mirror protecting tissue.

Note: There is a hole (dia 20mm) in the center of the tissue

4.2.2 Delayed Start

By default, triggering “measure” option invokes a 5 seconds delay before the measurement actually starts.

The objective of this feature is protection of the mirror. The **user can set-up and trigger the measurement still holding CT7 in his hands**. When everything is ready, he may carefully place it on fragile telescope mirror, avoiding rubbing of the surface.

The remaining time before measurement is indicated by a countdown on the display and a beep every second.

The delay timer may be set to a value between 0 and 99 seconds.



Count down: 5 seconds before the measurement becomes RED

The time-to-measure is color coded:

- **BLUE** – more than 5 seconds to measure
- **RED** - less than 5 seconds
- **YELLOW** star (*)– measurement in process
- **GREEN** -results table – measure done.

/see the full sequence – para 6.1.1 MEASURE /

4.2.3 Wavelengths selection: Carts and Customized measurements

The user can select 0 to 7 wavelengths to be used for measurement of reflection and 0..7 for scattering.

However, at least one wavelength shall be selected either in reflectivity or in scattering.

Once customized, given configuration may be named and saved.

User can store up to 64 named Carts of customized measurements. The Carts are created, deleted and edited from **CT7-Console**. /see para 4.3.2. PC Software: CT7 Console /

The aim of the **Cart** operation is the following: assuming that the user has a number of telescopes to monitor and that each of them has several mirrors, he can prepare dedicated **Cart** for each mirror .

NOTE: in 2019 was introduced alternative set of LEDs "Set 2019": 325nm, 375nm, 468nm, 523nm, 660nm, 850nm, 940nm, however in this manual most of examples and screen shots is given for "Set 2012": 365nm, 404nm, 464nm, 522nm, 624nm, 760nm, 970nm. The actual list of wavelengths is read from CT7 instrument and wavelength labels of CT7-Console are adapted to the instrument connected.

Index	Name	R 365nm	R 404nm	R 760nm	R 970nm	R 464nm	R 522nm	R 624nm	D 365nm	D 404nm	D 760nm	D 970nm	D 464nm	D 522nm	D 624nm
0	Normal	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
1	Reflection	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	UV 365nm	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	UV 404nm	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	IR 760nm	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	UV 365nm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	UV 404nm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	UV 404nm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17	UV 404nm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18	Mirror T01/1	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
19	Mirror Vis	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
20	Mirror IR	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
21	Mirror UV	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Cart selection list: R-reflection measurements, D- DUST measurements

Even after a long time, without noting anything, the user unloading the CT7 memory in its PC will be able to extract all measurements pertaining to any mirror of a particular telescope and trace its evolution with time (through the date and time attached to each measurement). In this example, we have chosen to select the same measurement sequence for each mirror of the same telescope but this is not requested.

The **Cart** operation is a powerful and simple way of keeping order and uniformity among measurements on the long term.

4.3 CT7 instrument interfaces

4.3.1 Viewing the results

The user can recall the results by selecting the View Results option. The most recent results are displayed first, and can be scrolled back and forward with the joystick.

4.3.2 PC Software: CT7 Console

The PC software is described in section 7 CT7-Console .

The main functions are:

4. Data retrieval
5. CT7 configuration
6. CT7 laboratory operation

4.3.3 Display

CT7 is menu operated. Menu system is inspired by DSLR cameras.

On the left side of the display, there is a category menu with pictograms, on the right side, for selected category, a sub menu presents text options.

In contradiction to LCD displays, this active organic LED display is fully operational in negative temperatures.

4.3.4 Joystick/Navigation Switch

The user selects options from the menu, thanks to a 5 position joystick (left- right, up – down, Enter =OK).

In addition, the joystick provides the Power-On function.

4.3.5 Beep

The operations are confirmed by a short acoustic beep.

4.3.6 USB connector

This is a data interface and an integrated battery charger power connection.

W connected to a PC, it will provide power for battery charging and give access to the PC operation of the instrument when the latter is set to **PC-link** mode.

4.3.1 Battery protection –switch off at low voltage

Battery is protected against uncontrolled discharge, potentially destructive.

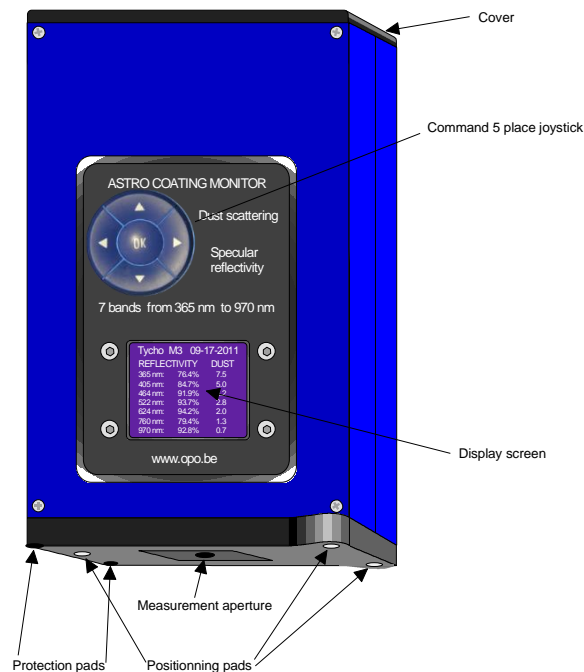
If left unattended, the CT7 will switch OFF after programmed time of 1 to 10 minutes.

In operation, before any action, the battery voltage is measured. If the voltage is dangerously low, after a series of 5 beeps, CT7 will switch off.

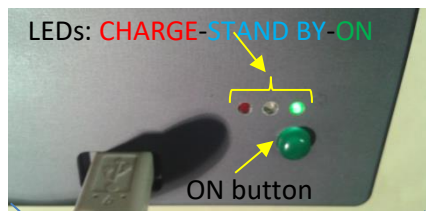
5 CT7 Operation

5.1 CT7 description

The following drawing shows the main features of CT7:



CT-7 Instrument.



On the top cover you find an access for the <mini **USB-B**> connector for connection CT7 to a PC (power and data connection).

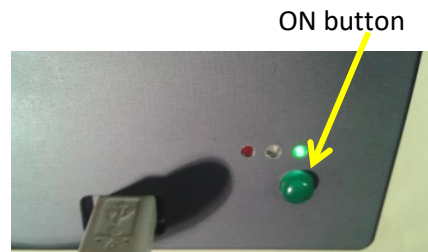
On the back side, there is a 1 mm hole that gives a protected access to a **RESET** switch.

Also on the back side you may find the **Serial Number** of the instrument. The same number is returned by soft to CT7 Console.

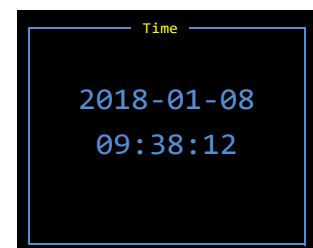
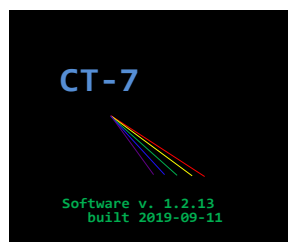
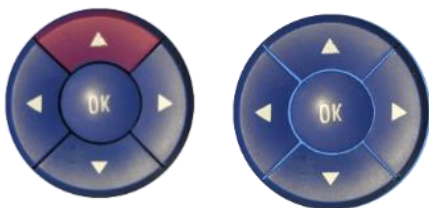
5.2 CT7 basics

5.2.1 Power ON

When performing actual measurements, usually CT7 is not connected to a PC. On Battery, to start, press ON button on the top of the CT7 and simultaneously push the joystick **UP**



Pressing shortly joystick will toggle the supply ON (green LED lights immediately) and initiate processor start-up. After a delay of few seconds, the **Start-up screen** will show up. A couple of seconds later, CT-7 *date and time* will be displayed.



Press UP > backlight appears promptly > Start Screen a few seconds later > and finally the Time.

After next few seconds, the ONE CLICK menu will appear.



NOTE: It is vital to set correctly the date and time. If the date and time is not set, the result indexing is not working correctly. The CT7 will prevent you from making the measurements and communicating with PC.



Time NOT SET >> Go to MEASURE / DATE TIME and set *date and time* or, much easier way: set the date from user friendly interface of **CT7-CONSOLE**.

5.3 Working with menus

The CT7 Interfaces are limited to






1. Color Display
2. Five way Joystick
3. USB connector

In the field operation, the user selects options from the menu with the joystick.

Most of the customization, requiring typing of text data, shall be performed from a PC.



Pressing joystick LEFT activates left column menu of pictograms representing higher level options:

- | | | |
|---|-------------|--------------------------------------|
|  | • One Click | fastest way to measure |
|  | • Measure | measure and related parameters |
|  | • Report | data reviewing |
|  | • Service | PC LINK and utility functions |
|  | • Factory | test and configuration functions |

Once the required menu is selected, pressing ENTER/OK opens the list of the lower level options on the right side.

The following paragraphs explain the available functions.

6 CT7 Menu reference

6.1 One Click menu

Easy operations without settings.

This menu is initiated by awakening the instrument; one can return to this menu from another one by pressing the joystick **LEFT** and selecting the first menu in the left column with the **Up** and **DOWN** positions of the joystick.



6.1.1 MEASURE

At power up **MEASURE** is highlighted on the **One Click** screen: you are ready to perform a measurement using the last CART selected , or by default **NORMAL**. Press OK to initiate the measurement. During “time delay” seconds you shall position the instrument on the mirror before the measurement actually starts. (see also 6.4.3 *Delay ms*).

- The time to measure is counted down on the screen (blue figures).
- 5 seconds before the measurements the color changes to red.
- During the measurement a yellow star is displayed.

The following screens illustrate the sequence:

- Countdown “Blue” - Countdown “Red” - Measure in process - Results



Press **ENTER** to go to the next measurement. Screen **ONE CLICK** appears and you can continue making successive measurements; you can also shift to **Meas.*10** or to **Low noise** type of measurement by selecting the one you want with up and down strokes of the joystick.

6.1.2 Meas.*10

CT7 performs and memorize the basic measurement 10 times and displays the last one on the screen.

6.1.3 Reference

Reference is the same action as **CALIBRATE** in menu **MEASURE** - see 6.2.4

6.1.4 Sleep

The last place on the **One Click** menu is **Sleep** . Entering **Sleep** will shut down the instrument.

6.2 Measure menu

Operations with settings

Selected as the second position in the list on the left of the screen; then go back to the right in order to navigate among the four operation options of the **Measure** menu. (Left – Down – Right)

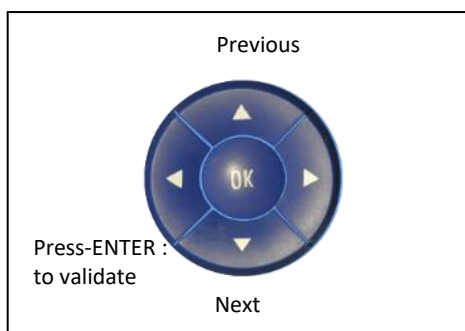


6.2.1 Measure

Measure operation is the same as on the **One Click** menu. Before start of a measurement, the operator is prompted for selection of CART for wavelength selection. The selected Cart becomes default for later operations.

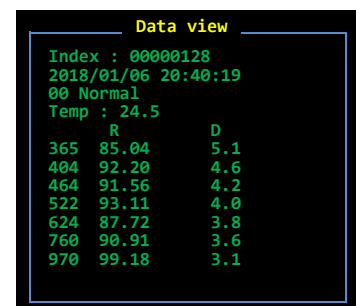
6.2.2 Sel. CART

Sel. CART operation allows selecting as default a CART without making a measurement from a list of pre-defined CARTS.



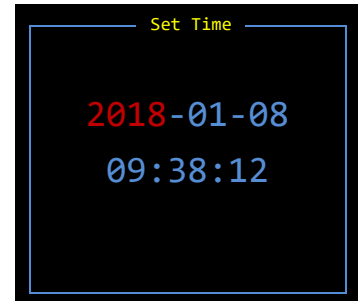
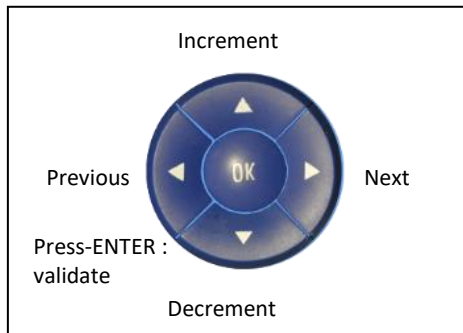
New CARTs or any modifications can only be introduced from CT7 Console. (7.2.12 Measurement Configuration)

After a new **CART** has been selected, the measurement with this CART can be immediately initiated from the same menu by entering **Measure** (one Up). When the measure is finished, the result is shown in **Data View**



6.2.3 Date Time

Date Time operation allows setting or resetting the date and the time. Pressing the joystick LEFT activates setting and entering the selected values (red highlight).



Pressing ENTER finish the date and time edition – red highlight disappears.
Pressing ENTER again, takes us back to MEASURE menu.

Note: There is button **COPY PC-Time to CT7** (on CT7 Console / Device Management panel) allowing one to copy PC time and date to CT in one –click.

6.2.4 Calibrate

In hand-held operation only REFLECTION channel may be calibrated.
Both channels Reflection and Dust Index may be calibrated when connected to PC-Console.

Place CT7 at the calibration target (MIRROR), activate menu **MEASURE / Calibrate**.

CT7a: place the arm in REFERENCE position (down)

Usually calibration is performed on CT7 when one suspects any pollution or if time elapsed since the last calibration is estimated too long, or if some measured values are suspect.

CT7a: CT7a typically is re-referenced before each series of measurement cancelling any aging, contamination or thermal effects.

The instrument performs calibration in sequence:

1. 5 second countdown,
2. measurement of an known mirror.
3. Compute and display coefficients for proofing.
4. Store in nonvolatile memory.

The reference values and actual coefficients may be read and modified in CT7 Console Device Management window.

DUST calibration may be conducted only from CT7-Console.

Note: CT7 may be referenced to local calibration values by changing reference target values in CT7 Console / Device Management, and writing them back to the CT7 instrument. See para. 8.1 Soft Calibration Target values for details.

6.3 Report menu

Reviewing data relative to measures:

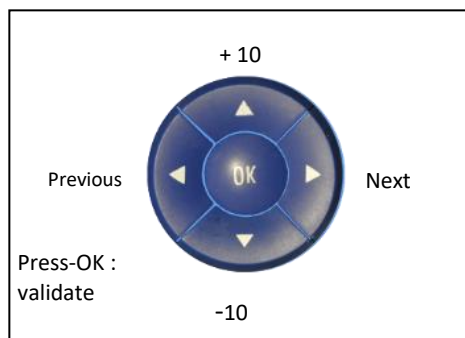
Choose the **Report** menu by navigating in the left column and entering the selected third place (Left – Down – Right).



6.3.1 Data

Data operation allows displaying the results that are memorized in the instrument.

The data pertaining to the last measurement are shown upon entering the **Data** operation.



Data view		
Index :	00000128	
2018/01/06 20:40:19		
00 Normal		
Temp :	24.5	
	R	D
365	85.04	5.1
404	92.20	4.6
464	91.56	4.2
522	93.11	4.0
624	87.72	3.8
760	90.91	3.6
970	99.18	3.1

When the screen shows a measurement data, other measurement can be displayed by navigating with the joystick: **LEFT** for displaying the previous measurement, **RIGHT** for displaying the next, **UP** will move 10 measurements later, and **DOWN** ten measurements before the displayed one. Measurements can be identified by their index and date.

6.3.2 Calib

Calibration coefficients are displayed.

Below the coefficients, there are:

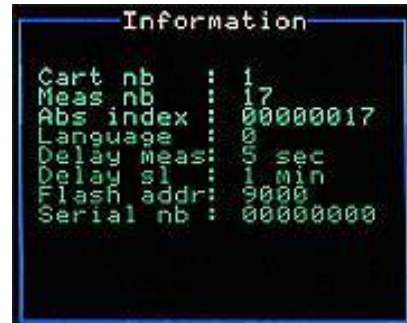
- calibration temperature of reflection channel (for temperature correction)
- date of reflection calibration (Refl:)
- date of dust calibration (Dust:)

Calibration		
LED	R	D
365nm	1.011	3.345
404nm	1.211	3.254
464nm	1.007	3.008
522nm	1.121	3.104
624nm	1.203	3.543
760nm	1.108	3.256
970nm	1.235	3.300
Cal. Temp	23.8 C	
Refl:	2018-01-09	
Dust:	2018-01-10	

Note: OPO has developped a VW jig allowing direct absolute calibration of a gauge just before using it. This is the only procedure that allows checking the calibration of the instrument and correcting it if needed.

6.3.3 Info

This operation will display general information about the instrument as it appears on the screen hereunder.



The list provides following parameters:

- Actual CART #
- Number of measurements in the memory (since last CLEAR)
- Absolute counter of the measurements since assembly of the instrument
- Language selected 0=English
- Delay after Trigger before start of the actual measurements (in seconds)
- Delay before Automatic Sleep (in minutes)
- Flash addr – base address of data block in internal FLASH memory
- Serial number of the CT7 instrument (same as on the back of the housing)
- Flash Addr: - The base address of block of memory actually used . The results, even for hundreds of measurement, are quite limited in volume: several kilobytes. CT7 changes periodically position of data block within its huge 2Gbytes flash data memory to avoid (hypothetic) flash memory burn-out.

6.4 Service menu

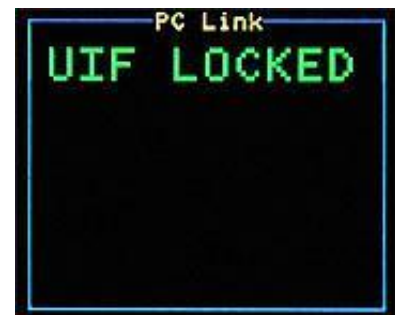
User settable parameters and monitoring



6.4.1 PC Link

PC Link operation is used to connect the instrument to a PC. The PC program **CT7 Console** must run and the USB connection done before this operation can be executed. The connection is validated by a mark in the case "**PC connected**" on the left bottom of the PC screen).

Once this operation has been entered, the autonomous operation of CT7 is disabled (the joystick is not operating anymore. The display shows **UIF LOCKED**. (User Interface Locked)



This status can be reversed by **closing the CT7 Console program** on the PC or by **resetting the instrument** using the reset switch at the rear of CT7.

Note: This mode may be used for long term test of CT7, and the instrument is assumed to be powered by PC via USB, so the Automatic SLEEP function is disabled. However, some PC with active power saving may shut down or hibernate after some time, switching off the USB. In such case CT7 will remain ON and heavy battery discharge may occur. (See "CT7 does not power up" troubleshooting).

6.4.2 Battery

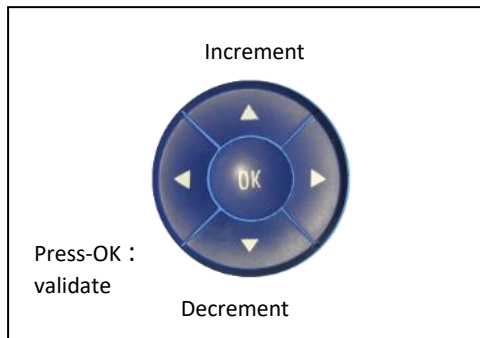
Get the battery voltage and remaining energy estimation.

NOTE: use this percentage as indication, not a measure.



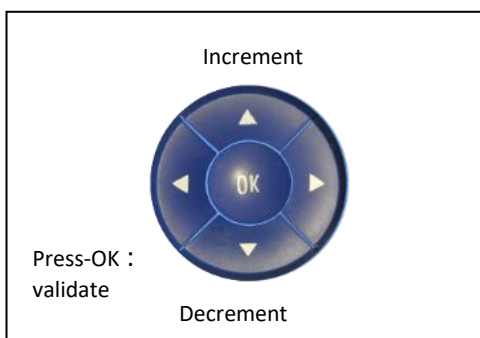
6.4.3 Delay Ms.

Wait time for **Delayed MEASURE**. Set the delay in **seconds** before the measurement starts after pushing the measurement start button.



6.4.4 Delay Sl.

Delay for **SLEEP** function. This operation allows resetting the delay in **minutes** before the instrument goes to sleep after the last touch to the joystick.



Before going to sleep, a beeping count-down will show for ten seconds.



NOTE: automatic sleep count-down is disabled in following actions: "Status", " Meas 1/Minute", and "UIF- Locked". Potentially a deep discharge of the battery may occur!

6.5 Factory menu

Internal settings and housekeeping.

6.5.1 Francais/English – Language toggle

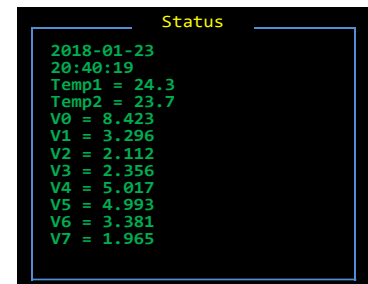
Choice allows toggling between French and English versions of menus.



6.5.2 Status

This operation displays various household data of the instrument the list of which is on the left of the screen.

Temp1 – Detector temperature
Temp2 – Battery temperature
V0 –LED supply: 8.4V
V1 –DSP supply: 3.3V
V2 –USB supply voltage
V3 -Battery voltage (Li Ion: 3V low – 4.2V Fully Charged)
V4 -Digital Supply: 5V
V5- Analog Supply: 5V
V6 -Aux DSP supply: 3.3V



6.5.3 Meas/1 min

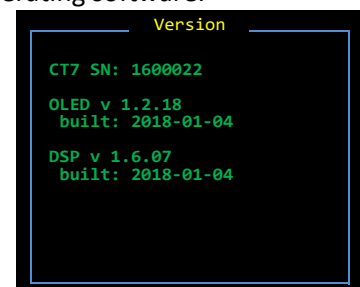
Meas/1 min : the instrument is set to perform and record one measurement per minute in endless loop. The measurements are done using the active CART. This function is used for performing thermal and battery life tests.

Note: Automatic SLEEP function is disabled in this mode. Battery discharge may occur if not powered with USB

6.5.4 Version

Display the serial number of the instrument and the versions of the operating software.

There are two software versions.
CT7 is powered by two processors: one for OLED display handles user interface and a second one, the principal, is a DSP processor, for acquisition control and data processing.



7 CT7-Console

The main functions of this PC interface are:

1. Data retrieval
2. CT7 configuration
3. CT7 laboratory operation

7.1 Installation

7.1.1 Components

Following elements shall be installed on the PC:

- USB driver
- .net Framework necessary for installation (automatic download)
- CT7-Console itself

CT7 installer, together with documentation, is provided on a USB Flash Drive.



NOTE: provided USB Flash stick is just a memory to ease the first steps with CT7.
CT7 does not require hardware key for operation. Same contents may be downloaded from support [www](#).

7.1.2 Win7- Win 10 (32/64 bit) Installation

The installation is performed in only two steps:

- Let Windows7 to find and install USB driver
- Run CT-7 Console setup

Now, let's have a look in details:

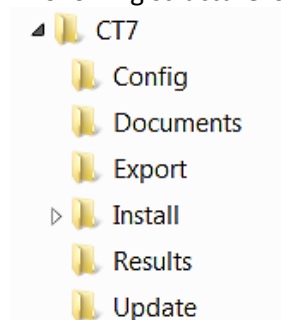
Let Win 7 to install driver:

Power ON the CT7 instrument and connect to USB port of the PC - after few seconds the CT7 device will be available and COM port created (see Hint 3 below).

Install CT7-Console:

Download from <http://www.a1pixel.pl/CT7/ct7-download.html> the latest version of CT7-Console package, extract the contents of CT7.zip to yours "My Documents" folder.

A following structure is created:



Go to **Install** folder and run **Setup**.

Start using the software.

Do not forget to switch CT7 into PC-Link mode (using it's joystick and menu), select the Communication port and you may enjoy the connection.

Hints:

1. Setup aborts if a previous installation performed from a different location is detected. Go to *Control Panel/Programs and features*, and remove the previous version manually.
2. If the driver is not correctly installed, or CT7 is not connected to PC you will most probably get error "No Communication Port Available". Windows creates dynamically the port when CT7 is connected (and powered).

3. Typical message during automatic CT7 driver installation:



7.1.3 Windows XP and Vista (-32) Installation

The installation is performed in only two steps:

- Download and install USB driver
- Download and Run CT-7 Console setup

The PC shall have internet access for downloading the “.net v 3.5” framework during setup.

Now, let's have a look in details:

Install driver:

The USB driver shall be installed manually prior to connection of the instrument.

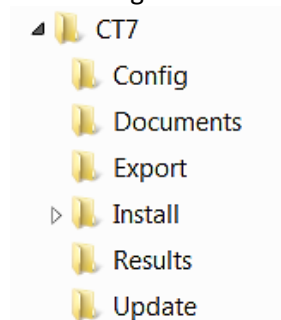
Download from <http://www.a1pixel.pl/CT7/ct7-download.html> the latest version of CT7 driver, extract from ZIP and start Setup

Power ON the CT7 instrument and connect to USB port of the PC - after few seconds the CT7 device will be available and COM port created (see Hint 2 below).

Install CT7-Console:

Download from <http://www.a1pixel.pl/CT7/ct7-download.html> the latest version of CT7-Console package, extract the contents of CT7.zip to yours “My Documents” folder.

A following structure is created:



Go to **Install** folder and run **Setup**.

If necessary, the ".NET framework" will be automatically downloaded (from Microsoft) during the setup of CT7 Console.

Start using the software.

Do not forget to switch CT7 into PC-Link mode (using it's joystick and menu: SERVICE/PC-LINK), select the Communication port and you may enjoy the connection.

Hints:

1. Setup aborts if a previous installation performed from a different location is detected. Go to *Control Panel/Programs and features*, and remove the previous version manually.
2. If the driver is not correctly installed, or CT7 is not connected to PC you will most probably get error "No Communication Port Available". Windows creates dynamically the port when CT7 is connected (and powered).

7.2 CT7-Console reference

7.2.1 Platform

The software is tested on following platforms: XP-32, Vista-32, Win7-32/64, Win10

Note: At XP and Vista systems .Net 3.5 is necessary (downloaded from Microsoft-Update www during installation). Win7 (and later) includes .Net 3.5.

7.2.2 USB connection

The USB interface is built around FTDI FT232D chip configured for *serial port- on-USB*. Windows recognizes this device and creates virtual COM port when CT7 is connected and switched ON.

Win XP and Vista: USB driver shall be installed manually from Ct7\Install folder

Win7/Win10: USB driver is downloaded automatically from Microsoft Update.

7.2.3 CT7 file system

However it is possible to change the folders' locations at ABOUT panel or with save/open file menus, we recommend to use the following folder structure:

CT7	
Config	Storage of CT7 instrument's configuration files (CARTS, parameters)
Documents	Folder of User Manual
Export	Folder for exporting data from Instrument (Data Panel)
Install	CT7Console Installation (setup.exe)
Results	Folder for storing Result Archives and results logged from PC
Update	Updates of firmware: CT7_DSP.bin and Display OLED: CT7.bin

7.2.4 Color convention

Name	Ref Calib coeff	Ref T coef[%]	Ref Target value	Ref LED mod	Ref. Ref PG	Ref. Ref Att	Ref Signal PG	Ref Signal Att	Ref Repeat	Dust Calib coeff	Dust T coef [%]	Dust Target value	Dust LED mod.	Dust Ref PG	Dust Ref Att	Dust Signal PG	Dust Signal Att	Dust noise offset	Dust Repeat	Led DC
365nm	1.0168	0.07100	100.000	1.000	28	1	1	1	1	1.000	0.00000	10.000	1.200	12	1	12	1	0.000	1	160
404nm	1.0277	0.02070	100.000	1.000	26	1	1	1	1	1.000	0.00000	10.000	0.800	12	1	12	1	0.000	1	160
464nm	1.2174	0.02940	100.000	1.000	30	1	2	1	2	1.000	0.00000	10.000	1.000	12	1	12	1	0.000	1	160
522nm	1.3505	0.02720	100.000	1.000	30	1	2	1	4	1.000	0.00000	10.000	0.800	12	1	12	1	0.000	1	160
624nm	1.2161	0.04840	100.000	1.000	30	1	8	1	12	1.000	0.00000	10.000	1.000	12	1	12	1	0.000	1	160
760nm	1.2893	0.02540	100.000	1.000	30	1	1	1	1	1.000	0.00000	10.000	0.800	12	1	12	1	0.000	1	160
970nm	1.5192	0.10210	100.000	1.000	30	1	6	1	12	1.000	0.00000	10.000	1.000	12	1	12	1	0.000	1	160

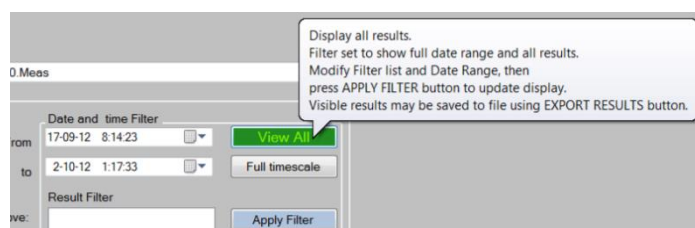
REFLECTION (data, parameters, config, etc.)- green

DUST (data, parameters, config.,

NOTE: in 2019 we have introduced alternative set of LEDs "Set 2019": 325nm, 375nm, 468nm, 523nm, 660nm, 850nm, 940nm, however in this manual most of examples and screen shots is given for "Set 2012": 365nm, 404nm, 464nm, 522nm, 624nm, 760nm, 970nm

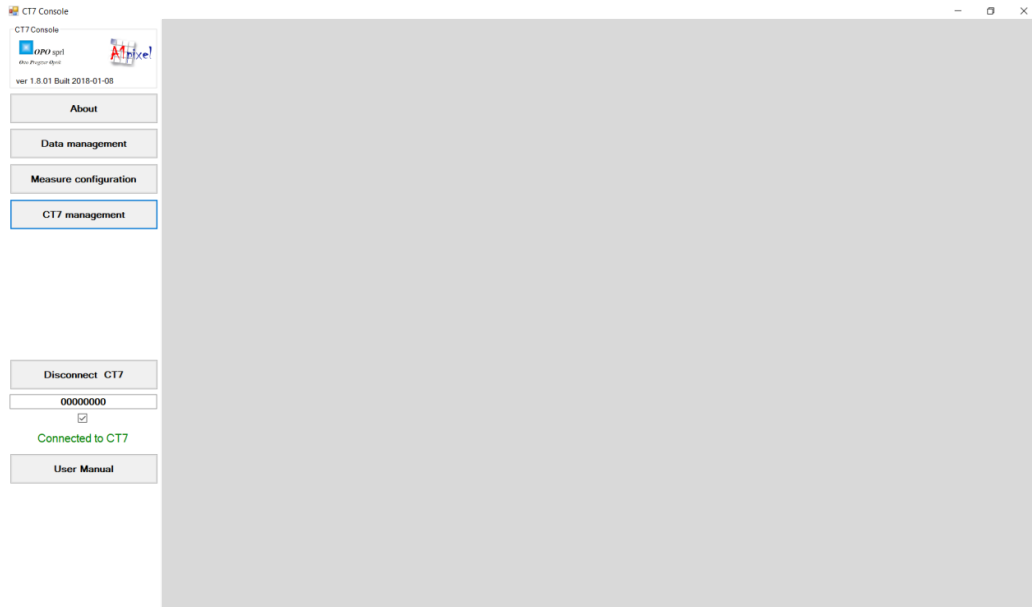
7.2.5 Instant Help

The user interface provides instant help. When the cursor is hanging over a function button or dialog for about 5 seconds, an instant help text appears.



7.2.6 CT7-Console start

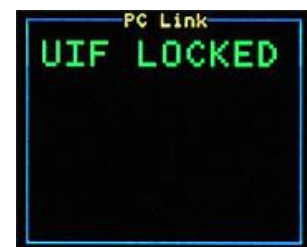
At CT7 Console start, the following screen appears:



The main part of the screen is empty. Following function panels may be called by buttons in the left column of the screen:

- About /version , authors, program mode, file structure, updates /
- Data handling /readout of data from instrument, filtering and export /
- Measurements configuration /selection of wavelength for measurements, editing carts /
- CT7 management /maintenance functions and parameter edition /
- User Manual /opens .pdf document in a new window/

You should observe in the lower left corner of the PC screen the case “**connected/non-connected**” shown as “**Connected to CT7**”. CT7 must be in SERVICE/PC-link state, indicated by message *UIF (user interface) locked*,



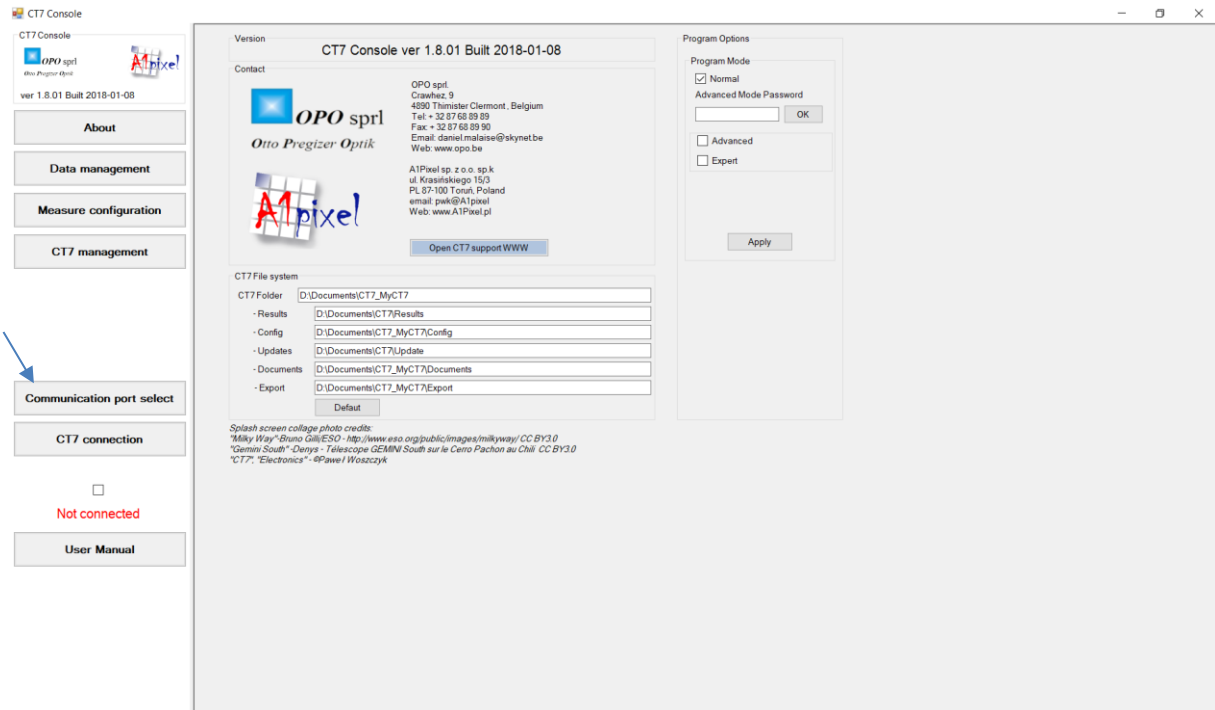
The **DATA MANAGEMENT** panel is fully operational also without CT7 connected.

Button *User Manual* opens the latest issue of the manual present in the CT7 folder.

7.2.7 About

This page contains

- Current software version
- Information on the software version and manufacturers OPO and A1Pixel address.
- Handling of the mode: Normal/ Advanced/ Expert. Mode defines the access to low level functions, parameters and diagnostics.
- CT7 file system configuration



NOTE: Since version 2.0.00 label "Communication port select" reads "COM port select"

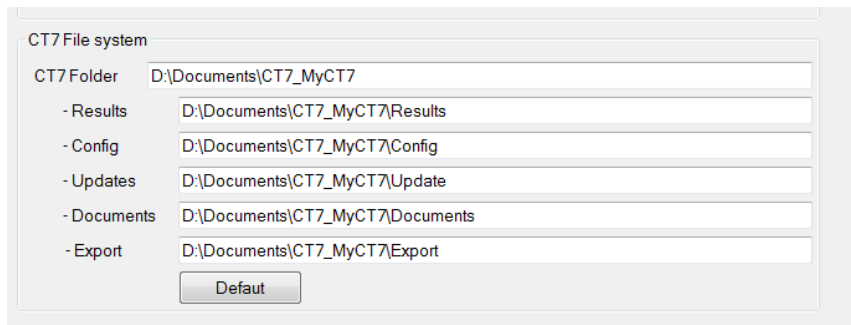
7.2.7.1 Support www page.



On the support www, which opens up after pressing the button, the latest versions information and download may be found. The Tech-Notes provides additional, practical answers to users' questions.

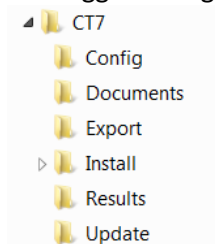
There is no automatic update check.

7.2.7.2 CT7 File system



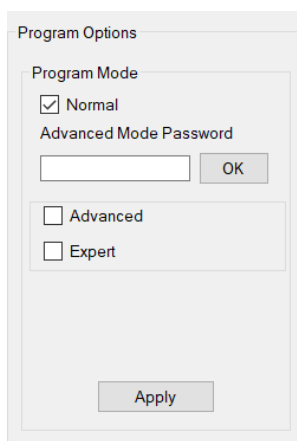
The sample file system is given here. Please observe that CT7 folder is not Documents\CT7\.. – you are absolutely free to keep the files in any folder you wish, even not on the same disk. However in the manual we describe all operations for the default structure, so it is easier to follow the instructions if you use a similar structure.

We suggest using such tree:



Storage of CT7 instrument's configuration files (CARTS, parameters)
Folder of User Manual
Folder for exporting data from Instrument (Data Panel)
CT7Console Installation (setup.exe)
Folder for storing Result Archives and results logged from PC
Updates of firmware: CT7_DSP.bin and Display OLED: CT7.bin

7.2.7.3 Program mode



The difference between program modes is a number of available functions, specially for CT7 Management.
Normal program mode is typical end-user mode with data management and houkeeping monitoring functions.
Advanced – additional functions for internal parameters edition are available.
Expert – all features, including factory setup, testing and peripheral devices.

Advanced and Expert modes are not described in this document. In case of need of in-deep diagnostics instructions will be provided by support team.

Passwords:

Normal: none

Avanced: "Mizar"

Expert: "MPC 14382" or "MoonLight"

Note: *Moonlight* was added as easier to remember. By the way: check Minor Planet 14382.

7.2.8 Data management

This entry initiates a function allowing manipulating the data, retrieving data from the instrument and saving them into the PC etc. Note that only the data recorded off line in the CT7 are concerned here; data recorded in PC mode are directly entered in a PC file and do not transit through the CT7.

It is operated through a self-explanatory screen as it appears below.

NOTE: in 2019 we have introduced alternative set of LEDs "Set 2019" : 325nm, 375nm, 468nm, 523nm, 660nm, 850nm, 940nm, however in this manual most of examples and screen shots is given for "Set 2012": 365nm, 404nm, 464nm, 522nm, 624nm, 760nm, 970nm

The screenshot displays the CT7 Console software interface. On the left, there is a sidebar with buttons for 'About', 'Data management', 'Measure configuration', and 'CT7 management'. The main window shows a table of measurement data with columns for Index, Date/Time, ID, Name, T°C, and various wavelength channels (R 365nm, R 404nm, R 460nm, R 522nm, R 630nm, R 760nm, R 970nm, D 365nm, D 404nm, D 460nm, D 522nm, D 630nm, D 760nm, D 970nm). Below the table, there is a section for 'ArchiveFile CT7 S/N : 00016022' with options to 'Change Archive File' and 'D:\Documents\CT7\Results\16022_test.Meas'. The 'Result Selection Filter' section allows filtering by 'Available Dates and time' and 'Date and time Filter'. The 'CT7 Import Results' section shows 'CT7 serial number' as 00016022 and 'Results in CT7 memory' as 26. There are buttons for 'Read CT7 results', 'Clear CT7 memory', 'Export Results', 'Show Charts', 'Last Calibration', 'Change CAL coeff.', 'Set CT7 to PC clock', 'Export CT7 Config', 'Import CT7 Config', 'Test CT7 Power', and 'CT7 Management'.

You have to define and save a folder to keep the data of the CT7 that is connected to the PC; once defined, each time the same instrument is connected, and it will open the defined folder and if data are read out from the CT7 new data will be appended to the previous ones in the folder.

7.2.8.1 Reading the results from CT7

In order to read new data from the CT7 you have to push the button **Read measurements** from CT7. Only new measurements will be appended to the folder.

The screenshot shows the 'CT7 Import Results' dialog box. It contains a 'CT7 serial number' field with the value '00000000', a 'Results in CT7 memory' field with the value '94', and a 'Read CT7 results' button.

Finish the operation and accept the data by pressing **Archive results**.

7.2.8.2 Result Filter

For selecting, comparing particular CART results, you should work with **Result Selection Filter**.

In the left column available results are displayed, in the right one – the selected ones.

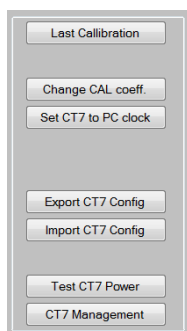
To see all results in the file press **View All** button (green).

- Select date range defined in the two dialogs at the top right of **Result Selection Filter** box :
- Select results by their name from a list of available cart names.
- The Available list is limited in time between two selected dates. Select data names in the **“Available list”** (left box) and toggle them to the Selected list (right box) using the appropriate button in between the two boxes (>); if you want to select all available data, use the >> button. The reverse buttons are used to suppress data names from the Select list.
- Once you have completed the selection you want, you may inspect the selected data (by pressing **Apply Filter**).
- Export the selected measurements for further handling by pressing **Export Results** button.

7.2.8.3 Mini CT7-Management pane

Some most common CT7-Management functions have been mirrored here for your convenience.

Please refer to CT-Management paragraphs for more in-depth description.



- Recall last calibration values and dates
- Go to CT7 Management to modify any parameter, in particular Target mirror or scattering sample value
- Set the real time clock of CT7 to actual time of PC
- Read all parameters from CT7 and save them to a .txt configuration file
- Import to CT7 parameters set from a configuration file
- Test the quality of USB power source and internal voltages
- Go to CT7 Management panel

7.2.9 Working with data

7.2.9.1 Archive file

The data from the Instrument may be retrieved to the PC and stored to the archive file. This file contains ALL the measurements retrieved from CT7.

The archive file is watermarked with CT7 serial number so it is not possible to mix results from different instruments in one file. On the other hand more than one file may be created for one instrument.

It is possible to work offline with archive file.

7.2.9.2 Data sorting

The viewer of CT-7 console allows sorting data by date and by cart.

7.2.9.3 Exporting data

The selected data lines may be stored in CVS format for further processing in EXCEL. Eventually a conversion DATA/ Text to columns may be necessary (delimited by tabulation). Excel provides full interface for graphic data presentation and report creation.

7.2.9.4 Data format

The fields in exported CVS file are separated with tabulation sign.
The record is terminated by a Carriage Return.

Time stamp; Cart; R1; R2; R3; R4;.. R7; S1; S2; .. S7; CR

Note: The user may select or not specific wavelengths for given CART. The results for not used bands are replaced by a place holder: zero "0"

Where:

Time Stamp yyyy/mm/dd hh:mm:ss

Cart: the name given for selection of wavelength used for this measurement

Rx - reflection for given emitter in %

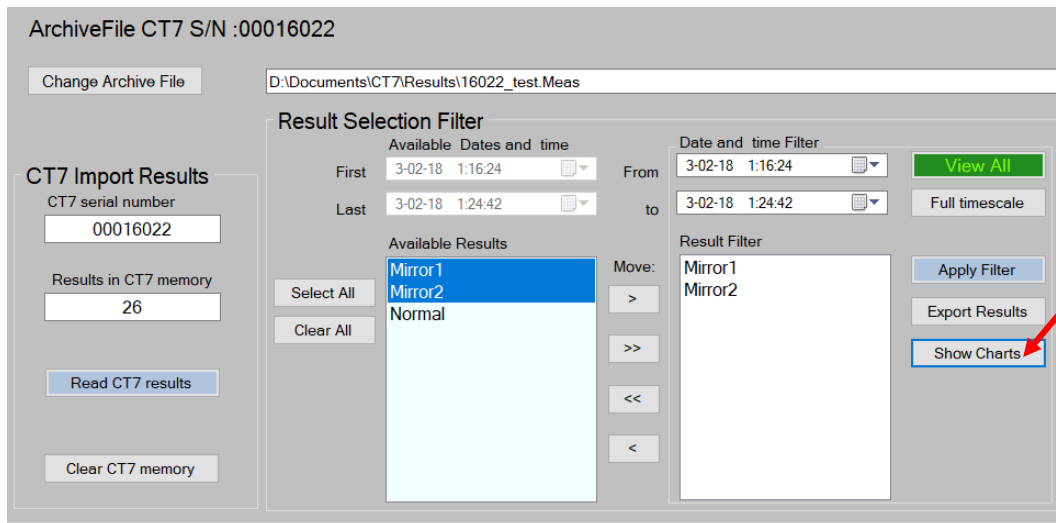
Sx - scattering (DUST) index for given emitter in %

Decimal separator: dot .

NOTE: In certain countries once .csv data is uploaded to Excel, the dots shall be replaced by commas before Excel recognize data as numbers.

7.2.10 Graph of archived results

7.2.10.1 General



The graphs are called in by pressing Show Charts button.

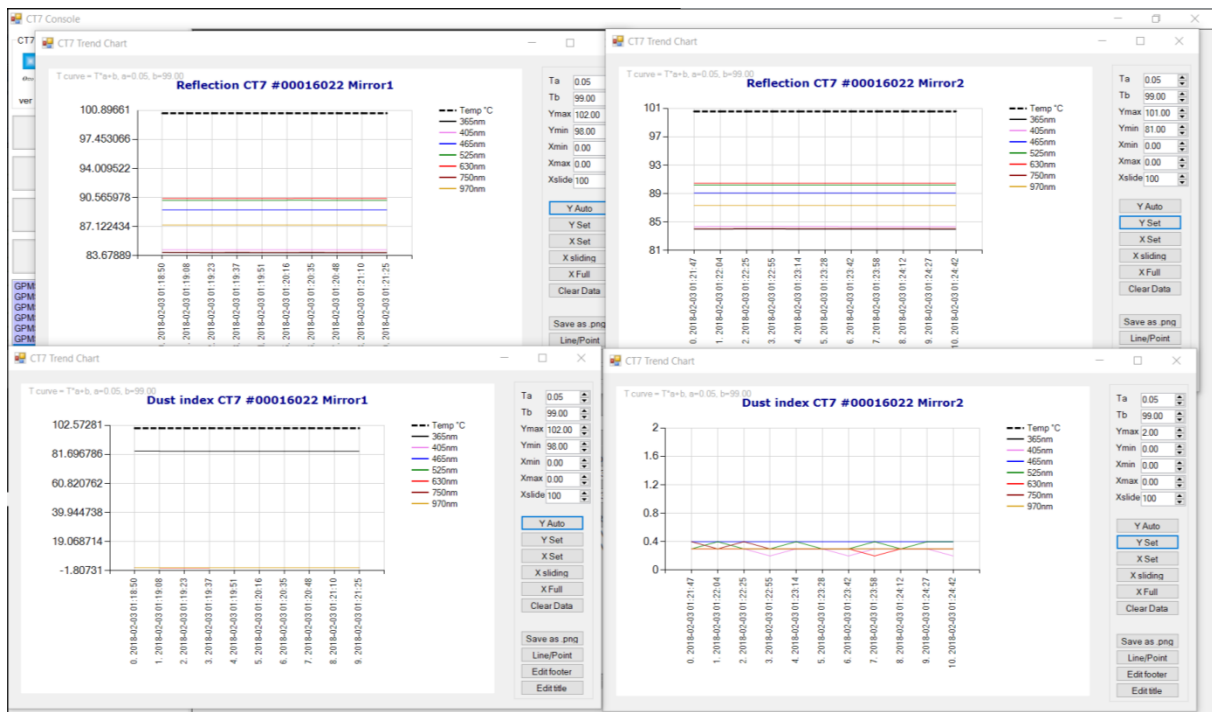
Only visible (filtered) results are processed by Show Chart function.

The X axis is the date and time, but in fact position on X axis is result index labelled with date.

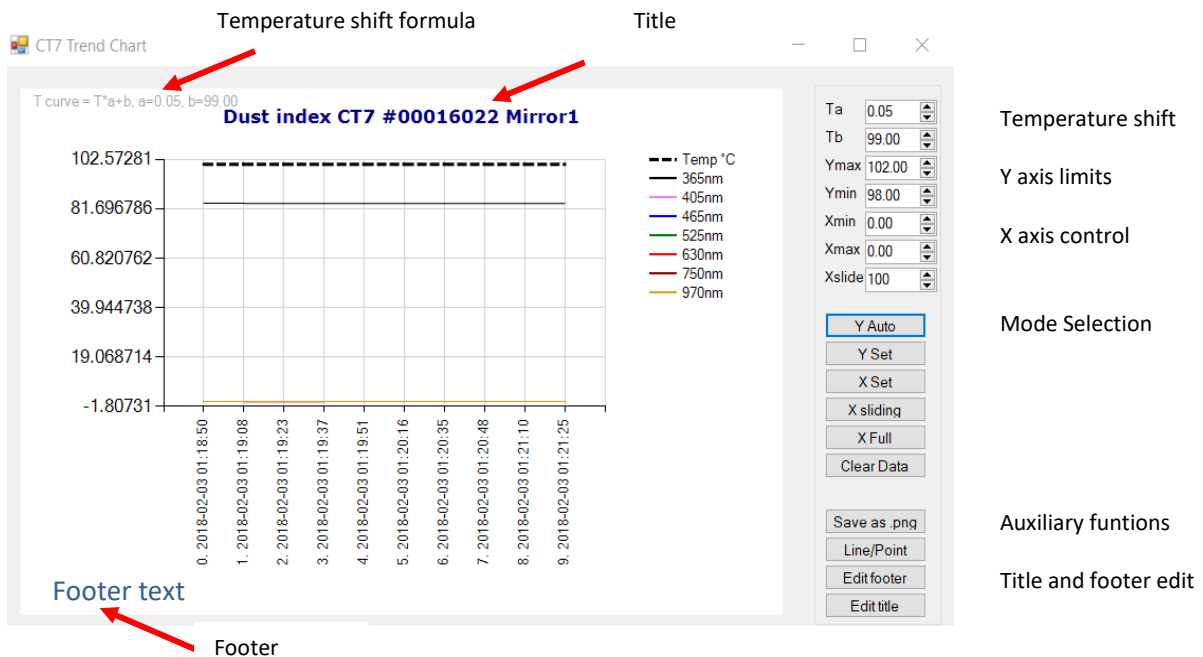
(i.e. time interval is not represented, only measurement position in series).

For each named measure, (like Mirror1) a pair of graphs is created: Reflection and Dust index one.

For example if Mirror1 and Mirror2 results are filtered out, the following charts will be created:



7.2.11 Chart functions



7.2.11.1 Auxiliary functions: save as .png, Title and Header edit, line/dot

Once results are shown for desired data range, and Y axis is set for nice presentation, the graph (the white area) may be saved as .png image by pressing *Save as .png* button.

By using *Title* and *Footer* text, a minimum description may be incorporated in the image itself. The button *Line/Point* toggles the style of the data curve.

7.2.11.2 Shifted temperature curve

The temperature which is normally in range -5..+30°C, does not fit into scale of the Reflection (~ 85) nor the Dust index (~ 1..5). The curve Temp on the graph is calculated with a formula $T_{curve} = T_a * T + T_b$, where T_a and T_b coefficients are editable in the left side dialog boxes. The current formula is shown at the graph upper left corner. This temperature curve shift and scale allows showing of the temperature change on the same graph region as the results. Press *Show Charts* button to apply the new values.

7.2.11.3 Y axis limits

Y axis limits for manual Y mode. (*Y-set* button)

7.2.11.4 X axis limits

X axis limits for manual X mode. (*X-set* button)

X-slide – number of last x points shown in *X-sliding* mode

7.2.11.5 Axis mode selection buttons

X-Set and *Y set* activate manual scaling of respective axis.

X-sliding – only selected number of last measurements is shown.

X-Full – cancels *X-manual* and *X-sliding* mode, all data points are shown

X-clear – removes from graph memory all data points, *X-full* will show 0 results.

7.2.12 Measurement Configuration

This function allows the user to define modify or cancel measurement CARTs, read the CARTs that are memorized in the CT7 and load CARTs in the CT7 memory.

These tasks are managed and performed through a graphic interface as shown below.

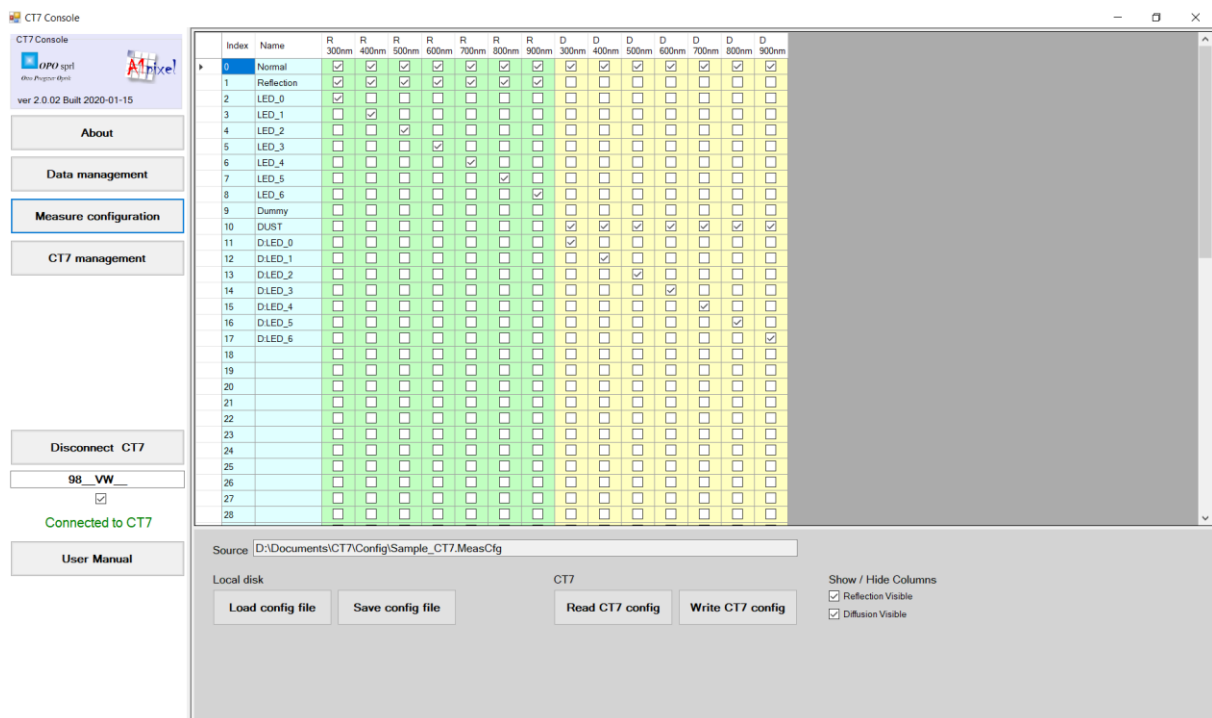
- Loading from an external file
- Saving in an external file
- Reading from CT
- Writing to CT7

The first two commands allow exchanging lists of CARTs between an external folder that you have defined and a CT7 instrument. This might be useful when several CT7 must work with the same choice of CARTs for instance.

The last two commands allow exchanging a list of CARTs between the PC and any CT7 instrument.

In the list, each line is a CART for which you may chose a name and select any combination of measurements. There should be at least one measurement on each CART.

The first CART, *NORMAL* (# 0) contains all measurement and cannot be modified or removed.



7.2.13 CT7 management

This screen allows to perform measurements, calibration and to introduce parameters into the CT7. This is done through a graphic interface shown below.

When **log** checkbox is checked, the displayed data is saved to a log file .csv .
The results are always appended to log file. No file is re-written.
Single and continuous measurements are logged in the same way.
Continuous measure allows endless measurements loop with **Interval** time between the measurements.

Show / Hide columns:
☒ Reflection Visible
☒ Diffusion Visible

The check-boxes allow to show or to hide columns of the results. No data is lost, the figures may be recalled at any time.

See the next paragraphs for description of available functions.

Hint: You may copy data from screen to clipboard and paste them to Excel.

Note:

The measurements initiated from PC are not stored to internal CT7 memory.
They are not included into result archive file, but they may be logged to log file or copied to Excel from screen.

7.2.14 CT7 Parameters Table

The large table in the bottom part of the page contains all parameters crucial for CT7 precision. In the NORMAL mode writing is disabled except of nominal values for reflection and diffusion targets used for calibration. The two columns with darker background: *Refl Target value* and *Dust Target value* can be written to flash memory of CT7 with buttons:



as explained in section 8.1 Soft Calibration Target values.

The others parameters are:

Name	Refl Calib coeff	Refl T coef[%]	Refl Target value	Refl LED mod	Refl. Ref PG	Refl. Ref Att	Refl Signal PG	Refl Signal Att	Refl Repeat	Dust Calib coeff	Dust T coef [%]	Dust Target value	Dust LED mod.	Dust Ref PG	Dust Ref Att	Dust Signal PG	Dust Signal Att	Dust noise offset	Dust Repeat	Led DC
365nm	1.0168	0.07100	100.000	1.000	28	1	1	1	1	1.000	0.00000	10.000	1.200	12	1	12	1	0.000	1	160

Parameter	Description
	REFLECTION Channel
Refl Calib Coeff	Calibration coefficient (calculated during calibration)
Refl T coef[%]	Thermal coefficient
Refl Target value	Nominal value of the reference target (mirror) in % - user settable. CT7a: always 100.00%
Refl LED mod	% of LED current amplitude to be used for modulation
Refl Ref PG	Analog Programmable Gain of the DSP processor for the reference channel
Refl Ref Att	Analog programmable attenuation of signal at DSP input for the reference channel
Refl Signal PG	Analog Programmable Gain of the DSP processor for the signal channel
Refl Signal Att	Analog programmable attenuation of signal at DSP input for the signal channel
Refl Repeat	Number of basic measurement blocks to use for the measure
	Dust Channel
Dust Calib Coef[%]	Calibration coefficient (calculated during calibration)
Dust T coef [%]	Thermal coefficient
Dust Target value	Nominal value of the reference target (diffuser) in % - user settable
Dust LED mod	% of LED current amplitude to be used for modulation
Dust Ref PG	Analog Programmable Gain of the DSP processor for the reference channel
Dust Ref Att	Analog programmable attenuation of signal at DSP input for the reference channel
Dust Signal PG	Analog Programmable Gain of the DSP processor for the signal channel
Dust Signal Att	Analog programmable attenuation of signal at DSP input for the signal channel
Dust repeat	Number of basic measurement blocks to use for the measure
Dust Noise offset	Noise offset floor of the channel
	Common
LED DC	DC current (bias) for the LED (Full amplitude in 254 steps)

7.2.15 CT7 Management Function Buttons

7.2.15.1 Single meas.

When pressed, the measure defined by selected on MEAS MANAGEMENT panel *cart* is performed once.

7.2.15.2 Calibration

Perform calibration – see para. 8.2.3 Calibration from CT7-Console.

7.2.15.3 Change CT7 readout resolution.

Beginning with version v 1.6.07 (built 2018-01-04) CT7 by default sends data with 2 decimals. In some situations it may be interesting to send 1, 2 or 3 decimals.

Date Time	Name	T°	R 365nm	R 404nm	R 460nm	R 522nm	R 630nm	R 760nm	R 970nm	D 365nm	D 404nm	D 460nm	D 522nm	D 630nm	D 760nm	D 970nm
2018-02-03 00:03:00	Mirror1	27.53	84.9	89.1	82.0	85.6	92.0	91.9	90.3	0.6	0.7	0.6	0.6	0.4	0.5	0.6
2018-02-03 00:04:00	Mirror1	27.63	84.9	89.1	82.0	85.6	92.0	91.9	90.3	0.7	0.7	0.6	0.7	0.4	0.6	0.7
2018-02-03 00:04:32	Mirror1	27.75	84.9	89.1	82.0	85.6	92.0	91.9	90.3	0.7	0.7	0.6	0.6	0.4	0.6	0.7
2018-02-03 00:04:53	Mirror2	27.88	84.84	89.10	81.98	85.61	92.03	91.94	90.26	0.65	0.67	0.63	0.63	0.42	0.53	0.64
2018-02-03 00:05:03	Mirror2	27.91	84.82	89.09	81.98	85.61	92.03	91.94	90.25	0.67	0.62	0.58	0.65	0.43	0.56	0.72
2018-02-03 00:05:12	Mirror2	28.03	84.81	89.09	81.98	85.61	92.03	91.94	90.24	0.71	0.74	0.62	0.62	0.40	0.48	0.64
2018-02-03 00:05:32	Mirror3	28.16	84.824	89.091	81.975	85.607	92.033	91.928	90.247	0.636	0.663	0.647	0.648	0.422	0.518	0.628
2018-02-03 00:05:42	Mirror3	28.16	84.803	89.088	81.975	85.608	92.035	91.920	90.239	0.696	0.693	0.593	0.608	0.403	0.513	0.687
2018-02-03 00:05:52	Mirror3	28.25	84.795	89.085	81.972	85.608	92.035	91.917	90.239	0.601	0.691	0.602	0.551	0.338	0.523	0.710

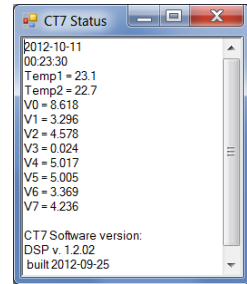
NOTE: When disconnected from PC, in the internal CT7 flash memory there are stored results with :
REFLECTION: 2 decimals
DUST INDEX: 1 decimal

7.2.15.4 Save Data Grid

This button allows for saving at any moment the visible in the data grid results as .CVS Excel compatible file.

7.2.15.5 Status

This function retrieves internal voltage and software versions from CT7.
See para 8.3.3 Testing USB cable with CT7Console for discussion of voltages.



7.2.15.6 Export Params/Import Params

This pair of functions allow saving (export) and loading (import) all CT7 parameters. The configuration file contains the data in a *.ini* style file and may be imported as a whole or only for selected parameters.

The file contains parameters and diagnostic information about CT7 and CT7-Console. Only the parameters grouped in blocks are uploaded:

[CONSOLE]
[Channels]
[DSPchannels]
[DSPparams]

Selective import of parameters is discussed in para. 8.1 Soft Calibration Target values .

It is important to remember that the parameter shall be preceded by his group header. CT7 Console will not start to look after this parameter until the group header is read. Use as a model the sample config file in *Annex 3 - Configuration file (Export/Import)*

7.2.15.7 Test CT7 Power

Performs test of CT7 power system and returns results with comments. This function is discussed in para. 8.3.38.3.3 Testing USB cable with CT7Console.

7.2.15.8 Read CT7

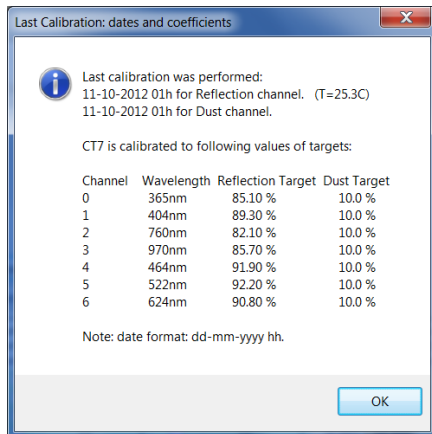
Reads all parameters from CT7 and display them on screen.

7.2.15.9 Write Mirror Target/Write Dust Target

You may manually edit columns of target coefficients for reflection and dust. These buttons write their respective columns to CT7. Another way to change these parameters is a use of **Import Params** function – see para. 8.1 *Soft Calibration Target values*.

7.2.15.10 Show last calibration

Recalls target sample parameters and the last calibration date stored in CT7 flash memory.



Note: Strictly speaking the target values are the ones actually in the memory, possibly the ones used to find the calibrations coefficients have been overwritten. In case of doubt, check the target coefficients and re-calibrate.

7.2.15.11 Set CT7 To PC Clock

This function get *time & date* from PC clock and adjust CT7 real time clock to this value. Very useful when changing the battery,

7.2.15.12 Start/Stop

Starts / stops the measurements defined by selected on MEAS MANAGEMENT panel *cart* is performed in a loop with *interval* period.

7.2.15.13 Log

When checked, all the results appearing in the results grid are logged to a file in append mode.

7.2.15.14 Interval

Selection of interval of LOOP MEASURE. When START is pressed the measure defined by selected on MEAS MANAGEMENT panel *cart* is performed each *interval* seconds/minutes.

7.2.15.15 DSP Update

Upload update of DSP firmware to CT7-Instrument. The uploaded file MUST be named CT7_DSP.bin. The process lasts literally few second. A progress-bar shows the status. The user is guided by messages popping-up at each step. The upload ends with manual restart of CT7, and manual re-connection to PC.

In case of problems reset CT7 by pressing with a pen-tip the hidden RESET switch at the back, restart and connect to PC normally.

7.2.15.16 OLED Update (Advanced mode)

Function available in *Advanced* and *Expert* mode of Console operation (change at Panel ABOUT, password required, 7.2.7.3 Program mode).

Update of OLED (display) firmware. The process is described in the chapter 8.5 CT7 display firmware update.

7.2.15.17 Connect OLED to SDK (Advanced mode)

NOTE : For Factory use.

Function available in *Advanced* and *Expert* mode of Console operation (change at Panel ABOUT, password required, 7.2.7.3 Program mode).

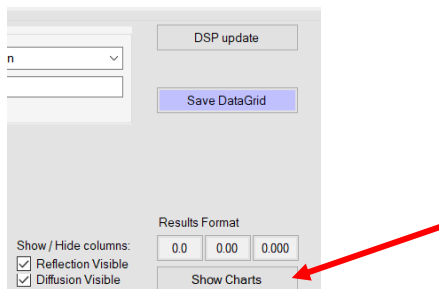
Update of OLED (display) firmware from 4DSYSTEMS SDK, source code needed.

CT7 console will close.

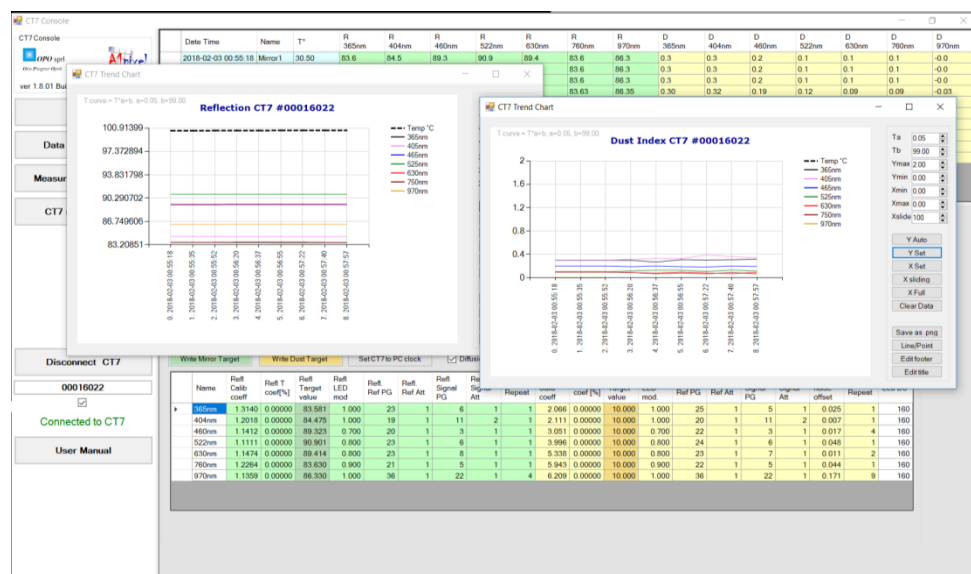
CT7 Instrument makes available direct USB connection to OLED, with proper SDK it is possible to upload any code to OLED. Navigation Switch is not operating.

Exit from this mode by pressing RESET button at the back of the CT7 instrument.

7.2.15.18 Show Charts



This button creates 2 charts: one for *Reflection* and one for *Dust Index* for all results present in the data grid.



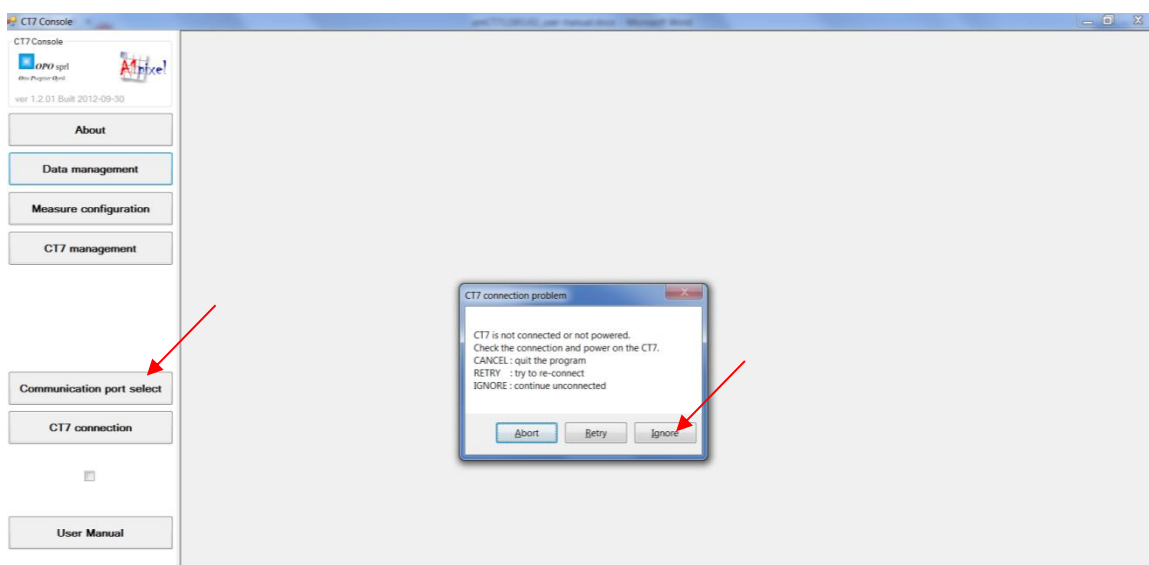
More information how to control the charts is presented in chapter: 7.2.11 Chart functions.

7.2.16 Connecting to CT7

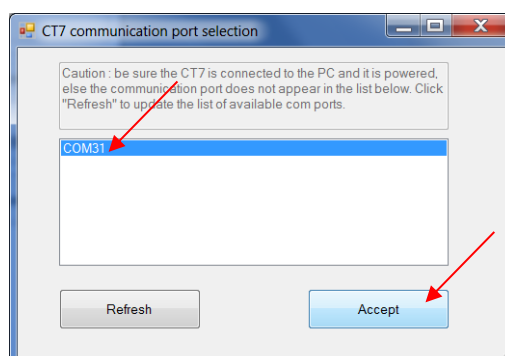
To use the PC-Link mode at CT7, you must:

- Connect the **CT7** with PC (*USB cable*)
- Awake **CT7**, activate **PC-link** (para 6.4.1 PC Link) (With the left menu (LEFT) select SERVICE (DOWN - DOWN); then select (RIGHT) and Enter the PC-Link function.)
- Run the **CT7 Console** program on PC,

Especially for the first time connection, you should observe in the lower left corner of the PC screen the case “**connected/non-connected**” shown as “**connected**”. If this is not the case, probably the time-out message will pop-up CONNECTION PROBLEM.



Press **Ignore** to acknowledge this message and push the button **Communication Port Select**. A list of active COM ports appears. Most probably the CT7 port is the last one on the list. Select it and press **ACCEPT** button:



Then try again the connection to CT7 – press **CT7 Connection** button. If connection is established, at the left bottom of the screen a message **Connected to CT7** will appear. The COM port number is stored, and the next time the connection will be transparent. In case of persisting connection problem see troubleshooting.

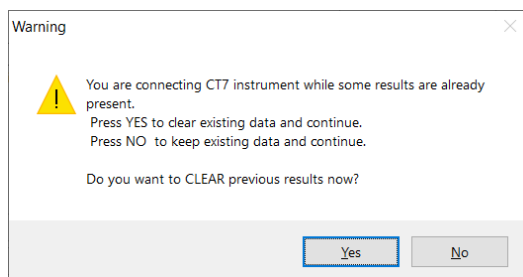
7.2.16.1 Connecting more than one instrument to CT7-Console

When some data are already present in the data-grid, importing more data from another instrument may lead to confusion.

NOTE:

The wavelengths labels are set accordingly to wavelengths list of actually connected CT7 instrument.

The last step in connection procedure is decision to clear the data-grid (or not).



If the already collected data comes from the same instrument, there is no reason to clear the previous results – select 'NO'.

If the already collected data comes from another instrument, we do not want to mix the results – select 'YES' to clear data-grid, parameters-grid and charts.

NOTE: Any time you may delete unwanted data rows. Simply select the unwanted data-grid rows and press 'Delete' keyboard-key.

8 Maintenance

8.1 Soft Calibration Target values

Note1: CT-7a is able to measure its own optical path, obtaining absolute by definition 100.00% reflectivity reference. However, if it is used with a gauge as reference, it becomes standard CT-7 and presented hereby procedure is fully applicable.

CT7 has no intrinsic reflectivity reference. The construction of the instrument and measurement technique ensures very high precision and stability of measured ratio of source intensity and returned signal.

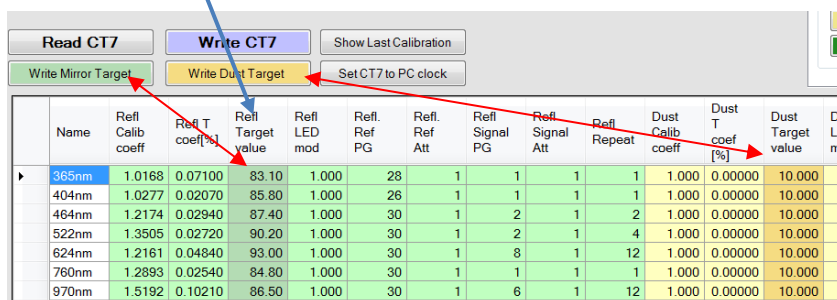
This ratio is converted to reflectivity value by dividing it by *calibration coefficient* which is found by measuring the known mirror in CALIBRATION operation.

For user convenience, a first surface AL mirror is provided as calibration reflectivity target. (see also para 8.2.1 Calibration Target)

Note2: At delivery CT7 will be loaded with parameters of provided reference mirror.

These parameters may slightly vary from values given in this manual.

Note3: For CT7a the Reflectivity Target is always 100.0% and shall not be modified unless deliberately decided to work with a gauge (see note 1)



	Name	Refl. Calib. coeff	Refl. T. coef[%]	Refl. Target value	Refl. LED mod	Refl. Ref. PG	Refl. Ref. Att	Refl. Signal PG	Refl. Signal Att	Refl. Repeat	Dust Calib. coeff	Dust T. coef [%]	Dust Target value	Du. LE mc
▶	365nm	1.0168	0.07100	83.10	1.000	28	1	1	1	1	1.000	0.00000	10.000	
	404nm	1.0277	0.02070	85.80	1.000	26	1	1	1	1	1.000	0.00000	10.000	
	464nm	1.2174	0.02940	87.40	1.000	30	1	2	1	2	1.000	0.00000	10.000	
	522nm	1.3505	0.02720	90.20	1.000	30	1	2	1	4	1.000	0.00000	10.000	
	624nm	1.2161	0.04840	93.00	1.000	30	1	8	1	12	1.000	0.00000	10.000	
	760nm	1.2893	0.02540	84.80	1.000	30	1	1	1	1	1.000	0.00000	10.000	
	970nm	1.5192	0.10210	86.50	1.000	30	1	6	1	12	1.000	0.00000	10.000	

The columns of Target values may be edited and uploaded to CT7 with **Write Mirror Target** and **Write Dust Target** buttons respectively. After changing values you must perform CALIBRATION on your sample. The change of target values may be performed with **IMPORT Param.** Function by importing your text file, named for example *MyTargetMirror.txt*, including just following lines:

```
[Channels]
RTcoef={83.1;85.8;87.4;90.2;93.0;84.4;86.7}
```

The figures are the reflectivity values of Al mirrors respectively for wavelengths of 7 installed LEDs. Similar formula for dust target:

```
[Channels]
DTcoef={10.0; 10.0; 10.0; 10.0; 10.0; 10.0; 10.0}
```

The CT7/Config folder contains file CT7_MirrorCoefficientsSample.txt. Importing this file will change only calibration target reflectivity values. **Simply replace our data by yours (yellow line), Import the file to CT7 and perform Calibration on your sample.**

;CT7 Parameters file

; This is a sample file allowing changing and keeping the reference of reflectivity values used for calibration of CT7

; The list of channels is given as a reminder of wavelength sequence

; You may replace reflectivity values of RTcoef (OPO Al mirror) by your values.

; Importing this file to CT7 will change only one column in parameters table and CT7 flash memory

; Note:

;1. The keywords: [Channels], RTcoef are obligatory, ";" is a comment sign

;2. You must use a DOT "." as decimal separator

;3. DTcoef is analogue parameter for dust

[Channels]

; wavelength deep-UV , UV, Blue, Greed, Red, NIR, deep-NIR

; LED list 1: 365nm; 404nm; 464nm; 522nm; 624nm; 760nm; 970nm

; LED list 2: 324nm - 940nm

RTcoef={85.1;89.3;91.9;92.2;90.8;82.1;85.7}

8.2 Calibration (Reference)

CT7: the instrument returns reflectivity values based on ratio of emitted and received light multiplied by *calibration coefficient* specific for each wavelength. The calibration process determines the scale for the measurements providing known point on 0 to 100% linear characteristics of CT7 channels. After calibration CT7 will provide the results according to this scale.

The measurement method, construction of the instrument, and processing algorithm were engineered in such way that only optical path degradation (dust, scratches, ageing) may change the reading.

A calibration target mirror with reflectivity measured in our labs is provided as physical reference (note: even this reference is subjected to ageing and degradations).

The instrument may be calibrated with provided reference mirror (see next paragraph) or with your own, known mirror. See chapter 8.1 *Soft Calibration Target values* to learn how to set CT7 to your laboratory values.

CT7a: all the measurements are relative to transmission of pure optical path without any additional sample, thus making the reference absolute 100.00%. Any effects of aging or dust deposit of internal optics are cancelled by taking the REFERENCE measurement.

8.2.1 Calibration Target

REFLECTION: known mirror

With the instrument a calibration mirror is provided.

The reference reflectivity values were measured with Strong's WV setup.

Sample values (each instrument has slightly different values):

channel	R365	R404	R460	R522	R630	R750	R970
uncertainty	0.2%	0.3%	0.1%	0.4%	0.2%	0.2%	0.5%
value	82.6%	83.1%	85.2%	89.9%	90.5%	83.8%	89.5%

Note1: Reflectivity values for the gauge vary slightly from mirror to mirror; always use the values given with your gauge.

Note2: Optical references are not invariable. The reflection properties may change even if stored in good conditions. Periodic validation of target properties with laboratory equipment is recommended.

Note3: For CT7a, no reference mirror is provided, the Reflectivity Target is always 100.0%

DUST INDEX: spectralon 10%

Dust index calibration is considered very stable. Field re-calibration is judged not necessary.

8.2.2 Calibration from navigation switch (standalone)

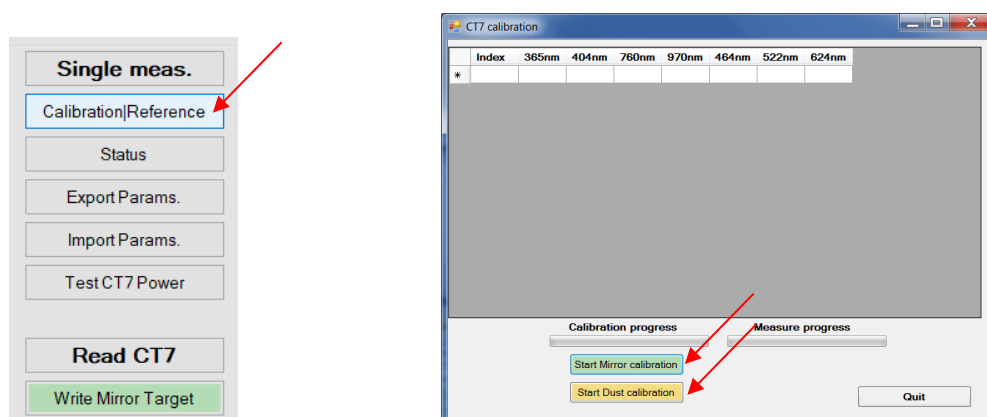
Usually calibration is performed when one suspects any pollution or if time elapsed since the last calibration is estimated too long, or if some measured values are suspect.

Activate Menu **MEASURE / Calibrate** and place CT7 at the calibration target (there is 5 seconds delay).

Calibration		
LED	R	D
365nm	1.011	3.345
404nm	1.211	3.254
464nm	1.007	3.008
522nm	1.121	3.104
624nm	1.203	3.543
760nm	1.108	3.256
970nm	1.235	3.300
Cal. Temp 23.8 C		
Ref1: 2018-01-09		
Dust: 2018-01-10		

Note: OPO has developed a VW jig allowing direct absolute calibration of a gauge just before using it. This is the only procedure that allows checking the calibration of the instrument and correcting it if needed.

8.2.3 Calibration from CT7-Console (from PC)



Calibration starts by pressing CALIBRATION/REFERENCE button on CT7-MANAGEMENT panel. Then you can choose between calibrations of reflection (mirror target) or dust (scattering target). You are again prompted for confirmation that the right calibration target is in front of CT7 – once confirmed, the calibration starts.

CT7 performs the measurement of ratio *reference signal/ target signal* and calculates the coefficients allowing fitting arbitrary ratio measurement to the known values of target samples as given in the editable table.

CT7a is a CT7 instrument with moving arm allowing use of internal path transmission as 100.00% reference.

Test CT7 Power

Read CT7

Write Mirror Target

Write Dust Target

Show Last Calibration

Set CT7 to PC clock

Show / Hide columns:

☒ Reflection Visible
 ☒ Diffusion Visible

Show Charts

Results Format

0.0

0.00

0.000

	Name	Ref1 Calib coeff	Ref1 T coeff[%]	Ref1 Target value	Ref1 LED mod	Ref1 Ref PG	Ref1 Ref Att	Ref1 Signal PG	Ref1 Signal Att	Ref1 Repeat	Dust Calib coeff	Dust T coeff [%]	Dust Target value	Dust LED mod	Dust Ref PG	Dust Ref Att	Dust Signal PG	Dust Signal Att	Dust noise offset	Dust Repeat	Led DC
▶	365nm	1.0000	0.00000	82.600	0.800	12	1	12	1	1	1.000	0.00000	10.000	0.800	12	1	12	1	0.000	1	160
	404nm	1.0000	0.00000	83.100	0.800	12	1	12	1	1	1.000	0.00000	10.000	0.800	12	1	12	1	0.000	1	160
	460nm	1.0000	0.00000	85.200	0.800	12	1	12	1	1	1.000	0.00000	10.000	0.800	12	1	12	1	0.000	1	160
	522nm	1.0000	0.00000	89.900	0.800	12	1	12	1	1	1.000	0.00000	10.000	0.800	12	1	12	1	0.000	1	160
	630nm	1.0000	0.00000	90.500	0.800	12	1	12	1	1	1.000	0.00000	10.000	0.800	12	1	12	1	0.000	1	160
	760nm	1.0000	0.00000	83.800	0.800	12	1	12	1	1	1.000	0.00000	10.000	0.800	12	1	12	1	0.000	1	160
	970nm	1.0000	0.00000	89.500	0.800	12	1	12	1	1	1.000	0.00000	10.000	0.800	12	1	12	1	0.000	1	160

8.3 Battery

8.3.1 Battery Charge

CT7 uses two protected Li-Ion 3.7V 900mAh in format 14500 (~AA) cells connected in parallel as a source of energy. Batteries Li Ion 800-1200mAh are also suitable but increasing their capacity will increase the charge time above 4h.

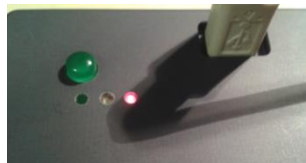
Any USB socket of a PC is able to provide current up to 500mA. Hence, full charging of empty CT7 accumulators may last **up to 3-4 hours**. The internal CT7 fuse (resettable) provides protection of the power source.

The state of charge can be checked thanks to STATUS function: V3 is the battery voltage. When V3=2.8V, the batteries are empty, at 4.2V they are fully charged.

CT7 is charging only in OFF state. If connected to PC and operating the charger is disabled and CT7 powered directly from USB socket. The current sourcing capacity of USB2 is too small to supply and charge in the same time.

The state of the instrument is indicated by 3 LED on the top of the CT7:

- Green: ON
- Blue: Charge ended / Stand-by.
- RED: Charge



CT7 in charge.

Note: that some USB cables are not suitable for supplying power. Exactly like for hard drives, a short, low impedance connection is required. The internal monitoring of CT7 helps to verify supply quality. See 8.3.3 Testing USB cable with CT7Console)

8.3.2 External power source

Since 2012, the CT7 works with dual supply: battery or USB connector. If the 5V power is provided to USB connector, CT7 does not need a battery to work.

In a laboratory use, operated from PC, batteries serve only to keep the clock running when CT7 is not connected.

HINT: The monitoring of telescopes' mirrors is not everyday task, it may happen that CT7 has discharged while waiting for weeks for being used, and the technical time slot for monitoring is "just now" for only several minutes. In such situation ANY device providing power to USB may be used as external power source for CT7: a laptop, an external battery pack like Belkin Power Pack 2000.



Power Pack 2000 (Belkin)

Power Pack is **not** delivered with CT7 instrument.

8.3.3 Testing USB cable with CT7Console

The battery and other internal voltages may be tested from Data-Management or CT7-Management panel by pressing the button:

Test CT7 Power

Power test reports for battery, “good” USB and “bad” USB cables.:

CT7 Power Supply Test report				
Pos.	Voltage	value	Limits	Evaluation.
0	V Led:	8.7 V	8.0-9.0V	OK
1	3.3V Digital:	3.3 V	3.1-3.4V	OK
2	V USB:	2.3 V	4.2-4.8V	No USB supply
3	V Battery:	2.5 V	2.2-3.2V	OK
4	5V Digital:	5.0 V	4.8-5.1V	OK
5	5V Analog:	5.0 V	4.8-5.1V	OK
6	3.3V DSP:	3.4 V	3.2-3.4V	OK
7	DCDC input:	2.1 V	2V / 4V	Battery
Battery evaluation: 73 %				
Conclusions: CT7 supplied by battery. OK				

CT7 Power Supply Test report				
Pos.	Voltage	value	Limits	Evaluation.
0	V Led:	8.7 V	8.0-9.0V	OK
1	3.3V Digital:	3.3 V	3.1-3.4V	OK
2	V USB:	4.7 V	4.2-5.1V	OK
3	V Battery:	2.7 V	2.2-3.2V	OK
4	5V Digital:	5.0 V	4.8-5.1V	OK
5	5V Analog:	5.0 V	4.8-5.1V	OK
6	3.3V DSP:	3.4 V	3.2-3.4V	OK
7	DCDC input:	4.4 V	2V / 4V	USB
Battery evaluation: 88 % Charging				
Conclusions: CT7 supplied by USB. OK				

CT7 Power Supply Test report				
Pos.	Voltage	value	Limits	Evaluation.
0	V Led:	8.7 V	8.0-9.0V	OK
1	3.3V Digital:	3.3 V	3.1-3.4V	OK
2	V USB:	3.1 V	4.2-5.1V	Change USB cable
3	V Battery:	2.7 V	2.2-3.2V	OK
4	5V Digital:	5.0 V	4.8-5.1V	OK
5	5V Analog:	5.0 V	4.8-5.1V	OK
6	3.3V DSP:	3.4 V	3.2-3.4V	OK
7	DCDC input:	2.6 V	2V / 4V	Battery
Battery evaluation: 100 % Full charge				
Conclusions: Excessive voltage drop over USB cable. Try another cable. CT7 supplied by battery. OK				

Battery operation

(no USB power connection)

Good USB

(Low impedance 60cm USB cable)

Poor USB supply

(High impedance 2m USB cable)

NOTE : Example of voltages and evaluation for NiMh batteries . Li-Ion have different voltages.

The poor USB cable generates alarms for more than one voltage. *Brown voltage* means “already not sufficient supply but not yet blackout”.

Please note *Charging* state for battery evaluation in Good USB cable report.

8.3.4 Checking the USB cable with CT7

Thanks to internal monitoring of the CT7 we may measure the voltage drop over the USB cable. It can be done with PC as in the previous paragraph, or from the CT7 menu. Go to menu FACTORY/STATUS, observe V2 which is USB entry voltage:

Status	Status	Status
2018-01-23 20:40:19 Temp1 = 24.3 Temp2 = 23.7 V0 = 8.423 V1 = 3.296 V2 = 2.112 V3 = 2.356 V4 = 5.017 V5 = 4.993 V6 = 3.381 V7 = 1.965	2018-01-23 20:40:19 Temp1 = 24.3 Temp2 = 23.7 V0 = 8.423 V1 = 3.296 V2 = 3.845 V3 = 2.356 V4 = 5.017 V5 = 4.993 V6 = 3.381 V7 = 1.965	2018-01-23 20:40:19 Temp1 = 24.3 Temp2 = 23.7 V0 = 8.423 V1 = 3.296 V2 = 4.041 V3 = 2.356 V4 = 5.017 V5 = 4.993 V6 = 3.381 V7 = 1.965
Battery	Bad USB cable	Good USB cable
	V2 = 3.845	V2 = 4.041

Depending on the cable (assuming with high probability that USB socket provides 5.0V) the entry voltage may vary. For a “very good” cable we may observe 4.7-4.8 V.

The minimum acceptable value of V2 is 4.0V.

Status function gives slightly lower values than CT7Console evaluation in CT7 Power Test.

8.3.5 Quality of the power source



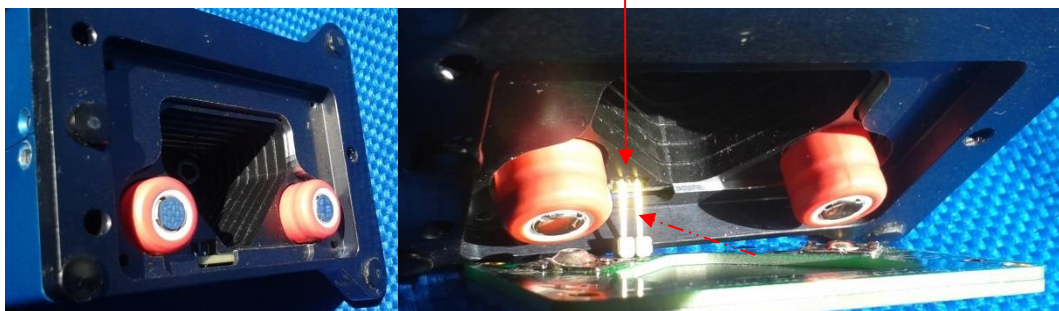
When connected to a power source, the battery state response shall contain the word **USB Power** or **Full Charge**.

The state of the charger is indicated by LEDs on the top of CT7.

8.3.6 Changing the battery

Battery change sequence:

- Unscrew the instrument bottom cover
- Gently remove (let them drop-out) old batteries
- Place new Protected Li-Ion 900mA (800-1200mAh cells.
- Take care about polarity: Minus to spring contact.
- Both Batteries are heading the same direction: “+” to the cover
- Gently introduce cover pins into the connector
- Press the cover and place the screws
- Replace the screws.



NOTE: Li-Ion batteries are placed heading BOTH “+” to the cover.

NOTE: We recommend changing the batteries every 2 years.

8.4 CT7 Firmware update

8.4.1 Procedure

The procedure is straightforward and takes just about 1 minute.

1. Get new version of **CT7_DSP.bin** from support [www \(link\)](#) and place it in **CT7\update** folder
2. Connect **CT7** to PC **CT7-Console**
3. At CT7-Console go to CT7 Management panel and click DSP update button.
4. In a *file-open dialog* select the new firmware (*) press OPEN
5. Observe progress bar. A message "*DSP upload success*" pops-up : click OK
6. Finish upload with CR7 restart to activate the new firmware
 - a. A message informs you that CT7 will be switched off to activate uploaded version - click OK.
 - b. CT7 is switched off. You have to power it up by pressing UP button of the CT7 navigation switch.
 - c. You have to activate PC-link mode. "*UIF Locked*" is displayed on CT7.
 - d. Now click OK on the PC CT7 Console message "Switch on CT7 and then press OK"
7. You may check the new version in the report generated by **CT7 Management: ExportParams.** function

(*) firmware must be named CT7_DSP.bin

Step	CT7 instrument	PC-CT7 console
------	----------------	----------------

- ## 2 Connect CT7 to PC **CT7-Console**



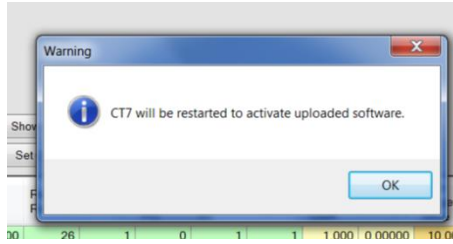
- 4 In a *file-open dialog* select the new firmware; click OPEN
- 5 Observe progress bar. A message “*DSP upload success*” pops-up : click OK



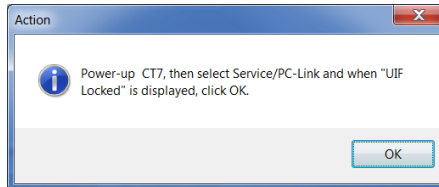
- 6 Finish upload with restart of CT7



CT7 is switched OFF by
PC-Console

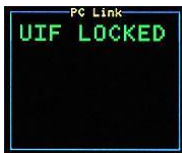


Click OK.



Press UP button.

Wait for CT7 displaying "UIF Locked" and click OK



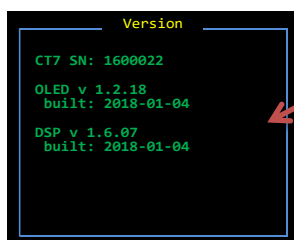
Done.

8.4.3 Firmware upload verification:

Select FACTORY / Version option from menu:



Verify DSP software version:



8.5 CT7 display firmware update

CT7 main processing and control is managed by

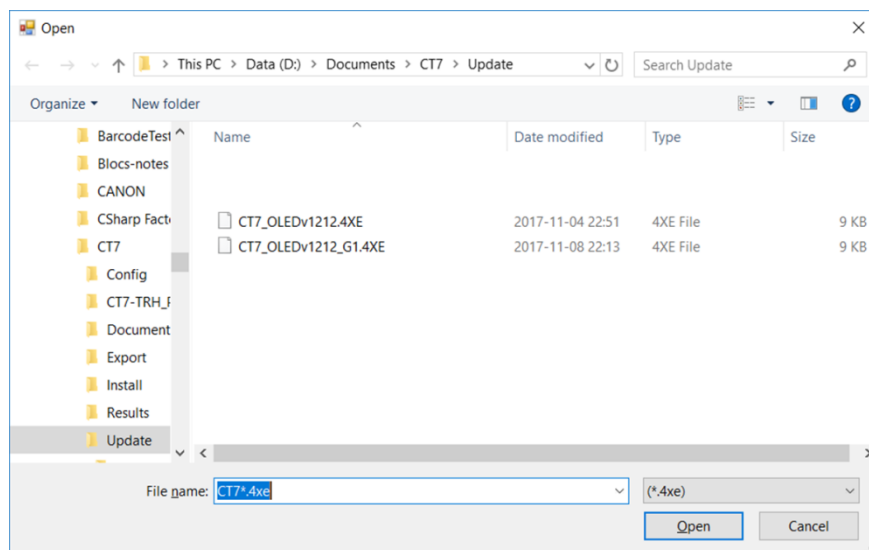
8.5.1 Procedure

CT7 console has no built-in routine to upload OLED firmware, in place of this the Console generates and executes a batch file who calls OLED firmware loader (SCRIPT.EXE) with selected firmware file and actual COM port.

1. Make function button visible by changing CT7 Console operating mode to Advanced or Expert (*About* panel)
2. Connect CT7 to Console
3. At *CT7 Management* panel press UPDATE OLED button
4. You are prompted for selection of the firmware file from folder CT7\UPDATE\OLED. Select firmware file: CT7_v1601.4xe (or another .4xe file if newer version was downloaded)
5. A Windows command window will open, where you may follow the progress of the process.
6. CT7 will freeze, than display will become black during upload
7. After the update, the display will show CT7 welcome screen and freeze.
8. End the procedure by switching CT7 off (RESET button on the back) and restarting it.

8.5.2 OLED update explained

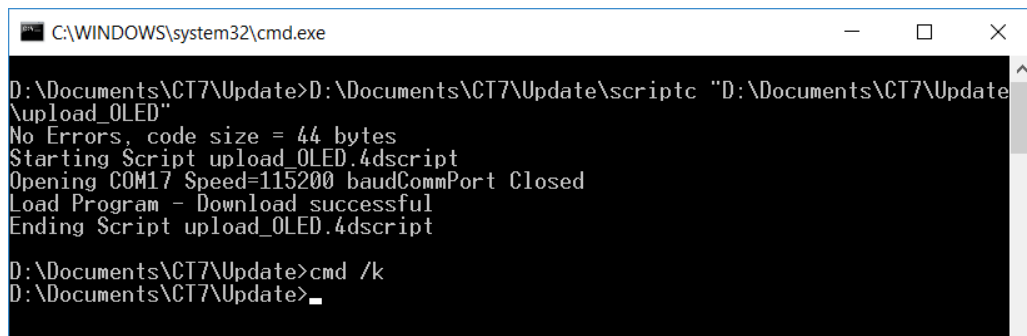
1. Place received or downloaded upgrade in the folder CT7\UPDATE\OLED
2. Folder CT7\UPDATE\OLED shall contain SCRIPT.EXE file (actual uploader)
3. Make function button visible by changing CT7 Console operating mode to Advanced or Expert (*About* panel)
4. Connect CT7 to Console
5. At *CT7 Management* panel press UPDATE OLED button
6. You are prompted for selection of the firmware file from folder CT7\UPDATE\OLED. Select firmware file: CT7_v1601.4xe (or another .4xe file if newer version was downloaded)



7. A Windows command window will open, where you may follow the progress of the process.

If the process goes without problems the CMD window will look like this (note green lines) :

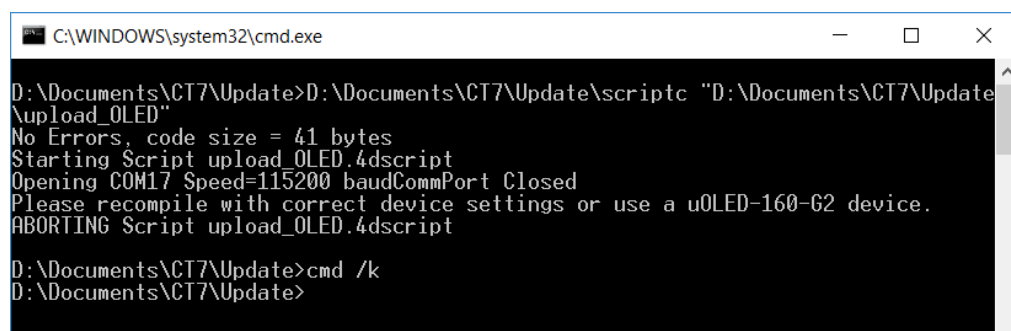
```
D:\Documents\CT7\Update>D:\Documents\CT7\Update\scriptc "D:\Documents\CT7\Update\upload_OLED"
No Errors, code size = 44 bytes
Starting Script upload_OLED.4dscript
Opening COM17 Speed=115200 baudCommPort Closed
Load Program - Download successful
Ending Script upload_OLED.4dscript
D:\Documents\CT7\Update>cmd /k
D:\Documents\CT7\Update>
```



The screenshot shows a Windows command prompt window titled 'C:\WINDOWS\system32\cmd.exe'. The command entered is 'D:\Documents\CT7\Update\scriptc "D:\Documents\CT7\Update\upload_OLED"'. The output shows the script running successfully, with green text for 'Load Program - Download successful' and 'Ending Script upload_OLED.4dscript'. The prompt then shows 'D:\Documents\CT7\Update>cmd /k' and 'D:\Documents\CT7\Update>'.

In case of problems you will find "ABORTING Script" message

```
D:\Documents\CT7\Update>D:\Documents\CT7\Update\scriptc "D:\Documents\CT7\Update\upload_OLED"
No Errors, code size = 41 bytes
Starting Script upload_OLED.4dscript
Opening COM17 Speed=115200 baudCommPort Closed
Please recompile with correct device settings or use a uOLED-160-G2 device.
ABORTING Script upload_OLED.4dscript
D:\Documents\CT7\Update>cmd /k
D:\Documents\CT7\Update>
```



The screenshot shows a Windows command prompt window titled 'C:\WINDOWS\system32\cmd.exe'. The command entered is 'D:\Documents\CT7\Update\scriptc "D:\Documents\CT7\Update\upload_OLED"'. The output shows the script running, but it encounters an error: 'Please recompile with correct device settings or use a uOLED-160-G2 device.' followed by 'ABORTING Script upload_OLED.4dscript'. The prompt then shows 'D:\Documents\CT7\Update>cmd /k' and 'D:\Documents\CT7\Update>'.

The source of such problem is that there are two generations of OLED display installed in CT7, called : G0 and G1. If you encounter such error, just try another firmware file .4xe provided.

8. CT7 will freeze, than display will become black during upload



9. After the update, the display will show CT7 welcome screen and freeze.
10. End the procedure by switching CT7 off (RESET button on the back) and restarting it.

9 Delivrables

CT7 box contents:



1. CT7 (with batteries)
2. Cable USB
3. USB Flash memory (Install and documentation)(*)
4. calibration mirror / CT7 only, no use for CT7a/

(*) – Optional, latest downloads are available at support page (see para. 13 Annex 4 - Support) the “soft” delivery helps us to provide the user always with the latest version of documentation and PC application

10 Abréviations

Cart	- The name given for selection of wavelengths used for a measurement
FWHM	- Full Width Half Maximum
TBC	- To Be Confirmed
TBD	- To Be Defined
USB	- Universal Serial Bus

nnex 1 - CT7 Characteristics

CT7

Accuracy of reflectivity is given for reflectivity>50% C

Wavelength (set 2012) [nm]	365	405	464	522	624	750	970
Wavelength (set 2019) [nm]	325	375	468	523	660	850	940
Bandpass [nm]	10	15	25	30	30	40	50
Absolute accuracy*	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.5%
Repeatability**	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.03%

* Absolute accuracy obtained using the VW jig for calibrating the gauge.

** for a single measurement

Note: Optical references are not invariable. The reflection properties may change even if stored in good conditions. Periodic validation of target properties with laboratory equipment is recommended.

CT7a

Accuracy of reflectivity is given for reflectivity>50% C

Wavelength (set 4) [nm]	375	411	528	620	750	850	940
Bandpass [nm]	15	15	25	30	30	40	50
Absolute accuracy*	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.4%
Repeatability**	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.05%

*Absolute accuracy obtained using the REFERENCE function. Aimed at 0.2% in next release.

** for a single measurement, no movements of rotating arm

	Parameter	Value	Comments
1	Repeatability	See table above	Short term (5 min)
2	Thermal Stability	CT7: $\pm 0.05\%/^{\circ}\text{C}$ CT7a: cancelled	% full range
3	Incidence angle	8°	
4	Reflection wavelengths	Set 2: (2012-2019) 365nm, 404nm, 464nm, 522nm, 624nm, 760nm, 970nm Set 3: (2019) 325nm, 375nm, 468nm, 523nm, 660nm, 850nm, 940nm Set 4: (2020...) 375nm, 411nm, 528nm, 620nm, 750nm, 850nm, 940nm Set 5: (2020...) 340nm, 411nm, 520nm, 630nm, 750nm, 850nm, 940nm	Sources are LED
5	Scattering (DUST) index wavelengths	Same as reflection	Sources are LED
6	Detectors	UV Enhanced Silicon Photodiodes	
7	Operating temperature	-15 .. +40 °C	Note : CT7 may need recalibration at actual temperature Batteries may show reduction of capacity at low temperatures.
8	Storage temperature	-20°C +60°C	Not operating.
9	Power consumption	5V, Current limited to 500mA 500 -350mA when in charge 450mA when ON	Limited by construction. Protected by resettable fuse
10	Battery	2x 14500 Li-Ion 800mAh 3.7V	800-1200 mAh are also suitable
11	Charge	About 3.5h	From USB socket, CT7 switched OFF
12	Battery practical capacity	Minimum 75 measures Reflection, 3 days in stand-by	Fully charged, new battery
13	Power/data connector	Mini USB, type B	
14	Dimensions	CT7: 73 x 85 x 147 mm CT7a: 82x116x143 mm	DxWxH
15	Mass	CT7: 700g CT7a: 850g	

11 Annex 2 - Troubleshooting

	Problem	Most probable Cause	Solution / notes
1	POWER: CT7 does not power-up	Battery discharged	connect to USB power, CT7 should start once powered, Check STATUS V3 (Vbat). V3 shall be above 3.0V to power up. CT7 may operate on USB power without batteries.
2	POWER: CT7 switch off during operation	Battery discharged	Charge the battery with USB, try to see Status voltage V3. V3 shall be above 3.0V to power up.
3	CONNECTION: CT-7 Console does not connect in automatic way to the connected instrument	Virtual COM port number has changed	CT7 instrument dialogues with PC using a virtual COM port. CT7-Console stores the last used port and tries to connect using the same the next time CT7 is connected. Open SELECT PORT option and REFRESH list of ports. As a first try Select the last port at the list (most probably this is CT7 port), if no connection is obtained than follow trying other ports from the list
4	CONNECTION: CT-7 Console does not connect in automatic way to the connected instrument, interface seems to be frozen	CT-7 is in "false UIF" mode – the processors of the OLED Display and DSP are desynchronized	RESET CT7, go to PC-link mode again. OBSERVE: at CT7-Console SELECT-PORT a list of COM ports before and after connecting CT7 USB cable (do not forget to refresh the list) – a new port shall appear.
5	BATTERY CHARGE After long charge from PC (CT7 is OFF), the battery discharge rapidly	1.Wrong USB cable. The serial resistance is too high, producing significant voltage drop over the cable. 2. Damaged battery	Use USB cable suitable for high supply current devices like hard drive. With USB connected: 1. Observe V2 at STATUS – this is USB socket voltage, if is less than 4.2V the CT7 will not charge the battery 2. Check BATTERY – if only percentage " x% " is displayed the charger will not operate with this cable. You shall see: " x% USB Pwr "

6	Results are NaN, +inf.	Division by 0 in processing. a) thermal coefficients are not initialized b) The codec (ADC) of the DSP has been set to incorrect configuration and returns 0.	Import last known good configuration file (or the sample one). Use CT7-Console/CT7 Management panel/Import Parameters
7	Low Battery CT7 emits a series of beeps and shuts down	Low battery. CT7 protects the battery against excessive discharge and disconnects the battery	Connect USB power to continue work with CT7. Leave CT7 connected (and OFF) until the BLUE led lights-up indicating full battery charge.

12 Annex 3 - Configuration file (Export/Import)

The example of configuration file generated by **Export Parameters** function:

```
;CT7 Parameters file
file_ver=2.0.00
file_date=15-01-2020 12:52
[CT7Console]
ConsoleSerial=ver 2.0.02
ConsoleBuiltDate=Built 2020-01-11
[CT7version]
serial=99000001
DSPversion=NOOLED 2.0.00
DSPBuiltDate= built 2020-01-03
OLEDversion=1.2.18
OLEDBuiltDate=2018-01-04
OLEDGversion=NA
[SOURCE]
LEDlambda={365;404;464;522;624;760;970}
LEDcurrent={100;100;100;100;100;100;100}
LEDindex={0;1;4;5;6;2;3}
[CONSOLE]
LED_DC=160
LEDcurrent=0.8
RrefTarget=56000
RsigTarget=48000
RPGALimit=36
RLEDLimit=0.85
DrefTarget=56000
DsigTarget=35000
DPGALimit=36
DLEDLimit=0.85
[Channels]
Channels={365nm;404nm;460nm;522nm;630nm;760nm;970nm}
Rcal={1.0202;1.0281;1.0549;1.0599;1.0532;1.0112;1.0247}
TRcal={0.04995;0.00883;0.01103;0.01233;0.01968;0.02404;0.06927}
RTcoef={82.6;83.1;85.2;89.9;90.5;83.8;89.5}
RModul={1;1;1;1;1;0.8;1}
RMCount={1;1;1;1;1;1;1}
Dcal={1;1;1;1;1;1;1}
TDcal={0;0;0;0;0;0;0}
DTCoef={10;10;10;10;10;10;10}
DModul={1;1;1;1;1;0.8;1}
DNOparam={0;0;0;0;0;0;0}
DMCount={1;1;1;1;1;1;1}

[DSPchannels]
GRRcoef={26;28;36;36;35;27;30}
GRScoef={0;3;12;9;7;0;10}
GDRcoef={26;28;36;36;35;27;30}
GDScoef={0;3;12;9;7;0;10}
IRRcoef={1;1;1;1;1;1;1}
IRScoef={1;1;1;1;1;1;1}
IDRcoef={1;1;1;1;1;1;1}
IDScoef={1;1;1;1;1;1;1}
```

```
LEDdc={160;160;160;160;160;160;160}
[DSPparams]
DSPFilter=1
DSPFinePhaseR=0
DSPDSPCoarseDelayR_R=0
DSPCoarseDelayR_S=0
DSPFinePhaseD=0
DSPCoarseDelayD_R=0
DSPCoarseDelayD_S=10
[status]
Vbat=2.77
Tbat=25.6
TDet=25.6
TLED=27.5
VxADC={8.63;3.3;4.72;2.95;4.96;5;3.36;4.33}
CT7Index=0
CT7time= 15-01-2020 13:05
LastRcalib= 15-01-2020 11 h
LastDcalib= 15-01-2020 11 h
LastRCalibT=21.3 C
LastDCalibT=22.2 C
[CT7Registers]
ConsoleVer=ver 2.0.02
CT7Folder=D:\Documents\CT7_MyCT7
ResultsFolder=D:\Documents\CT7_MyCT7\Results
ConfigFolder= D:\Documents\CT7_MyCT7\Config
UpdateFolder= D:\Documents\CT7_MyCT7\Update\CT7_DSP.bin
DocFolder=D:\Documents\CT7_MyCT7\Documents
ExportFolder=D:\Documents\CT7_MyCT7\Export
HelpFile=D:\Documents\CT7_MyCT7\Documents\umCT711001i08_user manual.pdf
UpdateDSPFile= D:\Documents\CT7_MyCT7\Update\CT7_DSP.bin
UpdateOLEDFile=NA
ExportFile=D:\Documents\CT7_MyCT7\Export\CT7DATA.CSV
MeasureFile=D:\Documents\CT7_MyCT7\Results\Archive0Archive99000001.Meas
MeasureConfigFile=D:\Documents\CT7\Config\Sample_CT7_LABO.MeasCfg
LogFile=D:\Documents\CT7_MyCT7\Results\CT7_99000001.csv
SupportWWW=http://www.a1pixel.pl/CT7/index.html
ComPort=COM2.
```

Note.

In blue: new section [SOURCE] is software definition of the LED source.

The CT7 instruments delivered before 2020 have all the same source and this section is not necessary.

If the CT7 instrument does not provide this information to PC-Console, the PC-Console will recognize the instrument as on from generation 2012 or 2016 and will use the correct values which are:

[SOURCE]

```
LEDlambda={365;404;464;522;624;760;970}
LEDcurrent={100;100;100;100;100;100;100}
LEDindex={0;1;4;5;6;2;3}
```

13 **Annex 4 - Support**

Additional information:

- CT7 Presentation
- Actual version
- Firmware update (download)
- CT7 Console update (download)
- User Manual (download)
- Technical notes

may be found at www.CT-7.eu in CT7 user area.

For any issue not covered by this document you may contact:

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Daniel.Malaise@skynet.be
www.opo.be

In particular OPO will answer questions on the general concept, system, optical design, mechanical design, processing.

Pawel Woszczyk
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www.CT-7.eu

In particular A1Pixel will answer questions on the system, electronics and software design, the operation scenario, software flow, updates, repair.