USER MANUAL

CAMctrl.exe (TW_ID02 REV 3a)

ticwave
solutions
the next generation of terahertz

Content

TWS-ID02 Digital THz Video Camera

TWS-ID02 (front) **TWS-ID02 (back)**

Ø 1/2" post mount
(post not included)

Touch screen

2" LCD
320 x 240

E-field polarization — Si-lens — Front mount M3 thread — Magnets

Post mount M4 thread

Reset

MicroSD card slot — Chopper port — AUX port — USB-C port — ON/OFF

Technical specification

- FPA: 33x33 pixel
- Frame rate: up to 54fps
- Bandwidth: 0.3-1.1THz
- Responsivity: max. 1G counts/W
- MDP: min. 1-2nW @ 320GHz/54fps
- NEP: min. 10-20pW/√Hz @ 320GHz
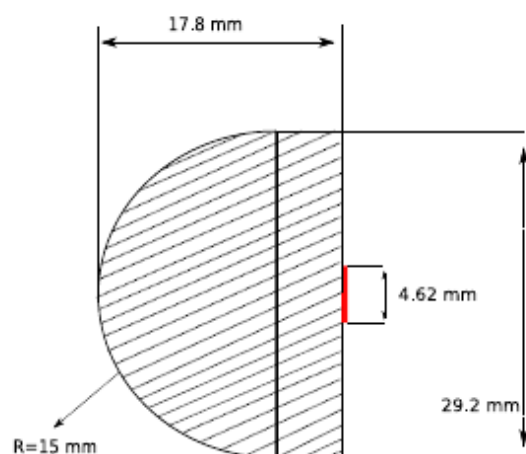- USB-C interface.
- Lens: HRFZ-Si D30 T17.80

Optical specification

- Effective focal length: 6.206 mm
- Back focal length: 0.996 mm
- Clear aperture: 29.2mm
- Center thickness tol.: ± 0.1mm
- Radius of curvature tol.: ± 0.1mm
- Pixel dimension: 140µm x 140µm
- Sensor dim.: 4.62mm x 4.62mm

Chopper port
1: gnd
2: 5V
3: Chopper-out
4: Chopper-in

AUX port
1: gnd
2: 5V
3: aux 1
4: aux 2

17.8 mm

4.62 mm

29.2 mm

R=15 mm

1. Introduction

The software (CAMctrl) is a CLI interface (command line interface) for the camera embedded firmware (TW_ID02 Rev 3a) preinstalled on the camera. A PC-based GUI (graphical user interface) is currently not supported. The software is intended for operation of the TicWave Solutions Camera (TWS-ID02). Please read the warning sections first before you use this software. Please contact TicWave Solutions (contact@ticwave-solutions.com) should you have any questions about this software.

System requirements:	Windows 10/11 (64-bit) or Linux

1) The TWS-ID02 offers dual power options via USB-C or an integrated battery, enhancing its portability. It mounts on a post or to custom adapter plates with front M3 threads and can attach to a 60 mm cage using an optional kit (not included). The camera features a hyperhemispherical HRFZ-Silicon lens with a 30 mm diameter and 17.8 mm thickness; alternative optics are available on request. Connectivity with the TicWave Solutions 420 GHz source array (TWS-SA420G) is achieved through an X-link cable, as detailed in the appendix wiring diagram.

2) The optional chopper box TWS-CB01 is designed for directly modulating the bias voltage of a Toptica photo-emitter. Connect the input of the chopper box to the camera's chopper port with the included chopper cable. Use a regular SMA cable to connect the SMA output connector to the photo-emitter bias port. Ensure that the voltage levels of the chopper box (on at -1.5V and off at +0.5V) are compatible with the specifications of the photo-emitter to ensure proper functionality and to avoid any damage. See the wiring diagram in the appendix.
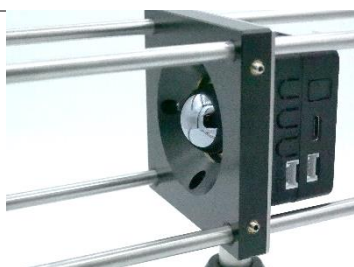
3) The optional 60 mm cage mount kit is attached to the camera via its front M3 front mount screws. Once attached, the kit is designed to slide onto the rods of a Thorlabs 60mm cage system, ensuring a secure and precise optical alignment of the camera in an optical system.

2. Warnings

Be careful not to drop the camera on the Si-lens. The 60mm cage mount kit may be attached during handling and installation. The conical recess of the kit provides protection of the lens. Never connect other than the specified voltages to the optional SMA connectors. It is recommended to only use the USB-C supply for the controller.

> **Make sure all devices are connected to each other with the provided cables before you start using this software**

3. Installation and Setup

Installation Instructions

Windows (Recommended)
- Execute `Setup.exe` from the USB stick (located in the windows sub-folder).
- The default installation path is `C:\Program Files (x86)\TicWave\CAMctrl`.

Linux
- Copy the binary `CAMctrl` from the USB stick (located in the linux sub-folder) to your local disk.

Connecting the Camera

- Connect a USB-C cable for communication and power supply.
- Connect the chopper X-link cable between the source and the camera. The connector receptors are located on the lens part of the Camera, not the rear part closer to the display. Note the appendix for a wiring diagram for a typical application.

Usage

Windows
- Open Windows PowerShell (Run as Administrator - required to create `.mat` file).
- Navigate to the installation directory: `cd "C:\Program Files (x86)\CAMctrl\TicWave"`
- Generate a command configuration file if needed: `.\CAMctrl.exe -Update`
- Command help: `.\CAMctrl.exe -h`

Examples:
- Stream for 10 seconds: `.\CAMctrl.exe -Stream 10`
- Save a 100-frame video to a `.mat` file: `.\CAMctrl.exe -GetMAT 100`

Linux
- Open a command line terminal.
- Example: `./CAMctrl -h`

Troubleshooting Driver Installation

Windows
- Open Windows Device Manager.
- Ensure the CP2104 USB to UART Bridge Controller is installed and active.

Linux
- Check if the USB device is attached: `lsusb | grep "Silicon Labs CP210x UART Bridge"`
- Check if the serial port /dev/ttyUSB0 is available: `ls -l /dev/ttyUSB0`

The following files will be installed:

- CAMctrl.exe: Executable command line program.
- CAMctrl.json: Command configuration file. Do not edit this file, it is automatically generated. If this file is missing, you may recreate it with
- CAMctrl.exe -Update command. This process requires a USB connection to the source controller.
- video.m: Matlab example script to play a recorded video from a recorded .mat file (e.g. video.mat).

4. Command line option

usage: CAMctrl.py [-h] [-b N] [-p N] [-ip N] [-int16] [-v]

            [-GetStatus N | -GetMAT N | -Stream N | -SaveCVS N | -SaveMJPG N |

                  -SetBaud N | -Reboot ... | -Reset ... |

                  -DataFormat N | -Update ... | -EnSudo ...]

OPTION	DESCRIPTION
-h, --help	show this help message and exit
-b N, --baudrate N	Set baudrate=N (default: N=2000000). Use this option to connect at a baud rate other than the default. Note that the camera may not accept commands if its baud rate does not match. First, use the -SetBaud option to reprogram the camera settings before this option can work.
-p N, --port N	Set the port number for a remote socket connection. Usually there is no need to change the default 8080 port.
-ip N	Connect to the camera at the IP address N to access the camera wirelessly, instead of the default wired USB connection. This option requires an activated Wi-Fi AP (access point). Navigate to the camera configuration menu to activate the AP and connect the local PC to the AP using the SSID 'TicWaveCam'. The current IP address, N, is shown in the table of the camera's Status Menu once the AP has been activated (e.g., N=192.168.4.1).
-int16	Use this option together with the -GetMAT option to record raw data in an int16 data format (the default is int32). The int16 data format for raw data storage is faster and may be beneficial if higher frame rates (approximately 2x) are desired. First, set the camera to int16 in the Camera Configuration Menu for this option to function, or execute -DataFormat 1 via CAMctrl.exe. Note that if int16 is used, the camera is limited to an averaging of 1 in the Slider Menu.
-v, --verbose	Use this option to increase the verbosity level (e.g., -v, -vv, or -vvv).
-GetStatus N	Get N-lines of camera status.
-Update	Update the config file (CAMctrl.json) with known commands from device. Only required if the CAMctrl.json file is not present or corrupted.
-GetMAT N	Save raw image data locally on the PC for N frames (the default filename is 'video.mat'). Note that the frame rate depends on the camera's integration time and the average setting in the Camera Slider Menu. Refer to 'video.mat' for an example of how to read and plot the content of this file.
-SetBaud N	Use this option to reprogram the baudrate to N, at which the controller accepts commands via USB. Note that once this command is issued, the camera will only be accessible at this new baud rate for any subsequent commands. Use the -baudrate option to match N in all subsequent commands.
-Reboot	Reboots the camera.
-Reset	Resets the camera chip.

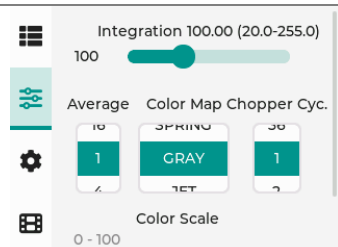|		
-Stream N		Stream an MJPEG video to your PC for a duration of N seconds. The MJPEG (Motion JPEG) file format compresses each video frame individually using JPEG compression. MJPEG is particularly beneficial for real-time video streaming applications due to its low computational complexity and the ability to maintain consistent quality across all frames. The video is displayed at a 800x800 pixel bicubic interpolation image.
-SaveCVS N	Save an .cvs data format to the microSD card for N frames. Each file is sequentially numbered to prevent overwriting previous files. Regularly delete unnecessary files to prevent storage shortages and maintain optimal performance. If the microSD card is not mounted properly, or if the device fails to recognize the card: reconnect or restart the camera, check the card's connection, reformat the card to FAT32, or try a different card.	
-SaveMJPG N	Record a video in MJPEG format for N seconds directly to the microSD card. Each video file is sequentially numbered to prevent overwriting previous files. Regularly delete unnecessary files to prevent storage shortages and maintain optimal performance. If the microSD card is not mounted properly, or if the device fails to recognize the card: reconnect or restart the camera, check the card's connection, reformat the card to FAT32, or try a different card.	

5. Embedded User Interface

The embedded firmware (TW_ID02 Rev3a) provides a user interface via its touch screen. No USB connection with the PC is required to operate the camera. In the following the navigation of the embedded firmware is described. Related remote control commands are indicated.

MENU	DESCRIPTION
Status	Shows status information about the camera (not editable). Scroll down to see the full list. The following information is provided:

Status	Description	CAMctrl command
Off	A long-press turns off the controller.	
Firmware/Revision	Firmware (TW_ID02) and revision number (3a) currently installed on the camera.	-GetStatus N
WIFI Status	WIFI status (shown if WIFI AP is active). Shows the IP address at which the camera can be found.	-GetStatus N
AC Supply	Status information about the USB supply voltage and current consumption.	-GetStatus N
Bat Charge Discharge	Battery charging and discharging current	-GetStatus N
Bat Status	Battery status indicator.	-GetStatus N
Vref	Detector bias voltage adjustment. Use POT channel 0. Default: 0.77V	-GetStatus N
VCC Det	Detector VCC supply. Use POT channel 1. Default: 1.2V	-GetStatus N
VDD VCO	Oscillator VDD supply. Use Pot channel 2. Default: 1.2V	-GetStatus N
Integration	Status of the current integration time setting.	-GetStatus N
Integration (HB)	Status of the current integration time setting.	-GetStatus N
Chip XCLK:	Chip reference clock. Default: 15 MHz	-GetStatus N
HSYNC Cyc.	Hsync cycles. Default: 4	-GetStatus N

![Slider settings icon] **Slider settings**

The slider settings menu is used to adjust various camera options. The following adjustments are possible:

Settings	Description	CAMctrl command
Integration	Set the integration time for the camera to balance image quality and frame rate. Increasing the integration time enhances the signal-to-noise ratio (SNR), yielding clearer images at the cost of reduced frame rates. Conversely, decreasing the integration time results in higher frame rates but lower SNR, which may affect image clarity. To optimize video quality for your specific application, adjust the integration time in conjunction with the number of averages.	
Average	Roller to select the frame averaging. Range: 1-16	
Color Map	Select color map used for the video image. Available options are Gray, Jet, Spring, Winter, Cool, Autumn.	
Chopper Cyc.	Roller to change the number of chopper cycles per integration time. Default is 1.	
Color Scale	Slider to change color scale for video image. Switch off the auto scale option in the Configuration Menu to enable this mode.	

MENU

⚙ Configuration

DESCRIPTION

This menu is used to configure camera options.

Configuration	Description	CAMctrl command
Autoscale video	Enable auto-scale for the video display to enhance contrast. For instance, in grayscale the brightest pixel is displayed as white, and the darkest pixel is shown as black. Please note that if auto-scale is on and there is no signal, the video may appear noisy, which is a normal occurrence under these conditions. This adjustment helps to ensure that all available detail in the video is visible, optimizing the display for easier viewing and analysis.	
H-Mirror	Mirror the video horizontally.	
V-Mirror	Mirror the video vertically.	
Rotate +90	Rotate the video by 90 degrees.	
int16 data format	Use this option together with the -GetMAT option to record raw data in an int16 data format (the default is int32). The int16 data format for raw data storage is faster and may be beneficial if higher frame rates (approximately 2x) are desired. Note that if int16 is used, the camera is limited to an averaging of 1 in the Slider Menu.	-DataFormat 1
Performance Monitor	Provides extra status information in the Status Menu and activates the video monitor in the video display (see Video Menu).	
EN WIFI AP	Enable WIFI access point with SSID 'TicWaveCam'. Check	-ip 192.168.4.1

|		
		this option to connect wirelessly to the camera. The current IP address and password are shown in the table of the camera's Status Menu (e.g., N=192.168.4.1).
	EN Subtract	Disable this option to operate the camera in Continuous Wave (CW) mode. This setting allows the use of CW sources without chopping. However, please note that in this mode, manual zeroing is frequently necessary. For instructions on how to perform manual zeroing, refer to the Video Menu. This adjustment ensures optimal functionality when using continuous sources, although it requires regular manual calibration.

MENU	DESCRIPTION

 Video Display

Read and write the internal SPI registers. Either directly select bits, or use the rollers for command short cuts. Remember that in some instances two consecutive writes are required.

	Settings	Description	CAMctrl command
	Level	Level all pixel responses. The level data is recorded with the same avg. as it is configured for the video (see settings).	
	Zero	Zero the video image. The zero data is recorded with the same avg. as it is con-figured for the video (see settings).	
	Scope	Experimental. It shows the time domain signal of the selected image pixel. To reselect other pixels, go back by unchecking this button, then move the red cursor to other pixel locations. The data may be auto-scaled.	
	Histogram	Experimental. It shows a histogram of the selected pixel. The x-axis is auto scaled to the min max values within a frame. Usage is similar to the scope.	
	Monitor	Shows selected pixel number (#), sampled count, effective fps (including avg.), min./max, SNR etc.. Touch the screen to select move the red pixel cursor. If this button is activated the status information is updated every 5 seconds. Note that there is extra time needed to acquire status information, which may interfere with the video capturing timing/process.	

6. Wireless Realtime Terahertz Video Streaming
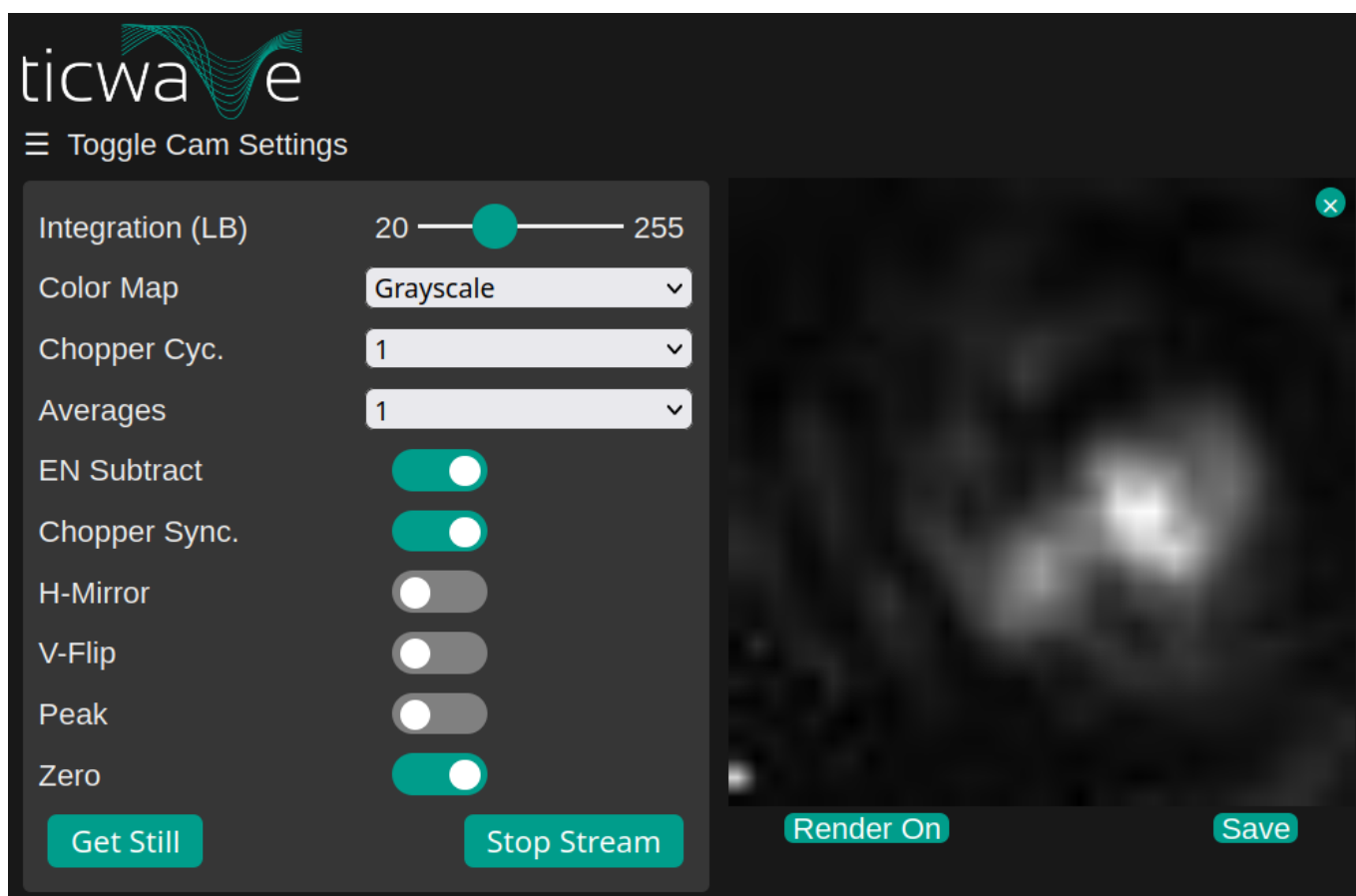
Wireless Terahertz video streaming

The TWS-ID02 camera offers a feature for real-time video streaming, enabling the camera to capture and transmit live video over Wi-Fi to various devices such as smartphones and web browsers. It supports configurable frame rates, adjustable image quality settings including integration time, averaging, offset compensation (zero), and color-maps. The TWS-ID02 low power consumption makes it ideal for battery-operated or remotely powered terahertz projects. With its integrated web server and customization options it is an ideal feature for wireless/handheld demonstrations.

	Settings	Description	CAMctrl command
	Integration	Refer to the CLI setting	
	Color Map	Refer to the CLI setting	
	Chopper Cyc.	Refer to the CLI setting	
	Averages	Refer to the CLI setting	
	EN Subtract	Refer to the CLI setting	
	H-Mirror	Refer to the CLI setting	
	V-Mirror	Refer to the CLI setting	

Peak/Level	Refer to the level CLI setting	
Zero	Refer to the CLI setting	
Get Still	Takes a screen shot	
Start/stop stream	Starts or stops the streaming application.	
Render on/off	Tuns on/off the bilinear interpolation.	

7. Functionality

Please note that this software is the current stable release.

8. Troubleshooting

Common issues are related to USB port settings. For more information on error messages increase the verbosity level (-vvv) on the command line. Please contact technical support in case there are unforeseen issues.

9. Maintenance and Upgrades

Software maintenance will be provided as updates become available. Upgrades can be seamlessly applied by flashing the controller firmware. For your convenience, a dedicated firmware upload script is also available.

10. Conformity

This product complies with the essential requirements of the relevant European health, safety, and environmental protection legislation and has been awarded the CE marking accordingly.

11. Appendix

Typical application (wiring diagram) for the camera together with a Ticwave source array (TWS-SA420G-ID01) or the chopper-box (TWS-CB01) in conjunction with a Toptica THz photo-emitter. Note that the chopper connection is not needed in CW operation. For CW operation disconnect any chopper cable and disable the EN-subtract option on the camera and then perform a zero with the source turned off.