WORKSWELL
WEOM USER MANUAL

USER MANUAL

FW Version: 2.1.10

Release date: 15th April, 2025

Revision 250415EN

WORKSWELL

Contents

1 Legal Disclaimer

All products (software, hardware or firmware) manufactured by Workswell s.r.o. are warranted against defective materials and workmanship for a period of twelve (12) months, provided such products have been under normal storage and use in accordance with herein instructions.

The warranty extends only to the original purchaser and is not transferable. It is not applicable to any product which has been subjected to misuse, neglect, accident or abnormal conditions of operation.

In the case of a defect in a product covered by this warranty the product must not be further used in order to prevent additional damage. The purchaser shall promptly report any defect to Workswell s.r.o. or its authorized distributor or this warranty will not apply.

Workswell s.r.o. will, at its option, repair or replace any such defective product free of charge if, upon inspection, it proves to be defective in material or workmanship and provided that it is returned to Workswell within the said twelve-month period.

Nobody but Workswell s.r.o. is allowed to open or modify such product.

Workswell s.r.o. has no other obligation or liability for defects than those set forth above. No other warranty is expressed or implied. Workswell s.r.o. shall not be liable for any direct, indirect, special, incidental or consequential loss or damage, whether based on contract, tort or any other legal theory.

1.1 Copyright

2 Help and FAQ

2.1 General Instructions

While looking for a solution of any technical problem we recommend following these steps:

- try to find an answer by searching this User Manual
- contact your dealer
- contact Workswell technical support via support.workswell.eu.

3 User Information

3.1 Typographic Conventions

Following typographic conventions are used in this User Manual:

- UPPER CASE is used for the names of keys, buttons and menu items
- `COURIER` is used for file names and paths
- *Italic* is used for important information and document names
- underline is used for the links to other sections, for function names or Internet sites

3.2 Help and Support

For technical questions that were not answered in this User Manual feel free to contact your dealer or visit the product website at workswell-thermal-camera.com, or contact our support team via support.workswell.eu.

3.3 Updates

The primary aim of Workswell s.r.o. company is to supply their products in a way that meets the current needs of its users and at the same time to remove all the weaknesses that were found in their use as quickly as possible. For this reason, Workswell s.r.o. regularly releases updates for all their products.

Visit my.workswell.eu to download the latest firmware release. The update process itself is described in a later section.

3.4 Firmware

Firmware is the „internal“ control program of the device. From the user's point of view, only the official firmware released by Workswell s.r.o. company can be used for update of the device.

4 Naming conventions

4.1 Abbreviations

Abbreviation	Term
AGC	Automatic Gain control
AUX	Auxiliary - used to describe ports with added functionality
CVBS	Composite Video Baseband Signal
GigE	Gigabit Ethernet
GUI	Graphical User Interface
HDMI	High-Definition Multimedia Interface
IGC	Image Gain Control
IP	Ingress Protection
MGC	Manual Gain Control
NTSC	National Television System(s) Committee
NVM	Non-volatile Memory - anything saved here will be retained after rebooting
NUC	Non-uniformity Correction
PoE	Power over Ethernet
TCSI	Thermal Core Serial Interface
USB	Universal Serial Bus
UVC	USB video class
VM	Volatile Memory
WEOM	Workswell Electro-Optical Module

Table 4.1: Used abbreviations

4.2 Numbers representation

Numbers in this document appear in decadic form, unless:

- They are prefixed with **0x** - those are **hexadecimal** form
- They are prefixed with **0b** - those are in **binary** form

5 Device overview

5.1 Article number specification

The WEOM's article number will always start with letters **WTC**.

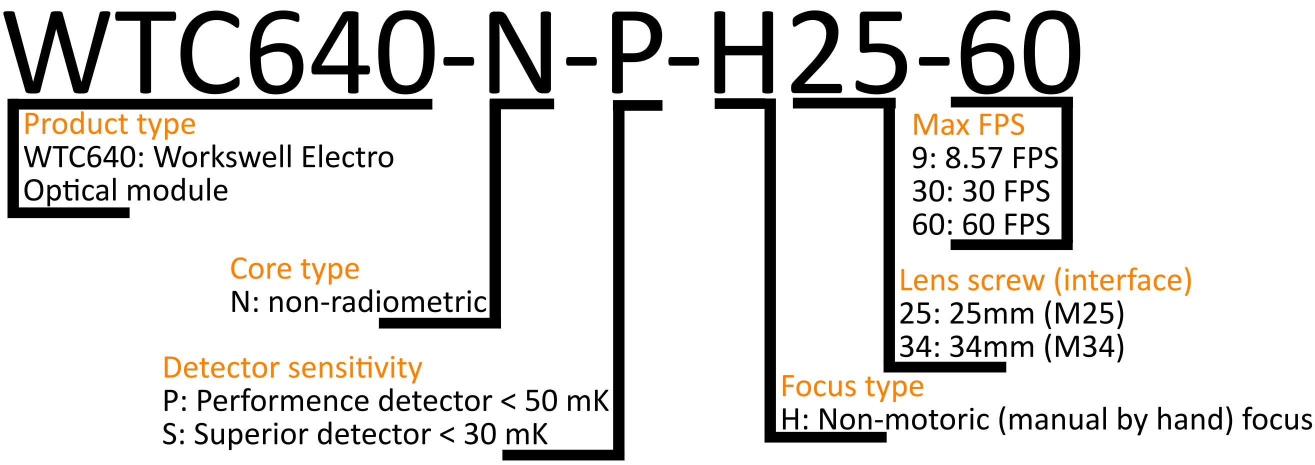

Figure 5.1: Article number explained

5.2 Software applications, libraries and SDKs

We have prepared a number of communication and set up tools for WEOM:

- WEOM GUI - a graphical interface application for quick and easy WEOM set up
- WEOMLink - a light weight C++ library for integrating WEOM into your application
- WEOMPY - a Python module for WEOM control

5.3 Latency

Latency in WEOM is defined as the time period between the detector capturing the full scene and a frame being produced at output. Latency for WEOM has been calculated to be less than 20 ms, or less then 2 frames, for CMOS. This value has been verified on HDMI plugin on a AOC AG251FZ 25" HDMI monitor with high speed Vision Research VEO camera.

5.4 Technical specification

Thermal detector specification	
Detector type	Uncooled LWIR detector, microbolometer
Spectral band	8-14 µm
Detector resolution	640 x 480 px
Detector pixel size	17 µm (up to 30% higher sensitivity than 12 µm detector)
Detector sensitivity	<30 mK or <50 mK
Image frame rate	9 Hz, 30 Hz or 60 Hz full frame rate
Scene temperature range	High Gain mode -50 °C to +160 °C, Low Gain mode -50 °C to 600 °C High Gain mode -58 °F to +320 °F, Low Gain mode -58 °F to 1 112 °F
Technical specifications	
Dimensions (CMOS version)	40.1 (h) x 37.8 (w) x 42.6 (l) mm (1.57 x 1.48 x 1.67 in) without the lens
Weight	< 65 g (2.29 oz) without the lens
IP rating (Encapsulation)	IP67 (at the front of the lens)
Operating temperature	-30°C to +70°C (-22 °F to 158 °F)
Storage temperature	-50 °C to +90 °C (-58 °F to 194 °F)
Humidity	5% to 95% non-condensing
Housing material	Durable aluminum body
ROHS, REACH, WEEE, CE	Compliant
Input voltage	5 VDC
Primary electronic interface	50-pin Hirose
Power Dissipation	CMOS: Typically 1.9 W, 2.1 W peak USB: Typically 2.0 W, 2.2 W peak HDMI: Typically 2.1 W, 2.3 W peak CVBS: Typically 2.3 W, 2.5 W peak GigE PoE: Typically 4.3 W, 4.6 W peak

Table 5.1: Technical specifications

5.5 CMOS interface

The CMOS interface is a digital video interface that enables efficient signal exchange between WEOM and the user's device. Based on CMOS (Complementary Metal-Oxide Semiconductor) technology, it ensures low power consumption, particularly when signals remain static, making it ideal for energy-sensitive operations. This interface supports high-speed data transfers and high-resolution processing, critical for managing the large volumes of data generated by our system.

5.5.1 Interface system connector

Electrical interface of WEOM consists of a single high-density 50-pin connector Hirose, type DF12-50DS-0.5V(86). See the red rectangle in figure 5.2. The recommended mating connector is Hirose DF12(5.0)-50DP-0.5V(86) for a mating stack height of 5 mm. Pin definition of Interface system connector is shown in table 5.2.

Warning: All the other connectors need to remain free.

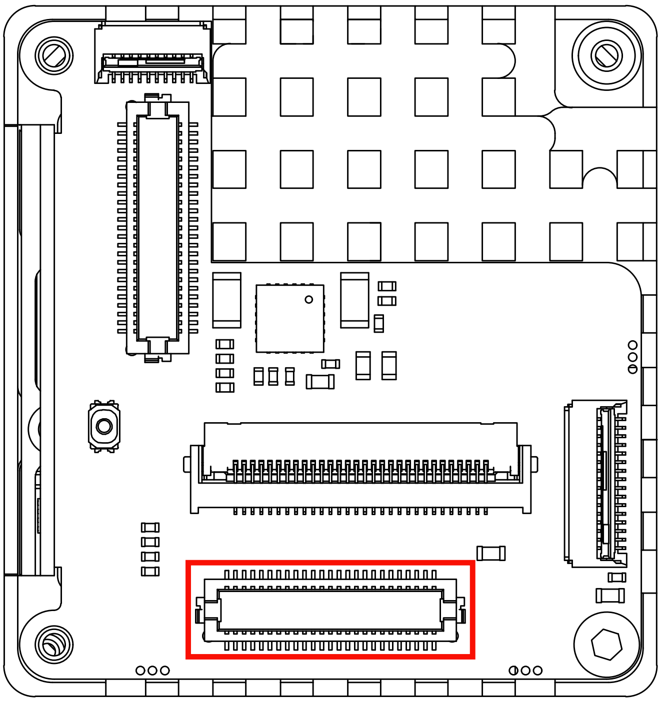

Figure 5.2: View of the rear side of WEOM with Interface System connector J1 (highlighted)

Warning: The electrical interface is extremely susceptible to Electrostatic discharge. ESD protection is required when manipulating the exposed interface.

Signal description	Pin	Pin	Signal description
CORE UART TX	49	50	CORE UART RX
CMOS HORIZONTAL SYNC	47	48	CMOS HORIZONTAL SYNC
Power supply Ground	45	46	Power supply Ground
Not connected	43	44	Not connected
Reserved - do not connect	41	42	Reserved - do not connect
Reserved - do not connect	39	40	Reserved - do not connect
Reserved - do not connect	37	38	Reserved - do not connect
Reserved - do not connect	35	36	Reserved - do not connect
Power supply Ground	33	34	Power supply Ground
Reserved - do not connect	31	32	CMOS VIDEO DATA 13
Reserved - do not connect	29	30	CMOS VIDEO DATA 12
CMOS VIDEO DATA 11	27	28	CMOS VIDEO DATA 10
CMOS VIDEO DATA 9	25	26	CMOS VIDEO DATA 8
Power supply Ground	23	24	Power supply Ground
CMOS VIDEO DATA 7	21	22	CMOS VIDEO DATA 6
CMOS VIDEO DATA 5	19	20	CMOS VIDEO DATA 4
CMOS VIDEO DATA 3	17	18	CMOS VIDEO DATA 2
CMOS VIDEO DATA 1	15	16	CMOS VIDEO DATA 0
Power supply Ground	13	14	Power supply Ground
CMOS Clock Signal	11	12	Not connected
Power supply Ground	9	10	Power supply Ground
Not connected	7	8	Not connected
Power supply Ground	5	6	Reserved - do not connect
Power supply Ground	3	4	Power Supply 5V/Input
Power supply Ground	1	2	Power Supply 5V/Input

Table 5.2: Interface system connector Pin-out

Note: All signals are using 3V3 voltage level, see section 8.1.

Warning: All GND terminals need to be connected!

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Na Okraji 335/42
162 00, Praha 6
Czech Republic

5.5.2 Digital video data

WEOM provides parallel VIDEO DATA interface in the conventional clock video format. The voltage levels of all signals are LVCMOS 3V3. All signals are single-ended. The VIDEO DATA are in 14-bit **Pre-IGC** or **Post-IGC** format with right side alignment. Unused bits are filled with 0. The CMOS clock runs at a frequency of 20 MHz for 60 FPS. For 30 or 9 FPS, a frequency of 10 MHz is used.

> **Note**: For explanation of video formats, see figure 7.1.

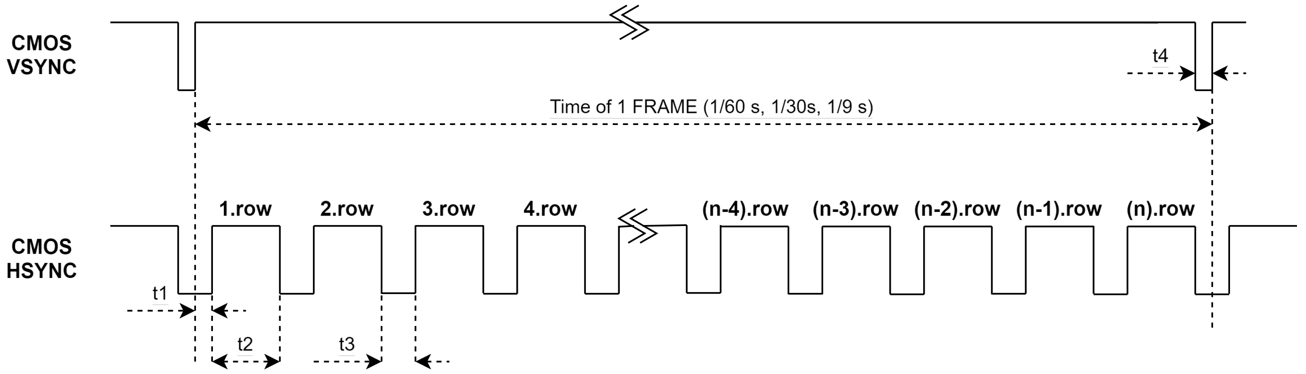


Figure 5.3: One frame transfer timing (n=480) t1=1×CMOS_CLK PERIOD, t2=480×CMOS_CLK PERIOD, t3=26×CMOS_CLK PERIOD, if 9 FPS is used t4=847010×CMOS_CLK PERIOD else t4=13677×CMOS_CLK PERIOD

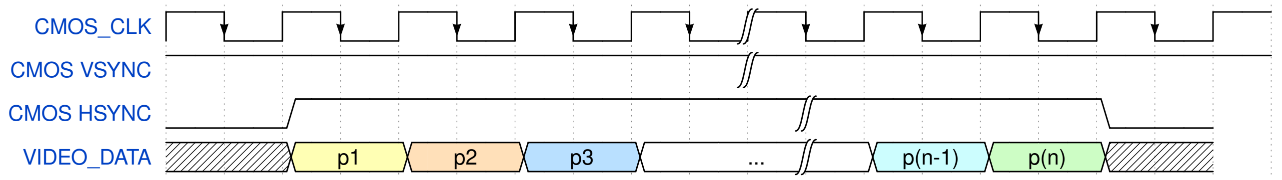


Figure 5.4: One row transfer timing (n=640). p(i) are individual pixels being transferred.

5.6 Plugins overview

Plugins are external components for WEOM, which allow for easy connection and set up. Plugins can be changed, with the only equipment needed being a **1.5 mm hex driver**. To change the plugin:

1. Remove the screws securing the current plugin (or protective cover) and pull it straight away from the core without twisting or tilting to prevent damage to the CMOS pins.
2. Take the new plugin, connect the exposed plugin pins to the core and press them together, and then secure it in place with screws.

After changing a plugin, WEOM's firmware needs to be updated to a version that is specific to WEOM's current plugin.

Warning: Do not remove the plugin (protective CMOS cover) while the core is powered!

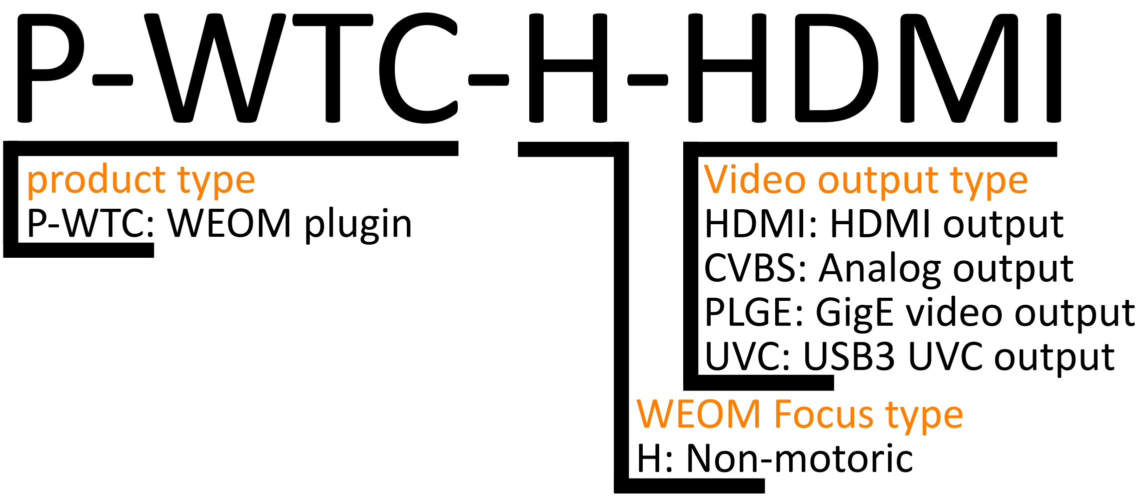


Figure 5.5: Plugin article numbers

5.6.1 HDMI plugin

HDMI plugin offers an all-digital transmission that eliminates signal degradation and provides a lossless connection between devices, ensuring crystal-clear video output. Output data are in **Post-Coloring** format.

Note: For explanation of video formats, see figure 7.1.

HDMI plugin uses micro-HDMI connector for video output and uses UART for camera control. UART is used in both PWRCOM and USB-C connector.

Note: For a detailed description of UART parameters, see section 8.1.

Warning: Either USB-C or PWRCOM can be used for communication and power. It's not possible to use both connectors at the same time.

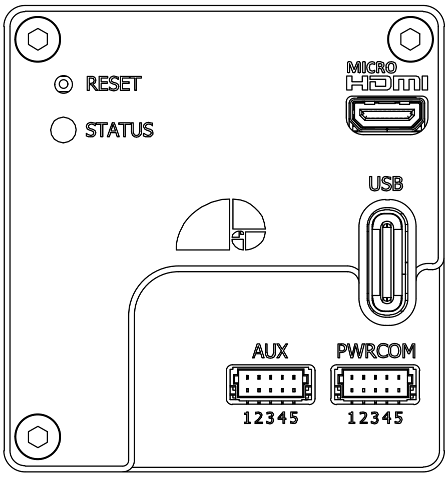


Figure 5.6: HDMI plugin (back view)

Connector	Type	Description
MICRO HDMI	micro-HDMI	video output
PWRCOM	JST	control and power supply
AUX	JST	AUX signals (for future purposes)
USB	USB-C	control and power supply

Table 5.3: HDMI plugin connectors

Pin	AUX	PWRCOM
1	*Do not connect*	input 5 VDC
2	AUX 2	Tx
3	AUX 1	Rx
4	AUX 0	*Do not connect*
5	GND	GND

Table 5.4: JST connectors pinout

JST connector headers are BM05B-SRSS-TB(LF)(SN). The recommended mating housing is SHR-05V-S.

Connector	Interface	Version
micro-HDMI	HDMI	1.4
USB-C	USB	2.0

Table 5.5: Interfaces

Note: Displays supporting newer versions of HDMI are backwards compatible with HDMI 1.4.

5.6.1.1 Mounting HDMI plugin

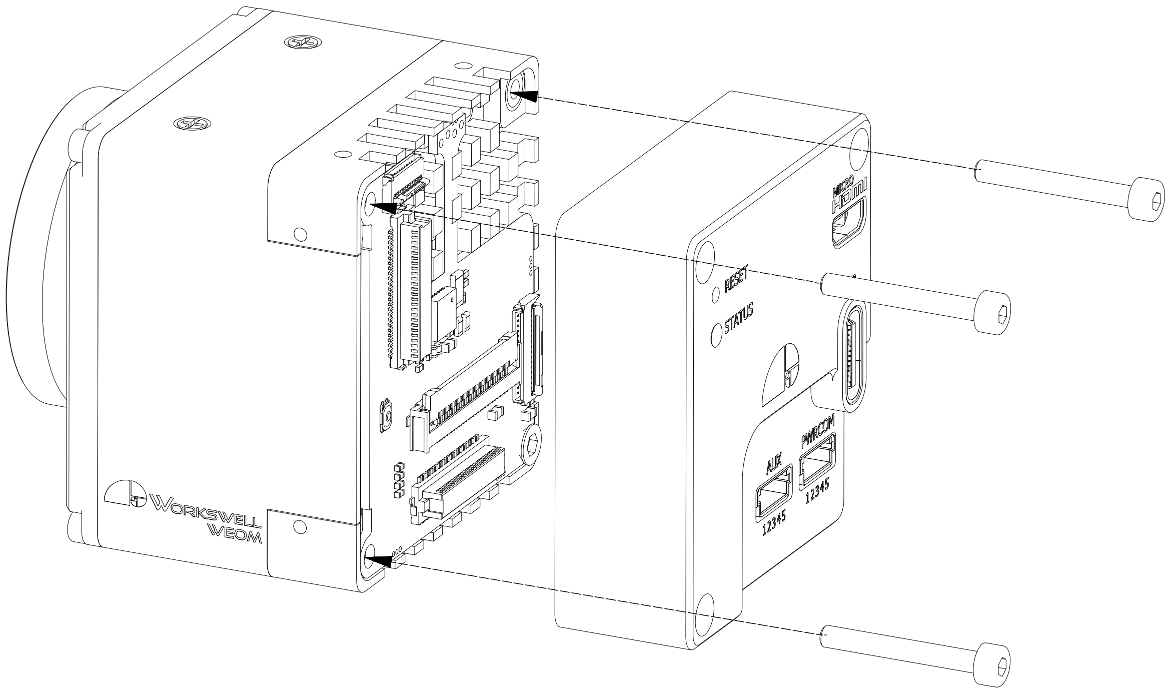


Figure 5.7: Mounting a HDMI plugin

> **Warning:** Do not remove the plugin while the core is powered!

5.6.2 Analog plugin

CVBS NTSC is compatible with a vast range of equipment such as analog displays or surveillance systems. Analog plugin uses a micro-coaxial connector for video output and uses UART for camera control. UART is used in both PWRCOM and USB-C connector. Plugin supports **NTSC video signal**. Output data are in **Post-Coloring** format.

> **Note**: For explanation of video formats, see figure 7.1.

For video connection between micro-coaxial connector and a target device, use a standard micro-coaxial cable with 75 Ω impedance.

Note: For a detailed description of UART parameters, see section 8.1.

Warning: Either USB-C or PWRCOM can be used for communication and power. It's not possible to use both connectors at the same time.

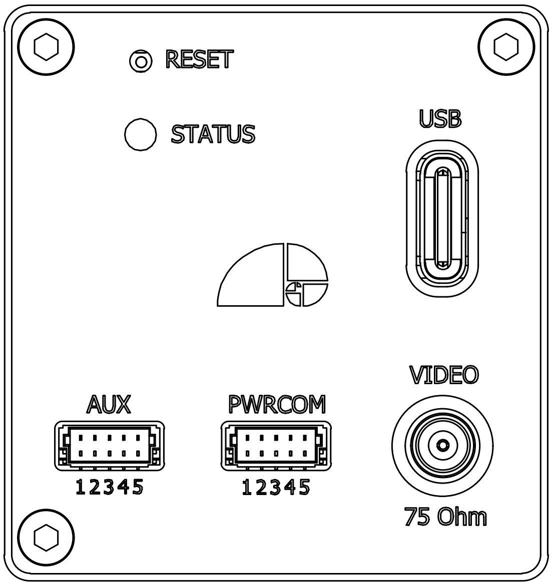


Figure 5.8: CVBS plugin (back view)

Connector	Type	Description
VIDEO	CVBS	video output
PWRCOM	JST	control and power supply
AUX	JST	AUX signals (for future purposes)
USB	USB-C	control and power supply

Table 5.6: HDMI plugin connectors

Pin	AUX	PWRCOM
1	*Do not connect*	input 5 VDC
2	AUX 2	Tx
3	AUX 1	Rx
4	AUX 0	*Do not connect*
5	GND	GND

Table 5.7: JST connectors pinout

JST connector headers are BM05B-SRSS-TB(LF)(SN). The recommended housing is SHR-05V-S.
The micro-coaxial connector is Johnson - Cinch Connectivity Solutions 133-8711-202.

Connector	Interface	Version
Video	CVBS NTSC	-
USB-C	USB	2.0

Table 5.8: Interfaces

5.6.2.1 Mounting Analog plugin

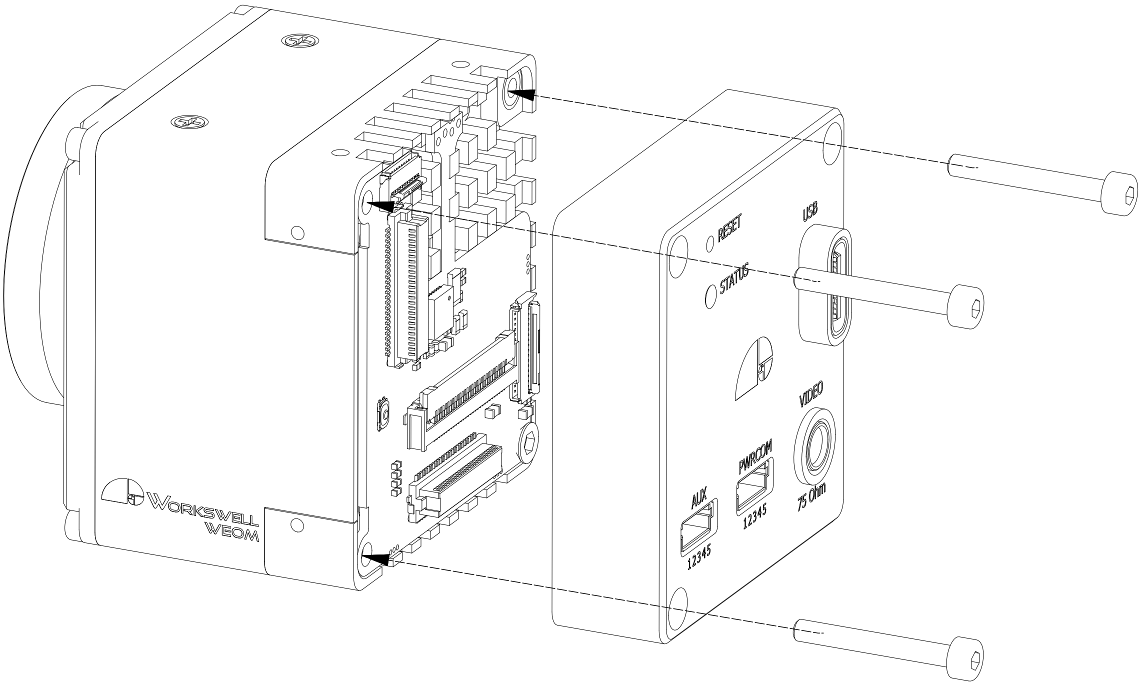


Figure 5.9: Mounting a CVBS plugin

Warning: Do not remove the plugin while the core is powered!

5.6.3 GigE video plugin

GigE video plugin is ideal for applications requiring fast, real-time thermal imaging over a network. GigE video plugin utilizes the Gigabit Ethernet interface for high-speed data transmission and power supply (PoE). The supported PoE standard is **IEEE 802.3a**. Both **Pre-IGC** and **Post-IGC** formats are supported for the capture of thermal images.

Note: For explanation of video formats, see figure 7.1.

Note: The user needs to ensure proper network setup and adequate bandwidth to optimize performance.

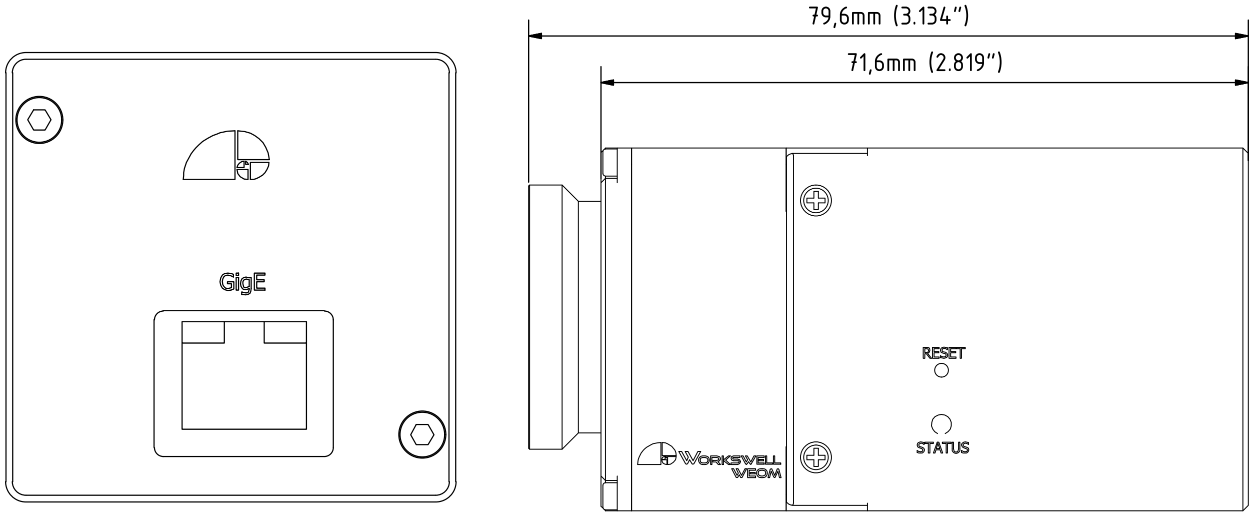


Figure 5.10: GigE video plugin rear and side view

5.6.3.1 Requirements

Pleora eBUS runtime environment, which is included with WEOM GUI application, is required for communication and streaming. Every network device between the WEOM and the receiver (a PC, drone, etc.) as well as the receiver's network interface card itself has to support Gigabit Ethernet speeds, as well as jumbo frames (payloads larger then 1500 bytes). For the best streaming performance, it is highly recommended that WEOM is connected directly to the receiver with no other network device between them.

5.6.3.2 Mounting GigE video plugin

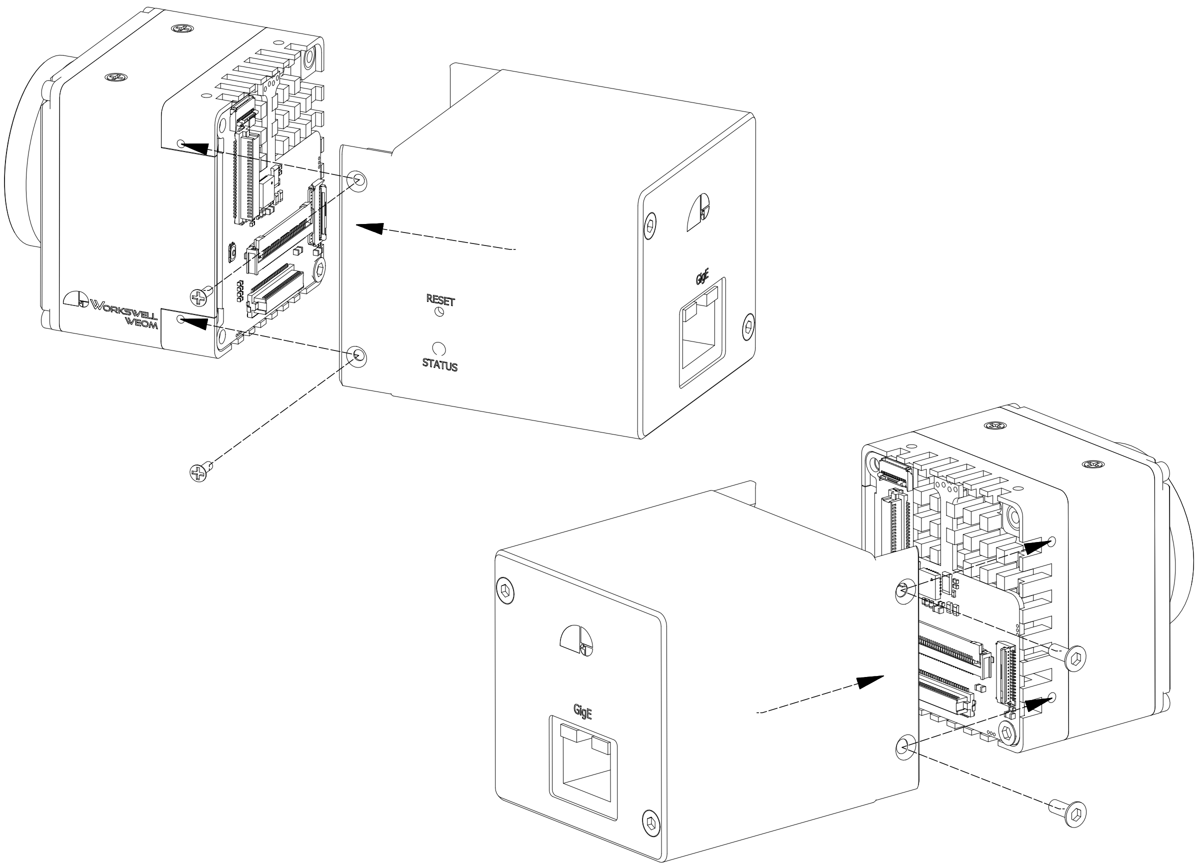


Figure 5.11: Mounting a GigE video plugin

Warning: Do not remove the plugin while the core is powered!

5.6.4 USB3 UVC plugin

UVC plugin uses USB-C connector for control, power and video stream. With UVC plugin, WEOM functions similarly to a standard USB camera. **Post-Coloring** format is supported. Communication is done via virtual COM port (UART).

Note: For explanation of video formats, see figure 7.1.

Note: For a detailed description of UART parameters, see section 8.1.

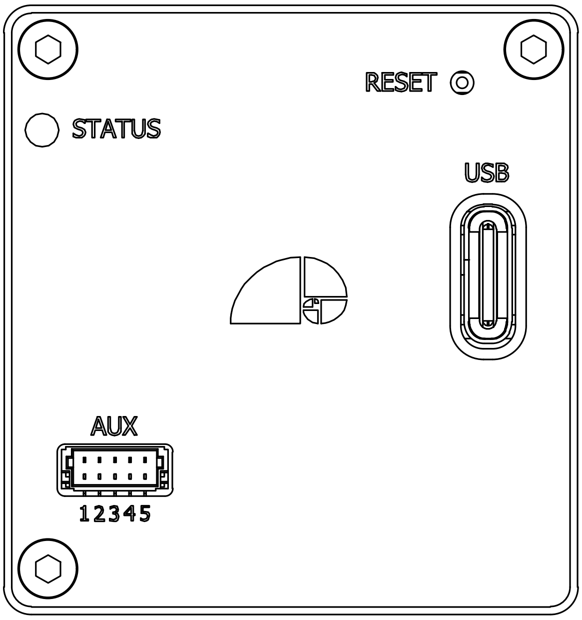


Figure 5.12: UVC plugin (back side)

Connector	Type	Description
USB	USB-C	Video, power supply and control
AUX	JST	AUX signals (for future purposes)

Table 5.9: UVC plugin connectors

Pin	AUX
1	*Do not connect*
2	AUX 2
3	AUX 1
4	AUX 0
5	GND

Table 5.10: AUX connector pin out

JST connector headers are BM05B-SRSS-TB(LF)(SN). The recommended housing is SHR-05V-S.

Connector	Interface	Version
USB-C	USB	2.0 compatible, 3.0/3.1 native

Table 5.11: Interfaces

5.6.4.1 Mounting USB3 UVC plugin

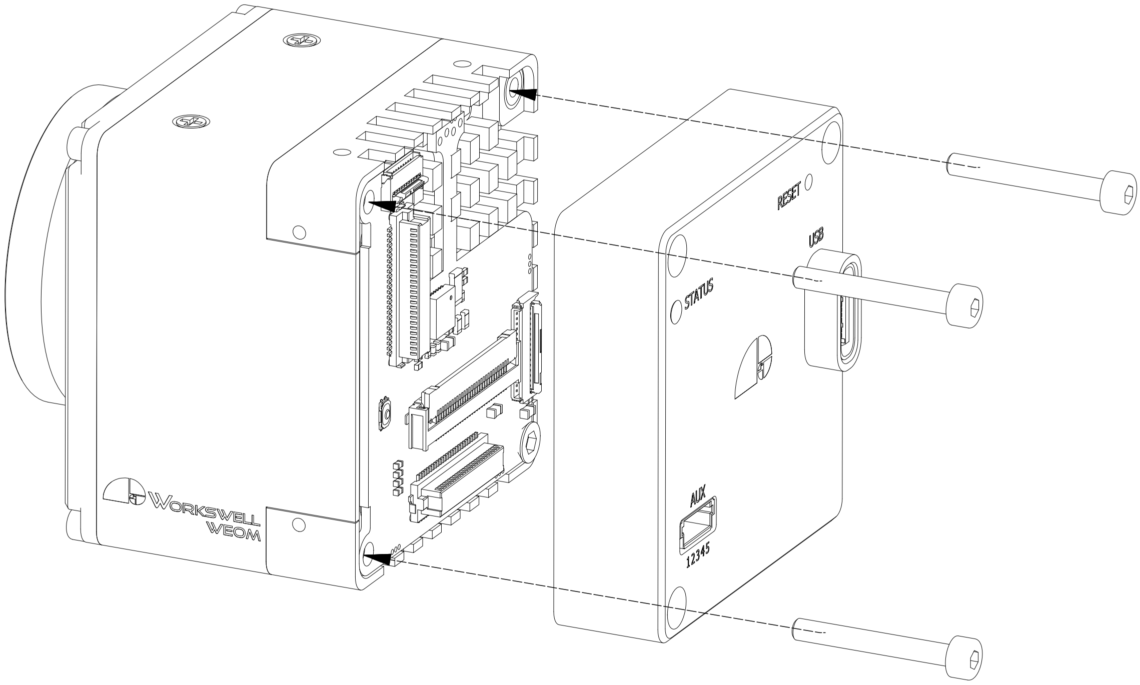


Figure 5.13: Mounting a USB3 UVC plugin

Warning: Do not remove the plugin while the core is powered!

5.6.4.2 USB3 UVC plugin firmware update

To update the plugin firmware you will need the WEOM GUI application (available for download at my.workswell.eu).

1. Unplug the USB cable connecting WEOM from the PC's USB port while keeping it connected to the plugin.
2. Unscrew all three screws holding the plugin and detach the plugin from WEOM core.
3. Locate a button on the inner side of the plugin (See figure 5.14).
4. Press and hold the button.
5. Reconnect the plugin to the computer with a USB cable.
6. Release the button.

7. Open WEOM GUI.
8. Choose the USB plugin option
9. In the Connection tab, click PLUGINS and choose PLUGIN #1. If you have multiple plugins connected, verify that the correct plugin is selected by its serial number.
10. Click UPLOAD FIRMWARE and pick the file containing the latest firmware version.
11. Wait for the update to finish.
12. Screw the plugin back on.
13. Restart WEOM.

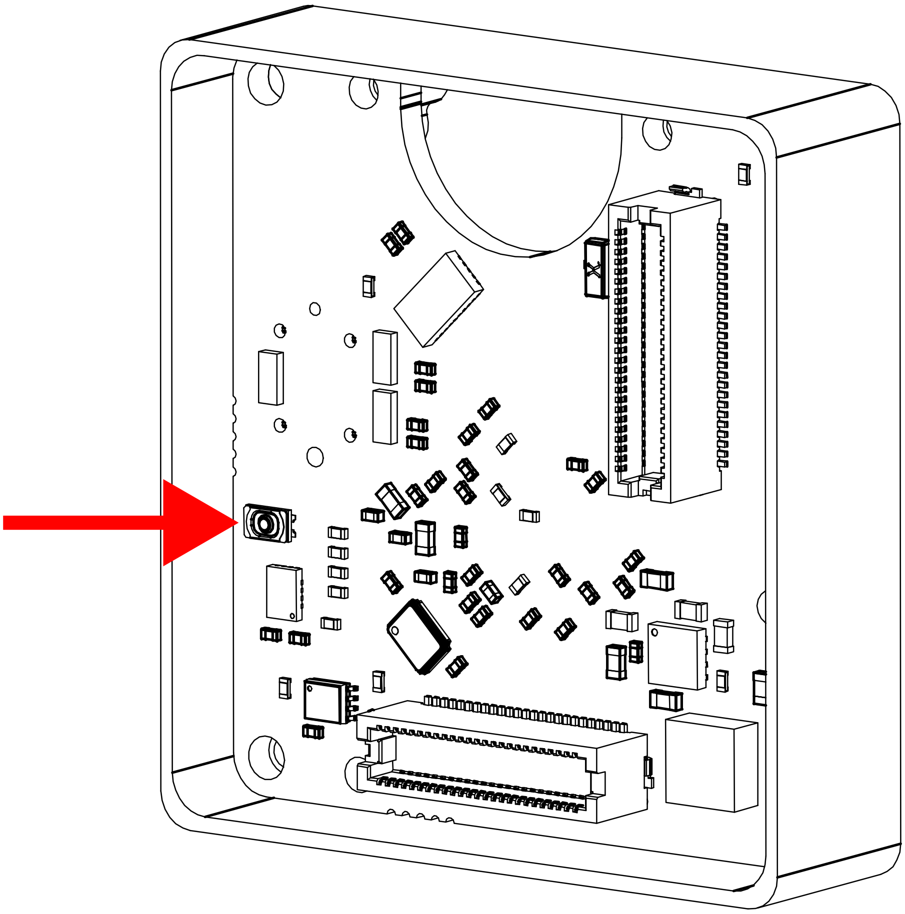


Figure 5.14: Button for UVC plugin firmware update

5.6.4.3 Video stream format

In order to obtain video stream from the USB3 UVC plugin, it's possible to use cv2 or a similar library. The following is a Python code snippet that opens the stream with the Post-Coloring format.

> **Note**: It's necessary to first install Open CV by running `pip install opencv-python` in the terminal.

```
import cv2 as cv
index = 0
camera = cv.VideoCapture(index, cv.CAP_DSHOW)

while True:
    ret, frame = camera.read()
    cv.imshow("Vide stream",frame )
    if cv.waitKey(1) == ord('q'):
        break

camera.release()
cv.destroyAllWindows()
```

> **Note**: The video format of the output video stream cannot be changed while the stream is open. It's necessary to close the stream and open another with the Pre-IGC format (Mono14).

5.7 Focusing system

5.7.1 Lens options

We offer a wide variety of lenses for WEOM. For more information, go to my.workswell.eu.

Article number	Focal length	FOV	f-number	Thread
L-WTC-14-HE25-A	14.2 mm	42.1° (H) x 52.2° (V)	f/1.2	M25
L-WTC-25-HE25-A	25 mm	24.2° (H) x 29.8° (V)	f/1.2	M25
L-WTC-35-HE25-A	35 mm	17.4° (H) x 13.2° (V)	f/1.1	M25
L-WTC-7-HE34-A	7.5 mm	90.8° (H) x 65.1° (V)	f/1.2	M34
L-WTC-14-HE34-A	14.3 mm	42.1° (H) x 52.2° (V)	f/1.2	M34
L-WTC-25-HE34-A	25 mm	24.2° (H) x 29.8° (V)	f/1.2	M34
L-WTC-35-HE34-A	35 mm	17.4° (H) x 13.2° (V)	f/1.2	M34

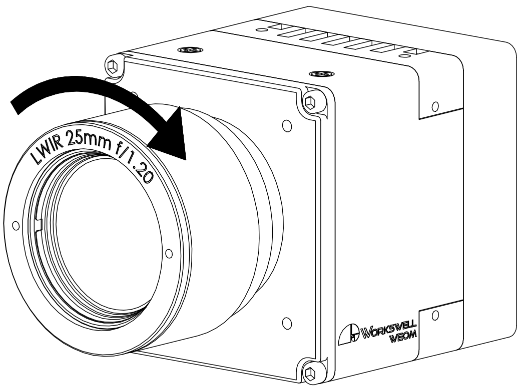
Table 5.12: Lens options for WEOM

If none of these options are applicable, new ones can be added after contacting us via support.workswell.eu.

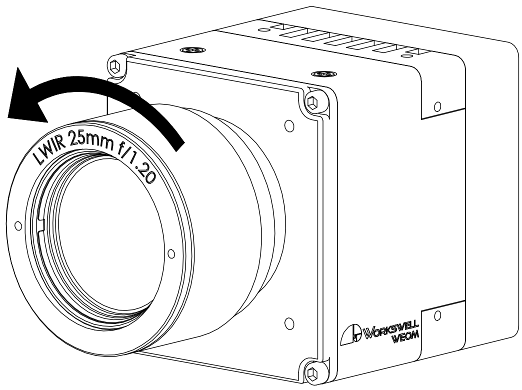
5.7.2 Focusing the lens

WEOM is equipped with a manual (non-motorized) focusing system.

Note: WEOM is focused to infinity during manufacturing and in most cases should never need adjustments.



(a) Adjusting focus for longer distance



(b) Adjusting focus for shorter distance

Figure 5.15: Non-motoric focusing system

5.7.2.1 Focusing to long distance

In order to focus on long distance (or infinity) gently rotate the lens clockwise (see figure 5.15a). During this movement, the lens retracts to the camera body. Rotating the lens too far in this direction can adjust beyond the intended focus range. Infinity focus is recommended for most applications.

5.7.2.2 Focusing to short distance

In order to focus for short distance, gently rotate the lens counter-clockwise (see figure 5.15b). During this movement, the lens extends from the camera body.

Warning: Over-rotating the lens may cause it to detach and fall out.

5.7.3 Changing and cleaning the lens

It is recommended to clean the focusing system with every lens removal. We recommend using the following procedure for changing and cleaning the lens:

5.7.3.1 Compressed gas specification

The compressed gas used to clean the focusing system should satisfy the following conditions:

- Leaves zero residue.
- Has no oil propellant or other impurities.
- Does not condense upon application.
- Has purity of at least 99% (e.g. isobutane, tetrafluorethane, CO_2 of optical grade purity).
- Has no odor, humidity or bittering additive.

Note: The gas should meet at least ISO 8573-1: Class 1.2.1 purity standards, or be specifically designated as "optical cleaning gas," such as those specified by manufacturers like Clean IT, Dust-Off, DataVac, etc.

Warning: Do not use standard industrial compressed air from a compressor unless it is additionally filtered through both oil and particle filters. Contaminants or microscopic oil droplets can cause irreversible damage to optical surfaces and sensors.

5.7.3.2 Preparation

1. Disconnect WEOM from the power supply.
2. Make sure the device has cooled down.
3. Remove the lens by turning it counterclockwise until it is fully detached.

5.7.3.3 Cleaning the lens and the focusing system

1. Hold the spray can upright (valve on top), with the nozzle aimed horizontally, approximately 10 cm from the surface being cleaned. Tilting the can may release liquid gas, which can damage the cleaned surfaces.
2. Before the actual cleaning, release a short burst into open space to remove possible condensate.
3. Use the included directional nozzle for precise control of the airflow.
4. Use short bursts to blow dust and debris off the sensor or optical surfaces. Avoid long, continuous sprays to prevent excessive cooling of the surface.

5.7.3.4 Safety precautions

1. Do not use near open flames or heat sources if you're using one of the flammable gases.
2. Ensure adequate ventilation in the room during use.
3. Do not inhale the released gas.
4. After use, the canister may feel cold to the touch—this is normal.

5.7.3.5 Lens installation

1. Immediately after cleaning with compressed gas, install the desired lens by screwing it in clockwise.
2. If necessary, the outer surface of the lens may be cleaned again using compressed gas or gently wiped with a cloth designed for delicate optical surfaces.

6 First connection

6.1 Powering on/off

WEOM will start to boot immediately after being connected to a power source. During the booting sequence, WEOM uploads the configuration, settings and calibration matrices from NVM, and then starts the main firmware. While the booting sequence is being executed, a black image is generated on the video output.
If a plugin is installed, the built-in LED quickly flashes white and then continuously glows blue, until the main firmware is started.

6.1.1 Temperature stabilization

It is standard for IR cores to require a temperature stabilization period after booting. For WEOM, a 15 minutes stabilization period is recommended for the best possible image quality.

6.2 Loader

Loader is a small part of firmware responsible for booting into main firmware and updating main firmware. If WEOM boots into loader it means an upload has failed and needs to be re-initiated or a new plugin has been installed. The user is able to boot WEOM into loader manually with the reset button (see section 6.5), or flipping the appropriate trigger bit (see section 8.2).

6.3 Firmware update

Firmware can be updated via WEOM GUI application or WEOMPy Python module mentioned in chapter 5.2.

> **Note**: The *.uwtc files are different for different plugins. Make sure the update file corresponds to the installed plugin.

Firmware update will not rewrite any changes in user available address space in NVM, including configuration registers, palettes or dead pixels.

6.4 LED

All of the WEOM plugins are equipped with a status RGB LED. The LED will change color and its behavior depending on the state of the device:

Color	Signal length	Description
Blue	2 short flashes every 2 seconds	Update in progress
Blue	Continuous	Device is booting up
Blue	1 flash every second	Reset button is pressed down
Red	Continuous	Critical failure
Red	1 flash every second	Non critical error
Red	2 quick flashes every 2 seconds	Update failed
Green	1 flash every second	Device is running

Table 6.1: LED signalization

Note:
- The various statuses described above are **ordered by importance**. So an update in progress status will take precedent over every other status.
- There is always exactly one status being signaled.

Note: If a critical failure occurs, the device needs to be sent via RMA for repairs.

Note: A non-critical error can usually be fixed by restarting the device after a short resting period, during which the device is unpowered.

The user is able to lower the intensity of every color or disable them completely (with the exception of red, which cannot be disabled).

6.5 Reset

WEOM and its plugins are equipped with a reset button at the back (or in case of GigE video plugin, at the side) of the device. Pressing and releasing this reset button will reboot the device with the configuration stored in NVM. Pressing this button and holding it down for at least 10 seconds will reboot the device with the factory default configuration.
If the reset button is held down while WEOM is booting, it will cause it to boot into loader.

Note:
- Releasing the button before 10 seconds is up will cause the device to simply reboot.
- Pushing the button shortly twice will cause WEOM to boot into loader.

7 Video pipeline

Video pipeline consists of the paths the image signal can take from a source to the video output. In summary, the image originates in the detector and goes through non-uniformity correction (NUC) to dead pixel replacement, then filters to a multiplexer. If a test pattern is selected, the video signal originating from the detector is blocked by the multiplexer and the test pattern signal is let through. Then, based on the connected plugin and output format setting, it either goes through an image gain equalization (IGC), is colored with palettes and goes to the video output, or it goes to the output directly.

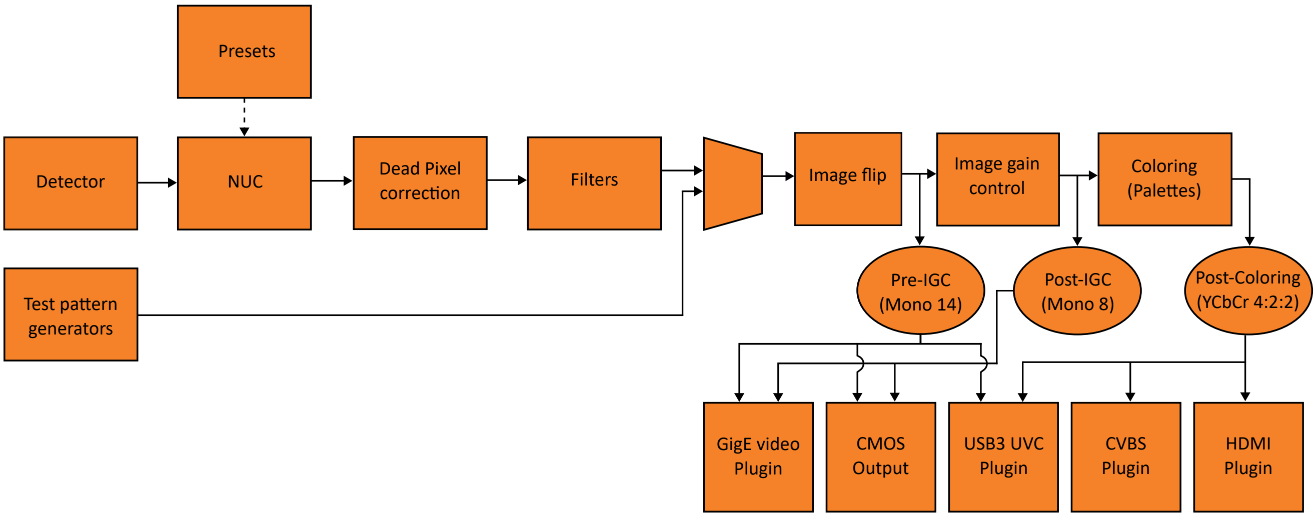


Figure 7.1: Video pipeline diagram

7.1 Presets

WEOM's preset consists of configuration data for a particular combination of a temperature range and lens. The presets are calibrated for every WEOM separately. Their purpose is to equalize potential variations in the manufacturing of WEOM's detectors and to counteract drift caused by the changes of ambient temperature.

Lens: The chosen lens determines the field of view, focal length and the infinity focus distance. For an overview of available lens options for WEOM, see section 5.7.1.

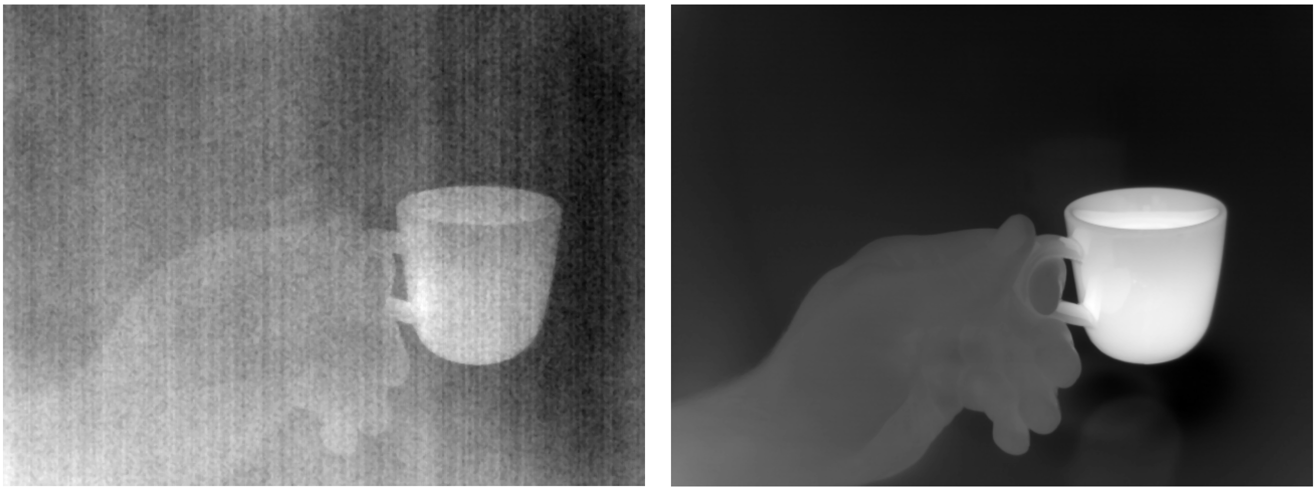
Gain: WEOM offers two gain modes to choose from.

- High gain: approximate range of -50 °C to +160 °C (-58 °F to 302 °F). Offers increased contrast between objects in a scene and high sensitivity.
- Low gain: approximate range of -50 °C to +600 °C (-58 °F to 1112 °F). Offers larger temperature range at the cost of decreased contrast between objects in a scene and lower sensitivity.

7.2 Non-uniformity correction

The non-uniformity is a time-dependent noise caused by the physical differences between detector pixels. These physical differences come from the fact that it is not possible for each pixel to be manufactured the same. This appears as a fixed noise pattern superimposed on the image (see figure 7.2a). To prevent this, WEOM uses non-uniformity correction (NUC) algorithm. WEOM holds matrices that for each pixel contains a value that counteracts the influence of noise as well as the influence of uneven heating.
To ensure the best possible image quality over time, it is necessary to update the data used to compute the correction. This process requires a uniform scene, for which WEOM uses its internal shutter. To perform a non-uniform correction offset update, the internal shutter closes, a picture is taken and the shutter opens again. The resulting picture is then used to update the matrix.
The whole update takes about a second and the image freezes for this duration.

Note: Scenes in this chapter were captured using 14 mm lens with high gain and Gray palette.



(a) NUC disabled

(b) NUC enabled

Figure 7.2: Scene before and after performing NUC offset update.

The user is able to chose between two NUC offset update modes:

- Periodic - NUC offset update is performed after a certain user defined period since the last NUC update.
- Adaptive - NUC offset update is performed after a certain user defined period since the last NUC offset update **or** WEOM's internal temperature has reached a user defined difference since the last NUC offset update.

Note:
- Period has a range from 120 to 7200 seconds (from 2 minutes to 2 hours). Both Periodic and Adaptive modes share this value between each other.
- Temperature values range from 0.25°C (0.45°F) to 10°C (18°F), incrementing by 0.0625°C (0.1125°F).

7.3 Dead pixel correction

A dead (defective) pixel is a pixel that is not functioning properly. This will result in that pixel appearing a solid color, usually black or white (see figure 7.3a).
Dead pixels are a normal occurrence in thermal sensors. They can be easily fixed through Dead pixel selector in our WEOM GUI application. After selecting a dead pixel, it is automatically mapped to its neighbor(s) which will then be continuously used to replace its value during operation.

Note: WEOM can replace up to 2048 pixels.

(a) scene with dead pixels

(b) after dead pixel correction

Figure 7.3: A zoomed-in cutout of a scene illustrating dead pixel correction

7.4 Filters

7.4.1 Median filter

The primary purpose of this filter is to eliminate spatial noise. This can be useful when removing random occurrences of bright and dark pixels. With median filter enabled, WEOM smooths the noise from the image by replacing the value of every pixel with the median value of that pixel and eight of its immediately adjacent pixels (except for the edges and corners, where only the available pixels are used), which leads to a more cohesive image but with less detail. The process is further explained in figure 7.4.

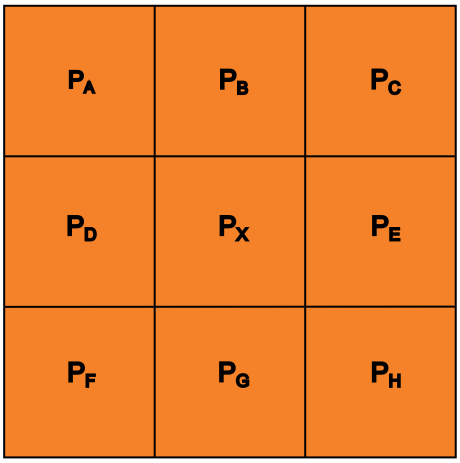


Figure 7.4: Median filter pixel replacement process

Pixel value P_X will be replaced by a median value from a sorted set of pixel values consisting of pixels $P_A, P_B, P_C, P_D, P_E, P_F, P_G, P_H$ and P_X itself.

7.4.2 Time domain average

Time domain averaging takes the average of the current and previous measured pixel values and replaces the pixel value of the current image. This will lead to further noise reduction, but at a cost of dynamic scenes appearing blurred.

Note: The best results are achieved with lower FPS values, as a dynamic scene will not be as affected.

Time domain averaging, when enabled, can be done from:

- 2 frames
- 4 frames

Note: Higher number of input frames means the changes to the output value will be less dynamic.

7.5 Frame rate

The current frame rate can be changed according to the WEOM article number (see figure 5.1). The current frame rate cannot exceed the maximum value.

Note: For example, a WEOM with article number WTC640-N-P-B25-**30** cannot be set to **60** FPS.

The frame rates available are:

- 8.57 FPS
- 30 FPS
- 60 FPS

7.6 Image freeze

WEOM is equipped with a feature that allows users to freeze the current thermal image for detailed analysis and enhanced user interaction. Image freezing offers the ability to pause the dynamic view, providing an opportunity to focus on specific details without the need for continuous live observation.

7.7 Image flip

For situations when capturing scenes that require mirrored visuals, or a need arises for inverted visuals, WEOM supports image flipping. Engineered for both hardware and software efficiency, the image flipping process is optimized to maintain full resolution and color accuracy, ensuring that every detail is preserved. Image can be flipped 4 ways:

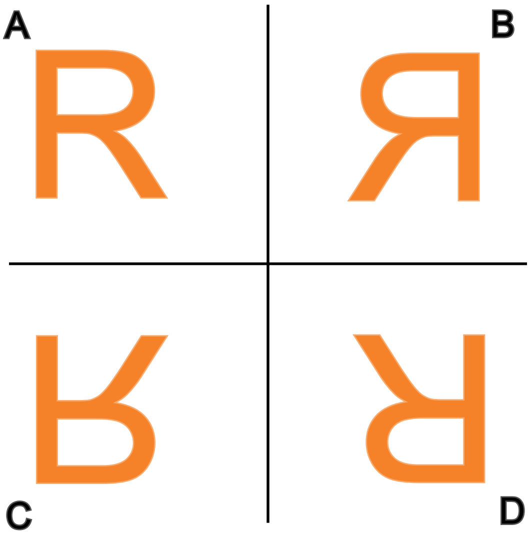


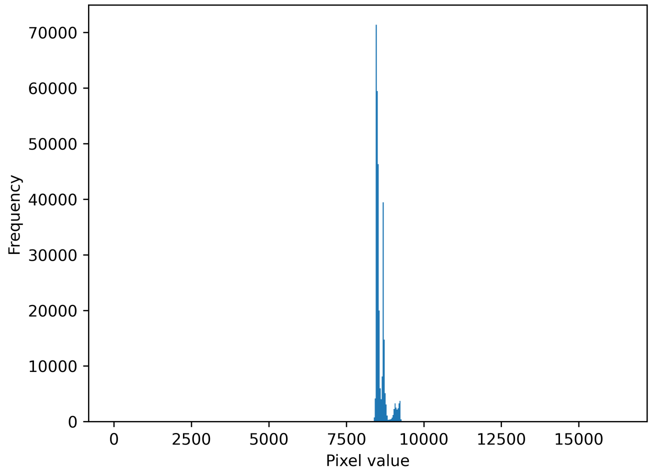
Figure 7.5: Image flip options

A: The default image orientation
B: Horizontal image flip enabled
C: Vertical image flip enabled
D: Both the horizontal and vertical image flip enabled

7.8 Image gain control

In normal operation, a scene will have non-uniform temperatures. Due to the relatively large scale of the detector temperature values, a scene with temperatures differing by a relatively small margin may appear as uniformly filled with the same color in the final image (see figure 7.6a). We can think of the image as a histogram, where the size of each bin represents the number of pixels of **Pre-IGC** (Mono 14) values (see figure 7.6b). The linear and non-linear equalization methods described below run concurrently to transform values to **Post-IGC** (Mono 8) format, so that crucial information will not be lost in the image. The user is able to adjust the weight of each of these values to be used in the final image.

(a) image



(b) histogram

Figure 7.6: A scene before applying any IGC

7.8.1 Linear equalization

Linear equalization transforms the histogram based on the desired brightness and contrast, where contrast adjusts the maximum and minimum values of the range used for the image and brightness then shifts this range to the left or right side of the histogram. Anything outside of the range is then mapped towards the maximum and minimum values of the contrast range. The process of choosing the contrast and brightness of the image can be done automatically or manually.

7.8.1.1 Automatic

Automatic linear gain control allows WEOM to automatically gauge the brightness and contrast in a scene from the current and previous images, which leads to cleaner and higher quality image. The user can choose how many previous images are used for this calculation, with the general rule of thumb being that more images provide greater stability but a slower response to changes in the scene. The user is able to choose averaging from:

- current image
- current and previous image
- current and 3 previous images
- current and 7 previous images
- current and 15 previous images

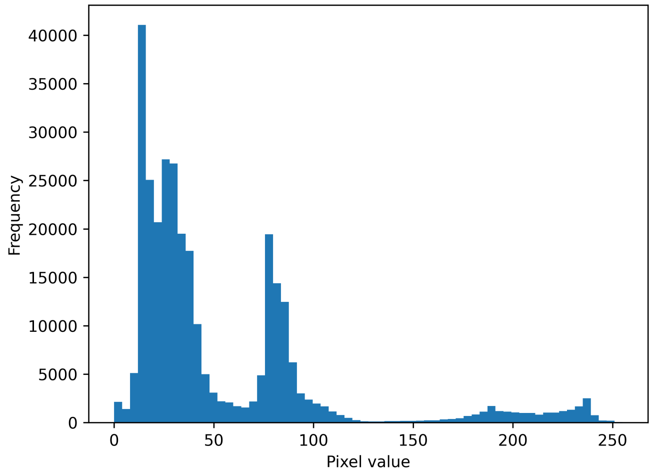
7.8.1.2 Manual

When selected, brightness and contrast are set manually. This allows for a precise user control of the qualities of the image. It can be useful if there is a very bright (i.e. warm) area in the image, but the area you are actually interested in is less bright (i.e. colder). For example if there are objects that are too cold to be visible with linear automatic gain control, you can raise brightness so that these objects become visible.

> **Warning:** Changing brightness or contrast from the calculated optimal value may cause some parts of the image to appear supersaturated.

If you set brightness too high, the image will be white. If you set it too low, the image will be black.

(a) image



(b) histogram

Figure 7.7: A scene with AGC applied

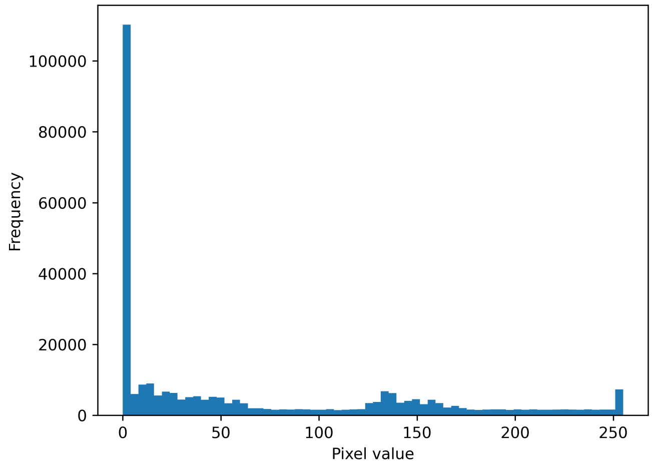
7.8.2 Plateau equalization

Plateau equalization redistributes the most represented values to pixels in a way that enhances image contrast. This can be useful when there are opposing temperature extremes present in a scene, which may lead to other objects with temperatures in between the extremes being hardly visible. Plateau equalization suppresses information about temperature extremes to enhance the visibility of other objects in the image.
The user is able to adjust the behavior of plateau equalization by changing:

- Clip limit - defines the maximum allowable height of the histogram bins. By setting a threshold, this prevents certain pixel intensity ranges from becoming overly dominant in the equalized image, ensuring smoother transitions between intensity levels.
  Clip limit can be adjusted to fine-tune the pixel distribution. Lower clip limits result in a more uniform intensity distribution, while higher clip limits preserve more natural contrast in the image.
- Tail rejection - controls the rejection of outlier pixel intensities. By removing a small percentage of the darkest and brightest pixels from the histogram, this setting prevents extreme values from skewing the

equalization process.
The tail rejection value should be set between 0 and 49% based on the intensity of the outlier pixels to be discarded. Higher values will result in a larger portion of outliers being excluded, preserving the integrity of mid-range details and improving overall image contrast.

(a) image

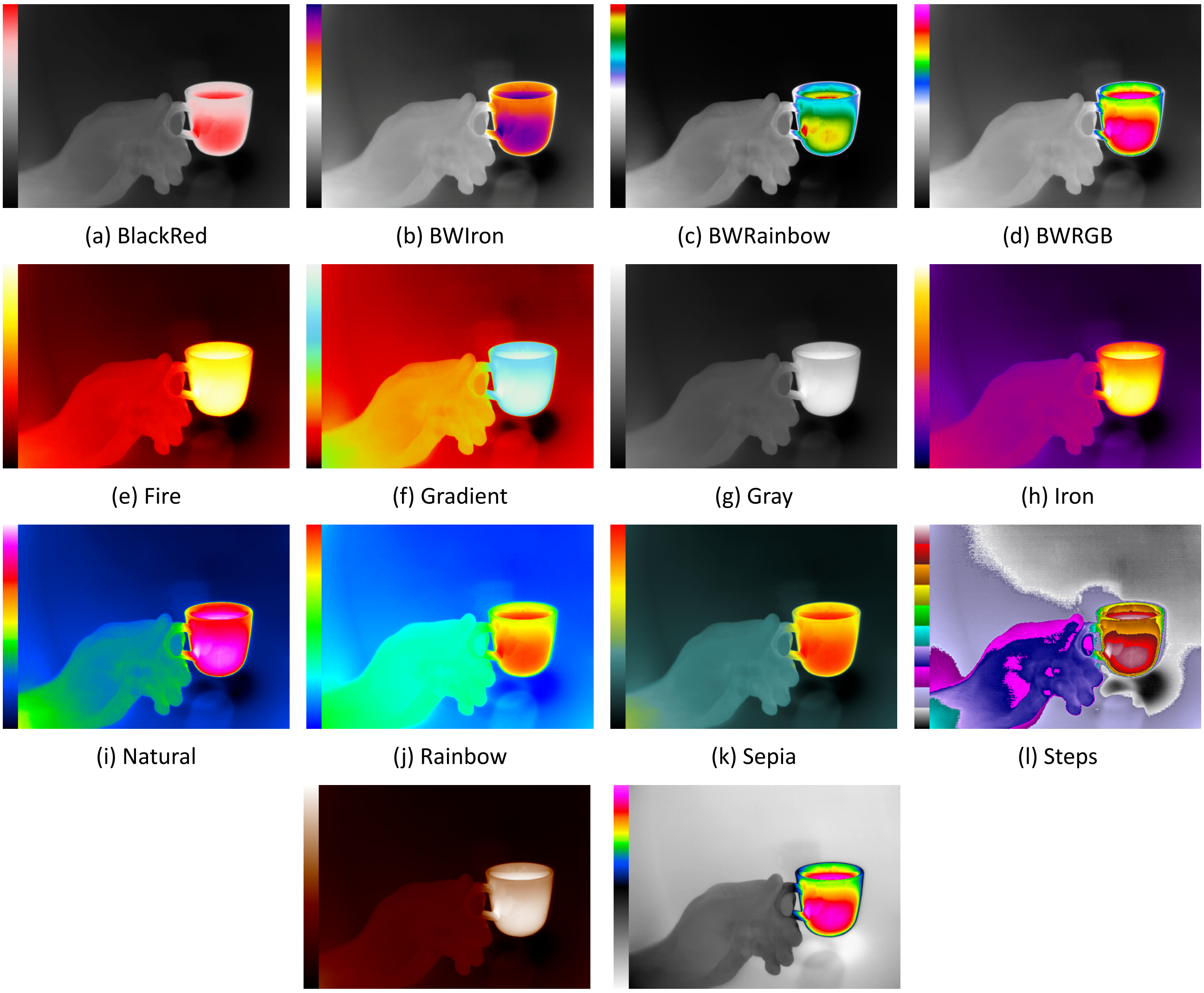


(b) histogram

Figure 7.8: A scene with Plateau gain control applied

7.9 Palettes

The last step before the image is sent to the output port is the application of a chosen palette.
A palette in this context is a table of 256 RGB values that are then used to map **Post-IGC** values to colors on the screen. In this context, the **Post-IGC** values can be thought of as indexes in the palette table. In the image, the lowest temperature maps to the first value and the highest temperature maps to the last value in the table. There are 14 palettes available to choose from in WEOM (see figure 7.9) and two more user palettes can be uploaded using WEOM GUI or WEOMPy.



(a) BlackRed (b) BWIron (c) BWRainbow (d) BWRGB

(e) Fire (f) Gradient (g) Gray (h) Iron

(i) Natural (j) Rainbow (k) Sepia (l) Steps

(m) Temperature (n) WBRGB

Figure 7.9: WEOM palette options

8 Communication protocol

WEOM provides a direct access to its registry. This chapter contains information about the memory, its structure and ways to access it.

Warning: Writing outside of WEOM's writable registers can result in undefined behavior.

8.1 UART

WEOM uses 3v3 voltage signal levels for UART communication.

Parameter	Value
Baud rate	Modifiable: ▪ 115 200 Bd (default) ▪ 921 600 Bd ▪ 3 000 000 Bd
Data Bits	8
Parity	None
Start/Stop bits	1/1
Flow Control	None

Table 8.1: UART parameters

8.2 Triggers

Six triggers can be accessed to execute various functions. They are placed in the register 0x4. To trigger an action, the corresponding bit has to be set to 1. See table 8.3.

8.3 Memory

Memory in WEOM is organized in registers. One register is 4 bytes (32 bits). Data arrangement is **little-endian**, meaning that the least significant byte is stored first.

8.4 Temperature conversion

When reading the shutter temperature, it is in the two's complement representation, stored in two bytes, with the useful information in bits 0-11 and the signed bit in bit 12. It needs to be converted to a human readable unit with one of these procedures:

For Celsius:
Take the first (upper) byte times 2^4 modulo 2^8. Take the second (lower) byte and multiply with 2^{-4}. Add them together. The result is signed according to the bit number 12. If the signed bit is 0, the calculation is finished:

$$T[°C] = (UpperByte \times 2^4 + LowerByte \times 2^{-4})$$

If the signed bit is 1, subtract the result from 256 and multiply by -1:

$$T[°C] = (256 - (UpperByte \times 2^4 + LowerByte \times 2^{-4})) \times -1$$

For Fahrenheit:
Take the result from previous conversion, multiply by 9/5 and add 32:

$$T[°F] = (T[°C] \times 9/5) + 32$$

8.5 Thermal Core Serial Interface

A serial interface is a type of communication interface that transmits data sequentially, one bit at a time, over a single communication line.
Thermal Core Serial Interface is an asynchronous protocol developed by Workswell used for communication over a standard UART port between WEOM (Device) and Host (e.g. PC).

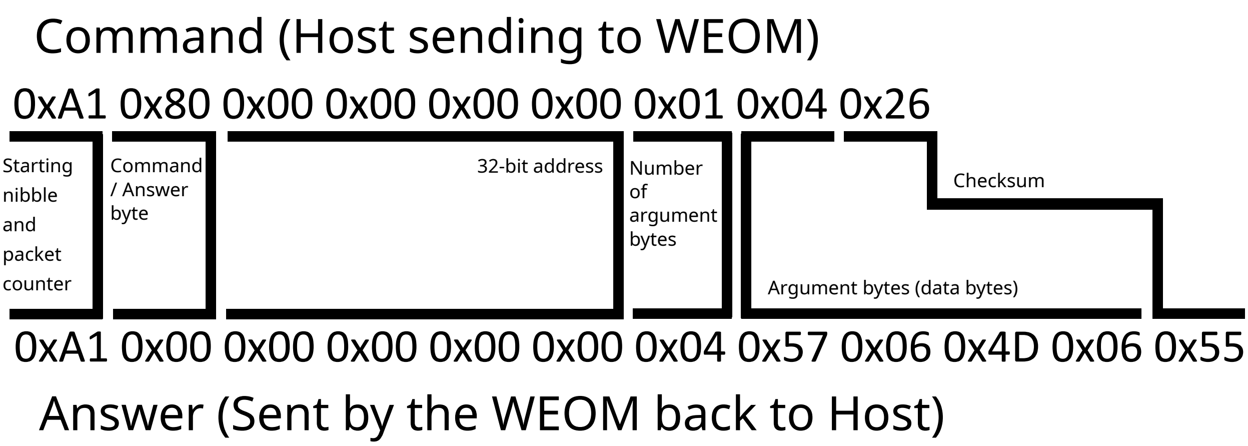


Figure 8.1: TCSI message structure

Note: In serial communication, WEOM will never sent data without being prompted by a host.

- **Starting nibble + packet counter**: Every TCSI packet starts with 0xA0 + cyclical 4-bit packet counter (0x00-0x0F), that ensures that WEOM always answers latest request from Host.
  Every TCSI packet must be answered by WEOM. If it is not answered, it means that communication between PC and WEOM is corrupted. If request is not answered by WEOM after finite amount of retries, communication is terminated.
  In the case of the image above, Host is sending its first packet, therefore counter is 0x01. Next packet will have its counter set to 0x02 and so on.
- **Command/Answer byte**: Depending on communication direction (to/from Host), second byte may be either ”Command” (Host is sending data to WEOM) or ”Answer” (WEOM is sending data to Host).
  Full list of commands and answers can be found in table 8.2.
- **32-bit address**: An address of a register. The leftmost byte is the least significant byte. For example, in order to access register 0x0614 (SPATIAL_MEDIAN_FILTER_ENABLE), TCSI packet address would be: 0x14 0x06 0x00 0x00.
- **Number of argument bytes**: Specifies the number of payload bytes of the packet.
- **Argument bytes**: In a Command, this specifies how many bytes is demanded in return. In an Answer, it carries useful data.
  In the image above, the number of argument bytes of the TCSI answer (WEOM is sending data to Host) is 4, and data bytes themselves are 0x57 0x06 0x4D 0x06 (reading a register always produces 32-bit answer, because WEOM registers are 32-bit), where the leftmost byte is least significant byte.
- **Checksum**: Sum of all values of the packet bytes. In case of overflow (value of this sum is higher than 0xFF), only the lowest 8 bits are used.

Direction	Status Byte Value	Command / Status	Definition	Detailed Description
Answer	0x00	Status	Acknowledgement	Packet was received and is correct
Answer	0x01	Status	Camera not ready	Either camera is not initialized, or a trigger is active.
Answer	0x02	Status	Unknown command	Command byte is incorrect.
Answer	0x03	Status	Incorrect checksum	Received checksum and the checksum computed from the packet do not match.
Answer	0x04	Status	Access Denied	Either the address does not exist, or the register does not support the requested operation.
Answer	0x05	Status	Incorrect argument count	Argument count byte has a different value than was asked **OR** The message is of a different length than expected.
Answer	0x07	Status	Operation unavailable	Current camera settings do not allow this operation to be made at the moment.
Answer	0x08	Status	Incorrect payload	The value being written to the register failed validation because it falls outside the allowed range (value < min or value > max).
Command	0x80	Command	Read	
Command	0x81	Command	Write	

Table 8.2: Command/Answer

8.6 Registers overview

8.6.1 Control

Address	Name	Description	Writable	Value		
				Min	Max	Default
0x0	Device identifier	**bits 0-7**: const = 0x57 - ASCII ”W” **bits 8-15**: const = 0x06 **bits 16-23**: const = 0x4D - ASCII ”M” **bits 24-31**: const = 0x06	No	-	-	-
0x4	Trigger	**bit 0**: Soft reset - restart WEOM (turn off and on again) **bit 1**: Reset to Loader - restart WEOM and enter the Loader **bit 2**: NUC Offset update - execute a NUC offset update immediately **bit 3**: Clean dead pixels - delete the current dead pixel set from WEOM **bit 4**: Set selected preset - Set preset whose ID is in register 0xA14 **bit 7**: Reset to factory default - Set default values to both VM and NVM and restart WEOM. See section 8.2.	Yes	-	-	0x0
0xC	Status	**bit 0**: NUC_active (1: It is possible to perform NUC offset update; 0: It is not possible to perform NUC offset update because a test pattern generator is on.) **bit 1**: Camera not ready **bit 4**: FW status (0: Main program; 1: Loader) **bit 11**: Trigger active	No	-	-	-

Table 8.3: Control registers

8.6.2 General

Address	Name	Description	Writable	Value		
				Min	Max	Default
0x100	Main Firmware Version	**bits 0-15**: Firmware Minor Version 2 **bits 16-23**: Firmware Minor Version **bits 24-31**: Firmware Major Version	No	-	-	-
0x104	Plugin Type	Currently connected plugin: 0b0001 = HDMI 0b1111 = CMOS 0b1110 = USB3 UVC 0b0011 = Analog video 0b0111 = GigE Video	No	-	-	-
0x108	Firmware Type	Current type of firmware: 0b0001 = HDMI 0b1111 = CMOS + GigE Video 0b0011 = Analog video 0b1110 = USB3 UVC	No	-	-	-
0x110	Shutter Temperature	RAW temperature value of the shutter To get temperature in degrees centigrade, see section 8.4.	No	-	-	-
0x114 - 0x130	Serial Number	WEOM's serial number is stored as ASCII characters. Every register holds four of these characters.	No	-	-	-
0x134 - 0x150	Article Number	WEOM's Article number is stored as ASCII characters. Every register holds four of these characters.	No	-	-	-

Address	Name	Description	Writable	Value		
				Min	Max	Default
0x164	Led R Brightness	Intensity of the red status LED where 1 = Lowest and 7 = Highest intensity	Yes	1	7	7
0x168	Led G Brightness	Intensity of the green status LED where 0 = OFF and 7 = Highest intensity	Yes	0	7	7
0x16C	Led B Brightness	Intensity of the blue status LED where 0 = OFF and 7 = Highest intensity	Yes	0	7	7
0x100	Loader Firmware Version	**bits 0-15**: Loader Firmware Minor Version 2 **bits 16-23**: Loader Firmware Minor Version **bits 24-31**: Loader Firmware Major Version	No	-	-	-

Table 8.4: General registers

8.6.3 Video

Address	Name	Description	Writable	Value		
				Min	Max	Default
0x200	Palette Index	Index of the current RGB Palette. See section 7.9.	Yes	0	15	0
0x204	Frame Rate	0 - 9 FPS 1 - 30 FPS 2 - 60 FPS See section 7.5.	Yes	-	-	-
0x208	Image Flip	0 - No flipping 1 - Vertical flip 2 - Horizontal flip 3 - Horizontal and vertical flip	Yes	-	-	0
0x20C	Image Freeze	0 - Image not frozen 1 - Image frozen	Yes	-	-	0
0x214	Test Pattern	Current image source: 0 - Real time infrared detector image 1 - Static test pattern generator 3 - Dynamic test pattern generator	Yes	-	-	0

Table 8.5: Video registers

8.6.4 NUC

Address	Name	Description	Writable	Value		
				Min	Max	Default
0x304	Time from last NUC	Seconds passed from the last NUC offset update See section 7.2.	No	-	-	-
0x308	NUC update mode	Current method of triggering NUC update: 1 - Periodic mode 2 - Adaptive mode	Yes	-	-	2
0x314	Internal shutter position	0 - Internal shutter Open 1 - Internal shutter Closed	Yes	-	-	0
0x320	NUC max period	Maximal allowed amount of time in seconds without a NUC offset update	Yes	120	7200	120
0x324	NUC adaptive threshold	Maximal allowed shutter temperature difference before triggering a NUC offset update. Has to be divisible by 4. To get temperature in °C, divide by 2^4.	Yes	4	160	16

Table 8.6: NUC registers

8.6.5 Connection

Address	Name	Description	Writable	Value		
				Min	Max	Default
0x400	UART baud rate	Connection speed options corresponding to a certain value in bauds (bits per second) 4 - 115200 Bd 7 - 921600 Bd 9 - 3000000 Bd	Yes	-	-	4

Table 8.7: Baud rate register

8.6.6 Filters

Address	Name	Description	Writable	Value		
				Min	Max	Default
0x600	Time domain average	Number of frames used to compute one output frame: 0 - no averaging 1 - averaging from 2 frames 2 - averaging from 4 frames See section 7.4.2.	Yes	-	-	0
0x604	Linear equalization type	Sets the method of gain control: 0 - Automatic 1 - Manual See section 7.8.1.	Yes	-	-	0
0x608	MGC contrast brightness	**bits 0-13**: contrast value bits 14-15: unused **bits 16-29**: brightness value bits 30-31: unused	Yes	0 0	16383 16383	16383 8000
0x610	Linear AGC smoothing	Frames used to compute values for Linear AGC: 0 - average from 1 frame 1 - average from 2 frames 2 - average from 4 frames 3 - average from 8 frames 4 - average from 16 frames See section 7.8.1.1.	Yes	-	-	2

E-mail and Web
info@workswell.eu
www.workswell.eu
Mobile:
+420 725 877 063
ID:
Reg. No.: 29048575
VAT No.: CZ29048575
Headquarters
Na Okraji 335/42
162 00, Praha 6
Czech Republic

Address	Name	Description	Writable	Value		
				Min	Max	Default
0x614	Spatial median filter enable	0 - Median filter disabled 1 - Median filter enabled 7.4.1.	Yes	-	-	1
0x620	Linear gain weight	Ratio of Linear to Plateau image equalization 0 - only Plateau 10 - only Linear See section 7.8.2.	Yes	0	10	1
0x624	Clip limit	**bits 0-7**: Plateau Clip limit determines the percentage of internally computed clip limit that will be used as "real" clip limit.	Yes	1	100	10
0x628	Plateau tail rejection	**bits 0-7**: Plateau tail rejection specifies the symmetrical (meaning on both sides of histogram) percentage of "tail" bins of histogram that will be ignored for Plateau computation.	Yes	0	49	0

Table 8.8: Filters registers

8.6.7 Dead Pixel Correction

Address	Name	Description	Writable	Value		
				Min	Max	Default
0x800	Enable Dead pixel correction	0 - Dead pixel correction disabled 1 - Dead pixel correction enabled See section 7.3.	Yes	-	-	1

Table 8.9: Dead pixels register

E-mail and Web
info@workswell.eu
www.workswell.eu

Mobile:
+420 725 877 063

ID:
Reg. No.: 29048575
VAT No.: CZ29048575

Headquarters
Na Okraji 335/42
162 00, Praha 6
Czech Republic

8.6.8 Presets

Address	Name	Description	Writable	Value		
				Min	Max	Default
0xA14	Selected preset ID	Consists of: **bits 0-3**: Temperature Range enum 7 - High gain 8 - Low gain see section 7.1 **bits 16-19**: Lens enum 0 - L-WTC-35-HE25-A **OR** L-WTC-35-HE34-A 1 - L-WTC-25-HE25-A **OR** L-WTC-25-HE34-A 2 - L-WTC-14-HE25-A **OR** L-WTC-14-HE34-A 3 - L-WTC-7-HE34-A see section 5.7.1	Yes	-	-	-
0xA18	Current preset ID	Consists of: **bits 0-3**: Temperature Range enum **bits 16-19**: Lens enum see register 0xA14	No	-	-	-

Table 8.10: Presets registers

E-mail and Web
info@workswell.eu
www.workswell.eu
Mobile:
+420 725 877 063
ID:
Reg. No.: 29048575
VAT No.: CZ29048575
Headquarters
Na Okraji 335/42
162 00, Praha 6
Czech Republic

9 Drawings

All WEOM drawings are available for download at my.workswell.eu. There are two documents available:

- Lens Specification, giving detailed info on all the lens options
- Engineering Drawings, specifying the dimensions of WEOM with each of the available plugins

10 Troubleshooting

10.1 Test pattern generator

WEOM provides 2 different test patterns. Their intended use is for adjusting image settings and/or diagnostic purposes. Images are generated in the same format as a normal video output, i.e. 640 × 480 px. The **Post-IGC** pixel values depend on the current image settings and palette. WEOM does not generate these images on its detector, so they are not affected by dead pixels or non-uniformity artifacts.

Note: The settings affecting the generated images include:
- Image gain control mode
- Brightness and contrast for manual gain control
- Image flip

10.1.1 Dynamic test pattern

The generated picture is composed of 24 horizontal stripes, each with a height of 20 px. **Pre-IGC** pixel value at the beginning of each stripe is equal to 640 × index of the stripe (index starts at 0). Pixel value at the end of each stripe is equal to the starting value of the stripe + 1278.

Note: For example, the second stripe will start with value 640 and it will end with a value 640 + 1278 = 1918.

$$pixelValue = 640 \times stripeIndex + 2 \times columnCoordinate$$

A black line with a height of 1 px is generated across the whole frame. Starting at the top of the picture and ending at the bottom, the line moves each frame by a value specific to the current frame rate:

- 60 FPS - 1 px
- 30 FPS - 2 px
- 8.57 FPS - 7 px

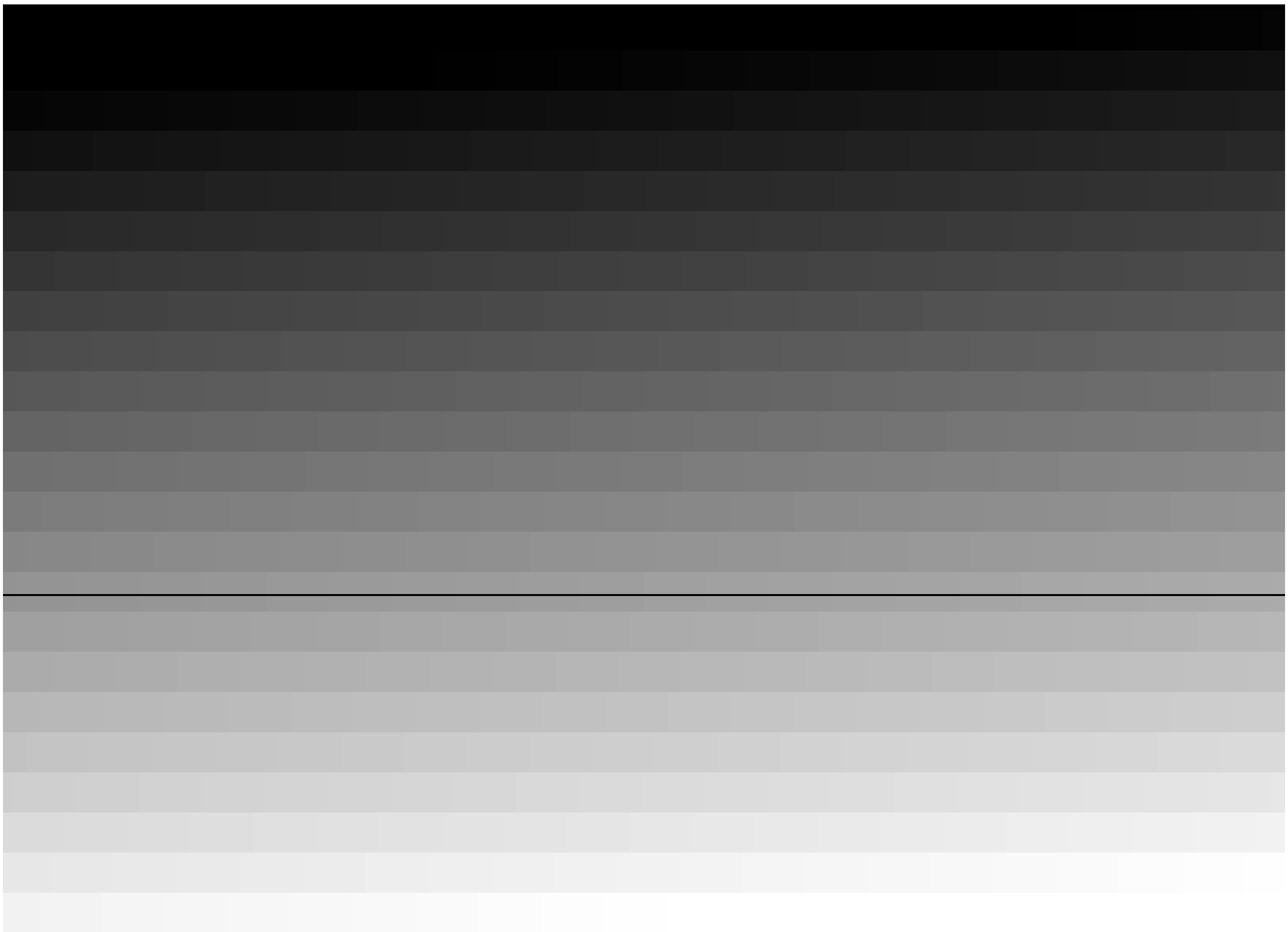


Figure 10.1: Dynamic test pattern with default settings

10.1.2 Static test pattern

A chessboard like image will be generated with each pixel having a different value than the ones sharing its side. The **Pre-IGC** value of a pixel is either 10,922 or 5461 (in binary 0b10 1010 1010 1010 and 0b01 0101 0101 0101). The value of the first pixel is 5461.

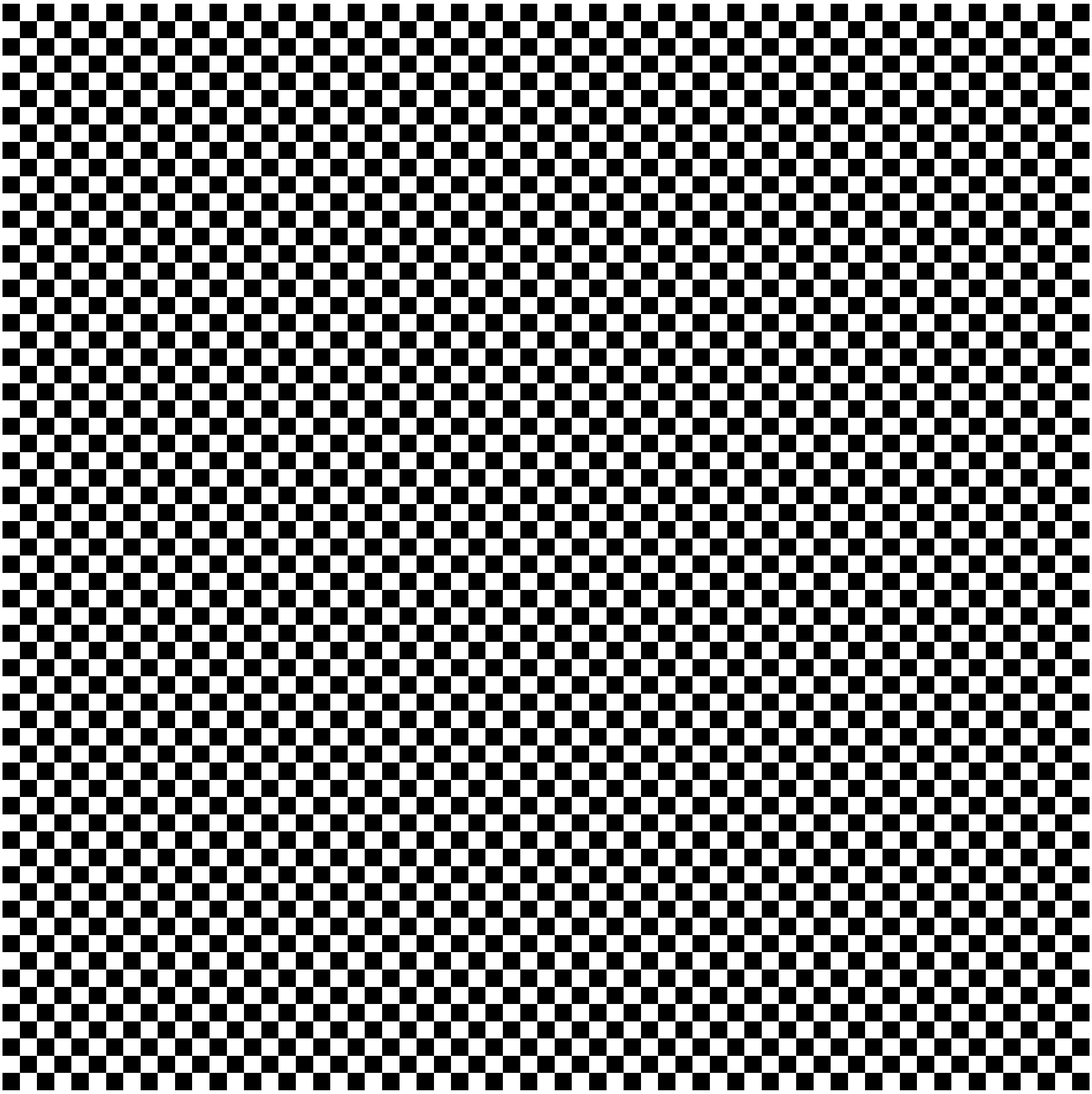
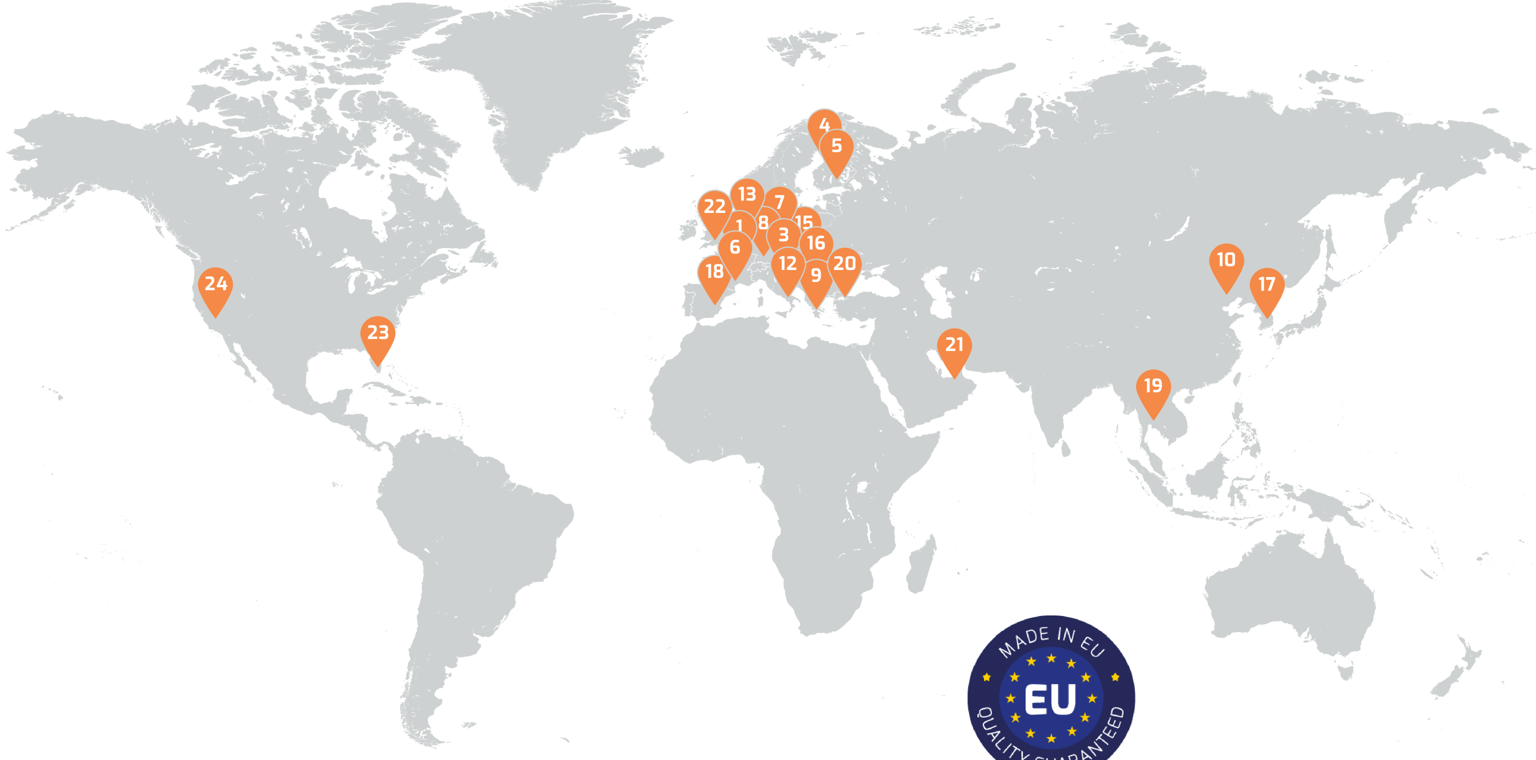


Figure 10.2: Static test pattern detail

10.2 Booting to loader

In the case of a corrupted firmware version (once booted, WEOM is unresponsive), the user is able to boot into Loader instead, as described in section 6.2. Once the user boots into loader, they can update to an uncorrupted version. After restarting, the WEOM will boot normally.



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