# Operation Manual
# HANDCAM



# 1. Introduction

The HANDCAM is a portable three-axis magnetic field imaging instrument. The embedded firmware acquires Bx,By and Bz from a 128x128 sensor array, render four live maps on the TFT (Bx, By, Bz and Btotal), calculates field statistics, support a pixel by pixel REL reference mode, and exposes the raw axis matrices over USB serial. A companion Python program downloads the matrices, preserves the received raw data in CSV and NPY files, reconstruct the display view, convert displayed values to mT and plot three three vector components.

REL stores a complete reference field image. Subsequent values are calculated independently for every pixel as the difference between the current and reference Bx,By and Bz samples. The same +-200mT directional display scale is retained.

The device features an integrated touchscreen that provides a direct view of the magnetic field strength and user-friendly software that allows for easy changing of the unit of the measured magnetic field, range, and measurement averaging time window.

Moreover, the device is powered by an internal rechargeable battery and does not require an external power supply (except for battery charging). Battery charging is realised with USB-C cable and connection to any PC or to appropriate electricity plug.

The display shows the spatial distribution of magnetic flux density rather than a single-point reading. For consistent results, keep the sensor face in a stable position relative to the test object and avoid moving the instrument during visual comparison of successive frames.

The four maps share the same sensing area. Bx, By and Bz represent signed orthogonal components, while Btotal is the magnitude of the field vector and therefore has no negative sign. The color convention is intended to help identify field polarity and spatial gradients quickly.

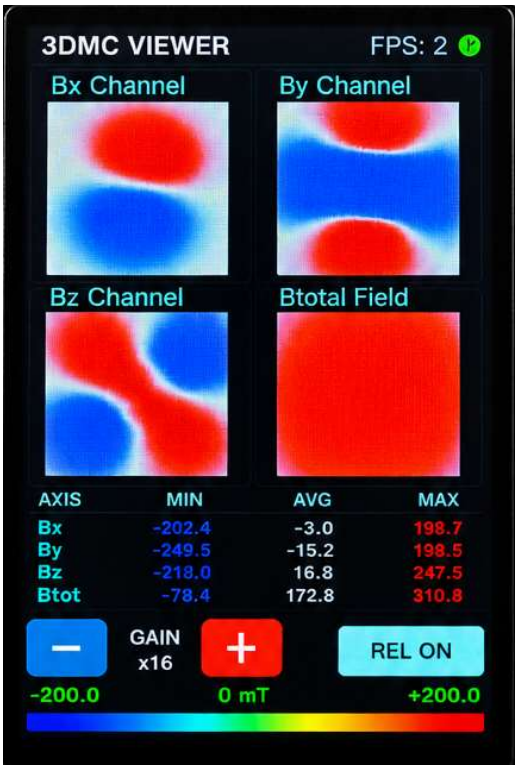



**Figure 1:** *HANDCAM GUI*

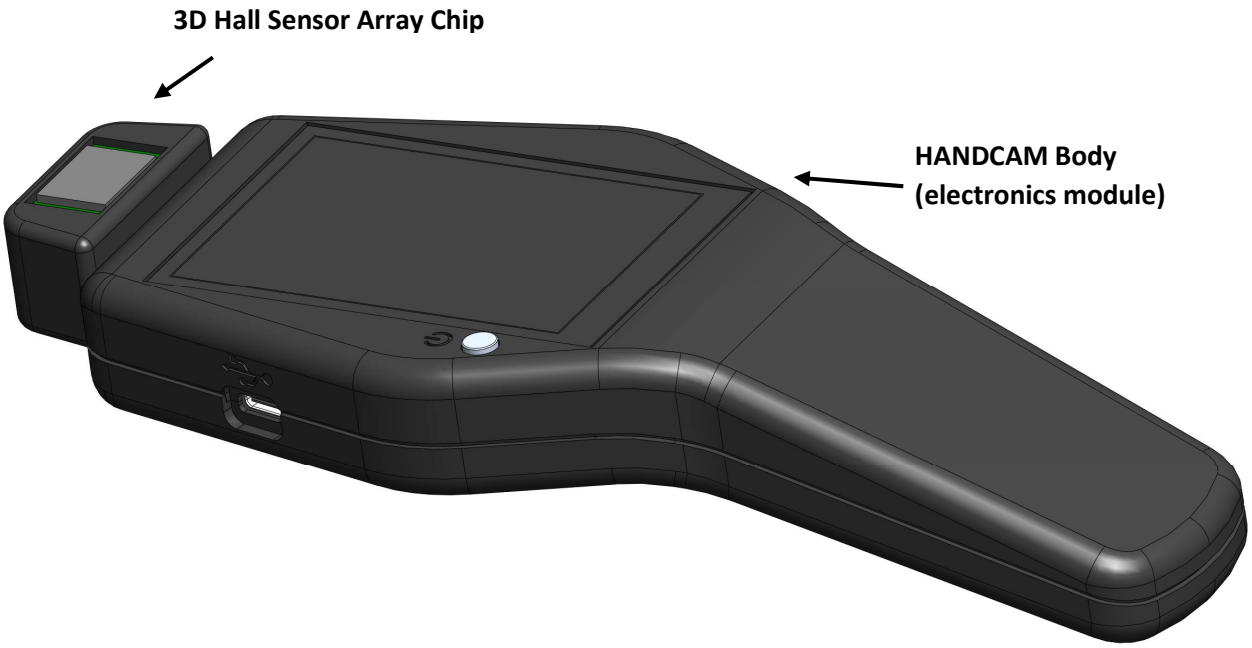



**Figure 2:** *SENIS HANDCAM Magnetic Camera, Front side*

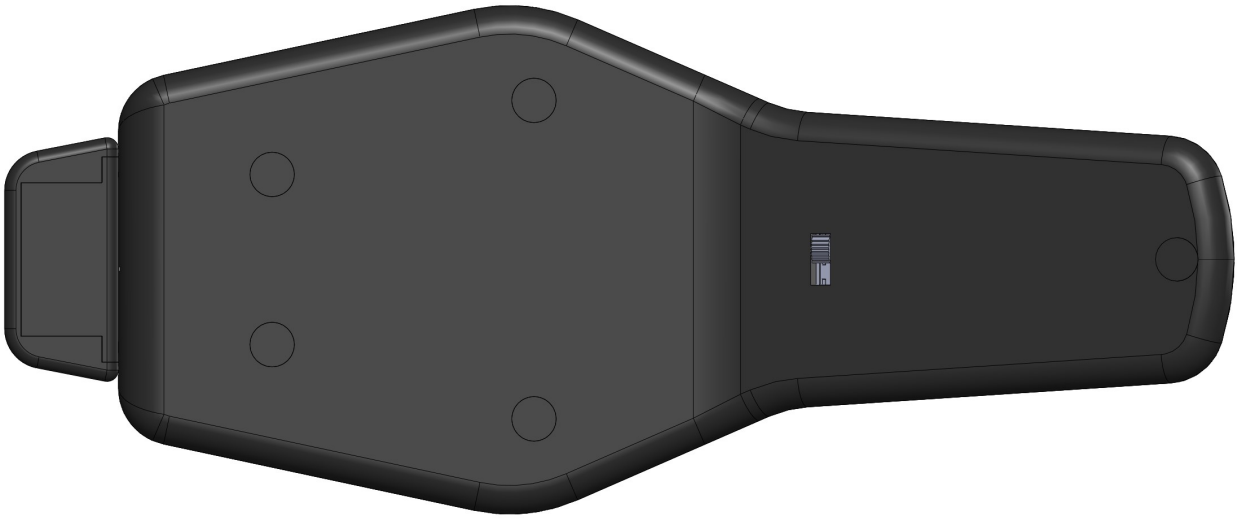


**Figure 3:** *SENIS HANDCAM Magnetic Camera, Back side*

## 2. Key features

| | |
|---|---|
| **Sensor** | |
| Sensor Type | Senis 3D Magnetic Camera, 128x128 pixels |
| Data Output | Calibrated true Bx/By/Bz live maps |
| Calculated field magnitude | Btotal map and statistics |
| Image acquisition time | 350ms |
| Imaging array | 128x128, Field Sensitive Volume: 27µm x 9µm x 4µm in each pixel |
| Pixel pitch | 0.1 mm x 0.1 mm |
| Active image Area | 12.8 x 12.8mm |
| Display convention | Blue=negative, White=zero, Red=positive |
| Relative measurement | Full-frame pixel by pixel REL |
| Statistics | MIN/ AVG/ MAX for Bx,By,Bz and Btotal |
| **Software and Communication** | |
| Supply Voltage | 5V, through USB connector or LiIon battery |
| Interface | USB -C |
| PC data export | Raw Bx, By, Bz matrices over USB serial, 115200 baud |
| PC file format | CSV and NPY via supplied Python downloader |
| Software | Python application |
| Operating System (optional) | WIN10 and later |
| Live frame rate indication | Displayed on instrument UI |
| Display | 320x480 portrait |
| Battery | LiIon 2Ah with charge indication |
| **Magnetic Field** | |
| Calibration ranges | 500mT, 100mT optional, displayed on bottom side |
| Absolute accuracy | < 2% of full scale |
| Digital resolution | 12 bit, 2048 raw counts |
| Resolution (within 1s) | 100µT RMS |
| Non-orthogonality of magnetic axes | < 0.5° |
| Calibrated temperature range | 20 - 30°C |

| | |
|---|---|
| Minimal measuring distance | < 300µm |
| **Mechanical** | |
| Housing | Rugged lightweight housing with easy mounting option |
| Total weight | ~300g |
| Operation temperature range | 10°C - 40°C, fanless operation |

## 3. Magnetic field scaling and statistics

For directional components the firmware convention is centered at 2048 counts with a displayed full scale of +/-200 mT or whatever range is calibrated.

The equation below describes the original centered-count display convention. It must not be treated as a substitute for individual-pixel calibration when calibrated coefficients are enabled. The displayed range and sensor gain configuration must agree with the calibration range selected in firmware.

**B [mT] = (raw - 2048) x (200 / 2048)**

The statistics code rejects endpoint/saturated raw values (raw <= 1 or raw >= 4095) before calculating MIN, AVG and MAX. Btotal is calculated from the three centered vector components and may numerically exceed 200 mT

MIN, AVG and MAX summarize valid pixels of the corresponding image component. Values near ADC limits may indicate saturation; if the image contains large uniform red or blue regions, reduce gain or increase the measurement distance and repeat the observation.

REL mode memorizes one complete Bx/By/Bz frame and subtracts it pixel-by-pixel from subsequent measurements. Directional maps retain the same full scale: -200 mT blue, 0 mT white and +200 mT red. The working architecture reuses three existing camera color buffers as reference storage while raw acquisition continues with the original timing and indexing.

For pixel i:

dBx(i)=Bx(i)-Bx_ref(i),

dBy(i)=By(i)-By_ref(i),

dBz(i)=Bz(i)-Bz_ref(i).

REL Btotal is sqrt(dBx^2 + dBy^2 + dBz^2).

In REL mode, capture the reference with the sensor and test object in the intended baseline arrangement. Subsequent maps show changes relative to that stored frame, not absolute field values. Re-capture the reference after changing gain, measurement range or sensor orientation.

GAIN +- button change magnetic sensitivity of camera. If magnet is too close to the surface It can be used to reduces sensitivity and obtain picture without saturation.

To use the cursor, touch a point in one of the displayed maps. The instrument reports the selected pixel position and corresponding field value in the top information area. The cursor is intended for localized inspection; use the statistics table to assess the entire field of view.

## 4. PC interface and data export

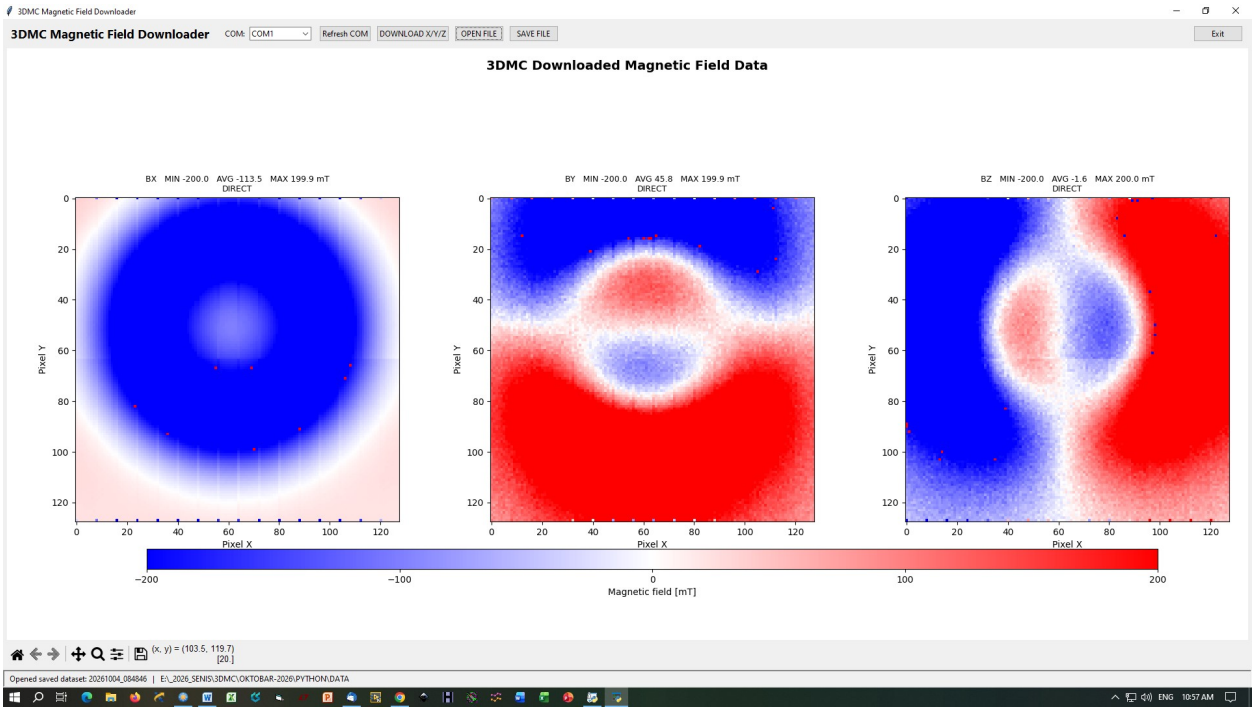
The companion Python utility provides direct acquisition of the three raw component matrices. The current serial interface operates at 115200 baud. It scan serial ports, lets the operator select the COM port, downloads Bx/By/Bz, and saves each received 128x128 raw matrix without numerical modification as both CSV and NPY. The saved files are the archival raw data.

| Command | Data |
|---|---|
| x / X | Bx raw matrix, uint16 buffer |
| y / Y | By raw matrix, uint16 buffer |
| z / Z | Bz raw matrix, uint16 buffer |

The present protocol has no packet header or CRC. The Python program reads exactly 32768 bytes for each axis and reports a timeout if the complete payload is not received.

The USB export is a binary transfer, not a printable text stream. Each axis contains 128 x 128 unsigned 16-bit samples (32,768 bytes). The receiving application must preserve the original sample order and byte order expected by the current firmware. Keep the USB connection stable until all three matrices have been received.

CSV is convenient for inspection in spreadsheet and analysis programs, while NPY retains the array structure for numerical processing in Python. Retain the original raw exports whenever calibrated or relative images are also generated, so that the measurements can be reprocessed later.



# 5. Setup

- Power the instrument and allow live maps to update.
- Use GAIN - / + as required.
- Use REL to memorize the current complete field frame for relative measurement.
- Connect USB serial and run the Python downloader.
- Select the COM port; the program requests x, y and z sequentially.
- Keep CSV/NPY as the raw measurement record; use plots for visual inspection.
- For repeatable measurements, record the instrument identification, selected gain/range, sensor-to-object distance, measurement orientation and whether REL was active. A consistent sensor position is particularly important when comparing spatial magnetic-field distributions.

## 5.1 Field Sensitive Volume – FSV

The FSV of the probe denotes the volume within which all three components of the magnetic field are measured. The horizontal and vertical Hall elements are symmetrically arranged around the centre of the FSV, ensuring accurate measurements. The FSV in the probe chip is 27 x 9 x4 $\mu m^3$, enabling precise and local measurements.

The coordinate directions shown in Figure 2 define the sign convention of Bx, By and Bz. A reversal of the test object's magnetic orientation can reverse the sign of one or more components while leaving Btotal approximately unchanged. The FSV describes the region in which the components are sensed; it is distinct from the 0.1 mm pixel-to-pixel pitch.

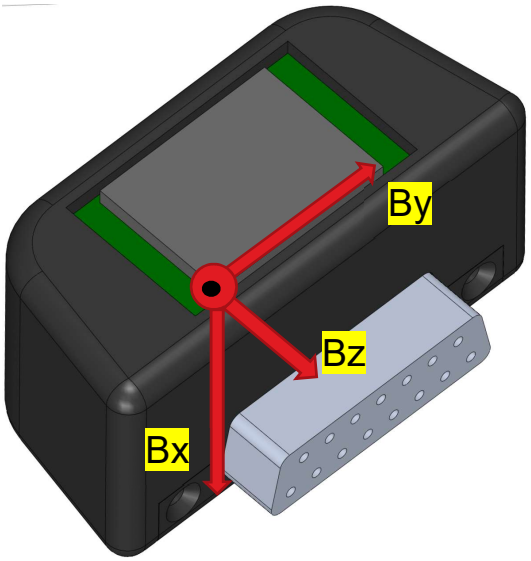



**Figure 4:** *Magnetic field sensitivity axis orientation (probe top view)*

## 5.2 Dimensions

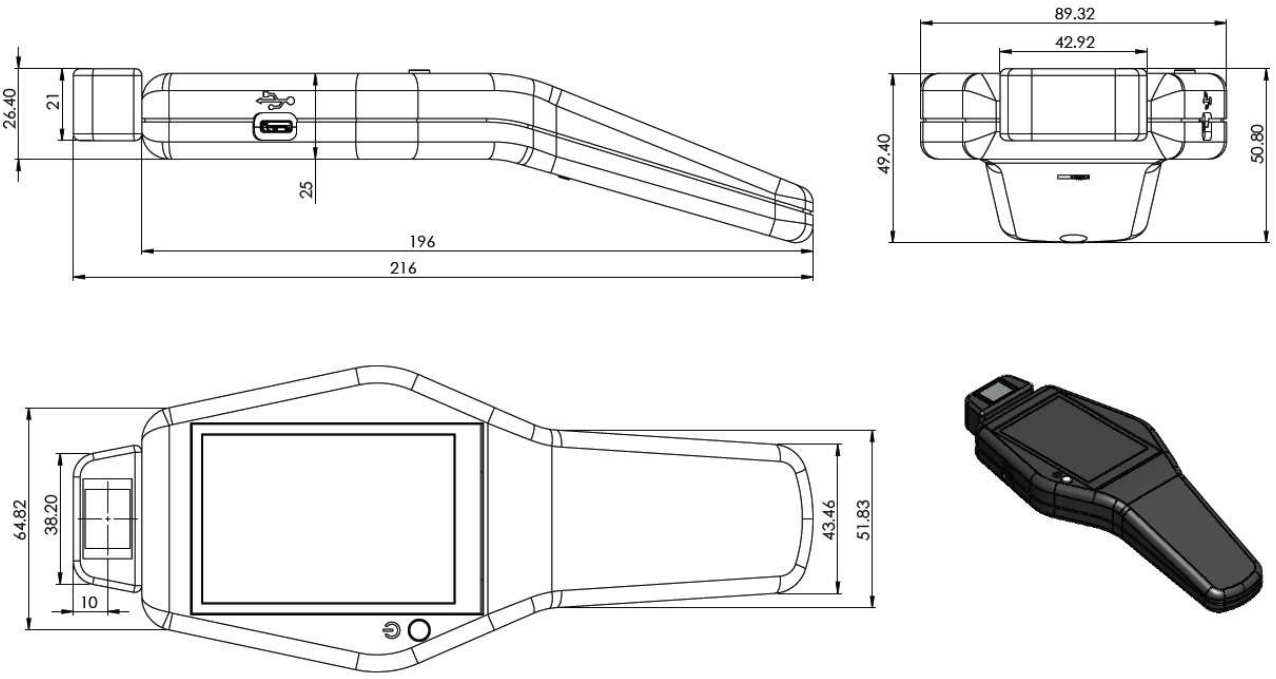



**Figure 5:** *Structure and dimensions of the HANDCAM Magnetic Camera.*

## 6. Examples




**Figure 6:** *Viewing of Magnetic field of magnet with diameter of 1mm.*




**Figure 7:** *Viewing of Magnetic field of magnet with diameter of 2mm.*

# 7. Table of Contents

1. Introduction ..... 2
2. Key features ..... 4
3. Magnetic field scaling and statistics ..... 6
4. PC interface and data export ..... 7
5. Setup ..... 8
*5.1 FIELD SENSITIVE VOLUME – FSV ..... 8*
*5.2 DIMENSIONS ..... 9*
6. Examples ..... 10