MAGNETO-OPTICAL VISUALIZER
Regula 4197

User's Guide

2018

CONTENTS

> **WARNING!**
>
> THE DEVICE CONTAINS STRONG MAGNETS. THESE MAGNETS CAN ATTRACT METALLIC FERROMAGNETIC OBJECTS ABRUPTLY AND UNEXPECTEDLY. THE ATTRACTED OBJECT MAY HIT THE DEVICE AND CAUSE DEVICE DAMAGE. DO NOT BRING OBJECTS MADE OF FERROMAGNETIC MATERIALS CLOSE TO THE DEVICE (E.G. TWEEZERS, SCREWDRIVERS, SCISSORS, KEYS, COINS, DRAWING PINS AND CLIPS, ETC.)

1 FUNCTION

Magneto-optical visualizer (hereinafter referred to as the «visualizer») Regula 4197 is intended for expert examination of document magnetic protection.

The device visualizes images executed with magnetic inks, tapes, fibers and other magnetic materials. The visualized images are displayed on a PC monitor and can be stored as files of normal raster graphic formats.

The visualizer allows assessing values of certain magnetic parameters of document magnetic protection elements. The results are presented in graphical and numerical form, and can be saved for later playback and analysis.

The visualizer delivery set includes specialized software that allows an expert to carry out digital postprocessing of scanned images for the purpose of their analysis, comparison, assessment of geometric parameters and sizes, improvement of legibility and clearness.

2 AREAS OF APPLICATION

Regula 4197 visualizer can be used in:

- Forensics: authenticity verification of securities, banknotes; classification of document and banknote forgery methods; examination of damaged documents (reading of stained texts printed in magnetic ink);
- Production of securities, banknotes, forms: quality control of magnetic protection elements; investigation of magnetic printing techniques and materials;
- Banking: authenticity verification of securities, banknotes;
- Authenticity verification of banknotes at customs.

3 DEVICE DESIGN

Visualizer Regula 4197 consists of the following components (Figure 1): an optical electronic block **1** and a magnetic excitation system **2**. The right **3** and left **4** functional buttons and a LED indicator **5** are located on the top of the optical electronic block. The sensitive element (magneto-optical crystal) **6** (Figure 2) is located on the bottom surface of the optical electronic block. The magnetic excitation system is removable. There are grooves **7** (Figure 3) intended for positioning the magnetic excitation system on the optical electronic block. The visualizer is connected to a PC via a USB cable located on the back of the device. There can be two versions of the visualizer with one (A) or two (B) USB plugs. In case (B) **both plugs should be connected to the computer sockets**.
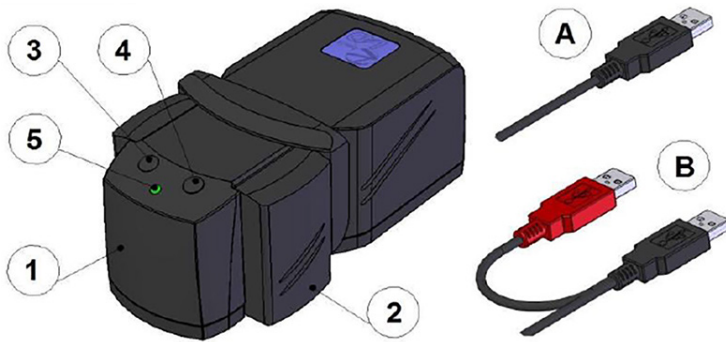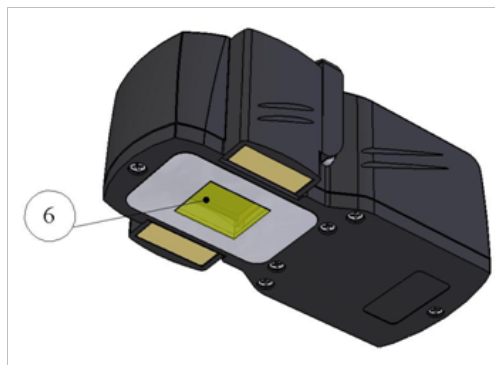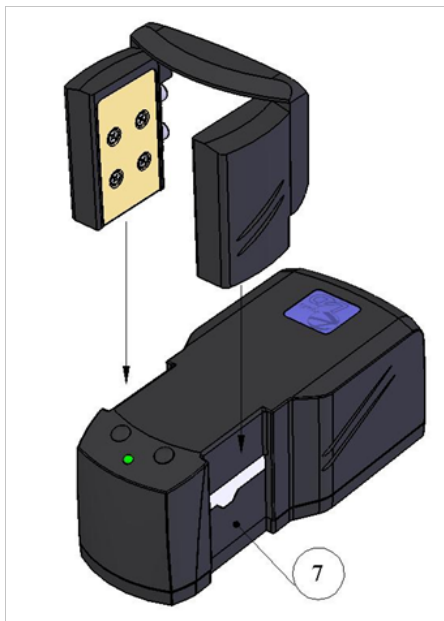

Figure 1

Figure 2

Figure 3

4 DELIVERY SET

The delivery set includes:
- Magneto-optical visualizer Regula 4197
- Visualizer pad
- Special software
- User's guide
- Test object

5 DESCRIPTION OF DEVICE OPERATION

The magneto-optical visualizer Regula 4197 is a USB device. Its power supply, control, output and processing of examination results are carried out with the help of a PC. The visualizer is to be connected to one of PC USB-ports.

The visualizer sensitive element (magneto-optical crystal) senses the magnetic field of a magnetic protection element in a questioned document. The sensitive element state is converted into a digital image with the help of the optical system and the digital camera, which are

located inside the device. After special preliminary processing, the image is output to the CADR application window.

Near the sensitive element there is an inductor. In certain visualizer operation modes, it generates series of magnetic impulses affecting the sensitive element. The inductor is intended to increase sensitivity of the visualizer, improve image quality and to generate magnetic displacement fields used in the mode assessing magnetic parameters of document security features.

The magnetic excitation system of the device is a source of external magnetic field for magnetization of magnetically hard materials and for magnetic excitation of magnetically soft materials used to produce magnetic protection elements.

*There are two types of materials used to produce document security features with magnetic properties: **magnetically hard** and **magnetically soft**.*

***Magnetically hard materials** obtain their own magnetic field after they are magnetized by an external magnetic field. The sensitive element responds to the magnetic field obtained by magnetically hard materials.*

***Magnetically soft materials** do not retain their own magnetic field after the source of external magnetic field is removed. But if they are kept in the magnetic field created by an external source, these materials cause distortions of the field. Such distortions are detected by the device sensitive element.*

The magnetic excitation system enables to distinguish security features made of different types of magnetic materials: the images made of magnetically soft materials are visible only if the magnetic excitation system is installed. The images made of magnetically hard materials, once magnetized, are visible both with the installed magnetic excitation system and without it. Some insignificant differences in the image brightness and contrast are possible.

The CADR software is intended for continuous displaying of the visualized magnetic image on a PC monitor and for storing separate image frames at the operator's choice. In addition, the CADR application provides a wide range of tools for digital image processing. The software is included in the visualizer delivery set.

6 OPERATION ORDER

6.1 Preparing for operation

Before the device is switched on for the first time:

– Make sure the device does not have any visible defects or damages.

If you notice any defects or damages, contact your supplier.

– Place the visualizer pad on a flat surface. Observe the requirements for the surface and for the surroundings of the workplace in which the visualizer will be used.

1) Objects made of ferromagnetic materials (materials which attract magnets) must not be placed closer than 0.2 m from the work area. Such objects are: metallic surface of the laboratory bench, steel furniture fasteners, tools (tweezers, screwdrivers, scissors, etc.), stationery (drawing pins, clips), coins, etc.

2) Sources of strong magnetic field (permanent magnets, electromagnets, inductance coils) must not be located closer than 0.5 m from the work area.

> **ATTENTION!**
>
> PROXIMITY OF FERROMAGNETIC MATERIALS AND SOURCES OF THE MAGNETIC FIELD TO THE VISUALIZER CAN DISTORT THE IMAGE FORMED BY IT.

> **ATTENTION!**
>
> IF OBJECTS MADE OF FERROMAGNETIC MATERIALS GET INTO THE MAGNETIC FIELD OF THE MAGNETIC EXCITATION SYSTEM, THE SYSTEM CAN ATTRACT THEM ABRUPTLY AND UNEXPECTEDLY. THE ATTRACTED OBJECT MAY HIT THE DEVICE AND CAUSE DEVICE DAMAGE.

Put the visualizer on the pad with the sensitive element facing downwards. Connect the device to the PC via the USB cable. The LED on the visualizer body lights up if the connection between the device and the PC is successful. (When activating the device for the first time, PC operating system requires installation of the visualizer driver. For more details see paragraph 6.2).

Visualizer software installation

The software supplied with Regula 4197 visualizer includes:

1) CADR application,

2) visualizer driver.

The procedure of software installation is the following:

Insert the installation medium with the visualizer software into the disk drive or USB port of the PC. **Create a working folder** and copy the software into it.

Connect the device USB cable to the corresponding port of the PC. If the USB connection between the visualizer and the PC is successful, the LED indicator on the visualizer body will light up.

The operating system will detect a new USB device and automatically launch the Device Driver Installation Wizard. Set the path to the device driver directory manually.

When installation is complete, open the Device Manager window to check that a new device «Magneto-optical Visualizer 4197» has appeared in the «Forensic Devices» section. Make sure that the device is installed correctly (without «?» or «!» marks in the Device Manager panel).

After the driver has been installed, the CADR application is ready to be started. You can launch the application by running the file CADR. EXE in the working folder or by using the application shortcut located in any suitable place.

6.2 Operation execution

Put an examined document and the visualizer (with the sensitive element facing downwards) on the visualizer pad.

To start the CADR application, double click on the application shortcut or on the icon of the file CADR.EXE in the folder where the application is installed.

In the appeared window of the CADR application, click the button of background image input **A** (Figure 4).

Figure 4
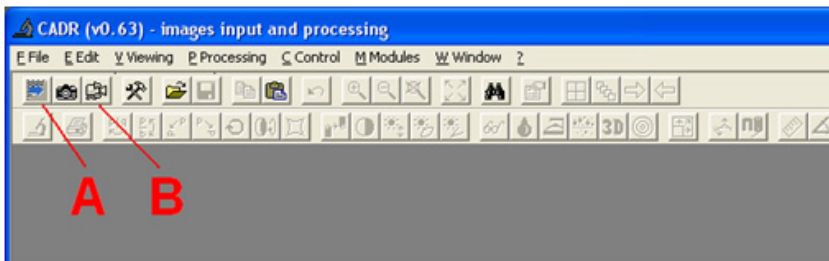
An information window with instructions will appear. Follow the instructions given: lift Regula 4197 5–10 cm above the examined document and press any of the two functional buttons (**3** or **4** (Figure 1)) on the visualizer body. After background image input is performed successfully, the information window will disappear.

The process of background image input can be repeated if necessary. This need may arise when the resulting image does not satisfy the user who assumes that the background image was poorly scanned.

Put the visualizer on the examined document with the sensitive element facing downwards.

Not all documents are printed using magnetic ink. So if there is no document with magnetic security features at the initial startup of the device, use the test object from the visualizer delivery set to check device operation.

See paragraph 6.5 for more information about the purpose and use of the test object.

To activate the mode of continuous image input, press the **right** functional button of the visualizer (Figure 1, pos. 3). This mode can also be activated by clicking on the button of continuous input **B** (Figure 4). The continuous input window displaying the visualization result of the magnetic image on the examined document (Figure 5) will appear in the CADR main window. When shifting the visualizer along the document surface, the image in the continuous input window changes accordingly.

Move the visualizer along the document surface to find images printed using magnetic inks.

In the continuous input window, the user can take a single frame of the examined image for further processing. For this purpose, place the visualizer so that the questioned image fragment takes the desired position in the continuous input window. Press the **left** functional button of the visualizer (Figure 1, pos. 4). The image fragment will be copied as a permanent frame into a separate window next to the continuous input window. Assess the result and, if necessary, repeat the copying procedure.

It is possible to capture several frames which will be displayed in separate windows. Afterwards, the images from these frames can be processed using the tools of the CADR software (for more information about the tools see the file CADR_ENG.DOC from the visualizer software set and paragraph 6.4 «Processing the Results»). The obtained results can be saved to the PC hard disk in one of the standard graphic formats. To do so, select the menu items [File]->[Save] of the CADR application.

In the process of device operation, background image input can be repeated (if necessary) by clicking on image input button and following the instructions described above.
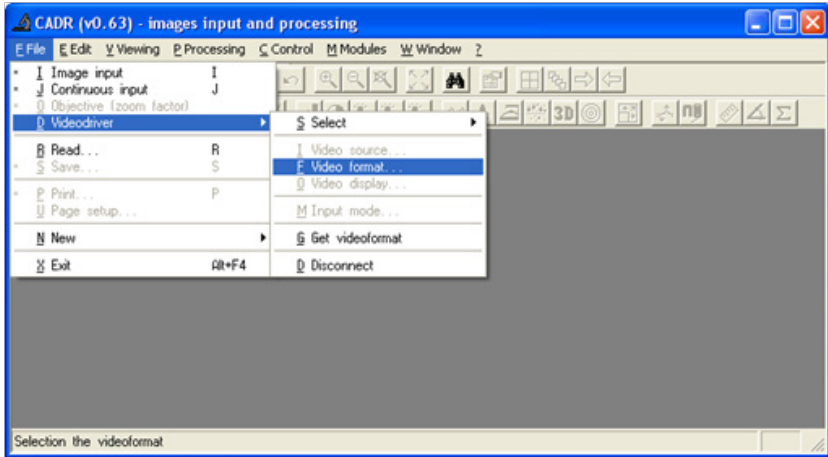
The visualizer supports two image formats — 512×640 pixels and 1024×1280 pixels. **We recommend using the 512×640 format (Figure 5).**

Figure 5
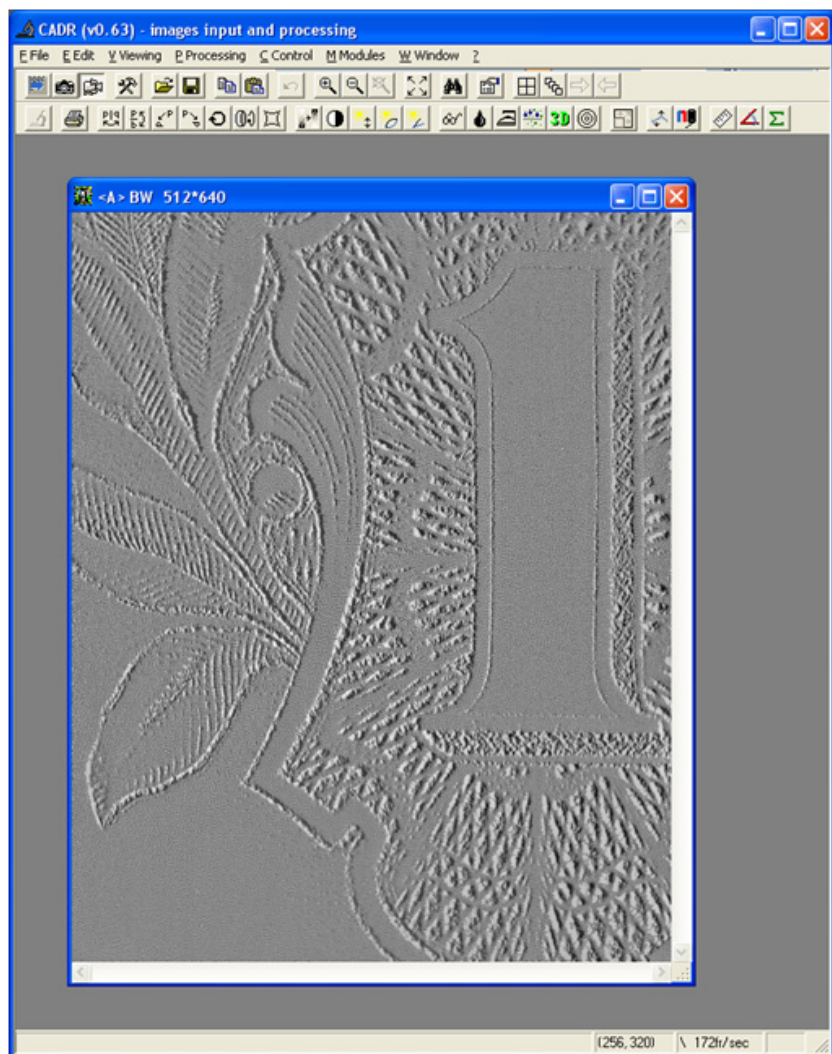
To switch the format, select the menu item [File] -> [Videodriver] -> [Video format] (Figure 6).

6.3 Background and frame input options

The visualizer can operate in several modes that allow obtaining images of different quality. But the modes in which high-quality images are captured require more time to form a frame.

The user should select an appropriate mode in accordance with his particular tasks.

To select an appropriate mode, right-click on the button of background image input **A** or on the button of single frame input **C** (Figure 7). The window «Mode of frames and background input» will appear.

A background image (background) is used in the visualizer to improve the quality of the obtained resulting images that the user examines in CADR windows. The background is input at the beginning of the device operation, as well as in the process of operation if necessary.

The background *should be input when the magneto-optical crystal is not in contact with any magnetic images or other sources of magnetic field.* ***A frame*** *(a single frame or series of frames in the mode of continuous input) is input when the sensitive element is in*

contact with the magnetic image of the examined document. Then the program **subtracts the background from the frame**. As a result, in the obtained image, the user can see only the document magnetic image against a solid gray background.

Such technology allows filtering possible noises, artifacts and brightness irregularities which the initial (background) image formed by the magneto-optical crystal may contain.

In the window «Mode of frames and background input», the user can select one of three standard modes of background and single frame input — «**View**», «**Discovery**» and «**Research**».
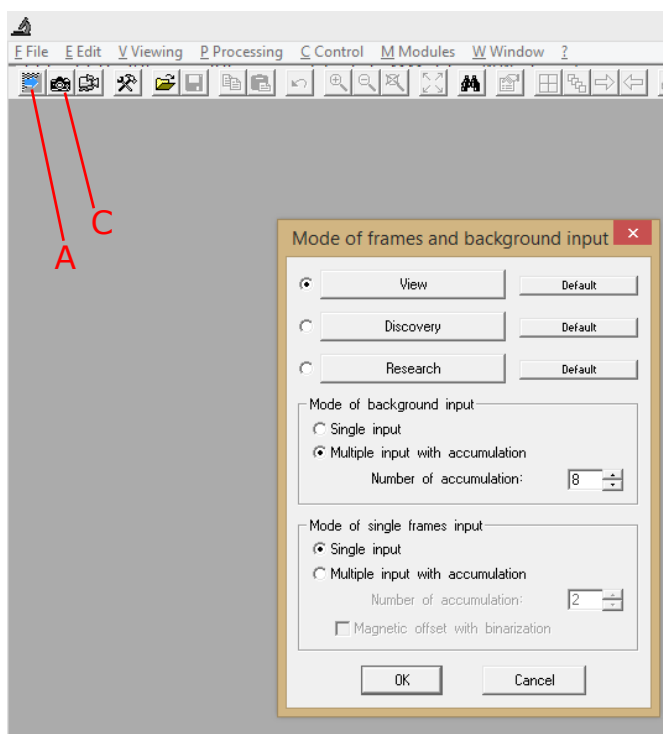
View — the visualizer is taken away from the examined document (and other possible sources of magnetic field) and a single background frame is input. Then the frame of the examined document is input

once. Afterwards, the background is subtracted from this frame. This operation mode is the most simple and quick.

Discovery — a background image is input twice. Then the arithmetic mean of those two images is used as the background. It means that two brightness values of each pixel are summed up and divided by two. It helps to reduce the influence of random noises (pixel brightness fluctuation) in the magneto-optical channel of the device. The frame of the examined document is input twice and averaged. Then the average background image is subtracted from the average frame image. This mode is slower but it provides resulting images that are more sharp and noiseless.

Research — a background image is input eight times and then averaged. A frame with magnetic image of the questioned document is also input eight times. In addition, the mode of **magnetic displacement** is activated. It means that the device inductor generates an additional magnetic field suppressing random single pixels irrelevant to the informative image. When the magnetic image is input eight times, the inductor generates N-S polarized magnetic field four times and four times the opposite — S-N polarized magnetic field. The frames obtained by this technique are averaged (eight brightness values for each pixel are summed up and divided by eight). Then the averaged background is subtracted from the averaged frame. This mode takes the longest time and produces the resulting image of the highest quality. But it can also suppress minor useful details and pixels of the examined image.

Parameters of the selected mode are displayed in the «Mode of background input» and «Mode of single frames input» sections. The user can customize these parameters if necessary.

To restore the default settings, click on the corresponding «Default» button.

6.4 Processing the results

The CADR software provides the user with a wide range of tools for processing visualized magnetic images. More information about the application tools is given in the User's Guide to the software.

Below we give the description of several functions of the CADR software: «Deviation from middle» and «Magnetization» that are most commonly used for processing magnetic images in security documents.

### «Deviation from middle» function

To activate the «Deviation from middle» function, scan a document which contains a magnetic image or open one of the previously saved images from the menu [File] - > [Read]. Then **right-click**

on the **F** button (Figure 8) located in the lower row of the toolbar. The «Deviation from middle» window will open.

If the mentioned button does not appear on the toolbar when starting the CADR application for the first time, double click on the free space of the toolbar lower row with the left mouse button while holding the <Ctrl> key. In the appeared «Customize Toolbar» window, it is possible to add the required button to the toolbar.

The «Deviation from middle» function calculates the average value of pixel brightness values in the processed monochrome bitmap. «Plus» or «minus» deviation from this value by some quantity is considered to be a dead zone. The pixel brightness values lying within the dead zone range are replaced by the average value. Brightness values exceeding the upper limit value of the dead zone are increased. Brightness values being less than the lower limit value are lowered.

Figure 8
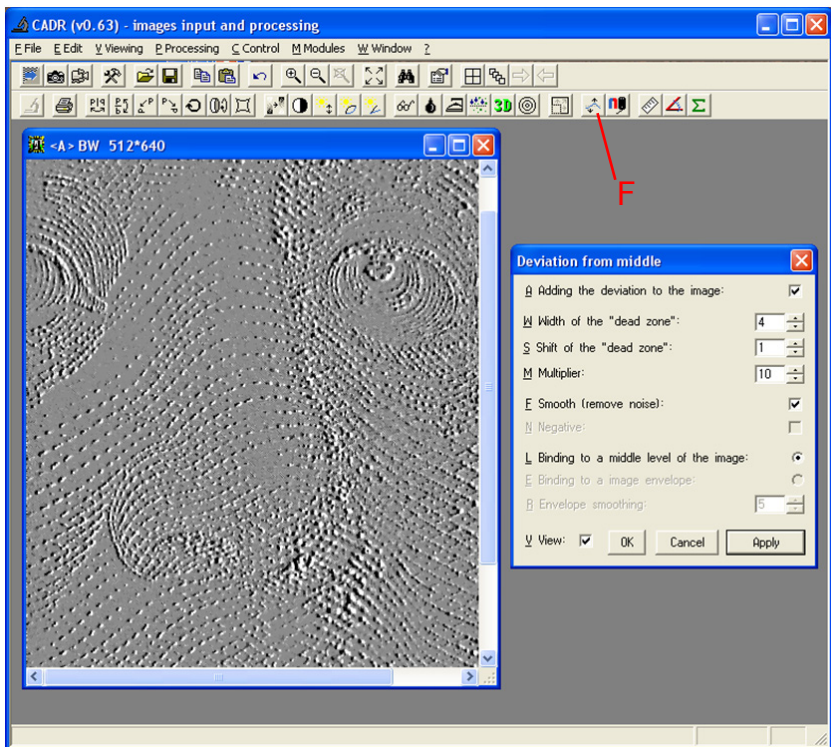
Here is the list of image processing parameters and their purpose:

Width of the dead zone — specifies the range of the pixel brightness deviation from the average value. Within this range, brightness values are adjusted to the average value.

Shift of the dead zone — allows shifting the dead zone by some positive or negative value relative to the brightness average value.

Multiplier — determines the degree of brightness change for the pixels with brightness values beyond the limits of the dead zone.

Smooth (remove noise) — reduces the contrast of pixels with random brightness deviation against the image general background.

Adding deviation to the image — if this option is not checked, the average brightness value is subtracted from all values of the image pixel brightness. The following options are available in this mode:

- **Negative** — converts a processed image to a negative.
- **Binding to a middle level of the image** — adjustment of the image pixel brightness relative to the average brightness value.
- **Binding to an image envelope** — correction of the image pixel brightness for uneven illumination distribution over the input frame.
- **Envelope smoothing** — the parameter of correction for uneven illumination distribution over the input frame.

View — if this checkbox is checked, all changes in image processing parameters will immediately cause corresponding image changes.

OK — exit from the «Deviation from middle» window saving the specified parameters of image processing. In this case, the image changes are not saved. The image preserves the parameters set before opening the «Deviation from middle» window.

Cancel — exit from the «Deviation from middle» function without saving the specified parameters of image processing. The image preserves the parameters set before opening the «Deviation from middle» window.

Apply — exit from the «Deviation from middle» function saving the specified image processing parameters. In this case, the image changes are applied.

The «Deviation from middle» function can also be activated by double clicking the **left** mouse button on the button **C** (Figure 8). In this case, the function is executed without displaying the image processing parameters which correspond to the latest saved.

Assessment of magnetic parameters

The «Magnetic measurements» function of the CADR software is intended for assessing magnetic parameters of the materials used to produce document security features and for comparing these parameters in examined documents and in templates (certainly authentic documents) for a further conclusion about a probable forgery.

The results of the «Magnetic measurements» function execution are the following: the histogram of the normal component of the magnetic induction vector B_n (mT) for a single image frame, the value of the modulus of the magnetic flux Φ_n (nWb) through the frame area, the distance d between histograms of the examined document and the template. Comparison of the measured parameters (B_n, Φ_n, d) allows carrying out document authenticity verification and assessing wear or damage rate of the magnetic image.

The normal component of the magnetic induction vector B_n is a component of the vector of the magnetic induction generated by the material of the magnetic image located in the visualizer frame area. This component is perpendicular to the frame surface.

Magnetic induction B_n is assessed for each pixel of the examined image according to the compensation scheme. This technology is used in the inductor that is a graduated source of the magnetic field.

The inductor generates 32 different levels of the magnetic displacement field that partially equalizes the residual magnetization field of the examined image. The CADR software captures 32 frames and counts the number of changed image pixels corresponding to each level of the compensating magnetic field.

This is the way brightness distribution in 32 image frames is formed. On the one hand, it is connected with the strength of the residual magnetization field generated by the magnetic material of the ink. On the other hand, it is connected with the level of the compensating magnetic field of the inductor.

The histogram of the normal component of the magnetic induction is built based on the brightness distribution in the coordinates $lg_{(n)}$-B_n (Figure 9d). Here n is the number of pixels in the image, B_n — magnetic induction.

The induction of the magnetic stray field is assessed in the range from the sensitivity threshold of the magneto-optical crystal (≈ 0.1-0.2 mT) to the maximum compensation field of the inductor (≈ 2.8 mT).

The magnetic flux Φ_n is calculated according to the histogram B_n and the known area of the visualized zone.

The distance **d** between the two histograms is calculated as follows: each histogram column is compared with the corresponding column of the other histogram, and the modulus of their difference is calculated. Then all moduli are summed up for all columns. This sum is the **d** parameter of the two compared histograms. It is a similarity parameter. The smaller **d** is, the more similar the histograms are and the higher is the probability that the two compared documents are printed with the same ink using the same technology.

For different types of documents and banknotes the value of the distance **d**, which distinguishes an original document from a forged document, may differ. An expert is to determine these values experimentally by accumulating experience and experimental data.

* The distinctive physical feature of the magnetic measurement process is a significant dependence of its results on the temperature at which the measurement is taken. In particular, the magnetic properties of the examined materials exhibit different degrees of dependence on the temperature.

In this connection, it is necessary to take measurements in the same narrow temperature range in order to improve the accuracy when comparing the obtained results.

Therefore, when executing the «Magnetic measurements» function, the ambient temperature should meet the requirements for the mode of magnetic parameter measurements (see section 7 «Technical Specifications»).

To call the «Magnetic measurements» function, **left-click** on **the E button** (Figure 9a) or **left-click** in the menu [Modules] -> [«MagMouse/Regula 4197»]->[Magnetic measurements](Figure 9b).

Before running the «Magnetic measurements» function, input a background image as described in paragraph 6.3 (Button A, Figure 7). During further work with this function, repeat the background image input for approximately every fifth function execution.

To access the options of the «Magnetic Measurements» function, **right-click** on **the E button**.

A window with the following options will appear (Figure 9c): «Threshold of histogram distance (d)», «Decreasing compensating field (recommended)», «Increasing compensating field» and «Improved precision of graph scales».

It is recommended to set the initial value of **d** in the range d = 15-20 and set the decreasing compensating field.

The option «Improved precision of graph scales» changes the number of digits in scale numbers of the magnetic induction histogram which is formed as a result of the magnetic measurements. If this option is enabled, the number of digits after the decimal point on the $lg_{(n)}$ scale is 2, on the B_n scale is 3. If the option is not selected, the number of digits after the decimal point is 1 and 2, respectively.
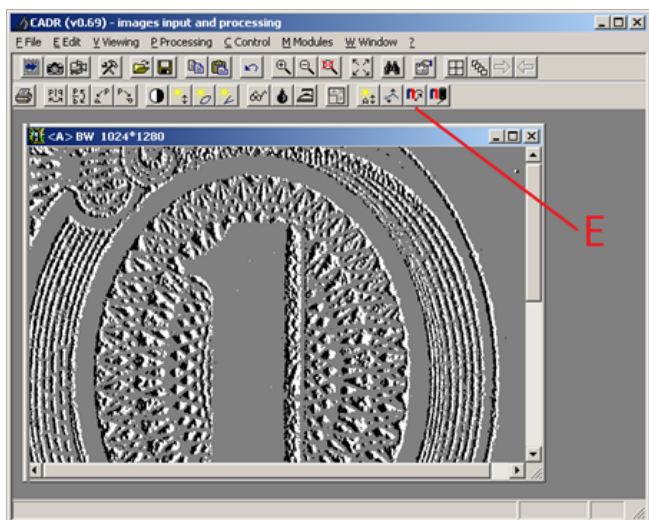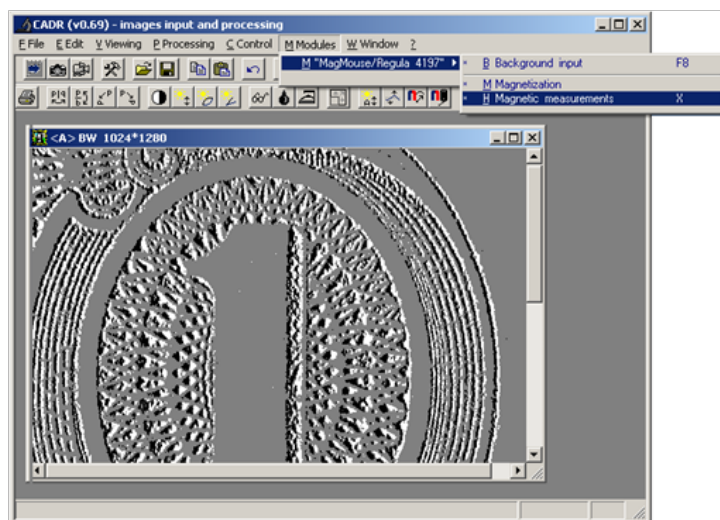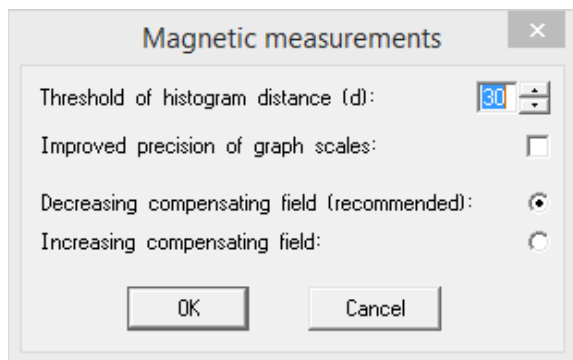
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To begin the procedure of magnetic parameter assessment, activate the mode of continuous image input (by pressing **the right button 3** of the visualizer (Figure 1) or by **left-clicking the B button** in the CADR application window (Figure 4)) and select the required fragment of the examined document by moving the visualizer.

Stop moving the visualizer. The device should stand still for about 30 s while the measurements are taken.

Then **left-click** on **the E button** (Figure 9a) or in the menu [Modules] -> [«MagMouse / Regula 4197»] -> [Magnetic measurements] to call the «Magnetic Measurements» function (Figure 9b).

As the «Magnetic Measurements» function starts, two windows open. The first window is intended for summation of 32 image frames with different levels of magnetic displacement. The second window shows a graph — the histogram B_n. The green LED blinking on the visualizer and a specific sound indicate that the device operates in the mode of taking magnetic measurements.

It is possible to input up to 3 graphs (Figure 9d) into the same histogram B_n window.

Figure 9d shows the histograms B_n for two authentic banknotes and a forged one. The distance between the histograms B_n for the pair of authentic banknotes is d=4. It is d = 89-91 for the pair «authentic-forged» (excess of the determined threshold d=15 is marked with a rectangular frame).
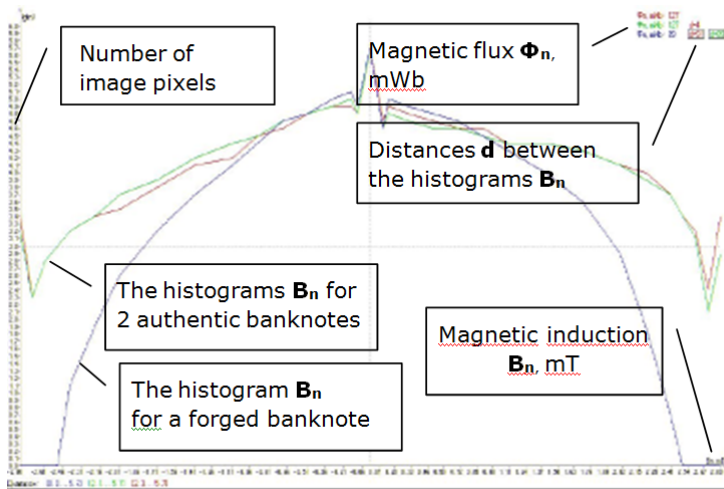
ATTENTION!

> TO ACHIEVE ACCURATE COMPARATIVE ASSESSMENT OF MAGNETIC PARAMETERS, MAKE SURE THE CONTROL AREAS OF EXAMINED AND REFERENCE DOCUMENTS COINCIDE. WHEN CHOOSING THE CONTROL AREA, THE AREAS WITH HIGHER PRINT DENSITY AND THICKER INK LAYER ARE PREFERABLE.

When examining crumpled documents and banknotes, press the visualizer manually to provide close magnetic contact between the document and the visualizer.

Magnetic parameters can be assessed with the installed magnetic excitation system (Figure 1) for all types of magnetic materials and with the removed magnetic excitation system for magnetically hard materials.

Ferromagnetic materials (including magnetic dust on the visualizer, the examined object and the pad) and the sources of the magnetic field located close to the device, may distort the measurement results.

ATTENTION!

> FERROMAGNETIC MATERIALS AND SOURCES OF MAGNETIC FIELD LOCATED CLOSE TO THE DEVICE MAY DISTORT THE IMAGE FORMED BY THE VISUALIZER AND THE RESULTS OF THE MAGNETIC MEASUREMENTS.
>
> BEFORE STARTING DEVICE OPERATION MAKE SURE THAT THE REQUIREMENTS OF PARAGRAPH 6.1 ARE OBSERVED.

Magnetic remeasurements

Function purpose and execution

The «Magnetic remeasurements» function allows saving the results of the «Magnetic measurements» function and reproduce these results.

To carry out magnetic remeasurements of any frame of the document, first perform the function of magnetic measurements for this frame.

After the magnetic measurements are taken, the frame image will slightly change. It will look a little smoother and more blurred (Figure 10a). This modified image contains information about the results of measuring its magnetic parameters.

This image can be saved (see paragraph **A**) in order to run the remeasurement procedure later after opening this image from the disk. It is also possible to perform the procedure of magnetic remeasurements with the given modified frame (see paragraph **B**) without saving it.

A. To save the image, which contains magnetic measurement data, activate the window with this image by clicking on it once. Then select in the CADR menu [File] -> [Save].

B. To perform the «Magnetic remeasurements» function:

- activate the window with this image by clicking on it once.
- perform the «Magnetic remeasurements» function from the CADR menu: [Modules] -> [MagMouse/Regula 4197] -> [Magnetic remeasurements].
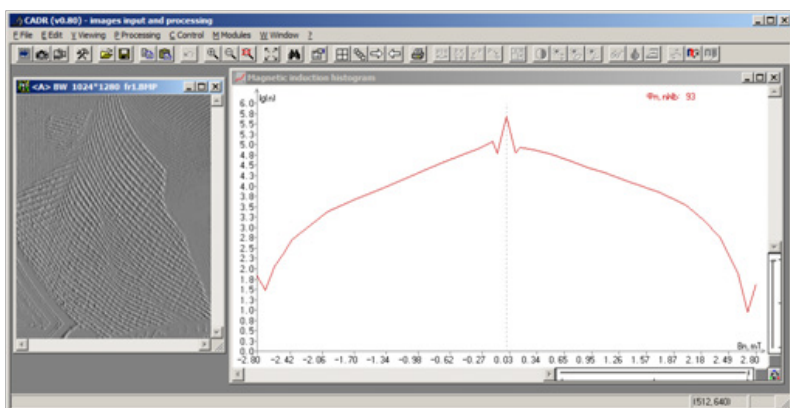
As a result of «Magnetic remeasurements» function execution a window appears. It contains a histogram of the normal component of the magnetic induction B_n for the image frame and the calculated value of the modulus of the magnetic flux Φ_n in the image area (Figure 10b).

The function of magnetic remeasurements can be performed multiple times for the same image.

Figure 10a

Figure 10b

Evaluation of magnetic parameters for a fragment of the image frame

The «Magnetic remeasurements» function allows assessing magnetic parameters not only for the whole image frame but also for a fragment of it.

To execute the «Magnetic remeasurements» function for an image fragment, select the required area of a modified image by holding the <Alt> key and moving the mouse cursor (with the left button pressed) in the window. The blinking frame will appear in the window (Figure 10c).
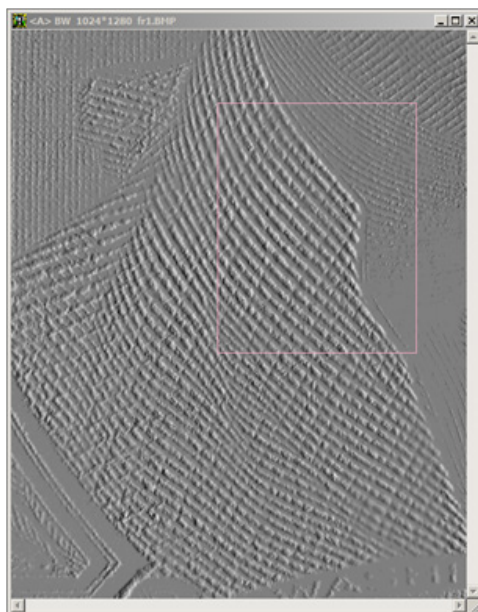
The frame shows a part of the whole image frame for which magnetic parameters will be measured. Its size and position can be changed by moving its corners with the mouse cursor. To specify exact settings of the frame, select in the CADR menu [Edit] -> [Fragment] (Figure 10d).

In the «Fragment» window, the four graphic windows display the location of each of the four frame corners. It is possible to move each corner of the frame by clicking the mouse in the corresponding window.
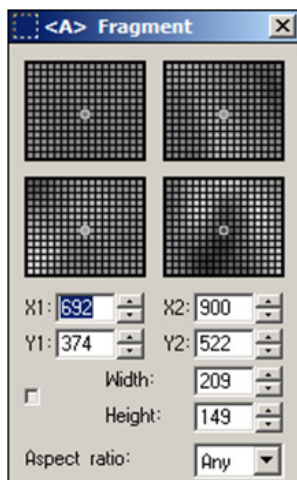
«X1,Y1» and «X2,Y2» are the coordinates of the upper left and the lower right corners of the frame. «Width» and «Height» are the width and height of the frame in pixels. «Aspect ratio» can be selected from the following: «Any», «1:1», «4:3», «3:4».

When the required position and dimensions of the frame are set, activate the function «Magnetic remeasurements» as it was described above ([Modules] -> [MagMouse/ Regula 4197] -> [Magnetic remeasurements]). The window will appear showing the histogram of the normal component of the magnetic induction B_n (tesla) for the image fragment selected with the frame and the calculated value of the modulus of the magnetic flux Φ_n (weber) in this fragment.

This operation can be also performed in a different order. Run the function «Magnetic measurements» first. Then, in the window of the image frame, form a rectangular frame (Figure 10c) by holding the <Alt> key and moving the mouse cursor (with the left button pressed) over the image. The data in the window of magnetic measurement results change dynamically depending on the position and dimensions of the frame.

Application of the «Magnetic remeasurements» function to multiple frames

The «Magnetic remeasurements» function allows getting up to three measurement results in one window. These results correspond to three separate image frames. As a result, it becomes possible to

compare the results of different measurements performed on different documents at different times.

First of all, in the CADR window open three images for which the magnetic measurements were taken. These could be the images: 1) processed and saved on a computer disk or 2) obtained as a result of three successive direct measurements or 3) any combination of previously saved and recently processed images.

Then activate one of these image windows by clicking on it once. Execute the «Magnetic remeasurements» function for it. Afterwards activate the second image window and execute the «Magnetic remeasurements» function. And in the end the same procedure should be repeated for the third image window.

As a result, three histograms of the normal component of the magnetic induction $\mathbf{B_n}$ and three values of the modulus of the magnetic flux $\mathbf{\Phi_n}$ for image frames of three different documents as well as distances $\mathbf{d}$ between the histograms $\mathbf{B_n}$ will appear in one window (Figure 10e).

Figure 10e

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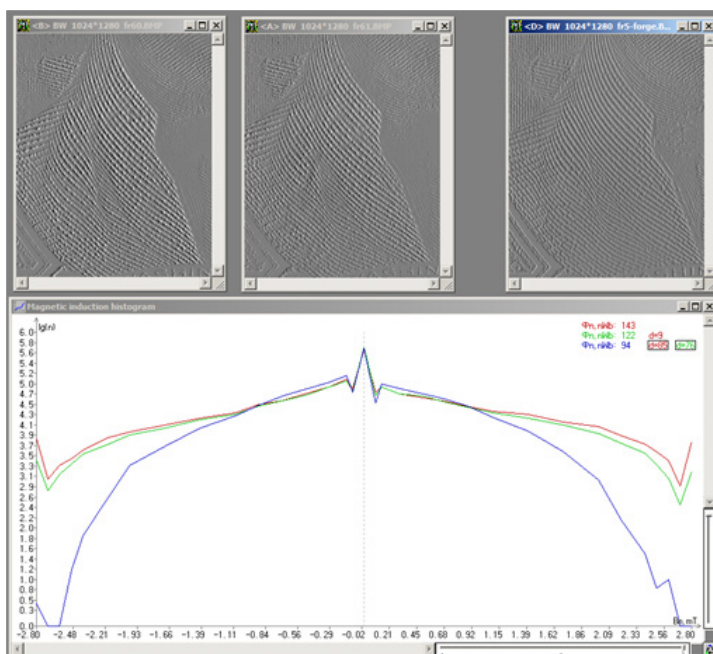
When the data obtained from several documents is represented in one window, it allows carrying out comparative analysis of these documents.

Assessment of magnetic parameters for a fragment of the image frame (as it is described above) can be performed for each image frame. In order to do this, form a rectangular frame in each image frame holding the <Alt> key and moving the mouse cursor (with the left button pressed). Magnetic parameters are measured for the areas selected within each frame.

Numerical representation of measurement results

The data of the histograms of the magnetic induction B_n normal component can be represented not only in graphical, but also in numerical form as columns of numbers.

To change the format of data presentation, activate the window «Magnetic induction histogram» by clicking on it once with the mouse cursor. Then press the key combination <Ctrl+C> or select the item [Edit] -> [Copy] in the CADR menu. As a result, the numerical data concealed in the «Magnetic induction histogram» window is copied to the computer clipboard.

Then open a text file of either Microsoft Word or Notepad (OS Windows). Paste the data from the clipboard into this file. The data consists of columns of numbers. The number of columns can vary from 2 to 5 depending on the number of histograms built in the «Magnetic induction histogram» window.

The first column contains the values of the magnetic induction B_n normal component in tesla. The rest of the columns contain **lg(n)** — the logarithms of numbers of pixels. The latter correspond to the values of the magnetic induction B_n given in the first column. The columns correspond (from left to right) to the red (R), a green (G) and blue (B) diagram.

«Approximation» function

The results of the «Magnetic measurements» function may be affected by the factors which decrease the comparability of measurement results obtained from different documents or different fragments of the same document. These factors can be, for example, image background noises, different magnetic print density of the compared images (the number of magnetic image lines per unit area of a frame), as well as preliminary biased magnetization in the magnetic images.

The impact of such factors can distort the results of the comparison between an examined document and a template.

Therefore, the «Approximation» function was added to the CADR software.

When the «Approximation» function is executed, the data of the histogram B_n are additionally processed. An approximating curve is built based on the processing results. The curve has the following properties:

1) The approximating curve is in the form of a quadratic parabola.

2) When the approximating curve is being built, the pixels appearing because of background noise (i. e. random pixels that arise in the frame having no magnetic image) are excluded from the array of the processed pixels.

3) *When the approximating curve is being built, special corrections are made. They make the shape and position of the curve independent of the number of magnetic image pixels that got into the processed frame. It means that the shape and position of the curve do not depend on how densely the frame is filled with the lines of the magnetic image.

Such corrections allow comparing the characteristics of document magnetic material by different content of compared frames.

4) *When the approximating curve is being built, some other corrections are made. They make it possible to compensate possible displacement of image magnetization towards **S** or **N** polarity.

When the «Approximation» function is executed, the distance **d** between the histograms B_n is recalculated taking into account all the corrections described above.

To call the «Approximation» function, first left-click on the appropriate «Magnetic induction histogram» window containing data which are to be subjected to the approximating procedure.

Then select in the menu [Modules] -> [MagMouse/ Regula 4197] -> [Approximation] (Figure 10f).

_____
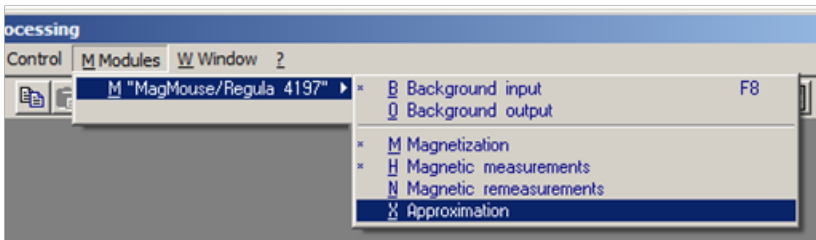
** Making the corrections described in items **3)** and **4)** is called NORMALIZATION of the approximating curve._

To execute the «Approximation» function with NORMALIZATION (see items 3) and 4) above), select it in the application menu holding the <Shift> key at the same time.

Figure 10g shows initial histograms B_n (the upper window) and approximated histograms (the lower window).
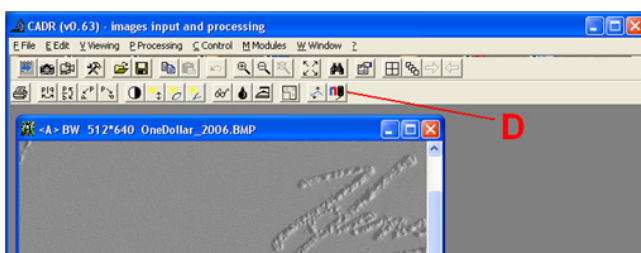
Figure 10g
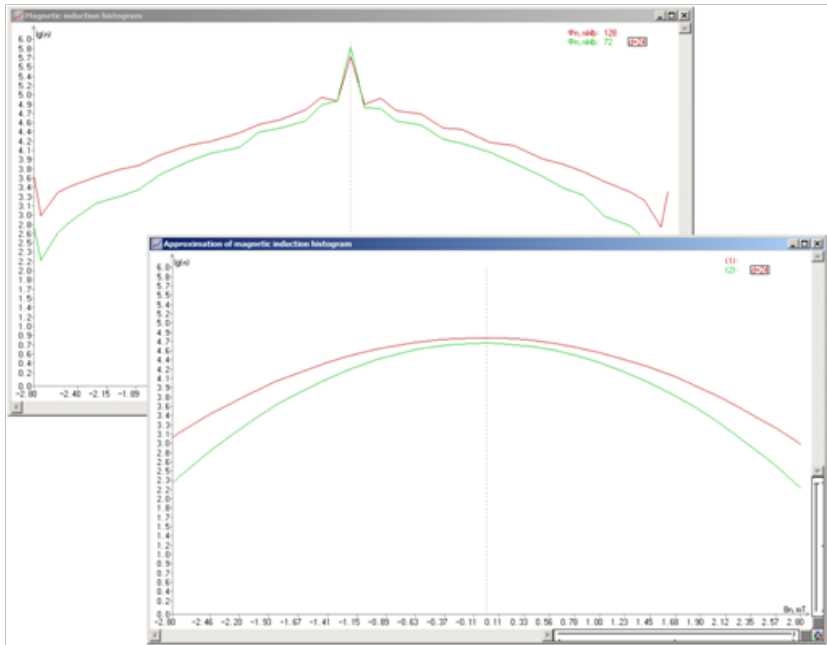
«Magnetization» function

The CADR application has a «Magnetization» function which allows comparing the levels of magnetization in a questioned document and in a template. The «Magnetization» function transforms an image printed with magnetic ink on the document surface to the colour map which displays the level of relative magnetization of image fragments. Comparison of the colour maps of an examined document and a reference document allows making a conclusion about document authenticity and about the degree of magnetic image deterioration or damage.

Source data for colour map calculation is the distribution of magneto-optical image brightness. The brightness distribution is connected with the strength of the magnetic stray field produced by the magnetic ink. The strength of the magnetic stray field is assessed in the range from the sensitivity threshold of the magneto-optical crystal to the strength of complete remagnetization.

To access the tools of the «Magnetization» function, **right-click** on the **D** button (Figure 11a) while the window with a magneto-optical image is active.

Another way to run the «Magnetization» function is to **right-click** the menu item [Modules] -> [«MagMouse/Regula 4197»] -> [Magnetization] (Figure 11b).

In the appeared window the following options are available: «Contouring», «Contours overlay» and «Painting by rainbow».

When «Painting by rainbow» is selected, the colour map is formed by filling in the zones having equal magnetization levels with the same solid colour (Figure 11c). In this case, the initial magneto-optical image is the background of the map.
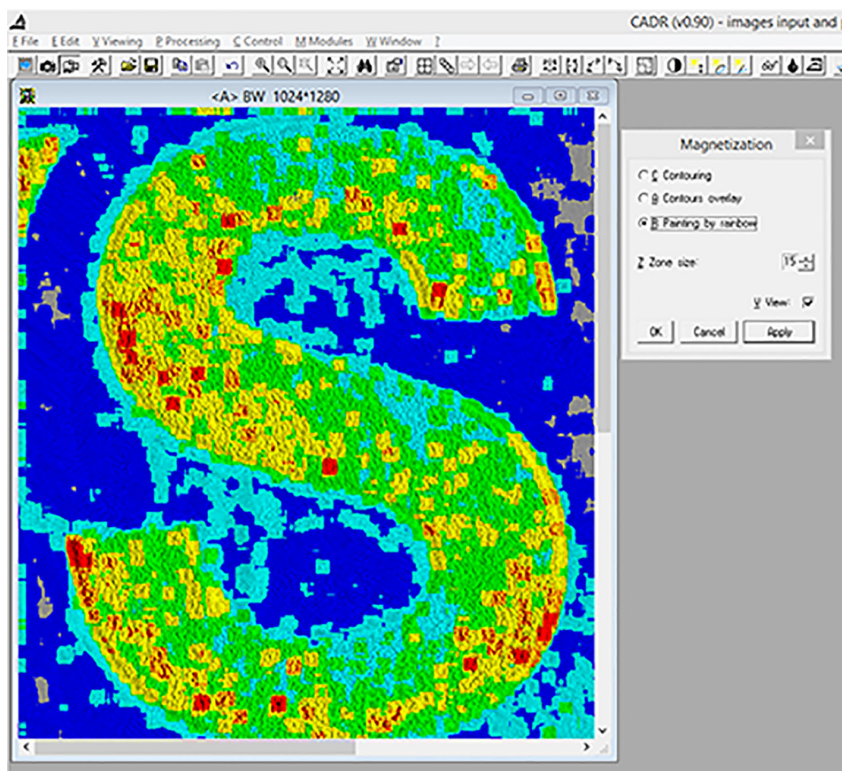
When the «Contours overlay» option is selected, the colour map is formed by contouring the zones having equal magnetization levels with lines of the same colour (Figure 11d). In this case, the initial magneto-optical image is the background of the map.
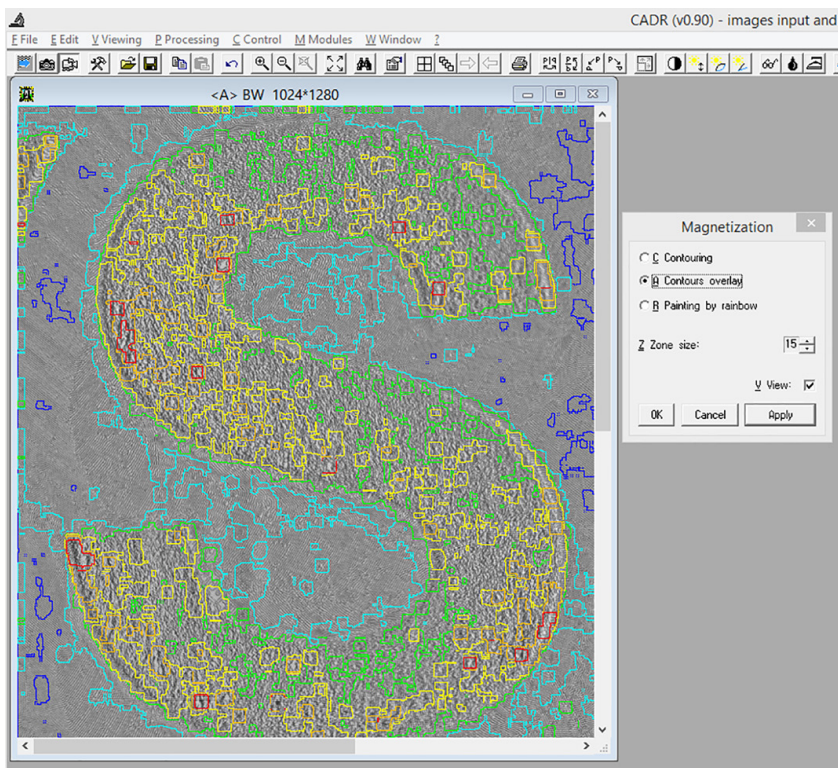
When the «Contouring» option is selected, the colour map is formed by contouring the zones having equal magnetization levels with lines of the same colour (Figure 11e). In this case, the magneto-optical background image is replaced by a black background.
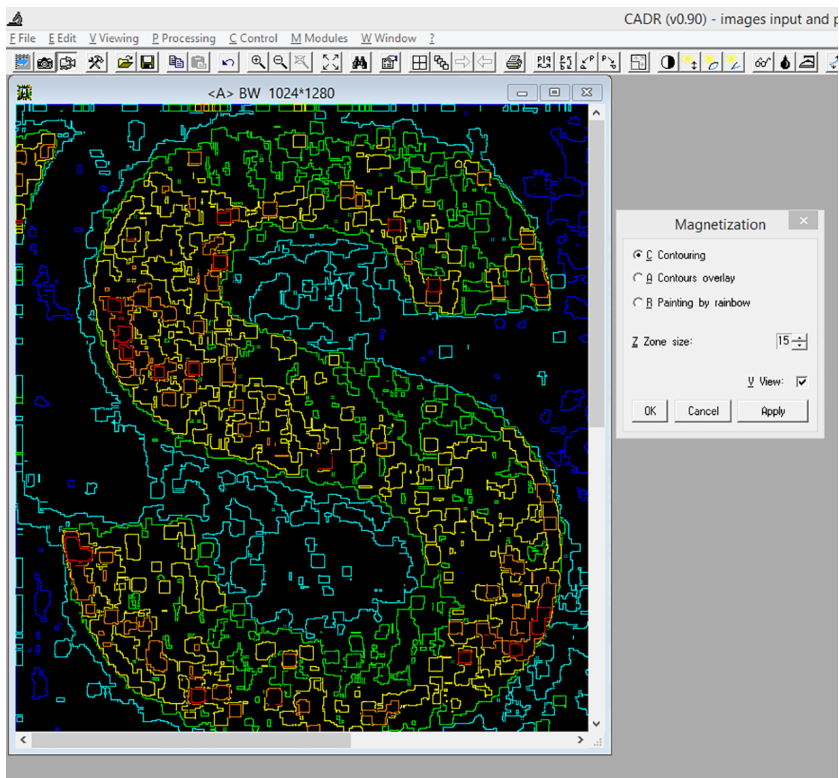
The parameter «Zone size» defines the size of the minimal area in which the magnetization level is averaged, and the area is transformed into a coloured spot of the corresponding colour.

It is also possible to execute the «Magnetization» function by **left-clicking** on the **D** button or through the menu [Modules] ->[«MagMouse/Regula 4197»] ->[Magnetization]. In this case the «Magnetization» window does not appear. The function is executed with the parameters set up earlier.

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Test object 4 (universal)

Test object 4 (universal) (Figure 12a) is intended for checking visualizer operation in case there are no other objects with magnetic printing. Novice users are to use this test object to gain initial practical experience in operating the device.

Set up background and frame input parameters (see paragraph 6.3) before using test object 4 (universal) for examination. In the window «Mode of frames and background input», select the «Discovery» mode. In this mode the parameters «Multiple input with accumulation» and «Number of accumulation: 2» are set automatically for the mode of background input and the mode of single frame input (see Figure 12b).

Different areas of test object 4 are used to control different aspects of visualizer operation.

Area A — control of display uniformity across the field of view for the grid of intersecting lines; control of the contact flatness between the visualizer sensor and examined object surface.

Area B — control of the geometric distortions of the visualizer optical system.

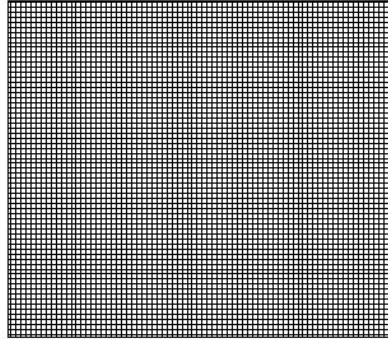**Area C** — control of the centring and size of the visualizer field of view.

Area D — control of microtext legibility.

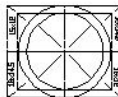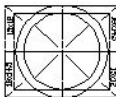## Test-object № 4 (universal)
for Regula 4197 and Regula 7701

Not a test-object.
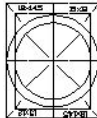The test-object is enclosed separately.
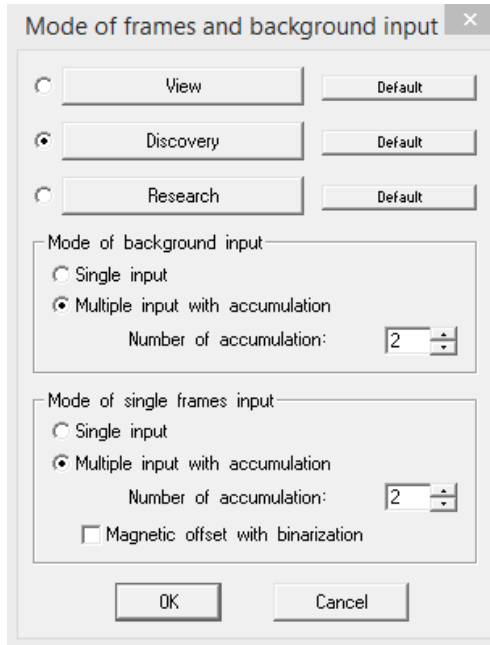
6.6 Operation completion

Close the CADR application.

Disconnect the visualizer's USB cable from the computer.

6.7 Maintenance

ATTENTION!

THE SENSITIVE ELEMENT SURFACE (FIGURE 2) IS VERY SENSITIVE TO SCRATCHING AND ERASING. AT THE SAME TIME, SOILING OF THIS SURFACE LOWERS THE IMAGE QUALITY. AVOID SOILING THE SENSITIVE ELEMENT.

Clean the sensitive element if necessary, especially when dirt prevents the device from normal functioning.

It is recommended to get rid of dust by blowing it off or flicking it off with a soft brush.

Remove sticky dirt and grease stains carefully with a cotton pad slightly moistened with some optics cleaning solution. If such cleansers are not at hand, use rectified alcohol. The cotton pad should be damp, but not dripping to prevent excess liquid from getting inside the device. After cleaning the sensitive element using liquids, wait for 3–5 minutes before turning the visualizer on. It will guarantee evaporation of the cleaning liquid.

Keep the visualizer pad clean. Avoid dust gathering on its surface. Wipe the surface of the pad regularly with the same cleaning solution that is used for the sensitive element. Wait until the pad surface is completely dry before starting to work with the visualizer.

To prevent dirt gathering on the device and the pad when they are not used, keep them in a clean plastic bag.

7   TECHNICAL SPECIFICATIONS

Parameters and Specifications	Value	Notes
Field of view, mm, min	14×18	
Image frame format, pxl	1024×1280, 512×640	

Spatial resolution of the image optical input system, mkm
   – for 1024×1280 image frame
   – for 512×640 image frame
	
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	28	

Ambient temperature range recommended for device operation:
 	
   – for magnetic parameter measurements*, °C;
 	
   – for other operations, °C.
	
	(25±1) °C
	
	(25±10) °C
		* — see «Assessment of magnetic parameters» and «Magnetic remeasurements» in paragraph 6.4 «Processing the results». Before performing the operation, the device should be warmed up for at least 15 min.

System requirements	OS Windows XP OS Windows 7 OS Windows 8 OS Windows 10	
PC connection interface	USB 2.0	
Dimensions, mm	59×113×50	
Weight, g	490	

8   TRANSPORTATION AND STORAGE

The visualizer is transported and stored in the manufacturer's packaging. Protect the packaged device from hits and vibrations.

The device contains magnetized material packed in accordance with the requirements of ICAO Doc 9284 AN/905. The device is allowed for transportation by passenger aircraft.

9   CLIMATIC CONDITIONS OF STORAGE AND TRANSPORTATION

Air temperature	from +5 to +40 ˚C
Relative air humidity	up to 80 % at the temperature of +15 ˚C
Atmospheric pressure	100±4 kPa (750±30 mm Hg)

10 ACCEPTANCE CERTIFICATE

Magneto-optical visualizer "Regula" 4197

Serial number _____ is produced and accepted in accordance with obligatory requirements of state standards, current technical documentation and considered serviceable.

Responsible for acceptance _____

_____   _____

    (signature)   (first and last name)

_____

(year, month, date)

Seal:

Manufacturer: JV RIODIN
Ukraine, 01133, Kiev, Leonid Pervomaisky street, 9a-26,
Phone/Fax: + 38 044 246 4164, + 38 044 288 0549,
E-mail: riodin.kiev@gmail.com

Address for mailing claims with regard to the quality of the device:
29 Kozlova Lane, Minsk 220037, Republic of Belarus
Tel. +375 17 224 66 44, Fax +375 17 318 95 73
E-mail: support@regulaforensics.com
Web: www.regulaforensics.com

11 SALE CERTIFICATE

Magneto-optical visualizer "Regula" 4197

№ _____

    (serial number)

Seal:

Ukraine, 01133, Kiev, Leonid Pervomaisky street, 9a-26,
Phone/Fax: + 38 044 246 4164, + 38 044 288 0549,
E-mail: riodin.kiev@gmail.com