

MAGCAM

advanced magnet



inspection

Fast and accurate inspection of permanent magnets
Magnetic field camera technology | For R&D and production

MULTIPOLE MAGNETS | UNIAXIAL MAGNETS | SENSOR MAGNETS | MOTOR MAGNETS | PERMANENT MAGNET ROTORS

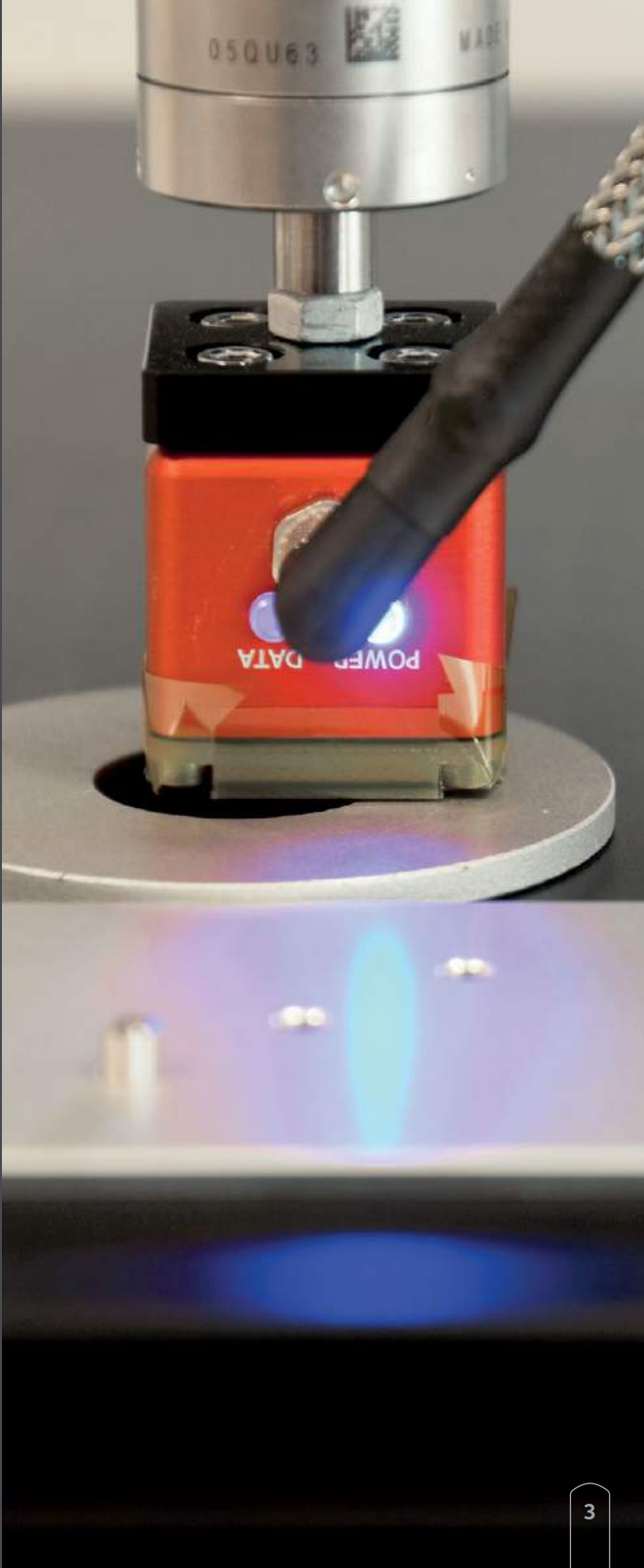
ABOUT MAGCAM

Magcam is a technology leader, specialized in advanced inspection systems for permanent magnets, based on its unique magnetic field camera technology.

Magcam's world-class magnetic field cameras are used for quality control, as well as development of high-end permanent magnets and magnet systems. Magcam's customers include sensor manufacturers, motor/generator constructors, medical and biotech companies, consumer electronics producers, high-end speaker OEM's, research labs, magnet producers and more.

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ADVANCED MAGNET INSPECTION

Complete quantitative characterization of magnets and magnet assemblies.

Magcam® offers a platform for advanced inspection of permanent magnets based on its unique and patented magnetic field camera technology, featuring a high-density 2D Hall sensor array integrated on a single semiconductor chip. The sensor chip records high resolution magnetic field maps at high speed.

These quantitative magnetic field maps contain large amounts of information about the magnet’s quality. The maps are analyzed using the versatile MAGSCOPE® software, resulting in a thorough and fast analysis of the magnet. Many quantitative magnet properties are extracted from the measurement data, making the Magcam system ideal for both R&D and production applications. Magcam also offers service measurements, renting services and custom software development services.

MEASURED PROPERTIES	MULTIPOLE MAGNETS	UNIAXIAL MAGNETS	MAGNET ASSEMBLIES
3D MAGNETIC FIELD DISTRIBUTION	✓	✓	✓
NORTH/SOUTH POLE IDENTIFICATION	✓	✓	✓
FIELD HOMOGENEITY	✓	✓	✓
LOCAL MATERIAL DEFECTS	✓	✓	✓
MAGNETIZATION DEFECTS	✓	✓	✓
POLE LENGTH/ANGLE MEASUREMENT	✓	✓	✓
NORTH-SOUTH POLE ASYMMETRY	✓	✓	✓
MAGNETIZATION ANGLE DEVIATION	✓	✓	
MAGNETIZATION VECTOR VALUE		✓	
MAGNET POSITION (4 DOF)	✓	✓	✓
LOCAL DEVIATIONS FROM THEORETICAL MAGNET		✓	
RADIAL MAGNETIC FIELD DISTRIBUTION	✓	✓	✓
MAGNET MISALIGNMENT			✓
CRACK DETECTION	✓	✓	✓

Works for all magnet materials, geometries and magnetization directions:

Materials: sintered magnets, plastic bonded magnets

Geometries: blocks, cylinders, rings, strips, complex shapes, PM rotors

Magnetization directions: axial, diametrical, radial, multipole

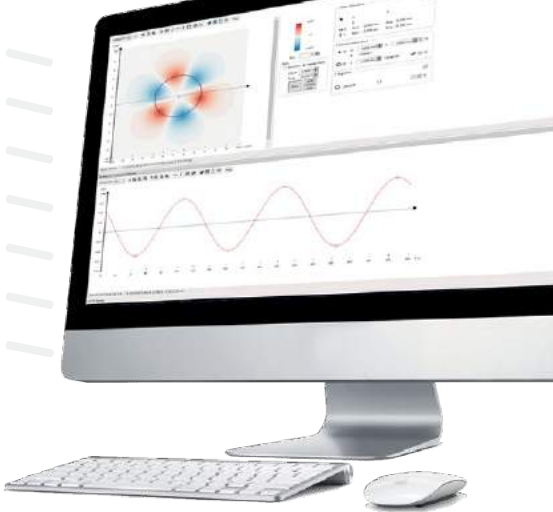
Permanent magnet rotors
Linear motor magnet plates
Sensor assemblies
Halbach arrays

Applications

- Inspection of sensor magnets
- Inspection of motor magnets
- Development of new sensor systems
- Magnet classification and sorting (pass/fail, binning, ...)
- Inline quality control (100%)
- Sample quality control
- Incoming / outgoing magnet inspection
- Magnet failure diagnosis
- Magnet certification
- Magnet assembly inspection
- Crack Detection

Benefits

R&D	PRODUCTION & QUALITY CONTROL
FASTER DEVELOPMENT CYCLES	HIGHER PRODUCTION YIELDS
BETTER, MORE ACCURATE PRODUCT DESIGNS	TIGHTER TOLERANCES
FAST BUILD-UP OF ADVANCED MAGNET EXPERTISE	100% INLINE TESTING
REDUCED DEVELOPMENT COST	FASTER MAGNET FAILURE DIAGNOSTICS

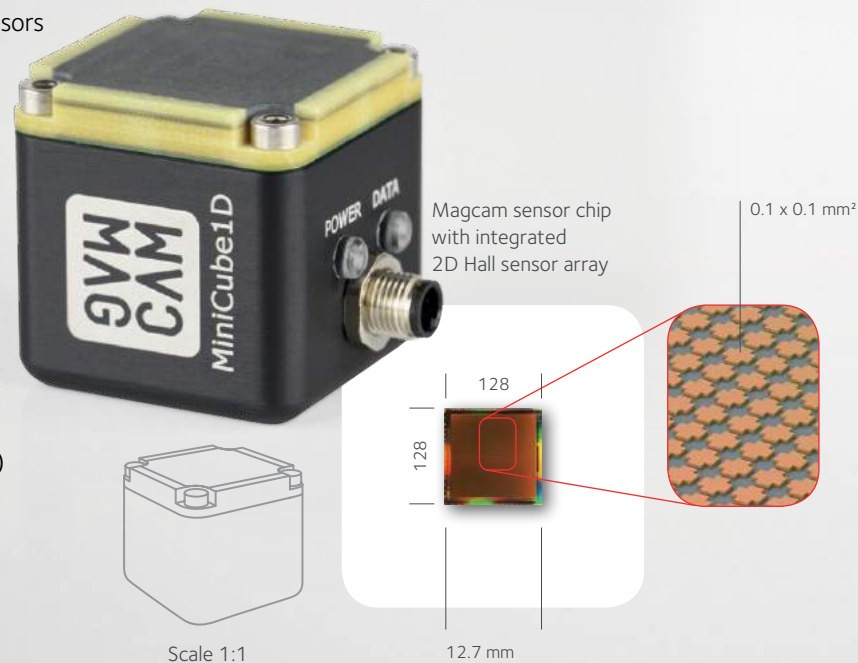


MINICUBE1D MAGNETIC FIELD CAMERA

The MINICUBE1D is a compact magnetic field camera containing Magcam's patented sensor chip with an integrated two-dimensional array of more than 16000 microscopic Hall magnetic field sensors. Each sensor independently measures the local magnetic field, resulting in a quantitative 2D magnetic field map with high spatial resolution, measured at record speed. This magnetic field map contains a large amount of information about the magnet's properties.

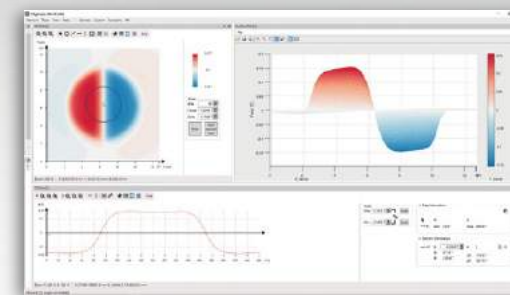
FEATURES:

- Quantitative digital Bz magnetic field mapping
- On-chip integrated 2D array of Hall sensors
- Number of measurement points:
 $128 \times 128 = 16384$
- Spatial resolution: $0.1 \times 0.1 \text{ mm}^2$
- Single sensor size: $40 \text{ }\mu\text{m}$
- Field of view: $12.7 \times 12.7 \text{ mm}^2$
- Magnetic field range: $\pm 1000 \text{ mTesla}$
- Magnetic field resolution: 0.1 mT
- Single measurement for full magnet analysis
- High speed measurements:
 $< 1 \text{ second per image (=16384 pixels)}$
- No moving sensor parts
- Size: $24 \times 24 \times 24 \text{ mm}^3$

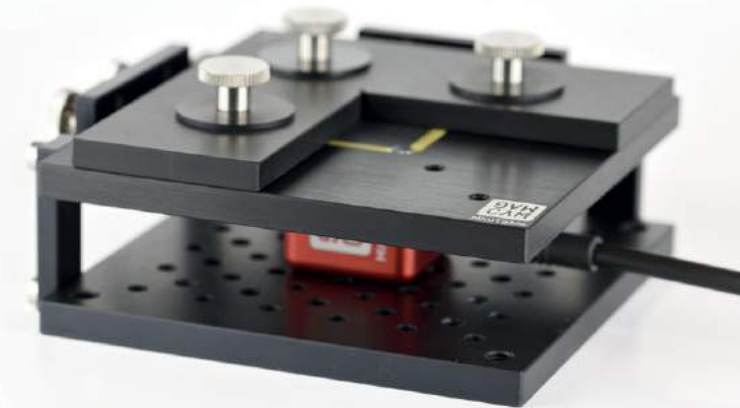
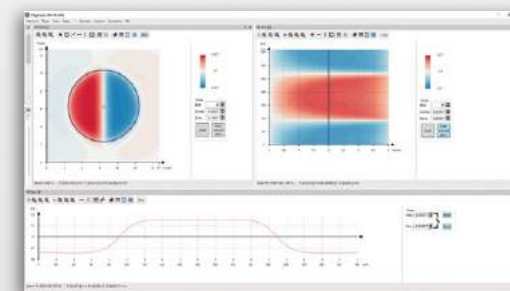
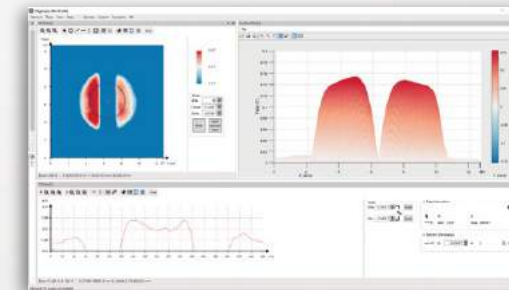


TYPICAL APPLICATIONS

- Magnetization vector angle deviation inspection
- Bz magnetic field inspection
- Field homogeneity inspection
- Crack detection
- Sensor magnets
- Motor magnets



Direct north-south pole uniformity inspection by using the absolute value of the Bz field and zooming around the pole value



MINITABLE

The MINITABLE is a working platform for measuring small magnets in which the MINICUBE magnetic field camera is built-in. The MINITABLE is equipped with an adjustable magnet positioning frame that allows to accurately position magnets with respect to the camera sensor in a reproducible way. The position of the frame can be adjusted in the XY plane in order to position magnets of different sizes.

FEATURES

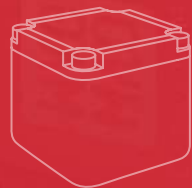
- Calibrated magnet positioning frame
- XY-position of frame corner with respect to sensor origin is continuously adjustable in range from 0 to 6 mm (X and Y independently)
- Size: $85 \times 85 \times 30 \text{ mm}$
- Retractable reference plates on X and Y sides
- Possibility to mount custom positioning frames
- Material: anodized aluminum

MINICUBE3D MAGNETIC FIELD CAMERA

Magcam presents the three-axis magnetic field camera MINICUBE3D, providing quantitative 3D (Bx,By,Bz) magnetic field maps in a 12.7mm x 12.7mm 2D plane with 0.1mm spatial resolution, measured at highest speed. The camera is based on Magcam's unique integrated 2D Hall sensor array technology.

FEATURES:

- Quantitative digital 3-axis magnetic field mapping (Bx, By, Bz)
- On-chip integrated 2D array of Hall sensors
- Number of measurement points: 128 x 128 = 16 384
- Spatial resolution: 0.1 x 0.1 mm²
- Field of view: 12.7 x 12.7 mm²
- Magnetic field range (Bx,By,Bz): +/- 1000 mTesla
- Magnetic field resolution (Bx,By,Bz): 0.1mT
- Single measurement for full magnet analysis
- High speed measurements: <1 second per image (=16384 pixels)
- No moving sensor parts
- Size: 24 x 24 x 24 mm³

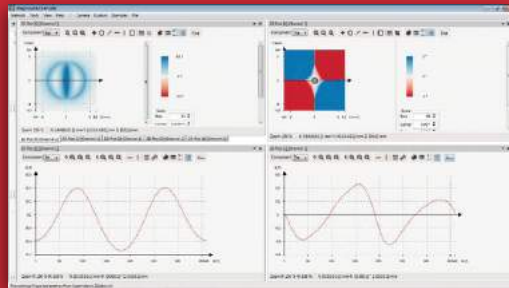
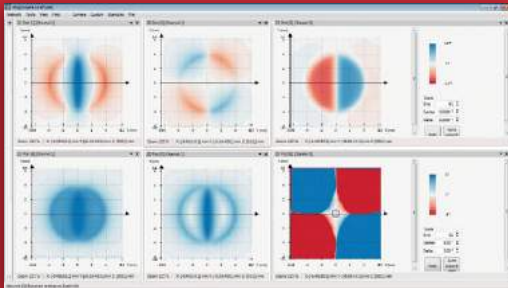


Scale 1:1

TYPICAL APPLICATIONS

- Magnetic vector field direction inspection (e.g. azimuth angle)
- In-plane (Bxy) field distribution inspection
- Total B field distribution inspection
- Volume vector field distribution measurement
- Sensor magnets (e.g. rotary encoder magnets)
- Motor magnets
- Halbach array assembly inspection
- PM rotor assembly inspection

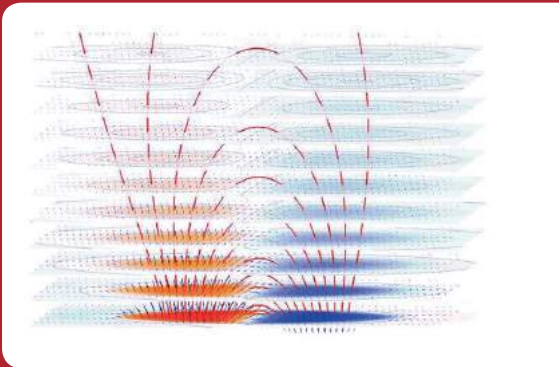
Bx, By ,Bz magnetic field distributions (top left to right). B, Bxy, azimuth angle distributions (bottom left to right) of a two-pole axially magnetized disk magnet (rotary encoder magnet).



Circle sections of the Bxy field (left) and of the azimuth angle (right) for a full analysis of the angle error of the magnet.

The MiniCube3D magnetic field camera, in combination with Magcam's MagScope software, is the ideal tool for analyzing the full three-component magnetic field distribution of all types of permanent magnets and magnet assemblies. Features include:

- Plotting color graphs and cross-sections of all magnetic field components: Bx, By, Bz, B (full field), Bxy, Byz, Bxz, azimuth angle (in-plane field direction), polar angle (out-of-plane field direction)
- Converting the magnetic field vector to spherical coordinates (azimuth and polar angles, field strength)
- Converting the measured data to cylindrical coordinates, resulting in following magnetic field components: Bradial, Btangential, Bz, B (full field) and any combination of 2 components.
- Generating vector plots of the field distribution



Combined vector / color / contour / field line plot of the measured full 3-component magnetic field distribution (measured at multiple distances from the magnet, requires Magcam Portal Scanner)

MAGCAM PORTAL SCANNER

Magcam's high speed PORTAL SCANNER is a motorized scan stage with an integrated MINICUBE3D or MINICUBE1D magnetic field camera. It uses an image stitching algorithm to measure large areas at high speed. The Portal Scanner allows measuring large flat magnets and magnet assemblies approximately 30x faster than single probe scanners. The scan stage is controlled automatically by the MAGSCOPE Measurement & Analysis software.

FEATURES HARDWARE:

- XY scan range: 300 x 300 mm
- Z scan range: 300 mm
- Integrated MINICUBE3D or MINICUBE1D magnetic field camera
- Closest measurement distance: 0.5 mm
- Mapping speed: 120 mm²/s (full resolution)
- Dimensions (WxDxH): 780 x 1000 x 1900/2200 mm (height in transport/installed mode)
- Repeatability per axis: +/- 1.3 µm
- Integrated calibrated positioning frame for accurately positioning magnets in a reproducible way
- Motor type: synchronous servomotor on all axes
- PLC controller
- Automatic collision detection
- Optional extension to 4-axis Combi version for Rotor Scanner
- Optional high accuracy laser for sample size measurement
- Optional safety light curtain

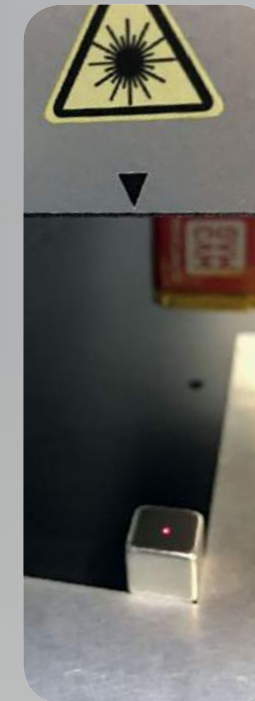
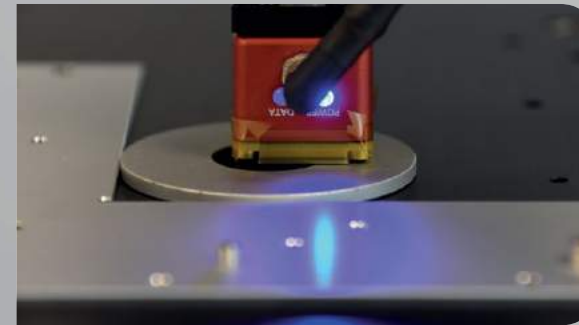
SOFTWARE:

- The scan stage is controlled automatically by the MagScope Measurement and Analysis software.
- Automated scanning and image stitching

The stitched large area images can be analyzed in the same way as individual camera images.

BENEFITS:

- 30x faster than single sensor systems
- Fully automatic measurement procedure
- Measurements of large area magnets and assemblies
- Volume magnetic field measurements
- Measurements at accurate distances from magnets
- Accurate magnet positioning



**OPTIONAL
HIGH ACCURACY
LASER SENSOR**
for automated sample
size measurement

TYPICAL APPLICATIONS:

- Large magnets (flat side measurements)
- Halbach array assembly measurements
- Magnet plate assembly inspection
- Batch measurement of magnet trays

MAGCAM COMBI SCANNER

Magcam's new generation Magnetic Field Scanners are now available and for the first time a combination between Portal and Rotor Scanner is offered.

The Rotor Scan Extension converts the Portal Scanner into a COMBI SCANNER by adding a rotary stage for measuring the magnetic field distribution of permanent magnet rotors and curved magnet segments.

PORTAL SCANNER + ROTOR SCAN EXTENSION = COMBI SCANNER

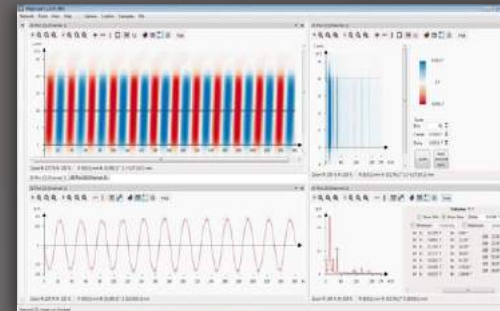
In order to convert the Magcam Scanner to Rotor Scan mode, the rotary stage is mounted on the sample plate of the Scanner and the MiniCube Magnetic Field Camera is rotated over 90°. This add-on eliminates the need for a separate Magcam Rotor Scanner for measuring PM rotors.

ROTOR SCAN EXTENSION FEATURES:

- Removable motorized rotary stage with clamping chuck
- Additional motor controller terminal and motor cable added to the PLC (no extra space required)
- Easy swapping between XYZ scanning and Rotor scanning
- Rotor diameter range: 0 - 300 mm - Axial range: 0 - 310 mm (Z axis range), with 5 dowel pinned offset positions separated 60mm each, increasing the total axial range to 550mm
- Scanner plugin for MagSope software
- Scan speed: up to 12.7mm axial length in 2 seconds (with 0.1mm axial resolution, 1° angular resolution)



Measured magnetic field map of a 24-pole rotor and cross section graph with automatic zero crossing detection, pole angle and peak values measurement, as well as Fourier analysis of harmonics in the magnetic field distribution.



MAGCAM ROTOR SCANNER

Magcam's high speed ROTOR SCANNER is a 3-axis motorized scan stage with an integrated MINICUBE1D or MINICUBE3D magnetic field camera for measuring the radial or 3D magnetic field distribution of permanent magnet rotors, respectively. The magnetic field distribution on the full rotor surface can be measured in a few seconds with high axial and angular resolutions at close radial distances. It features PLC-controlled motorized axes for the radial, axial and angular directions. The scan stage is controlled automatically by the MagScope Measurement & Analysis software.

FEATURES HARDWARE:

- Rotor diameter range: 0 - 500 mm
- Axial measurement range: 300 mm
- Scan speed: up to 12.7 mm of axial length in 2 seconds
- Dimensions (WxDxH): 780 x 1000 x 1900 mm
- Integrated MiniCube3D or MiniCube1D magnetic field camera
- Repeatability of X and Z axes: 1.3 μ m
- Repeatability of angular axis (unidirectional): 0.2 arc-min
- Mounting direction of rotor under test: vertical axis
- Motor type: synchronous servomotor on all axes
- Automatic collision detection
- PLC controller

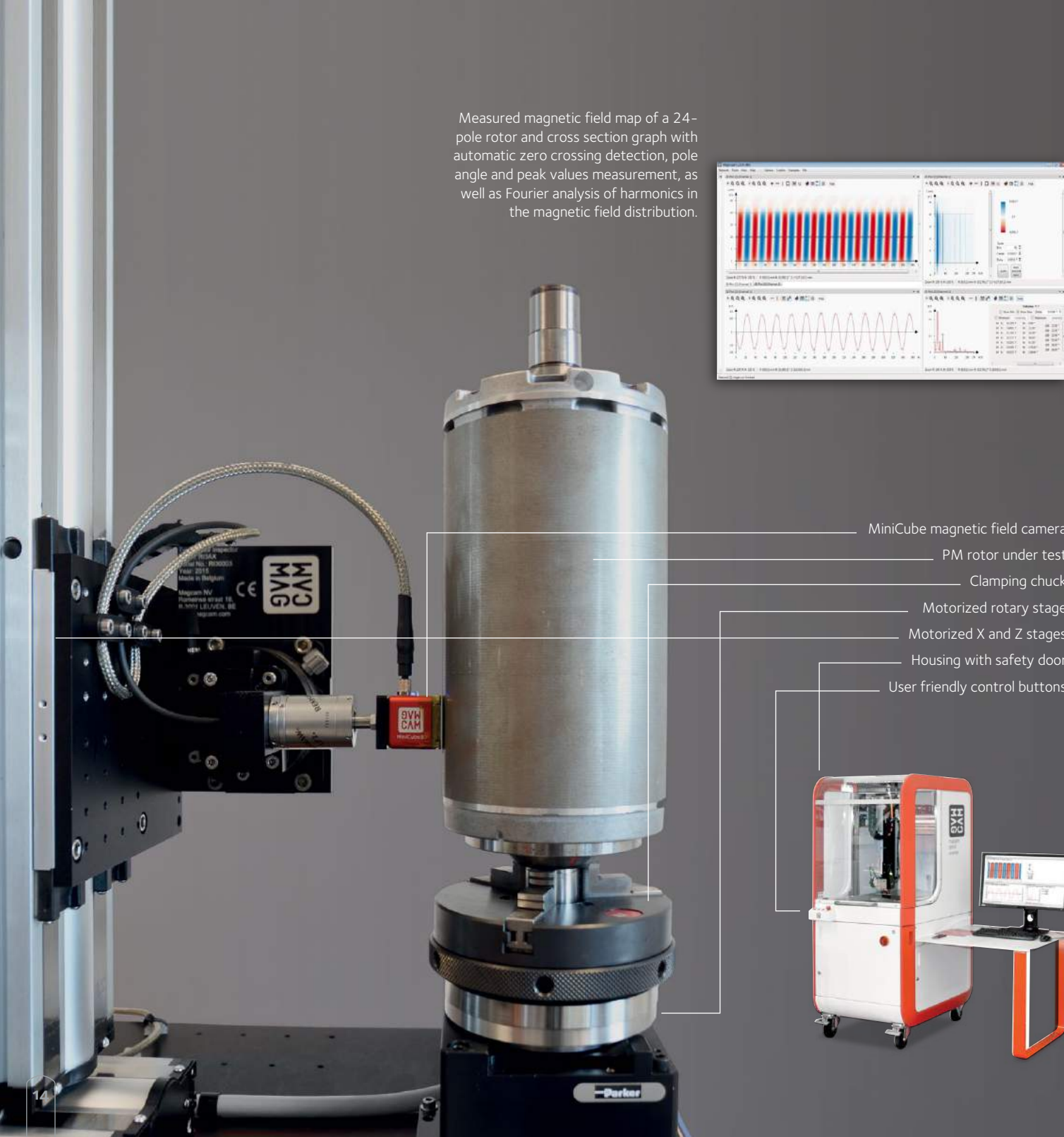
SOFTWARE:

- The scan stage is controlled automatically by the MagScope Measurement and Analysis software.
- Automated scanning and image stitching

The stitched large area images can be analyzed in the same way as individual camera images.

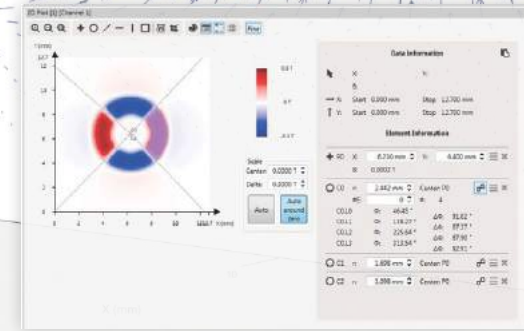
DATA ANALYSIS POSSIBILITIES INCLUDE:

- Automatic zero crossing detection
- Automatic pole count
- Automatic pole size measurement
- Pole height uniformity
- North-South pole symmetry
- Local magnetization / material defects
- Fourier analysis of harmonics, e.g. for noise analysis
- Analysis of radial, tangential and axial magnetic field components (with MiniCube3D camera)
- Crack detection



MAGSCOPE MEASUREMENT & DATA ANALYSIS SOFTWARE

MAGSCOPE® is Magcam's advanced data analysis software for measuring and analyzing magnetic field distributions in real time. MagScope is designed to extract as much information as possible from the measurement data. All types of field distributions can be analyzed. Analysis configurations can be saved.



MAGSCOPE FEATURES INCLUDE:

- Highly flexible and modular measurement and analysis capabilities
- **Real time measurement and analysis** of magnetic field images captured with the MINICUBE1D and MINICUBE3D magnetic field camera
- Integrated **Python Scripting Module** for e.g. automated **pass/fail analysis** and **data logging**
- Integrated MAGFIT analysis module for **magnetization vector size and angle** analysis
- Interpolation of magnetic field maps for **micrometer-resolution** analysis
- 2D color plots of magnetic field maps
- 2D and 1D (cross-section) region selection in **Cartesian and polar coordinates** for cut-out and analysis
- Line plots of **cross sections** in Cartesian or polar coordinates
- Automatic **multipole** segment detection and measurement of pole sizes/angles
- **Statistical analysis** on images and cross sections
- Accurate **distance/radius/angle measurements** on image features (e.g. pole segment sizes)
- Advanced image processing
- Numerous data processing and analysis functions
- Noise reduction and cancellation
- **Save/load configurations** for measurement and analysis
- **Save/load recorded images** to/from CSV and binary file formats
- Automated data saving
- Automated analysis result export to Excel
- Automated screenshot saving
- Flexible docking structure for customized layout
- Batch processing of large amounts of data files
- Crack detection algorithms



MAGFIT MAGNET ANALYSIS MODULE

The MAGFIT® Magnet Analysis software module, which is standard included with MAGSCOPE, offers advanced data analysis capabilities for a complete characterization of uniaxial permanent magnets.

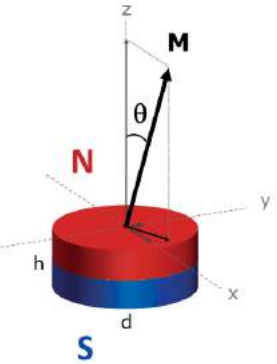
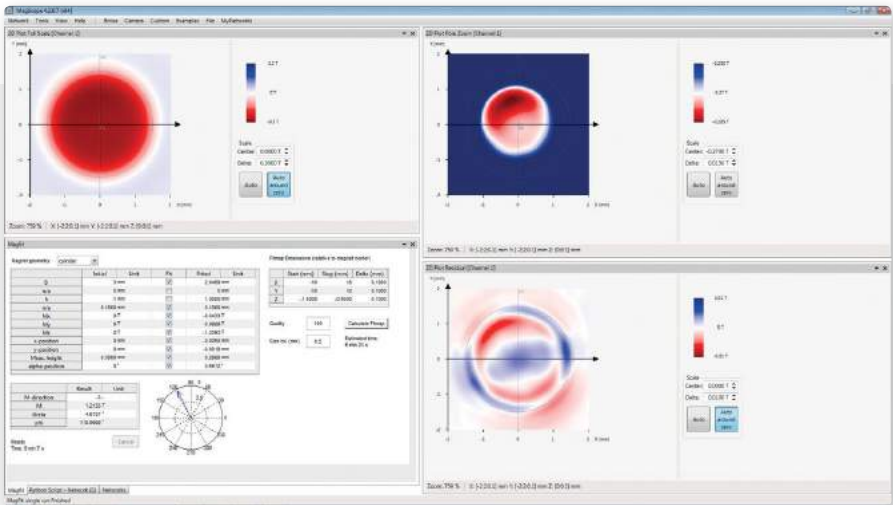
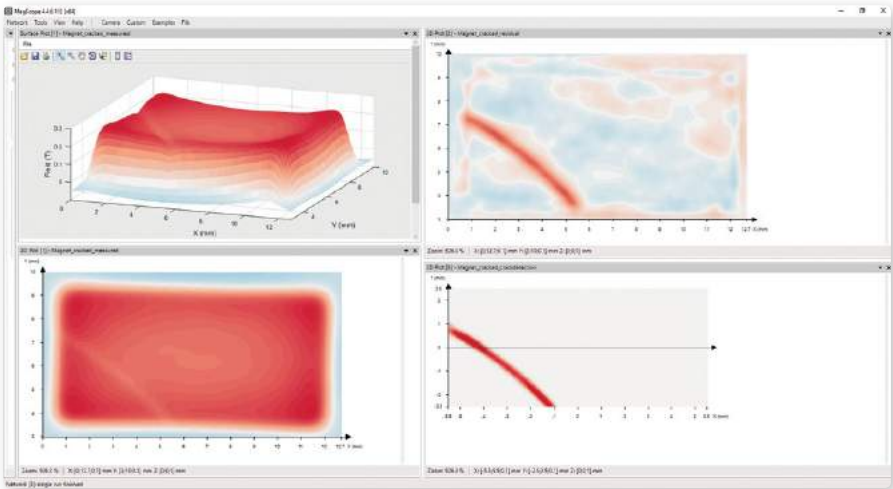
By comparing the measured data with theoretical magnet models, MAGFIT extracts a lot of extra information from the data, such as:

- Full **magnetization vector** in cartesian and spherical coordinates
- **Angle deviation** of magnetization vector from the geometrical magnetization axis (0.1 ° resolution)
- Main magnetization axis (with respect to the magnet geometry)
- Deviations from a perfect theoretical magnet
- **Local material defects** in the magnet material and in the magnetization
- Magnet's 3D **position** (X, Y, Z)
- Magnet's angular position in the sensor plane
- Magnet dimensions
- Pass/Fail quality control (in combination with Python Scripting Module)
- Automatic data logging (in combination with Python Scripting Module)
- Crack detection
- Import STL-files for any magnet geometry

For each parameter, the user can choose whether MagFit should optimize the parameter or keep it constant in the fitting procedure. The fitted parameters can be used for a pass/fail quality control, with user-defined quality tolerances.



Crack detection. MAGFIT can filter out the signature of cracks from the background field distribution and automatically detect cracks.



MAGFIT calculates the angle deviation (θ) of the magnetization vector (M) based on the measured magnetic field distribution.

PYTHON SCRIPTING MODULE

The MAGSCOPE Measurement and Analysis software supports the use of Python scripts to add unlimited flexibility and functionality. MagScope comes standard with Python script templates which can serve as a basis for writing your own script to define custom functionality. Alternatively, Magcam offers services for writing custom scripts.

- standard included in magscope software.
- adds unlimited flexibility to magscope

TYPICAL APPLICATIONS:

- Use MagScope analysis results directly in scripts for e.g. pass/fail analysis
- Automatically log analysis results / export raw data
- Perform custom data analysis
- Create custom user interfaces
- Remote control of MagScope using e.g. TCP/IP communication

MULTIPLE WAYS OF USING PYTHON SCRIPTS IN MAGSCOPE:

- Execute a Python script triggered by a measurement
- Entire control over MagScope using a master Python script
- Include Python code in a MagScope 'processing element'
- Combine multiple Python scripts
- Combine Python scripts with other programs or programming languages (e.g. C++, LabVIEW®, MATLAB® etc.)

```
245 network = networkRepository.Get( 'Magfit' )
246 magfit = elementRepository.Get( 'Magfit' )
247 if magfit == None or network == None or magfit.Result() == None :
248     self.lg.Log( 'Magfit element or network not found!!' )
249     return
250
251 magnetization = magfit.Result().magnetizationSpher
252 M = magnetization[ 1 ]
253 theta = magnetization[ 2 ]
254
255 self.magSize.Update( M )
256 self.magTheta.Update( theta )
257
258 result = self.magSize.result and self.magTheta.result
259 if result : passfail = 'PASS'
260 else : passfail = 'FAIL'
261
262 measNo = network.MeasurementNumber
263 fsys = FileSys( self.fsysView.OutputDir() )
264
265 CsvFileWriter( fsys.CsvFile( 'results' ) ).AppendResult( measNo, M, theta, passfail )
266
267 src = elementRepository.Get( 'Source' )
268 if src != None :
269     src.SaveDataToMcb( fsys.McbFile( self.fsysView.OutputFile( measNo ) ) )
270 else :
271     self.lg.Log( 'Source element not found, no mcb file saved.' )
272
273 self.lg.Log( 'Measurement {} : {}'.format( measNo, passfail ) )
274 self.lg.SetColor( result )
```

Pass/Fail				
id	min	max	val	unit
Br	1.320	1.370	1.329	T
Theta	0.000	3.000	4.864	°
Measurement 45 / FAIL				

APPLICATIONS

Magcam's inspection systems are suited for R&D as well as production and quality control environments. The magnetic field camera equipment can be used in all applications that involve high quality magnets and magnet assemblies. The following pages show several typical applications in different industries.

Contact us to discuss how Magcam can help with your specific application.

Industries

- Automotive
- Industrial
- Medical
- Consumer electronics
- Magnet production
- University research labs

Components

- Rotary encoder magnets
- Permanent magnet rotors
- Gear tooth speed sensor magnets
- Linear encoder strip magnet
- Reed switch magnets
- Magnetic coupling magnets
- Microphone and speaker magnets
- Linear actuator magnets
- Linear motor magnet tables
- Halbach arrays
- Undulator magnets
- NMR magnets
- Electric Vehicle motor magnets
- Precision positioning and holding magnets
- Hearing implants

Analyzed properties

- Bz field distribution
- Bxy field distribution
- Field direction (azimuth angle) distribution
- Field homogeneity
- Magnetic center vs mechanical center
- Material defects
- Magnetization vector size and angle deviation
- North-south symmetry
- Pole peak detection
- Field distribution statistics
- Zero crossing detection
- Pole length/angle measurement
- Pole skewing angle measurement
- Crack detection



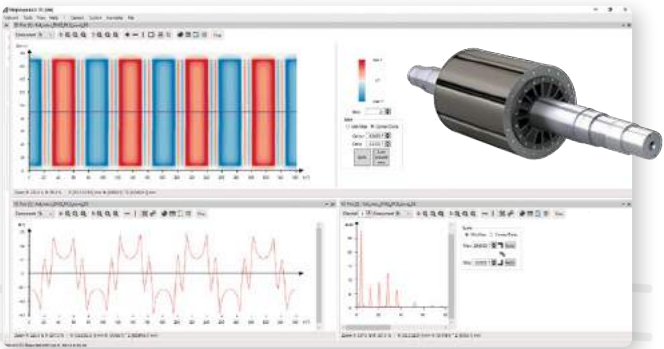
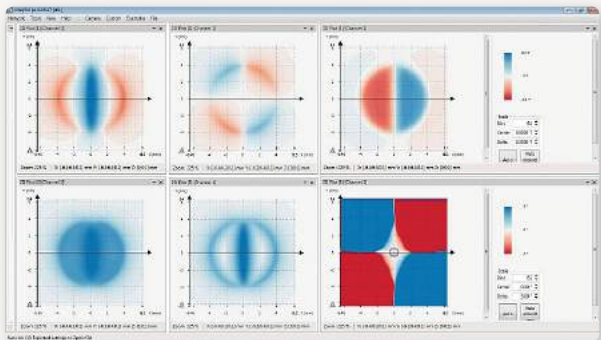
Automotive

2-POLE ROTARY ENCODER MAGNETS

For this application the in-plane field is important. With the Magcam MiniCube3D the spatial distributions of the Bxy field component and azimuth field angle are readily measured and analyzed, providing many quality aspects of the magnet:

- Angle error distribution
- Bxy field distribution
- Magnetic vs mechanical center

Advanced algorithms even allow noise free analysis at larger distances from the magnet.



PERMANENT MAGNET ROTORS

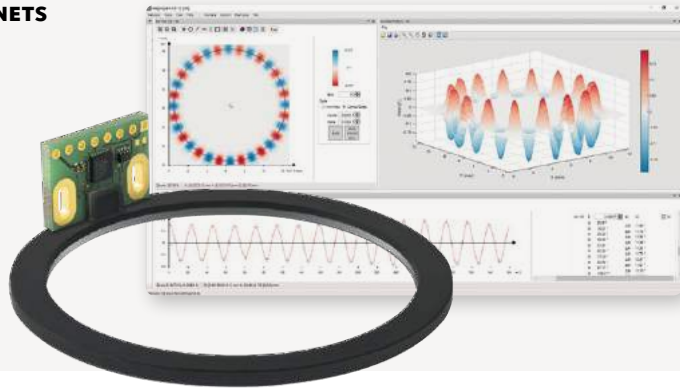
Both small electric rotors and larger rotors for e.g. electric drives are measured with Magcam's Rotor or Combi Scanner, providing high speed measurements of the radial, tangential and axial field distribution on the rotor mantle. Analysis possibilities include:

- Cross section analysis
- Pole peak detection
- Zero crossing detection
- Pole angle measurement
- Pole skewing angle measurement
- Fourier harmonics analysis (for e.g. noise problems)
- Crack detection

Industrial

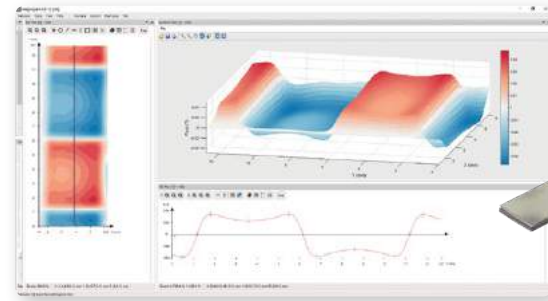
MULTIPOLE ROTARY ENCODER MAGNETS

- Pole peaks detection
- Peak homogeneity analysis
- Zero crossings detection
- Pole angles measurement
- Fourier harmonics analysis



LINEAR ENCODER STRIP MAGNETS

- Pole peaks detection
- Peak homogeneity analysis
- Zero crossings detection
- Pole angles measurement
- Fourier harmonics analysis

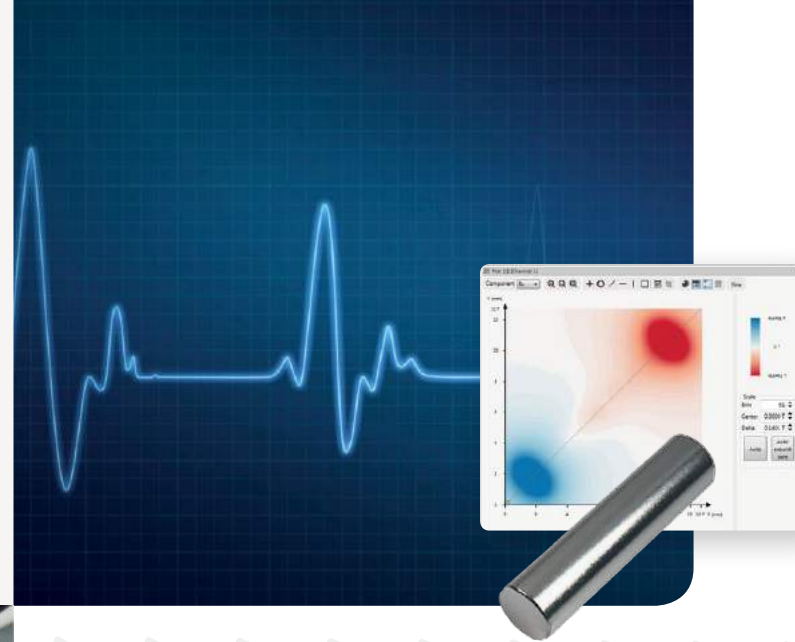


Medical

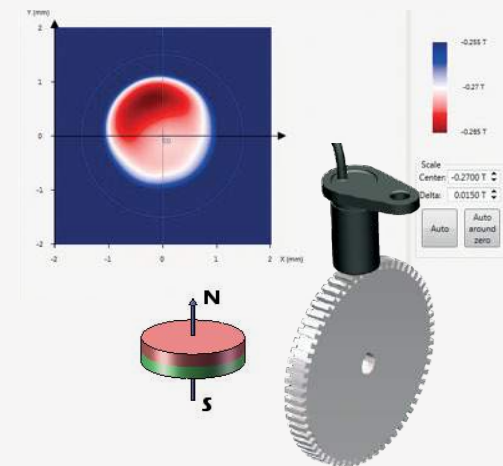
DIPOLE POSITION SENSOR MAGNETS

- 3D field distribution
- North-south asymmetry
- Zero crossing detection
- Magnetization vector angle deviation*
- Magnetization magnitude*
- Deviation from perfect theoretical magnet*

*(MagFit analysis)



Magnet Manufacturing
100% Production Testing
and Quality Control



GEAR TOOTH SPEED SENSOR MAGNETS

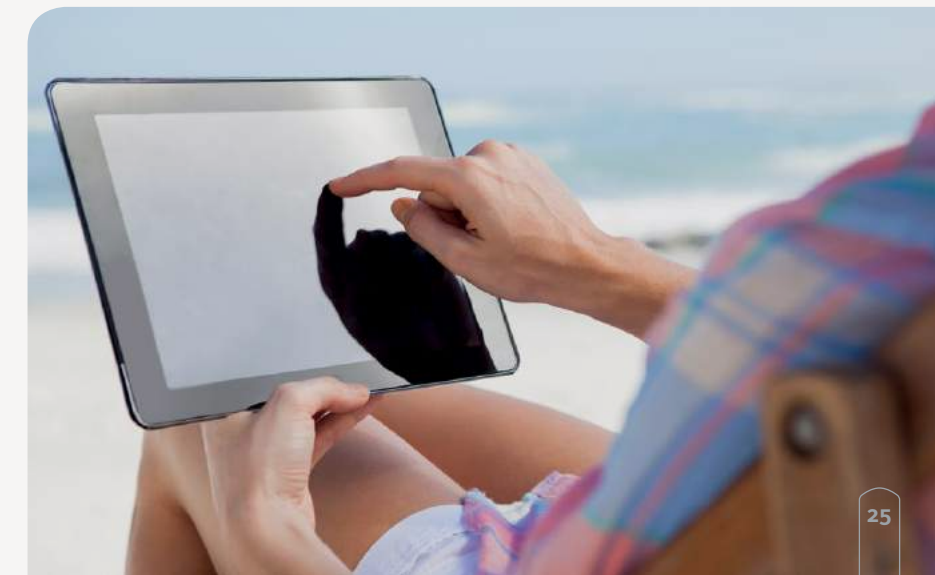
For this application the B_z component is relevant. The MiniCube1D camera instantly measures the B_z field distribution and provides many analysis possibilities:

- Field homogeneity
- Magnetization vector size
- Angle deviation
- Deviations from a perfect theoretical magnet

Consumer Electronics

COMPONENTS

- Microphone and speaker magnets
- Precision positioning and holding magnets



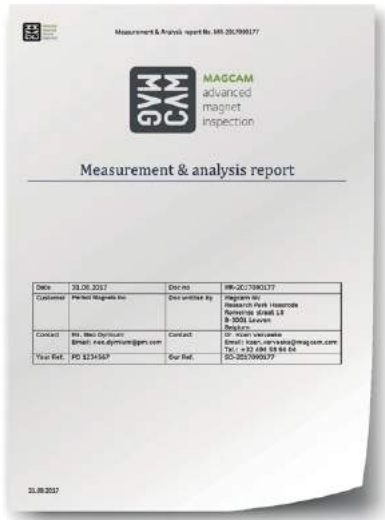
SERVICES

Measurement and Analysis service

Send your magnets to Magcam to be measured and thoroughly analyzed by our experts using the most advanced magnet inspection equipment and analysis software currently available. Typical magnet quantities range from 1 to several 100 magnets. Thanks to the inherent measurement speed of the Magcam magnetic field camera equipment measurements of larger batches can be performed in a short time. Combined with powerful MagScope software features such as batch processing of large amounts of data files, saving analysis configurations and automatic exporting of analysis results allow for e.g. a statistical analysis of the properties among a batch of magnets, yielding valuable knowledge about the quality distribution.

Deliverables of a service measurement include a detailed measurement report, accompanied by the raw measurement data files in CSV format and additional summary results in e.g. an Excel file.

CONTACT US today for a discussion of your needs.



Software Development service

Magcam provides the service of adding extra functionality to our MagScope software upon request. This option is typically useful when the required feature is generally useful and adds value to MagScope for one or more typical applications. Alternatively, for very specific requirements we will propose to write a Python script to fulfill the desired functionality. In both cases our team of experts is available to provide the required functionality and can also advise about the most optimal way of achieving the desired results.

CONTACT US today to discuss how the Magcam solution can be used for your specific application. Chances are good that the existing MagScope functionality is already capable of meeting your magnet inspection tasks requirements.





MAGCAM
advanced
magnet
inspection

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