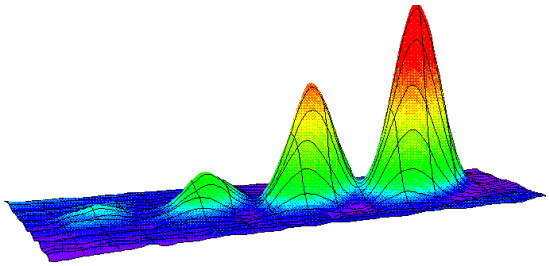
SMM-701 SQUID Magnetic Scanner
For Non-Destructive Testing

TRISTAN TECHNOLOGIES

The Tristan model SMM-701 Magnetic Scanner is designed to measure magnetic fields with mm or sub-mm spatial resolution. It can be used to image diverse objects such as:

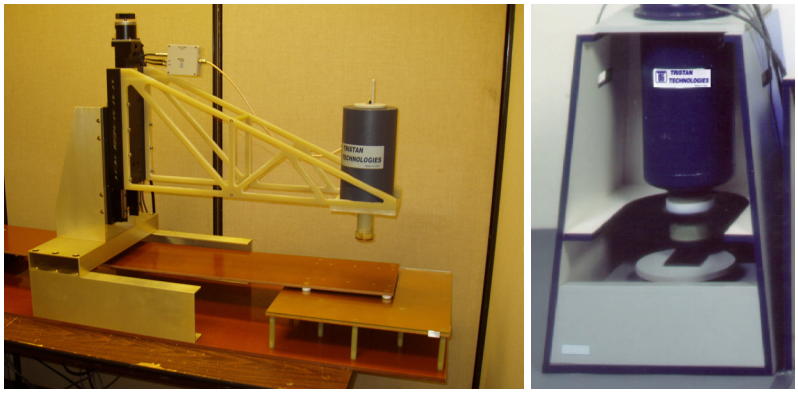
- subsurface cracks and flaws
- embedded magnetic sensors
- composite structures
- corrosion sites – hidden or exposed
- impurities in metals and insulators
- imaging of magnetically tagged nanoparticles



Scan of 1, 3, 5, and 10 mm holes in a steel plate

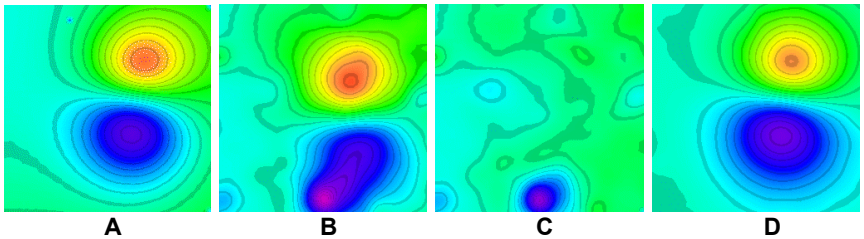
Besides measuring magnetic fields, the SMM-701 can also be configured to detect:

- current distributions
- induced magnetization
- aging and stress in ferromagnetic materials
- magnetic susceptibility
- eddy currents
- magnetic hysteresis
- rock magnetometry



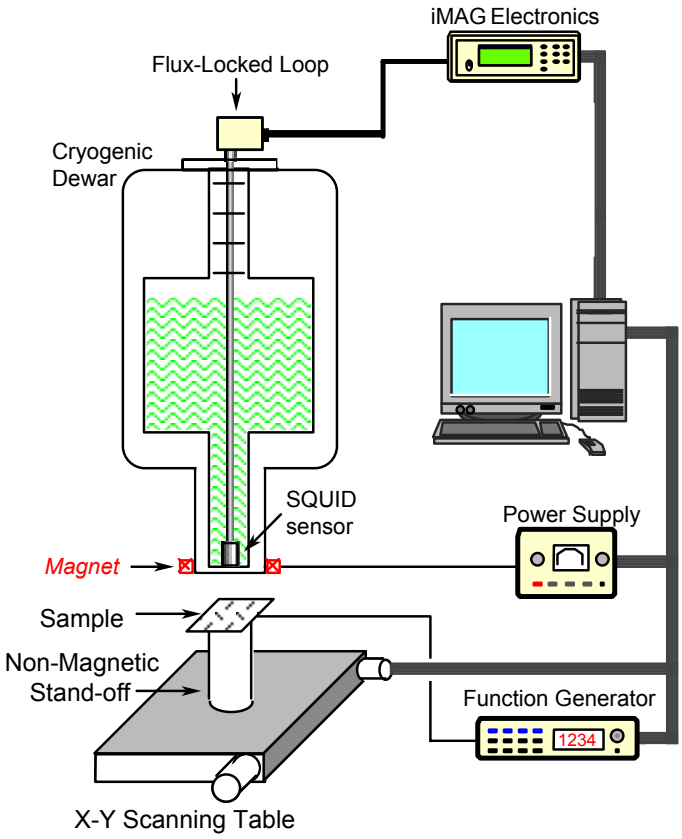
Model SMM-701 Scanning SQUID Microscope with dc and ac biasing magnets. Left side shows 3-axis XYZ stage for large samples, right side shows XY stage for small samples.

- The SMM-701 is a fully featured measurement system that allows the user to extract a magnetic image of the object being measured over the entire dc – 10 kHz frequency range.
- The use of a HTS dc SQUID sensor gives it unparalleled sensitivity. Its flat phase response allows both in-phase and quadrature information to be obtained without distortion. Additional SQUID sensors (see Table I) can be supplied to give gradient or vector information. The design of the SMM-701 allows any of the HTM series of magnetometers to be interchanged, allowing a wide variety of sensitivities and spatial resolutions.
- Its low frequency response means large penetration depths even in metallic samples. Another advantage of the model SMM-701 is its ability to operate in gauss fields for dc susceptibility measurements. In addition, it can operate in ac fields with kHz bandwidths for eddy current measurements.
- The SMM-701 allows computer controlled scans of objects over a large (15 x 15 cm) area with 25 µm stepping capability (larger scan areas and/or smaller step sizes are available as an option). Scanning stages can be provided with 3-axis positioning if needed. Tristan can also supply a wide variety of scanning platforms to meet the user's needs, *e.g.*, diving board style, non-magnetic XY stages to fit inside a magnetic shield, etc.
- The SMM-701 requires minimal setup. Automated setup and computer control makes measurements rapid and repeatable. The use of open architecture software allows the user to customize nearly all aspects of operating including image processing.
- For environments where the ambient noise is excessive, Tristan can supply µ-metal magnetic shields. Contact Tristan for details.



A **B** **C** **D**

Magnetic field maps of an embedded strain sensor under a 4 cm thick concrete overcoating. **A** - bare sensor showing dipole characteristics, **B** - sensor under concrete, **C** - bare concrete. Image **D = B – C** is a digital subtraction of B and C showing that it is possible to image objects deep underneath magnetically complex coverings. The scans cover a 6 cm x 6 cm area.



Components of the Model SMM-701 system including optional accessories

The standard model SMM-701 is configured to detect magnetic fields generated by electric currents and to measure remnant magnetic fields. It includes a Single-Channel Scanning SQUID Magnetometer Probe, iMAG® SQUID Electronics, Cryogenic dewar, Room Temperature Scanning Stage, Computer Control and Data Acquisition System, and Imaging Software. The model SMM-701 can be supplied with additional capabilities to extend its measurement capabilities.

The standard SQUID sensor for the SMM-701 is the HTM-8. Because of its high sensitivity, a SMM-701 equipped with a HTM-8 should be operated in a magnetic shield. Other SQUID sensors can be substituted on request. The table below gives sensitivity and coil dimensions.

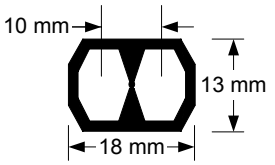
sensor	sensitivity	"loop" dimensions
HTM-8	50 fT/√Hz	8 mm x 8 mm
HTM-3	700 fT/√Hz	3 mm x 3 mm
HTM-2	1,000 fT/√Hz	2 mm x 2 mm
HTM-1	2,000 fT/√Hz	1 mm x 1 mm
HTG-10N	70 fT/cm √Hz	see figure

Table I: SMM-701 sensor selections

OPTIONS AND ACCESSORIES

Additional Detection Channels: The model SMM-701's measurement capabilities can be extended to multi-channel capabilities. This can mean either vector (B_X ,B_Y and B_Z) capabilities or additional vertical (B_Z) measurement sites to reduce measurement time. Noise reduction channels can also be added for sites where environmental noise is excessive.

Planar gradiometer detection coil: The SMM-701 can also be supplied with a 1-cm baseline planar gradiometer (HTG-10N) that has the ability to operate unshielded in most environments and provide up to 1 mm spatial resolution. It can be oriented to operate in either vertical or horizontal orientations.



Mask of HTG-10N planar gradiometer input coil

dc Field Capability: This option generates a vertical (B_Z) dc field on the sample. This allows magnetic susceptibility measurements on insulators, conductors and ferrous materials to be performed.

ac Field Capability: This option allows a small vertical (B_Z) ac magnetic field to be imposed on the sample. This capability is of particular interest when eddy current measurements are desired

Horizontal Field (B_x and B_Y) Sheet Inducer: A horizontal field sheet inducer, which can apply an ac magnetic field parallel to the test surface, to induce an eddy current in a desired orientation. These can be used to image cracks or material loss deep in conductive (*e.g.*, aluminum) structures.

Scan Area: Larger scan areas (in excess of 1.5 m x 1.5 m) and/or higher resolution stepping (as small as 0.1 µm) are available upon request.

Magnetic Shield: For situations where environmental noise is excessive, Tristan can supply µ-metal shields.

SPECIFICATIONS

SENSOR: High temperature superconducting quantum interference device (SQUID) operating at 77 K

SPATIAL RESOLUTION: sensor dependent, see table for details

SENSITIVITY: sensor dependent, see table for details

DISTANCE TO SAMPLE: **dewar dependent,** typically 6 mm.

OPERATING BANDWIDTH: dc – 10 kHz. Measurements can be made at any frequency.

CRYOGENIC COOLING: To avoid low frequency noise below 200 Hz, the system uses liquid nitrogen to cool the sensor.

CRYOGENIC HOLD TIME: 3+ days

SAMPLE SCANNING RANGE: 15 cm x 15 cm in x-y directions; larger scan areas and different scan tables available

SCAN STEP SIZE: Adjustable with minimum step size of 25 µm. smaller step sizes available as an option.

SAMPLE PREPARATION: None required. Samples are measured at room temperature

POWER REQUIREMENTS: 100, 115 or 230 V_{AC}, 50 or 60 Hz

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