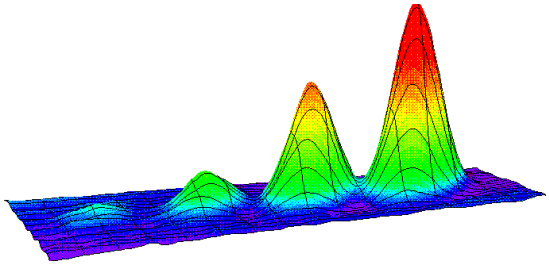
SMM-601 SQUID Magnetic Scanner
For Non-Destructive Testing

The Tristan model SMM-601 Magnetic Scanner is designed to measure magnetic fields with a spatial resolution better than 300 μm. 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



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

Besides measuring magnetic fields, the SMM-601 can also be configured to detect:

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

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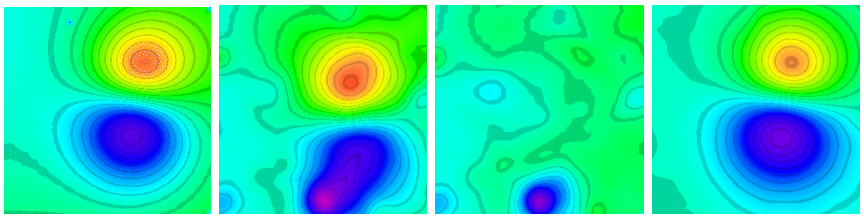
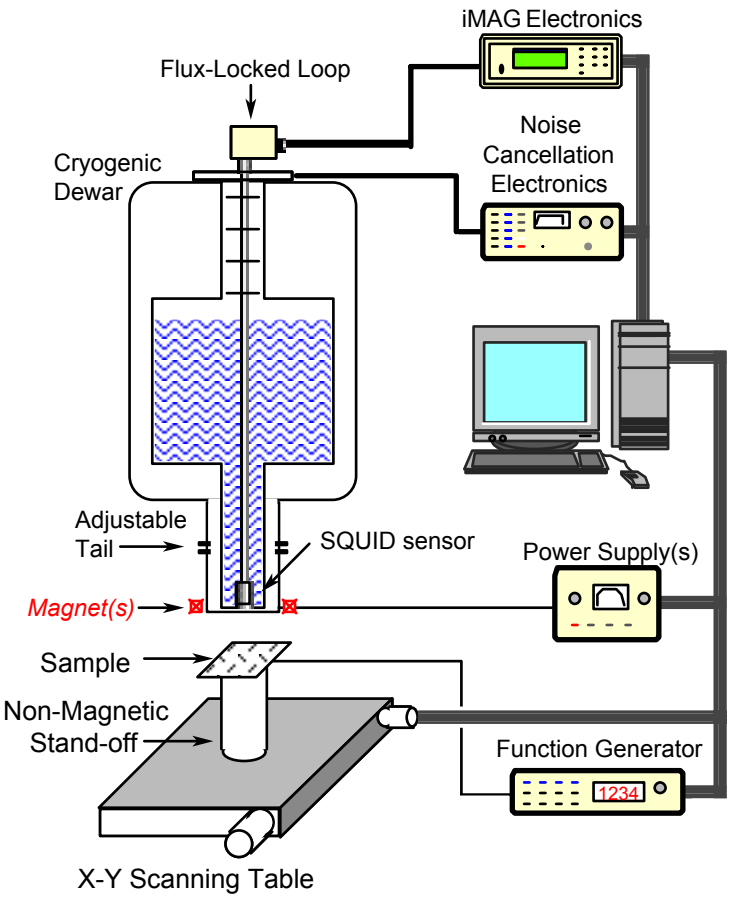
Model SMM-601 Scanning SQUID Microscope with dc and ac biasing magnets

- The SMM-601 is a fully featured measurement system that allows the user to extract a magnetic image of the object being measured over the entire dc – 50 kHz frequency range. The adjustable tail dewar allows the spacing between the detection coil and sample(s) to be as small as 3 mm.
- Its low frequency response means large penetration depths (deep penetration). Another advantage of the model SMM-601 is its ability to operate in tesla fields. This allows it to make susceptibility measurements on the same sub-mm spatial resolution scale. In addition, it can operate in ac fields with kHz bandwidths for eddy current measurements.
- The SMM-601 allows computer controlled scans of objects over a large (15 x 15 cm) area with 25 μm stepping capability.
- The use of a dc SQUID sensor gives it unparalleled sensitivity. Its flat phase response allows both in-phase and quadrature information to be obtained without distortion. If ultimate sensitivity is needed, larger detection coils with resolutions exceeding 5 fT/√Hz are available. Additional detection coils can be supplied to give vector information.
- The SMM-601 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.



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-601 system including optional accessories

The standard model SMM-601 is configured to detect 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-601 can be supplied with additional capabilities to extend its measurement capabilities.

OPTIONS AND ACCESSORIES

Additional Detection Channels: The model SMM-601'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.

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

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.

ac Field Capability: This option allows a small ac magnetic field to be imposed on the sample. The field is vertical (B_Z) and can have a peak-to-peak magnitude up to 1 oersted. 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 a large extended eddy current in a desired orientation, can be used to image cracks or material loss deep in conductive (*e.g.*, aluminum) structures.

ac Field Compensation Electronics: When an ac signal is directly coupled into the system, the resultant signal (from the field coils) may be much larger than the signal from the sample. In the case of a ferromagnetic materials such as carbon steel, the induced magnetization (even with a small ac field) may be quite large and the dynamic range of the data acquisition system may not be adequate to track this large signal while still resolving the small signal from defects in the metal.

To minimize this, Tristan can supply an ac Compensation system to null the ac signal in the detection coil and extract the induced signal in the object being measured.

SPECIFICATIONS

SENSOR: Low temperature superconducting quantum interference device (SQUID) operating at 4.2 K.

SPATIAL RESOLUTION: Better than 300 µm

SENSITIVITY: 6 x 10^{-14} tesla/√Hz (60 fT/√Hz) for 3 mm coils

DISTANCE TO SAMPLE: Adjustable to be less than 5 mm

OPERATING BANDWIDTH: dc - 50 kHz. Measurements can be made at any frequency. Bandwidths up to 1 MHz are available.

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

CRYOGENIC HOLD TIME: Time between refills of liquid helium is typically 3 days

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

SCAN STEP SIZE: Adjustable with minimum step size of 25 µm.

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

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

dc Field Option: greater than 10 gauss with 10 A power supply

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