SHIELDING MACS/D FOR ELECTRON MICROSCOPY

MACS/D FOR ELECTRON MICROSCOPY

- **High Performance All Digital/DSP-based Architecture Applies Advanced Signal Processing Algorithms to Achieve Superior Environmental EMI Shielding Specifically for Charged-Beam Instrumentation**
- **Superior Magnetic Field Shielding for High-resolution Electron Microscopy, Scanning Electron Microscopy, e-Beam Lithography, and Nuclear Magnetic Resonance Instrumentation**
- **Three-axis High Power Compensation Corrects for Magnetic EMI in Extreme Environments**
- **Cancellation of Environmental Magnetic Interference Over Wide Frequency Range**
- **Effective Protection Against Fluctuations in Magnetic Fields Caused by Subways, Elevators, Moving Vehicles, and Electrical Distribution Equipment**
- **Wide Range of Permissible Compensation Coil Geometries**
- **Probe Positional Offset Achieved Electronically Via Included ACR Option**
- **Remote Access for All Monitor, Setup, Diagnostic and Parametric Adjustment Capabilities**
- **HTML Trace Page Permits Scrolling Display of Any Combination of 41 Selected Parameters**
- **Secure VPN-protected Remote Access via Password Protected Hierarchal Levels; Critical Adjustments Access Limited to Highest Security Level**
- **Uniaxial Fixed Gradient Compensation (FGC) Capability Included; Uniaxial Adaptive Gradient Capability with Dual Probe Option (DPO)**

ETS-Lindgren's EMF-compensating (EMFC) MACS/D systems provide cost effective, maintenance-free attenuation of dynamic environmental magnetic fields for maximum performance of high resolution electron microscopy instrumentation and other magnetically sensitive charged-beam scientific and production apparatus. The ETS-Lindgren MACS/D system features high resolution, ultra low latency digital signal processing with low intrinsic noise floor and negligible drift, permitting wide dynamic range and inherent stability. For applications requiring ultra low system noise or extended high- or low-frequency response, specialized probes and complementary signal processing options are available.

Active Compensation Ratio (ACR) technology (U.S. patent 9,692,391 B2) incorporated in the MACS/D digital architecture typically provides a higher interference attenuation factor than either conventional analog compensation systems or passive shielding alone in sites subject to high interfering field gradients. This feature permits location of the MACS/D sensor probe away from sources of high extraneous magnetic fields such as ion pumps without significant attenuation loss at the protected instrument location. Firmware provisions are also included for compensation in a critical axis of significant static or dynamic gradients that may be encountered.

MACS/D capabilities are based on fast, high-resolution digital signal processing (DSP) and a unique control/computing architecture that combines maximum signal processing resolution and throughput with software and firmware flexibility. In addition to performance and operational advantages, a significant advantage of the MACS/D advanced DSP capability over competing systems is the ability to compensate for high field gradients from proximate sources.

The MACS/D system's negative feedback closed loop configuration provides high attenuation over a dynamic range extending from 0.2 nT (20 µG) to at least 15 µT (150 mG) with standard compensation coil sets. MACS/D standard compensation coil are comprised of a set of 0.5 inch (13 mm) diameter cables which define the endplanes of the Operational Volume (OV) for each of the three axes. An efficient, high-power multichannel coil driver amplifier provides extraordinary system capability and reliability in compensation of high-level interfering fields. For special applications requiring ultra low system noise or extended high- or low-frequency response, specialized probes and complementary signal processing options are available.

The MACS/D system controller front panel screen provides three-axis scrolling displays of the residual magnetic fields, with concurrent numeric readouts of instantaneous axial field values, MACS/D system configuration, system state, time and date, and LAN IP. Full LAN-based capability is provided for site setup and remote diagnostic viewing, with access to all data logging tools and files password protected. This capability includes a real-time HTML-based monitoring display page in which up to 41 parameters may be selected for simultaneous viewing. VPN client support is available for secure remote data logging and diagnostics via the designated "Capture" page, which acquires system parameters data over a configurable amount of recording time, sample rate, and file repetitions. Captured data files are stored locally and are downloadable as .csv files for viewing and analysis of system performance. The VPN support ensemble also includes provision for downloading of software upgrades.

From a reputation as industry leader with over 200 high performance MACS EMFC installations worldwide, introduction of the MACS/D system advances ETS-Lindgren to the preeminent position of sourcing the world's premier active compensation system for electron microscopy and other sensitive charged-beam instrumentation and manufacturing operations.

Features

Autonomous Operation

Even absent remote monitoring or control, the MACS/D will resume normal operation in compensation mode with current parametric settings after an a.c. power interruption. At any startup, the system performs comprehensive self-tests to confirm hardware and software integrity.

Secure Access

Remote Internet access via ETS-Lindgren managed VPN server provides maximum network security. The VPN client provides the ability to assign an access hierarchy and remotely and securely monitor, troubleshoot, diagnose, and update firmware/software from any Internet access point.

Increased Power

The MACS/D system employs significantly more powerful and efficient coil drivers than previous MACS versions or any competing commercially available active compensation system, resulting in at least 100% greater field compensation ability in each of the 3 axes. Maximum compensation is typically >15µT (150mG) for coils utilizing a single turn per axis of MACS/D standard gauge multiconductor cable installed in accordance with typical room geometry, up to 45µT (450 mG) peak, depending on coil cable type and geometry.

Comprehensive Monitoring

The front panel LCD displays real-time field level monitoring, system status, time and date, local IP address, system configuration, and warning/error messages. In the event of primary power interruption, the system self-restores and continues to provide field compensation with the same parameters, and with a notification message presented in place of the normal readout display.

Straightforward Setup

Setup calibration requires only straightforward adjustment of the axial output gain settings, which are room geometry and probe location dependent, and a subsequent adjustment of the ACR level parameters, if probe offset is desired in the presence of significant protected volume interfering signal gradients. The setup parameter values are stored in nonvolatile memory and are reloaded at each power-up occurrence.

Fixed Gradient Compensation

Fixed Gradient Compensation (FGC) firmware is included for improved nulling of site Z-axis interfering fields that exhibit excessive gradients due to a proximate source or non-optimal coil geometry, building structure and or other similar causes. A fixed manual compensation adjustment for the FGC coefficient is included in the Z-axis parametric setups page.

Dual-Probe Option

A Dual-Probe Option (DPO) for selected-axis adaptive gradient compensation is included in the system firmware and can be implemented by the addition of a second probe. The Dual-Probe configuration of the MACS/D active compensation system implements a truly adaptive gradient operational mode in a single axis of the triaxial system. Its operation is essentially "automatic" in optimal compensation for one or more proximate interfering sources affecting the protected volume (PV).

Technical Specifications

Electrical	
Input Voltage	95 to 125V or 210 to 240 AC (50/60Hz), 15A / 10A Maximum
Maximum Compensating Field	>15 μT (150 mG), Standard Cable Installation; >45 μT (450 mG) Augmented Cable Installation
Magnetic Field Sensor	0.1 mT/1 G Fluxgate Probe, Tri-axial, Plug-compatible with and Powered by MACS/D EMFC-Configured Controller; 1 mT/10 G Probe Option
Noise Floor	<0.3 nT (3.0 μG) rms, Determined Primarily by Sensor Noise Contribution; Optionally 0.15 uT (1.5 μG) with Low Noise Probe
Baseline Acquisition Range	±90μT (0.9G) Maximum Environmental Static Field for Specified System Operation
Operational Range	Baseline ±50 μT (0.5G)
Front Panel Field Display Range	Autoscaled, up to 50 μT (±0.5G) (Averaged, Weighted Peak Absolute Magnitude)
Frequency Range	0.8 mHz to 500 Hz; ACR .01 to 10 Hz
Magnetic Field Attenuation	Factor of 70 (38 dB) Minimum. For Compensation of Field Gradients, Proximate Source Gradient Matching May be Optimized via FGC or DPO Modes
Remote Monitoring	X, Y, Z Axial Fields (Absolute Magnitude) Residual Main Probe X, Y, Z Axial Fields Residual Aux (Optional Probe) X, Y, Z Axial Fields PEM (Parameter Extraction Module) X, Y, Z Coil Currents Drive Signal to Coil Driver Amplifier (CDA) X, Y, Z CDA CURRENT (a.c. Mains Input Current) Utility I/O Channel Values
Physical	
Dimensions	53.3 cm x 22.9 cm x 43.2 cm (21 in x 9 in x 17 in)
Weight	27.3 kg (60 lb)

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