MEDICAL SHIELDING MAGNETIC ACTIVE COMPENSATION SYSTEM (MACS/D) FOR MRI

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- **Remote Access for All Monitor, Setup, Diagnostic and Parametric Adjustment Capabilities**
- **High Performance, Reliable Adjustable Ratio Compensation Architecture Applied to Environmental Shielding Designed Specifically for MRI Systems**
- **Three-axis High Power Compensation Corrects for EMI in Extreme Environments**
- **Cancellation of Environmental AC/DC Electromagnetic Interference Over Wide Frequency Range**
- **Effective Protection Against Fluctuations in EMI Fields Caused by Subways, Elevators, Moving Vehicles, Magnetic Navigation Systems and Electrical Distribution Equipment**
- **Utilizes a Hemholtz coil design with Wide Range of Permissible Compensation Coil Geometries**
- **Probe Positional Offset Achieved Electronically Via ACR Option**
- **Remote Access for All Monitor, Setup, Diagnostic and Parametric Adjustment Capabilities**
- **HTML Trace Page Permits Scrolling Display of Any Subset, or All, of 35 Parameters**
- **Data Logging Screen Provides Detailed Output of System Status and Status History when Required**
- **Secure VPN-protected Remote Access; Critical Adjustments are Password Protected**

ETS-Lindgren's digital Magnetic Active Compensation System (MACS/D) provides cost-effective, maintenance-free high performance attenuation of dynamic environmental magnetic fields for magnetic resonance imaging (MRI) and spectroscopy (NMR/EPR) sites. The MACS/D system incorporates ACR technology (U.S. patent 9,692,391 B2), which provides higher compensation at the magnet's isocenter than other active compensation systems, with effective attenuation factors in the isocenter of up to 350 versus 40 or less attainable by competing systems. Custom high-power coil drivers provide constant attenuation over a wide dynamic range that can extend to 45 m Tesla (450 mGauss) with standard coil sets in each of the three axes. Additionally, the MACS/D high efficiency, low dissipation coil driver amplifier insures long-term system reliability at sites with frequent high-level interfering field levels.

Signal processing within the MACS/D system is accomplished entirely in the digital domain by a 450 MHz DSP engine. For ACR magnet isocenter attenuation enhancement, the digital processing algorithm applied in real time to the compensating signal includes modeling of the magnet's external to isocenter transfer characteristic.

For operator convenience, the MACS/D controller front panel screen provides three-axis residual magnetic field scrolling displays, with text descriptions of instantaneous axial field values, the MACS/D system configuration, system state, time and date, and LAN IP. An embedded machine control computer provides full LAN-based capability for site setup and remote diagnostic viewing that includes real-time HTML-based monitoring displays of up to 35 parameters. Additionally, password protected access to MACS/D standard and advanced operational parameters, DSP coefficients and system configuration is included in the standard software package. VPN client support is available for secure remote data logging and diagnostics, and the VPN support ensemble also includes provision for downloading of software upgrades.

ETS-Lindgren MACS/D systems for MRI and magnetic resonance spectroscopy employ traditional negative feedback, but with wideband, high resolution state of the art signal processing entirely in the digital domain, permitting incorporation of complex ACR algorithms to enhance performance. Tri-axial compensation provides additional attenuation in all axes by minimizing field gradients through the magnet volume. Along with the flexibility of the DSP based technology, the MACS/D provides superior compensation for higher order effects attributable to residual environmental field gradients and the MRI magnet's frequency-dependent response to such fields.

MACS/D ACR technology, fast, high-resolution DSP based conversion and computing and universal architecture provides maximum software and firmware flexibility, enabling the MACS/D to be locally and remotely updated with software upgrades, maximizing long-term utility. From a reputation as industry leader with over 100 high performance MACS MRI installations worldwide, introduction of the MACS/D system advances ETS-Lindgren to a preeminent position of currently sourcing the world's premier active compensation system, specifically tailored for MRI sites.

Features

Autonomous Operation

Even absent remote monitoring or control, the MACS/D will resume normal operation in compensation mode with most recent parametric settings after a.c. power interruptions. At start-up, the system performs comprehensive self-tests under MCC control to confirm hardware and software integrity.

MCC (Linux-based Machine Control Computer)

Remote Internet access via VPN client provides maximum network security. The VPN client provides the ability to remotely and securely monitor, troubleshoot, repair, diagnose, and update firmware/software from any Internet access point.

Increased Power

The MACS/D has significantly more powerful coil drivers than previous versions or any competing system, resulting in an additional 100% or better field compensation ability in each of the 3 axes, typically >45uT peak, depending on coil cable type and room geometry. Switch mode amplifier architecture provides up to 500W of output power per axis at 90% efficiency.

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.

MACS/D-EMFC-ACR (MEA) Controller front panel display: (1a) Field Level Monitor, provides readouts and 1 minute, 1 sample/second scrolling record of averaged magnetic field absolute magnitude; (1b) System Status, displays system machine state, "OPERATE" indicates normal operative condition; (1c) Time and Date, automatically updated when accessing VPN server, maintained by local reference clock when external lookup not available; (1d) Local IP Address, DHCP or fixed, displays "No IP Address" if LAN is not connected or is inoperative; (1e) System Configuration, displays configuration in format "MxA", where "x" indicates the application, for EMFC sites the configuration is "MEA" as shown. LAN/Remote monitoring includes independent selection of all or any subset of system readable variables (see specifications, below), updated on a 1 reading/second chart or charts.

Straightforward Setup

Setup calibration requires only uncomplicated adjustment of the axial output gain settings, which are room geometry and probe location dependent, and a subsequent adjustment of the ACR level parameter for each axis, which is primarily dependent on the MRI magnet isocenter susceptibility to external magnetic fields. These setup parameter values are stored in nonvolatile memory and are reloaded at each power-up occurrence.

Technical Specifications

Electrical	
Input Voltage	95 to 125V or 210 to 240 AC (50/60Hz), 15A Maximum
Maximum Compensating Field	>15 mT (150 mG), Standard Cable Installation; >45 mT (450 mG) Augmented Cable Installation
Magnetic Field Sensor	Bartington Mag-03 MC 1000 (1 mT/10 G) Probe, Tri-axial, Plug-compatible with and Powered by System MMA-configured Controller
Noise Floor	<0.4 nT (4.0 mG) rms, Determined Primarily by Sensor Noise Contribution
Baseline Acquisition Range	900 T (Maximum Permissible Environmental Static Field for System with Above Probe)
Operational Range	Baseline 99.99 mT
Front Panel Field Display Range	99.99 mT (Averaged, Weighted Peak Absolute Magnitude)
Frequency Range	0.8 mHz to 100 Hz (-3 dB); 0.5 mHz to 180 Hz (-12 dB); ACR .01 to 10 Hz
Attenuation, MRI Isocenter	B_0 Axis: Factor of 100 (40 dB) Minimum, 200 (46 dB) Typical, 350 (51 dB) Typical with Optimized Magnet-specific ACR Coefficientsts
Remote Monitoring	Residual Main X, Y, Z Axial Fields, Absolute Magnitude, 99.99 T Maximum Residual Main X, Y, Z Axial Fields, Raw Data, 99.99 T Aux (Optional Probe) X, Y, Z Axial Fields, Absolute Magnitude, 99.99 T Maximum Aux (Optional Probe) X, Y, Z Axial Fields, Raw Data, 99.99 T PEM (Parameter Extraction Module) X, Y, Z Coil Currents, 7A Nominal Drive (Signal to CDA/Coil Drive Amplifier) X, Y, Z, 10V f.s. AMP CURRENT (CDA a.c. Mains Input Current), 10A rms, Maximum ACR Signal Nodes through DSP Processing Chain (Development Aid)
Physical	
Dimensions	53.34 cm x 22.9 cm x 43.18 cm (21 in x 9 in x 17 in)
Weight	27.22 kg (60 lb)

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