RMS INSTRUMENTS
For Geophysical Exploration

AARC500

ADAPTIVE AEROMAGNETIC REAL-TIME COMPENSATOR

For Geophysical Exploration and Environmental Surveys

2nd-Generation AARC500

- ***Magnetometer interface for up to 8 high-sensitivity sensors (Cs, He or K)***
- ***Front-end sampling rates up to 1280 Hz***
- ***Magnetometer processor: 0.32 pT resolution, < 0.1 pT system noise, ±10 ppb temp. stability***
- ***Real-time compensation: up to 8 total-field magnetometers, and true gradients***
- ***Proven, extremely robust compensation algorithms (AADCII legacy)***
- ***Adaptive signal processing techniques – improved compensation and simplified calibration procedures***
- ***User may customize Front End processing to specific installation requirements***
- ***Embedded GPS receiver option (single-, dual- or triple-frequency)***
- ***Data recording & output, up to 80 Hz: complete raw, pre-processed and compensated data sets***
- ***NEW: Post-flight compensation utilities***
- ***NEW: Dynamic compensation of on-board electronic systems***
- ***NEW: Gating of magnetometer readings for concurrent use with EM systems***
- ***Real-time graphical output to built-in display, external display and chart recorder***
- ***Four analog inputs for radar/laser altimeter, barometric pressure sensor, etc.***
- ***Flexible and simple user interface***
- ***Full monitoring/control from any Windows device (via Ethernet, or through the Internet)***
- ***Real-time operating system (RTOS): QNX 6.5***
- ***State-of-the-art HW & FW architecture based on advanced 64/32-bit processors***
- ***Compact and light: 19"-rack mountable, 5.25" height, under 18 lb.***

The first in a new family of instruments for aeromagnetic compensation and data acquisition, the RMS Instruments' AARC500 has its roots in the AADCII, for many years the *de facto* standard in aeromagnetic compensation in the geophysical exploration industry throughout the world. The AARC500 offers the ultimate in compensation, delivering unparalleled performance, accuracy, consistency and reliability.

The result of many years of research and development on aeromagnetic compensation by RMS Instruments, and collaborations with the Flight Research Laboratory of the National Research Council of Canada, the AARC500 continues the AADCII tradition of consistently producing outstanding data in a cost effective manner.

The system is built on the foundation of state-of-the art, very reliable hardware and firmware, and sophisticated and robust compensation algorithms that have been proven in a multitude of installations.

Aeromagnetic Compensation

The quality of the data collected in aeromagnetic surveys is largely dependent on the quality of compensation. Despite the outstanding sensitivity of modern magnetometers, in the absence of good compensation anomaly signals can be completely masked out by the interference of the nearby magnetics of the aircraft.

The aircraft's magnetic interference is related to its motions about its principal axes. A mathematical model may be built to accurately represent the aircraft's magnetic signature. Careful optimization and implementation of this model, within the framework of sophisticated hardware and firmware technologies, can lead to real-time compensation that effectively eliminates the aircraft's magnetic interference.

The RMS Instruments' AARC500 Adaptive Aeromagnetic Real-Time Compensator provides real-time compensation of local magnetic interference for inboard magnetometer systems in fixed wing aircraft and helicopters, to the point where the full resolution of modern high sensitivity magnetometers can be utilized. The compensation accounts for the effects of permanent and induced magnetism, Eddy currents, and heading errors from the sensors.

The importance of real-time compensation

The magnetic signature of typical survey aircraft changes dynamically, even while in-flight. A simple toolbox or headphones misplaced in the cockpit, for example, will cause a significant DC-shift. Detecting subtle changes while monitoring uncompensated signals is practically impossible, as the disturbances introduced are “buried” under aircraft interference noise. State-of-the-art aeromagnetic surveying requires real-time monitoring of compensated data – problems are thus identified immediately and are promptly corrected. Relying solely on post-flight compensation is akin to “flying blind”.

Calibration mode, model and solution

The AARC500 uses a 3-axis fluxgate magnetometer to monitor the aircraft's position and motion with respect to the ambient magnetic field while flying a set of standard maneuvers of rolls, pitches and yaws in orthogonal headings. This *calibration* process, which typically takes 6-8 minutes, yields a (mathematical) *solution* that models the aircraft’s magnetic signature. The solution is calculated instantly, upon termination of the calibration maneuvers. It is immediately available for use in compensated (i.e., survey) mode, or for further analysis and comparison with other solutions.

With the AARC500 there is no need for any post-flight software. The calibration is effective for the full 360º range of headings. At very low dip angles, *partial calibrations* for each active zone can be readily combined to produce a single robust solution for the full 360º range.

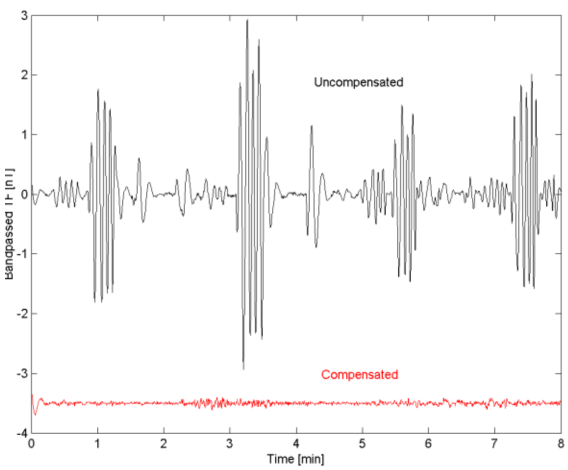
Compensation – total fields & gradients

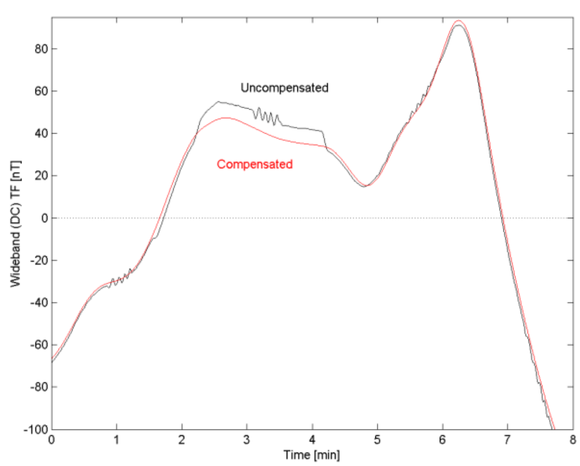
In *compensation* mode up to 8 total-field (TF) high-sensitivity magnetometers, as well as associated gradients, are compensated in real-time using the last solution obtained (or any other solution previously archived). Compensated and uncompensated data, along with the 3-axis vector magnetometer and other ancillary data, are monitored and recorded in real-time.

Importantly, the system provides *true* gradient compensation: independent calibration solutions are calculated for the lateral, longitudinal and vertical gradients.

Adaptive compensation

The AARC500 incorporates adaptive signal processing techniques that allow the system to continuously "learn" from input signals, and adapt the solution coefficients for optimum compensation. The underlying recursive algorithm has significant computational advantages over the “conventional” alternative, and leads to improved band-passed and gradient compensation. Adaptive compensation substantially eases calibration procedures, and yields solutions that remain close to optimum as the aircraft’s magnetic signature changes with time.





Left – Bandpassed uncompensated and compensated data for a full calibration flight (8 minutes). The uncompensated waveform clearly shows the aircraft interference on the four headings.
Performance indicators: σ_{uncomp} = 0.5502 nT, σ_{comp} = 0.0282 nT, IR = 19.5. (Waveforms are offset for clarity.)
Right – Wideband uncompensated and compensated waveforms. (Mean value subtracted for clarity.)

Dynamic compensation of OBE systems

The AARC500 incorporates new technology that allows real-time dynamic compensation of the effects of DC currents from on-board electronic (OBE) systems, such as avionics, hydraulics, control systems and other instrumentation. The compensation model is augmented by a suitable set of terms calculated by running a simple “calibration” procedure. OBE compensation simplifies operational requirements for operators during surveys, increases robustness and tolerance to electrical sources, and improves overall compensation performance. The technology works both for fixed- and variable-current devices, for as many as four independent OBE systems.

System Description

The AARC500 is based on a flexible architecture with advanced 64/32-bit processors. It includes state-of-the-art COTS (industrial-grade) electronics, and a proprietary magnetometer interface.

Front End subsystem

The Front End in the system handles all magnetics data acquisition and processing, and provides accurate synchronization to GPS.

The magnetometer interface, most critical for high performance and data quality, uses the latest in analog and digital electronics to achieve excellent accuracy and synchronization for up to eight high-sensitivity magnetometers. It uses a highly stable and reliable time base (OCXO). The proprietary counter circuitry delivers outstanding performance with negligible noise and temperature drift.

A three-axis fluxgate (vector) magnetometer is included with the system. Signals are processed using a high-resolution (16-bit) A/D converter.

Front End sampling rates are user-selectable, up to 1280 Hz. Finely tuned, user-selectable transfer functions deliver outstanding anti-aliasing characteristics. The user may also customize Front End processing to the specific requirements of an installation.

For concurrent use with EM systems a gating signal qualifies magnetometer readings.

Host subsystem

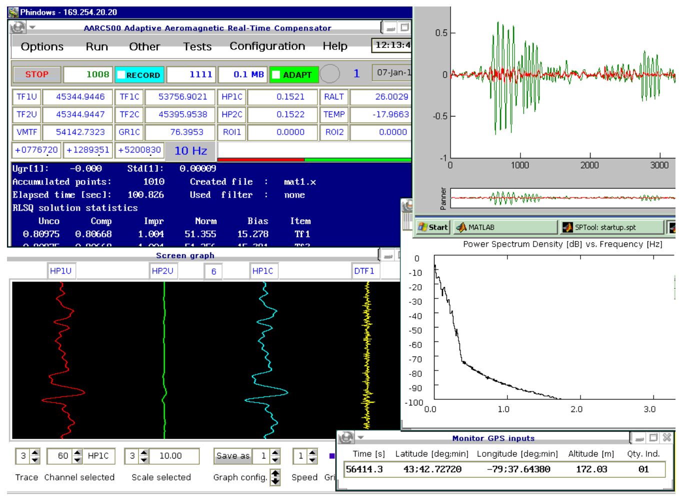
The application software and real-time operating system (RTOS) reside in (solid-state) Flash memory. The RTOS is QNX 6.5 (or later), a deterministic and extremely reliable operating system tailored to mission-critical applications, that guarantees compliance with the strict timing constraints of all critical tasks.

Comprehensive statistical information is provided to assess the quality of compensation. The AARC500 will typically achieve *Improvement Ratios* (IRs) in the range of 10–20 for total fields in large and magnetically complex aircraft. For gradients, figures in the range of 20–100 are typical, with better performance possible when using adaptive compensation. The Host software offers optional filtering with user-selectable bandwidths, and includes facilities for data analysis in the time and frequency domains.

All magnetics (raw and compensated) and ancillary data may be recorded and monitored in real-time, at rates up to 80 Hz. Monitoring, in graphical and numerical form, can be done simultaneously on the built-in display, an external display/monitor, and a chart recorder. Real-time data output via a serial port or Ethernet is also available.

Embedded solid-state Flash (≥ 16 GB) is typically used for data recording. Direct recording on a Flash disk connected to one of the USB ports is also available.

In addition to comprehensive data acquisition functionality, the host subsystem also provides extensive general-purpose I/O: simultaneous output to the built-in display and an external one (via a standard VGA port), and multiple Ethernet, USB and UART interfaces. Configuration and control of the system are supported through an easy-to-use graphical user interface.



Remote control from Windows

A remote connectivity tool for the AARC500 allows users full control and operation of the unit from a remote Windows-based system, across an IP network.

The user interface of the AARC500 is seamlessly replicated in the Windows-based computer. The mouse and keyboard attached to the computer have the same effect as if they were directly connected to the AARC500.

This technology facilitates integration of complex systems, with a single computer/laptop being used to control and operate the AARC500 and other instruments, while simultaneously running complementary software.

GPS receiver

The system is available with an embedded (typically dual-frequency) GPS receiver. All magnetics and ancillary data are referenced to GPS time and position. A variety of receivers are available to satisfy different requirements in accuracy. The AARC500 gives users direct access to two ports on the receiver. This provides, for example, the interface to a navigation system. The system can also be used with an external (user-supplied) receiver.

Post-flight compensation & analysis functions

Advanced embedded functions allow post-flight survey compensation, in the event a suitable calibration was not available at time of flight. This complements the fundamental real-time compensation function, key for productive and efficient airborne magnetometry. Also included are functions for in-depth analysis of calibration data, and frequency-domain analysis.

ORDERING INFORMATION

- *AARC500-x*: Adaptive Aeromagnetic Real-Time Compensator. [x = # of magnetometer inputs; 2 ... 8]
  Includes: – *Vector (fluxgate) magnetometer.*
  – *License/Key for QNX (RTOS) & Phindows* (remote control from any Windows computer via IP network over Ethernet).
- *Advanced Functions*: Multiple FE smpl. rates & transf. funcs., raw FE logging, in-field FW updating, mag. gating for concurrent use with EM.
- *Post-Flight Compensation*: PFC and calibration analysis functions. Requires the Advanced Functions option.
- *RMS4880A Magnetometer Power/Decoupler Module:* RMS4880A-1 (up to 4 inputs), RMS4880A-2 (up to 8 inputs).
- *GPS Receiver Option*: Internal (consult RMS Instruments for list of receivers available) or External.
- *Front-End-Sampled Analog Inputs*: 4 differential inps., 16-bit ADC. Required for OBE compensation.

AARC500 SPECIFICATIONS

Magnetometer Inputs:
Up to 8 high-sensitivity magnetometers; any combination of:
Cs: Typ. 70 kHz – 350 kHz
K-41, K-39: Typ. 140 kHz – 700 kHz
He: Typ. 560 kHz – 2.8 MHz

Magnetic Field Range:
Per the magnetometer's range; e.g.: [1]
G-822A, G-823A: 20,000 – 100,000 nT
CS-3, CS-L, CS-VL: 15,000 – 105,000 nT
GSMP-30A: 20,000 – 100,000 nT

Front End (FE):
Time base: > 100 MHz, OCXO
Resolution: 0.32 pT [2]
System noise: σ < 0.1 pT [3]
Temperature stability: ≈ ±10 ppb [4]
Sampling rate: 160, 640, 800 or 1280 Hz – user-selectable [5]
Transfer function (bandwidth): 1.6 Hz, 3.25 Hz, 6.4 Hz, 9.8 Hz, 20 Hz, 0.16F_{SH} or Cstm. Transfer Funct.–user-select. [5]

Compensation Performance:
IR (total field): 10 – 20, typical
IR (gradient): 20 – 100, typical
(further improvement possible with adaptive compensation, 2X to 5X typical, band-passed TF and gradient)

Compensation Accuracy:
σ ≈ 20 pT, entire flight envelope, 0 – 1 Hz

Optional Filter (Host):
User-selectable, 0.4 – 3.0 Hz BW

Calibration Duration:
6 – 8 minutes, typical

Vector Magnetometer:
Included with the AARC500
3-axis fluxgate
Oversampling, 16-bit, self-calibrating ADC

Data Output & Recording:
F_{SH}: 10, 20, 40, 80 [6] Hz (GPS-PPS or internal synch.); external-trigger
Serial port: 115.2 kbps, ASCII/Binary
Ethernet: TCP/IP packets, ASCII/Binary
Recording media: embedded Flash memory (≥ 16 GB), USB Flash disk
Chart recorder
Display (built-in and external)

OBE Compensation:
Dynamic compensation of up to 4 independent on-board elec. systems
Requires FE-sampled Analog option

Event Inputs/GPS Synch.:
Four latched event inputs
LS-TTL levels, edge-sensitive
Event tags included with output data
Accuracy: per Front End sampling rate

Raw Data Logging: [5]
At Front End sampling rate
1-MB buffer
Ex.: 41666 records for 4 mag. inputs

FE-Sampled Analog – Optional:
Four differential inputs
16-bit resolution, self-calibrating ADC
Input range: ±5 Volts
Input resistance: 1 MΩ, typical

Display:
6.5" colour TFT digital LCD
VGA resolution (640 x 480)
Antiglare surface treatment
Backlight: LED (white)
Luminance: 1000 nits

Mouse:
Silicone-rubber actuators
Pressure-controlled operation
No moving parts

Remote Control:
From any Windows-based computer, via IP ntwk. over Ethernet – replica of AARC500's user I/F on computer.
Via serial (RS232) port – ASCII cmnds.

Indicators, General-Purpose I/O:
8 LEDs for mag. input status
2 LEDs for Front End status
Five USB 2.0
Data output (RS232, 9-pin D-sub)
Remote control (RS232, 9-pin D-sub)
Two 10/100/1000Base-TX Ethernet, one reserved for future use (RJ45)
Analog RGB (15-pin D-sub)
Chart recorder I/F (9-pin D-sub)

GPS Receiver Option:
Magnetics data tagged with GPS time, lat., long., altitude and auxiliary data
Up to 10 Hz
Internal (embedded) configuration – Single-, dual- or triple-frequency receiver from Novatel's OEMV-1, OEMV-2, OEM6 or OEM7 series
External configuration – Any GPS receiver with standard NMEA GGA output via serial (RS232) port (up to 10 Hz), and PPS trigger

Post-Flight Compens. – Optional:
Post-flight compensation & analysis functions for AARC500 binary d-files

Power:
+28 VDC (± 6 VDC), 3.0 A
For each mag. input connected through the RMS4880A Magnetometer Power/Decoupler Module: 0.5 A typical; up to 1.0 A at turn-on [7]

Environmental:
Operating Temperature: 0 to +50ºC

Storage Temperature: –20 to +55ºC

Relative Humidity: 0 to 99%, non-condensing

Altitude: 0 – 6,000 m (0 – 20,000 ft)

Size (W x H x D): 483 x 133 x 381 mm, (19 x 5.25 x 15 in)

Weight: 8.2 Kg (18 lb)

Notes:
[1] Per manufacturer's specs. at print time: G-822A, G-823A (Geometrics), CS-3, CS-L, CS-VL (Scintrex), GSMP-30A (GEM Sys.).
[2] 1.6-Hz BW, 625-ms integ.
[3] Typical; 1.6-Hz BW, 625-ms integ., 10 Hz.
[4] Within operating temp. range. Over –20 to +70°C, < ±35 ppb.
[5] With AARC500 Advanced Functions Option. Defaults: 640-Hz, 1.6-Hz BW.
[6] Some restrictions apply for 5–8 mag. inputs.
[7] Per Geometrics G822A-type sensors. May vary for other sensors.

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For additional information on these and other products, contact:

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