

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 which fall off as the third or fourth power of distance, 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 need for real-time compensation

The magnetic signature of typical survey aircraft is extremely prone to change in-flight. Something as simple as switching-on a light in the cockpit may cause a significant DC-shift in the compensated data. Detecting these changes while monitoring uncompensated data is practically impossible. State-of-the-art aeromagnetic surveying requires real-time monitoring of compensated data, so that problems are identified immediately and are promptly corrected. Relying solely on post-flight compensation is akin to "flying blind".

Calibration 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. During the calibration mode of approximately 6-8 minutes, the positional data together with the magnetometer sensor(s) readings are utilized by a sophisticated model to arrive at a solution of approximately 30 terms.

The solution is a comprehensive mathematical model that accurately describes the magnetic interference of the moving aircraft. It is calculated instantly, upon termination of the calibration maneuvers. It is immediately available for use in compensation mode or for further analysis and comparison with other solutions.

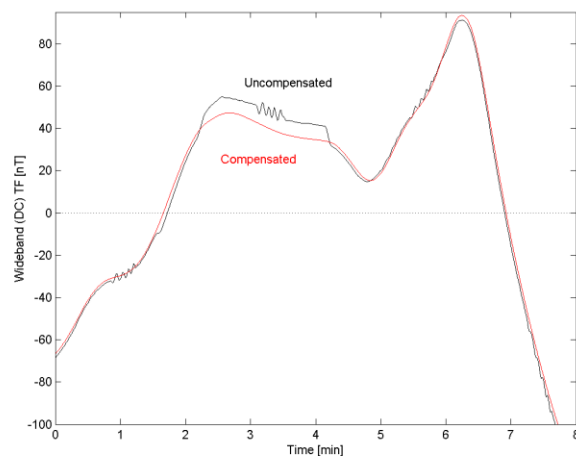
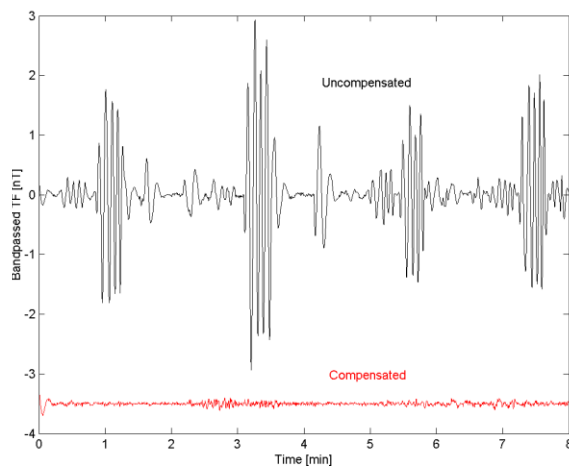
With the AARC500 there is no need for any post-flight software. The system uses the full 360° pattern to obtain a robust solution. If necessary, in the event full 360° signal acquisition is not possible, the AARC500 allows calibration for each active zone, and a corresponding solution. Furthermore, any set of such *partial calibrations* can also be readily combined to produce a single robust solution for all of the sensor's active zones.

Compensation – total fields & gradients

In compensation mode measured values of up to 8 total field high-sensitivity magnetometers and gradients are corrected in real-time using one of the solutions previously obtained. Compensated and uncompensated signals along with the 3-axis vector magnetometer and other ancillary data, are available for real-time recording and monitoring.

Adaptive compensation

The AARC500 incorporates sophisticated adaptive signal processing techniques that allow the system to continuously "learn" from input signals, and adapt the solution coefficients for optimum compensation. This can lead to improved band-passed and gradient compensation (up to several times lower residual errors), and simplified calibration procedures. Other novel approaches are continuously being developed and can be readily incorporated into the system thanks to its flexible architecture.



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: $\sigma_{uncomp} = 0.5502 \text{ nT}$, $\sigma_{comp} = 0.0282 \text{ nT}$, $IR = 19.5$. (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

RMS Instruments' new compensation technology is based on a flexible architecture that incorporates dual 64/32-bit processors. It includes state-of-the-art COTS (industrial-grade) electronics, and a new 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 (e.g., minimize effects from the rotor system in a helicopter).

The high-speed raw data, at the primary Front End sampling rates, is optionally available. This allows in-depth frequency domain analysis.

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

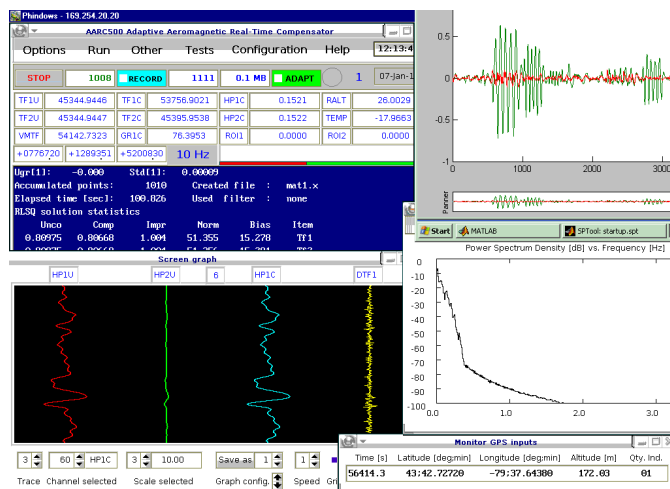
Host subsystem

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.

Raw and compensated data are available in real-time, at up to 80 Hz: (a) for recording on embedded Flash or a USB-based Flash drive, (b) via a 115.2-kbps serial port, (c) via an Ethernet port as TCP/IP packets, (d) for graphical

output on the built-in display and/or an external monitor, and (e) for output to a chart recorder.

The software includes an easy-to-use graphical user interface, and a rich set of utilities to analyze data and help troubleshoot aeromagnetic installations.



Comprehensive statistical information is provided to assess the quality of the calibration/solution. The information includes the *Improvement Ratio* (IR), a standard measure of the effectiveness of the compensation. The AARC500 will typically achieve 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 integrated graphics controller allows simultaneous output to the built-in display and to any external display connected via the analog RGB interface. The system also includes extensive general-purpose I/O (Ethernet, USB, UART).

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 option

An embedded GPS receiver is the source of all timing within the system. GPS data are appended to recorded and transmitted magnetics data blocks. 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 GPS receiver option is also available for use with an external (user-supplied) receiver.

Post-flight compensation & analysis option

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: $\sigma < 0.1$ pT^[3]

Temperature stability: $\approx \pm 10$ 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 adap-
tive compensation, 2X to 5X typical,
band-passed TF and gradient)

Compensation Accuracy:

$\sigma \approx 20$ 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:

Rate (F_{SH}): 10, 20, 40, 80 Hz, external
trig., external-PPS – user-selectable^[6]

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 inde-
pendent 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 period
(down to 781 μ s)

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 M Ω , typical

Display:

6.5" colour TFT digital LCD

VGA resolution (640 x 480)

Antiglare surface treatment

Backlight: CCFL, 2 replaceable tubes

Luminance: 400 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 cmdns.

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 re-
ceiver 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 func-
tions for AARC500 binary d-files

Power:

+28 VDC (± 6 VDC), 3.0 A

For each mag. input connected through
the RMS4880A Magnetometer Pow-
er/Decoupler Module: 0.5 A typical; up
to 1.0 A at turn-on^[7]

Environmental:

Operating Temperature: 0 to +50°C

Storage Temperature: –20 to +55°C

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, $< \pm 35$ ppb.

[5] With DAARC500 Advanced Functions Op-
tion. 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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owners.*

*Specifications subject to change without notice
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