RMS INSTRUMENTS
For Geophysical Exploration

DAARC500

DATA ACQUISITION & ADAPTIVE AEROMAGNETIC REAL-TIME COMPENSATION

2nd-Generation DAARC500

General-Purpose Data Acquisition

- *Comprehensive, flexible data acquisition*
- *Embedded GPS receiver option (typ. dual-frequency, L-band corrections)*
- *Eight isolated RS232 serial ports (115.2 kbps), two Ethernet (10/100/1000 Mbps)*
- *Flexible ASCII, binary and raw-data protocols, with large buffers*
- *16 differential/32 single-ended analog inputs, 16-bit resolution*
- *Fully compatible with all leading sensors and instrumentation in airborne geophysics: spectrometers (RSI), navigation systems, etc.*
- *Serial/analog/Ethernet data synchronized to magnetics, with time & event tags*
- *Flexible and simple user interface via built-in TFT LCD and external display*
- *Full monitoring/control from any Windows device (via Ethernet, or through the Internet)*
- *Real-time graphical output to built-in display, external display and chart recorder*
- *Embedded storage: on-board Flash (≥ 32 GB), and hard-disk/solid-state drive (≥ 500 GB) – robust, reliable, redundant recording*

Magnetics & Compensation

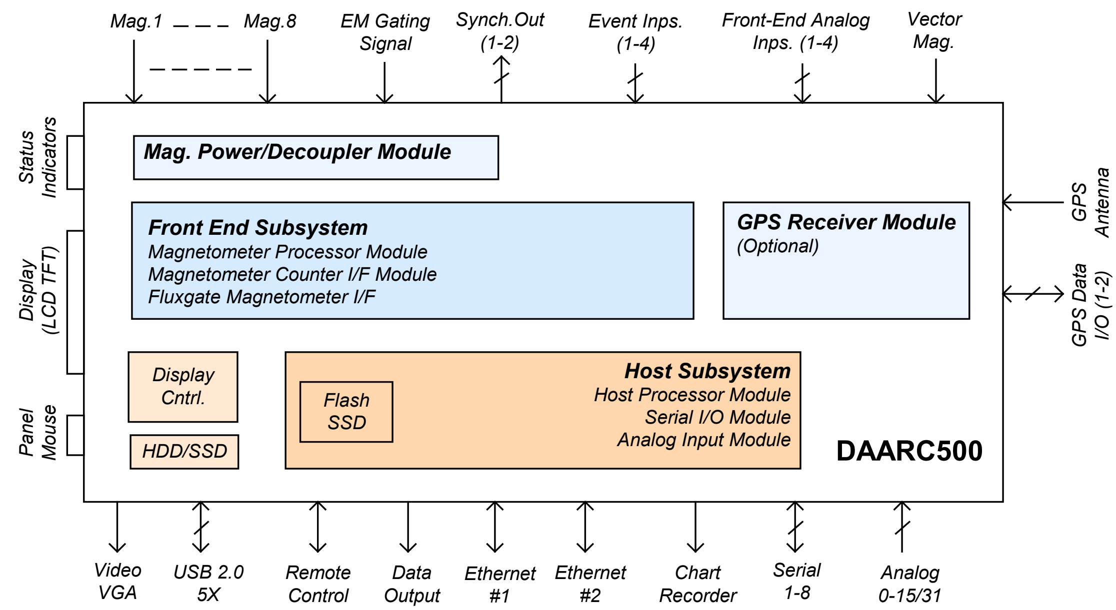
- *Magnetometer interface for up to 8 high-sensitivity sensors (Cs, He or K)*
- *Front-end sampling rates up to 1280 Hz*
- *Magnetometer processor: 0.32 pT resolution, < 0.1 pT system noise, ±10 ppb temperature stability*
- *Real-time compensation: up to 8 total-field magnetometers, and true gradients*
- *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*
- *Data recording & output, up to 80 Hz: complete raw, pre-processed and compensated data sets*
- *Post-flight compensation & analysis functions*
- *Dynamic compensation of on-board electronic (OBE) systems*
- *Gating of magnetometer readings for concurrent use with EM systems*

- *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, 19 lb.*

The RMS Instruments' DAARC500 offers the ultimate in aeromagnetic compensation, together with comprehensive and flexible data acquisition and recording. Powerful, versatile and rugged, yet compact and light, the DAARC500 is ideally suited to airborne and mobile geophysical and environmental survey applications.

Aeromagnetic compensation in the DAARC500 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 result of many years of R&D by RMS Instruments, and collaborations with the Flight Research Laboratory of the National Research Council of Canada, the DAARC500 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. Consistent with compensation, data acquisition is delivered with unparalleled performance, accuracy and reliability.



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' DAARC500 Data Acquisition System & 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

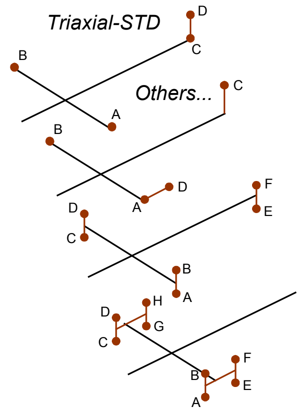
The DAARC500 uses a 3-axis fluxgate magnetometer to monitor the aircraft's position and motion with respect to the ambient magnetic field while flying a set of standard maneuvers of rolls, pitches and yaws in orthogonal headings. This *calibration* process, which typically takes 6-8 minutes, yields a (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 DAARC500 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 and 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 fluxgate magnetometer and other ancillary data, are monitored and recorded in real-time.

The standard gradient geometry with four magnetometer inputs, *Triaxial-STD*, yields lateral (A–B), longitudinal [(A+B)/2–C] and vertical (C–D) gradients. The DAARC500 also allows users to easily define other gradient geometries – a unique and valuable flexibility in systems with complex arrays of magnetometer sensors.

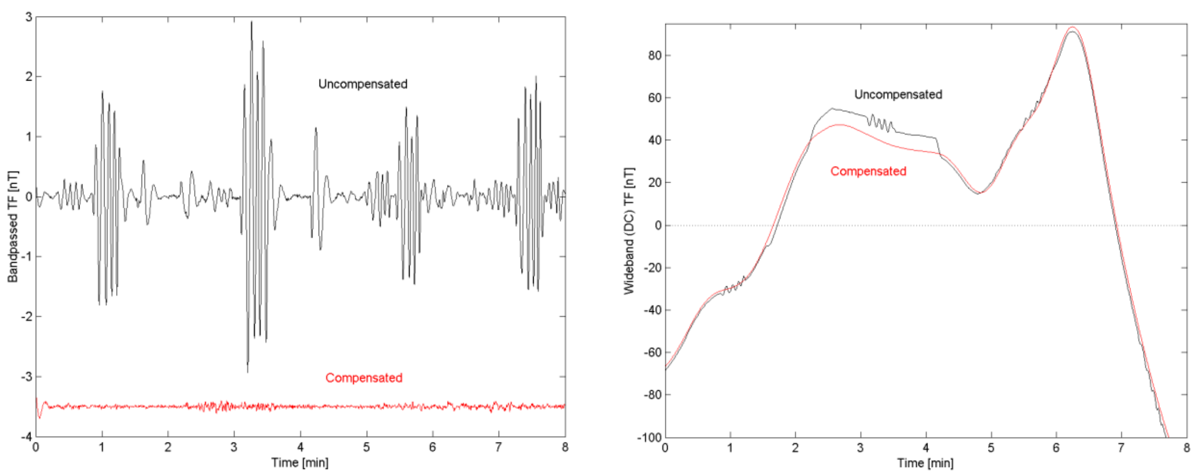


Importantly, the system provides *true* gradient compensation: independent calibration solutions are calculated for each of the gradients supported.

Adaptive compensation

The DAARC500 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.

In the DAARC500 adaptive compensation can operate in manual mode (controlled explicitly by an operator), or in an automatic mode whereby the system automatically engages and disengages adaptive mode at user-defined altitudes. The latter permits “continuous” optimization of a calibration solution, without operator intervention.



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 DAARC500 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, typically on the ground.

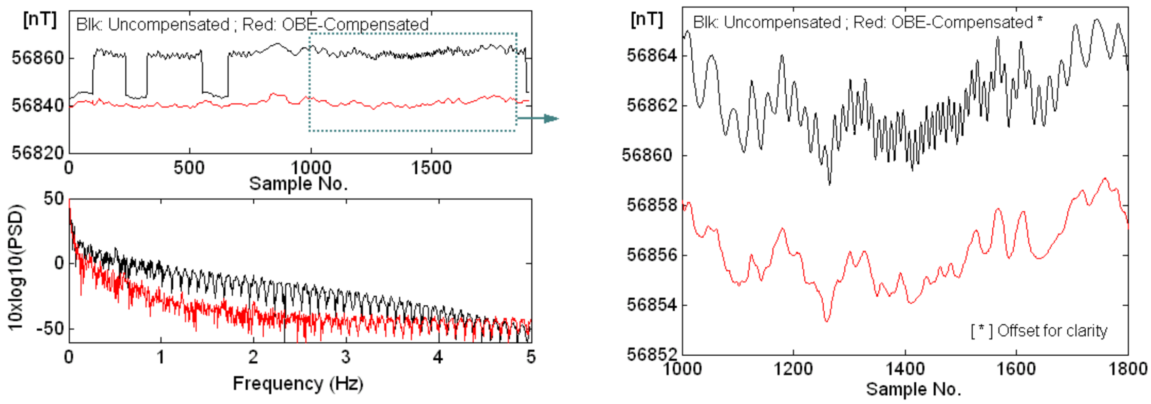
In real-time compensated run mode, the various terms for an OBE system are incorporated into the overall model under control of analog signals used to monitor the status of the system. The technology works for devices that draw fixed currents (discrete mode), as well as for devices that draw slowly-varying currents (continuous mode). As many as four independent OBE systems can be processed simultaneously.

OBE compensation is complementary to conventional compensation, and offers important benefits to users – it simplifies operational requirements in surveys, increases robustness and tolerance to electrical sources, and improves overall compensation performance.

Data Acquisition System

Comprehensive and flexible data acquisition and recording complement the aeromagnetic compensation functions in the DAARC500.

External devices with digital (serial) and analog outputs can be connected directly to the DAARC500. The system provides 8 high-speed, isolated, serial (RS232) inputs and outputs, 16 differential (or 32 single-ended) analog inputs, and two Gigabit-Ethernet interfaces (one dedicated to data acquisition, with dual logical connections).



OBE compensation in continuous mode, for intermittent interference consisting of a level shift (≈ 20 nT), and current load modulation (0.2–1.0 Hz, ≈ 2 nT p-p). Left: uncompensated and OBE-compensated signals in the time and frequency domains. Right: zoomed-in section of the signals in the time domain.

Flexible serial protocols and practically unlimited buffering space, allow easy interfacing to most devices.

All data sampling is at rates based on the same time base. All data streams are perfectly synchronized and are recorded with time and event tags that allow accurate reference to GPS time and position.

Analysis, Control & Support Software

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.

Data exporting software

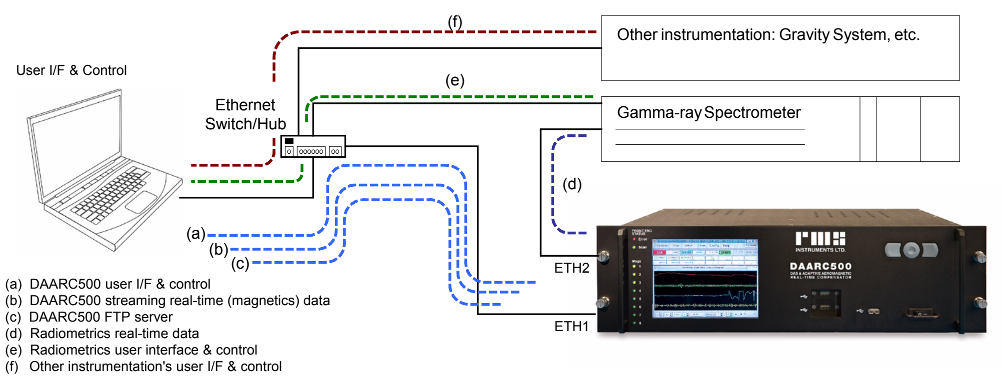
The data files recorded by the DAARC500 have a structure optimized for efficiency and performance. *Ex-portDAARC* is a comprehensive support software package included with the DAARC500 which allows exporting data files to industry-standard formats (e.g., flat-ASCII, 'XYZ', Geosoft 'GBN').

Remote control from Windows

A remote connectivity tool for the DAARC500 allows users full control and operation of the unit from a remote Windows-based system, across an IP network.

The user interface of the DAARC500 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 DAARC500. The figure below illustrates typical connections and data flow.

This technology facilitates integration of complex systems, with a single computer/laptop being used to control and operate the DAARC500 and other instruments, while simultaneously running complementary software.



System Architecture

The DAARC500 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 is based on a high-performance, low-power, RISC PowerPC processor. The magnetometer interface, most critical for high-performance compensation, uses the latest in analog and digital electronics to provide excellent accuracy and synchronization for up to eight total-field magnetometers. It uses a highly stable and reliable time base (OCXO). The proprietary counter and synchronization hardware deliver outstanding performance with negligible noise and temperature drift.

A three-axis fluxgate (vector) magnetometer, used for attitude reference, 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 is used to qualify magnetometer readings.

Host subsystem

The host subsystem is built around one of Intel's most recent multi-core processors. The application software and real-time operating system (RTOS) reside in (solid-state) Flash memory. The RTOS is QNX 6.5 (or later). This is a deterministic and extremely reliable operating system tailored to mission-critical applications, that guarantees compliance with the strict timing constraints of all critical tasks.

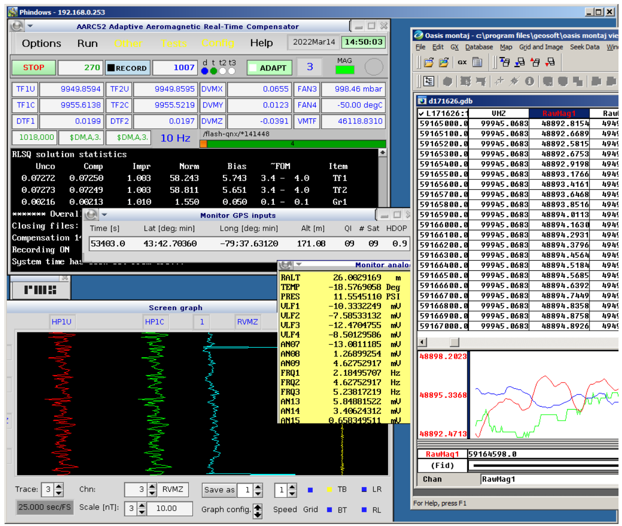
Comprehensive statistical information is provided to assess the quality of compensation. The DAARC500 will typically achieve *Improvement Ratios* (IRs) in the range of 10–20 for total fields in large and magnetically complex aircraft. For gradients, figures in the range of 20–100 are typical, with better 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 streaming data output via a serial port or Ethernet is also available.

Embedded recording options include on-board Flash (≥ 32 GB), and a mass-storage device (HDD or SSD, ≥ 500 GB). Direct recording on a Flash disk connected to one of the USB ports is also available.

The file systems managed by the RTOS are extremely robust. Even in the event of a power failure during flight, for example, all open files at the time of the fault will in all likelihood be recoverable. For additional safety, the DAARC500 also allows *redundant real-time recording* on two media.

Configuration and control of the system are supported through an easy-to-use graphical user interface.



Magnetometer power decoupler

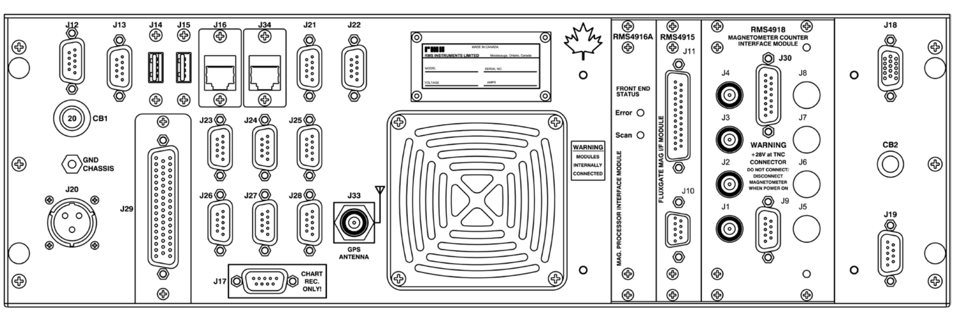
The DAARC500 is available with an embedded power/decoupler module for up to four or eight inputs. The decoupler separates the Larmor outputs of the magnetometers from 28-Volt power, and monitors the quality of magnetometer input signals.

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 DAARC500 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.

ORDERING INFORMATION

- *DAARC500-X: DAS & Adaptive Aeromagnetic Real-Time Compensator.*
  Includes: Counter/processor for 'X' (2...8) magnetometer inputs; fluxgate magnetometer; QNX license; interface for external GPS receiver; mating connectors; user's guide (electronic); AFSC (firmware/support contract) for one year.
- *Performance Package: Selectable Front End (FE) sampling rates & transfer functions; advanced user-customizable FE processing; field-upgradable FE firmware; mag. gating for concurrent use with EM; post-flight compensation & analysis functions; FE analog inputs (including OBE compensation & embedded barometric-pressure & temperature sensors).*
- *RMS4880A Magnetometer Power/Decoupler Module: RMS4880A-1/3 (up to 4 inputs), RMS4880A-2/4 (up to 8 inputs).*
- *RMS2938-1: 32 single-ended analog channels (instead of the standard 16 differential channels).*
- *Embedded GPS Receiver Option: Typically, Novatel dual-frequency OEM-7 series supporting L-band corrections.*
- *Phindows Software & License: Connectivity tool allows MS-Windows platforms to remotely control the system via a TCP/IP network.*



DAARC500 SPECIFICATIONS

Magnetometer Inputs:
Up to 8 high-sensitivity magnetometers:
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]
CS-3, CS-L, CS-VL: 15,000 – 105,000 nT
G-822A, G-823A: 20,000 – 100,000 nT
GSMP-30A: 20,000 – 100,000 nT

Gradiometer:
True gradient compensation – individual models/solutions for each of 3 gradients
≤ 4 Mags: fixed (triaxial) sensor geometry
> 4 Mags: user-defined sensor geometry

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}, 0.13F_{SH} or Custom –user-select. [5]

Compensation Performance:
σ ≈ 20 pT for entire flight envelope, 0–1Hz
IR, total fields (TFs): 10–20, typical
IR, gradients: 20–100, typical
Adaptive mode: Recursive approach with user-selectable gain; up to 2–5X further improvement (typical), band-passed TFs & gradients.

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

Calibration Duration:
6–8 minutes, typical

Fluxgate (Vector) Magnetometer:
Included with the DAARC500
3-axis fluxgate
Oversampling, 16-bit, self-calibrating ADC

OBE Compensation: [5]
Dynamic compensation of up to 4 independent on-board elec. systems
Uses FE analog inputs

Data Output & Recording:
F_{SH}: 10, 20, 40, 80 [6] Hz (GPS-PPS or internal synch.); external-trigger
Serial port: to 115.2 kbps, ASCII/Binary
Ethernet: TCP/IP packets, ASCII/Binary
Recording media: internal Flash (≥ 32 GB), internal HDD or SSD (≥ 500 GB), USB-Flash disk
Chart recorder
Display (built-in and external)

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

EM Gating: [5]
For concurrent use with EM systems
LS-TTL input with pull-up

Embedded Barometric Pressure & Temperature Sensors: [5] [8]
Differential inputs, 16-bit ADC
600 to 1100-mbar range; ±5 mbar total accuracy
–50 to +100°C range; ±1°C abs. error

FE-Sampled Analog Inputs: [5]
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:
Optional: From any Windows-based computer, via Ethernet – full replica of user I/F
Via serial (RS232) port – ASCII cmnds.

Data Acquisition – Analog:
16-bit, self-calibrating A/D converter
RMS2938: (standard)
16 differential, 20-Hz AA
RMS2938-1: (optional)
32 single-ended, 20-Hz AA
Input range:±10 Volts (standard), ±5 Volts
Input over-voltage protection:
–20 Volts to +52 Volts, power ON
–35 Volts to +55 Volts, power OFF
Sampling & recording: F_{SH} or submult.
Input resistance: 1 MΩ, typical
CMRR (60 Hz): 96 dB, typical

Data Acquisition – Serial:
8 isolated RS232 channels
Up to 115.2 kbps, HW handshaking
Input:
ASCII, Binary and Raw protocols
Sampling & recording: F_{SH} or submult.
Output:
User-defined packets synch. to F_{SH}

Data Acquisition – Ethernet:
10/100/1000Base-TX
Real-time, streaming data (TCP/IP)
Two independent logical connections
Sampling & recording: F_{SH} or submult.

Synch. to External Devices:
Two independent pulse-train outputs
Rate: F_{SH}/x, with $1 \le x \le 255$
Low-going pulses, > 10-μsec width

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 for data acquisition (RJ45)
VGA video (15-pin D-sub)
Chart recorder I/F (9-pin D-sub)

GPS Receiver:
Standard: Interface to any GPS receiver with NMEA GGA output via RS232 (115.2 kbps, up to 10 Hz), PPS (LS-TTL, LV-TTL)
Optional: Embedded receiver – dual-frequency, GPS+GLONASS+QZSS, L1/L2, SBAS L1, PPP+Single-Point+DGPS-PNT, L-Band corrections (Other options: BeiDou, RTK posit., etc.)
Magnetics data tagged with GPS time, lat., long., altitude, and auxiliary data
Up to 10 Hz

Post-Flight Compensation: [5]
Post-flight compensation & analysis functions for DAARC500 binary d-files

Power:
+28VDC (± 6VDC)
3.75A plus, for each mag. sensor, 1–1.5A[7] during warm-up, 0.5A thereafter

Environmental:
Operating Temperature: 0 to +50ºC
Storage Temperature: –20 to +55ºC
Relative Humidity: 0 to 99%, non-cond.
Altitude: 0–3,000 m (0–10,000 ft); HDD
0–6,000 m (0–20,000 ft); SSD
Size (W x H x D): 483 x 133 x 381 mm, (19 x 5.25 x 15 in)
Weight: 8.6Kg (19lb)

Notes:
[1] Per manufacturer's specs. at print time: CS-3, CS-L, CS-VL (Scintrex), G-822A, G-823A (Geometrics), 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] Requires Performance Package. Defaults: 640-Hz samp. rate, 1.6-Hz BW.
[6] Some restrictions apply for 5–8 mag. inputs.
[7] Dependent on type/model of magnetometer sensors.
[8] Uses 2 of the 4 FE analog inputs available.

*Specifications per Host FW ≥ RMS11030-04-H, FE FW ≥ RMS1877-05-D, HW Rev. ≥ 2.20, and subject to change without notice – **Jan 2025**.*

For additional information on these and other products, contact:

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