GPS-Disciplined Rubidium Clock

AR51A-04

Ultra high stability and accuracy
Full military qualification

Key Features

- **Time Accuracy (1PPS):** 30ns RMS
  (50ns under environmental conditions)
- **Frequency Accuracy:** 2E-12
- **Holdover (without GPS):** < 1µs/24 hours
- **GPS in standalone, common and differential modes**
- **Position Accuracy:** 2m (differential mode)
- **Outputs:** 2x10MHz, 14x1PPS (TTL & RS-422), 2x51.2MHz, LAN
- **Disciplined to GPS or Ext 1PPS**
- **Input and output delay corrections in 10 ns steps**
- **Excellent Phase-Noise under vibration**
- **GPS modes:** standalone, differential or common view
- **Network Time Server:** NTP and SNTP server
- **LAN & RS-232 for command, control and data**
  Operation Temperature: -40 °C to +55 °C
- **22-32 VDC per MIL-STD-704A**
- **1-hour rechargeable battery back-up**
- **Vibration isolator included**
- **Full MIL-STD for military airborne & ground applications**

Description

The AR51A-04 is a fully Militarized GPS-Disciplined Rubidium Clock which offers ultra-high-stability and extraordinary accuracy. The unit is designed for demanding platforms such as airborne, helicopters, UAV’s, shipboard and ground mobile. It provides time accuracy of <30ns and < 50ns under all environmental conditions. Frequency accuracy is better than 2E-12. The unit has multiple outputs with very low phase-noise under vibration. Receiver operation modes are: standalone, differential or common-view.

The unit includes a militarized Rubidium-Atomic-Standard which is phase-locked to the GPS or to other external inputs. All outputs are derived from the Rubidium-Atomic-Standard that maintains accurate time and frequency even when GPS reception is interrupted.

The AR51A-04 has been qualified for operation in harsh environments. It was tested for wide temperature range, vibration, shock, altitude, EMI (see more details in the specification). In addition the AR51A-04 was tested by a GPS simulator in many modes of operation and passed real flight tests.

The unit includes a rechargeable battery module which is easily disconnected for ease of maintenance.

Applications

- Secure Communication
- ELINT Receivers
- Electronic warfare
- Radar, Bi-static Radar
- Field calibration
- Telemetry test fields
- C4I (Command, Control, Communications, Computer & Intelligence)
**SPECIFICATIONS**

All specs are at room temperature, quiescent conditions, sea level ambient unless otherwise specified

### Input & Outputs

#### Outputs

- **10 MHz Sine wave** 12±2dBm / 50Ω
- **10 MHz Clock RS-422**
- **8 X 1PPS TTL 50 Ω, 300μs Puls width, Rise Time < 10ns**
- **6 X 1PPS RS-422, 300μs Plus width, Rise Time < 10ns**
- **2 x 51.2 MHz Sine wave 15dBm±2dBm / 50Ω**
- **GPS antenna (15 VDC)**
- **LAN: NTP & SNTP for time, navigation, status and BIT**

#### Input

- **Ext. 1 PPS (for locking to external source)**
- **LAN for command, control and data: setting time/date, delay correction for 1PPS 10ns steps, mode of operation (disciplining GPS, to Ext 1PPS, holdover, UTC time, GPS Time, Local Time, Day Light Saving) etc.** (see IDD document for more information)

#### Monitor & Control

- **RS-232 for command, control and data: setting time/date, delay correction for 1PPS 10ns steps, mode of operation (disciplining GPS, to Ext 1PPS, holdover, UTC time, GPS Time, Local Time, Day Light Saving) etc.** (see CLI document for more information)

### Performance

<table>
<thead>
<tr>
<th>Mode of operation:</th>
<th>Disciplined to GPS or to Ext. 1PPS</th>
<th>Free running Rubidium-Standard (holdover)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time (1PPS)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term Accuracy</td>
<td>&lt;30 ns RMS; &lt; 50ns RMS under environmental conditions</td>
<td>&lt; 1μs/day (typical), 5μs/week (typical)</td>
</tr>
<tr>
<td><strong>Long Term Stability</strong></td>
<td>&lt;2E-12</td>
<td>5E-11 / month drift in holdover</td>
</tr>
<tr>
<td><strong>Short Term Stability</strong></td>
<td>&lt;3E-11 @ 1sec ; &lt;3E-12 @ 100sec</td>
<td></td>
</tr>
<tr>
<td>Temperature Stability</td>
<td>±3E-10 over -40°C to +55°C ; ±2.5E-10 over -40°C to +55°C (typical)</td>
<td></td>
</tr>
<tr>
<td><strong>Phase Noise</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;95 dBc/Hz @ 10Hz</td>
<td>&lt;90 dBc/Hz @ 10Hz</td>
<td></td>
</tr>
<tr>
<td>&lt;130 dBc/Hz @ 100Hz</td>
<td>&lt;128 dBc/Hz @ 100Hz</td>
<td></td>
</tr>
<tr>
<td>&lt;148 dBc/Hz @ 1kHz</td>
<td>&lt;140 dBc/Hz @ 1kHz</td>
<td></td>
</tr>
<tr>
<td>&lt;152 dBc/Hz @ 10kHz</td>
<td>&lt;155 dBc/Hz @ 10kHz</td>
<td></td>
</tr>
<tr>
<td>51.2MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;100 dBc/Hz @ 10Hz</td>
<td>&lt;72 dBc/Hz @ 10Hz</td>
<td></td>
</tr>
<tr>
<td>&lt;130 dBc/Hz @ 100Hz</td>
<td>&lt;115 dBc/Hz @ 100Hz</td>
<td></td>
</tr>
<tr>
<td>&lt;140 dBc/Hz @ 1kHz</td>
<td>&lt;130 dBc/Hz @ 1kHz</td>
<td></td>
</tr>
<tr>
<td>&lt;140 dBc/Hz @ 10kHz</td>
<td>&lt;144 dBc/Hz @ 10kHz</td>
<td></td>
</tr>
<tr>
<td><strong>Harmonics (10MHz)</strong></td>
<td>-45 dBc</td>
<td></td>
</tr>
<tr>
<td><strong>Spurious (10MHz)</strong></td>
<td>-85dBc (+100KHz from carrier)</td>
<td></td>
</tr>
<tr>
<td><strong>Warm-up</strong></td>
<td>5E-10 within &lt;7 min, 5E-11 within &lt; 60 min, 1E-11 within &lt;4hrs</td>
<td></td>
</tr>
<tr>
<td><strong>RS232 Output</strong></td>
<td>Time, date, location and status, 19,200bps, 1 frame/sec</td>
<td>10 frames/sec</td>
</tr>
<tr>
<td><strong>LAN</strong></td>
<td>10/100 Base-T - All Commands, Control and Communication, TOD, Location. Support any client which comply for NTP Standards protocol ver. 3.0</td>
<td></td>
</tr>
</tbody>
</table>
SPECIFICATIONS (continu)

All specs are at room temperature, quiescent conditions, sea level ambient unless otherwise specified

### Power Supply
- **Operating Voltage**: 28 VDC per MIL-STD-704A
- **Current**: <2.5A @ warm-up ; <1A @ steady state 25°C
- **Battery Back-Up**: 1 hour operation (25°C) 16 hours charge

### GPS Receiver
- **General**: L1, C/A code, 12 channel continuous tracking, All-In-View
- **Dynamic**: Velocity 0 to 515 m/s, Acceleration 4g, Jerk 4g/s
- **Altitude**: –1000 to 18000 m
- **Update data**: 10 Hz
- **Accuracy**:
  - Position: 2 m RMS in differential modes ; 3 m RMS in common mode ; 15m RMS in standalone mode
  - Velocity: 0.05 m/s RMS
- **1PPS Accuracy**: 40 ns RMS
- **TTFF (Time To First Fix)**: 20 sec typical (with current ephemeris) ; 50 sec typical (without ephemeris); Cold Start: 2 min typical (@25C)

### GPS Antenna
- **Available Antenna**
  - **Airborne** (AccuBeat P/N: EM30035)
    - Frequency: L1,L2 GPS ANTENNA: 1227 MHz ±10 MHz; 1575 MHz ± 10 MHz
    - Gain: 36 dB ± 2db
  - **Ground** (AccuBeat P/N: EM30036)
    - Frequency: L1 GPS Antenna
    - Gain: 36 dB

### Dimensions & Weight
- **Without vibration isolator**
  - Dimensions: 241 (w) x 128 (h) x 246 (d) mm
  - weight: 4.0 kg
- **With vibration isolator tray and battery module**
  - Dimensions: 280 (w) x 183 (h) x 352 (d) mm
  - Weight: 8.0 Kg (Unit + 2.5 kg battery + 1.5 kg shock absorber tray)

### Environmental
- **Temperature**
  - Operating: -40°C to +55°C
  - Storage: -40°C to +85°C
- **Temperature/ Altitude**
  - MIL-STD-810C. Method 520.1, procedure III modified, 45000 feet (with internal battery 9000feet
- **Vibration**
  - MIL-STD-810D, Method 514.3 Cat.6 Level 0.01g²/Hz 2 hours per axis (with Shock Mount)
  - Various vibration spectra 5-2000 Hz with 5.2 g RMS, 2 hours per axis.
- **Transportation vibration**
  - MIL-STD-810D, Meth.514.3, Cat. I Fig. 514.3-1,2,3 (1Hr per Axis)
- **Bench-handling Shock**
  - MIL-STD-810E, Method 516.4, Proc. 6
- **Shock (operation)**
  - MIL-STD-810E, Method 516.4, Proc 6, (20g, ramp, 11msec 3 axis total 18 Shocks –all with Shock Mount)
- **Crash Safety Shock**
  - MIL-STD-810E, Method 516.4, Proc 6, (40g, ramp, 11msec 3 axis total 12 Shocks –all with Shock Mount)
- **Rapid decompression**
  - MIL-STD-810E, Method 500.3, Procedure 3
- **Explosive atmosphere**
  - MIL-STD-810E, Method 511.3, Procedure 1
- **EMI / RFI**
  - MIL-STD-461C, CE03, CS01,CS02, CS06, RE01, RE02, RS01, RS02, RS03, CE06,CS03, CS04, CS05
  - RTCA/DO160-Lighting induced curent, bulk cable injection
- **Humidity**
  - 95% RH, MIL-STD-810E, Method 507.3, Proc. 1 Cycle 3 Fig 507.3-1
- **Dust**
  - MIL-STD-810E Method 510.3
- **Water drip**
  - MIL-STD-810E, Method 506.3, Procedure 2
- **Fungus**
  - MIL-STD-810E, Method 508.4 analysis
- **Salt Fog**
  - MIL-STD-810E, Method 509.3, Procedure 1 analysis

### Reliability, Maintainability, Testability
- **MTBF**: 6,713 Hrs. 45°C AUG; 9,014 Hrs. 30°C AUG; as per MIL-HBK-217F N2 (Include battery)
- **Built-In-Test (BIT)**: 87% - O level; 90% - I level
- **Display LED's**
  - Lock to Rb, Lock to GPS, Lock to External, LAN, Power and Battery
- **MTTR**
  - **O Level**: 17 min to replace failed unit
  - **I Level**: 37 min to replace failed module
### SPECIFICATIONS (continu)

All specs are at room temperature, quiescent conditions, sea level ambient unless otherwise specified.

#### Principles of Operation

The following block diagrams depict the operation of the AR51A-04. The unit includes a Rubidium Standard and accepts input from either internal GPS receiver or external 1PPS signal. All outputs are derived from the internal Rubidium Clock, which is phase locked via a digital PLL to the internal GPS receiver or to the external input. Thus, the Rubidium Clock - frequency and time - follows the GPS on average. If GPS reception is lost for a time period, the Rubidium Clock continues to maintain accurate time and frequency. The unit can control, via LAN, GPS and external 1PPS inputs and output delay corrections.

![Block Diagram](image1.png)

**Data flow & Inputs Selection**

**Rubidium-GPS D-PLL and Inputs**

#### Mechanical ICD

![Mechanical ICD](image2.png)

#### Electrical ICD

<table>
<thead>
<tr>
<th>Connector</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1 - Supply</td>
<td>D38999/24WA98PN</td>
</tr>
<tr>
<td>J2 – Battery in</td>
<td>D38999/24WD35SN</td>
</tr>
<tr>
<td>J3 – 10MHz Clock and 6X 1PPS RS-422 outputs</td>
<td>D38999/24WD35SB</td>
</tr>
<tr>
<td>J4 – Extern lock Input and Factory use</td>
<td>D38999/24WB35SN</td>
</tr>
<tr>
<td>J5 – 10 MHz sine output</td>
<td>SMA</td>
</tr>
<tr>
<td>J6 and J7 other frequency</td>
<td>SMA</td>
</tr>
<tr>
<td>J8 – 6X 1PPS TTL outputs</td>
<td>D38999/24WE06BN</td>
</tr>
<tr>
<td>J9 – LAN</td>
<td>D38999/24WA35SA</td>
</tr>
<tr>
<td>J10 – GPS Antenna output</td>
<td>TNC</td>
</tr>
<tr>
<td>J11 – GPS Antenna Input</td>
<td>TNC</td>
</tr>
<tr>
<td>J12 – Factory use</td>
<td>SMA</td>
</tr>
<tr>
<td>J13 and J14 – 1PPS TTL</td>
<td>SMA</td>
</tr>
</tbody>
</table>
All specs are at room temperature, quiescent conditions, sea level ambient unless otherwise specified.

### Typical Performance Plots

- **Typical time error in Holdover (without GPS)** – 710ns in ~64000s
- **Typical time error fluctuations when disciplined to GPS**

### HOW TO ORDER

<table>
<thead>
<tr>
<th>ACCESSORIES</th>
<th>AccuBeat P/N:</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR51A-04</td>
<td>AR51004</td>
</tr>
<tr>
<td>Battery</td>
<td>AA50408</td>
</tr>
<tr>
<td>Vibration isolator</td>
<td>MU50012</td>
</tr>
<tr>
<td>Airborne L1,L2 GPS Antenna 36 dBm</td>
<td>EM30035</td>
</tr>
<tr>
<td>Ground L1 GPS Antenna 36 dBm</td>
<td>EM30036</td>
</tr>
<tr>
<td>Antenna Cable</td>
<td>Contact Factory</td>
</tr>
</tbody>
</table>