# N238PS — G1000 LOW VOLTS Troubleshooting Guide

**Aircraft:** N238PS (Diamond DA40NG, MAM40-858) **Problem:** G1000 NXi displays lower voltage than actual bus voltage, causing intermittent LOW VOLTS annunciations **Date:** February 2026 **Prepared by:** Aircraft Owner (Ingram Leedy)

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## The Problem

The G1000 consistently reads **1–2 volts lower** than actual bus voltage, with transient dips up to **5.6 volts low** during high-current events. This causes false LOW VOLTS annunciations in flight even though the electrical system is charging normally.

### FlySto LOW VOLTS Events (In-Flight)

These FlySto screenshots show actual LOW VOLTS events captured from G1000 flight logs. The voltage drops below the 25V threshold repeatedly during normal flight operations:

**85 seconds below 25V** — approach and taxi at KBOW, voltage swinging wildly between 24–27V:


**18 seconds below 25V** — during landing, and **5 seconds below 25V** — at altitude during cruise:

## Volts < 25 V

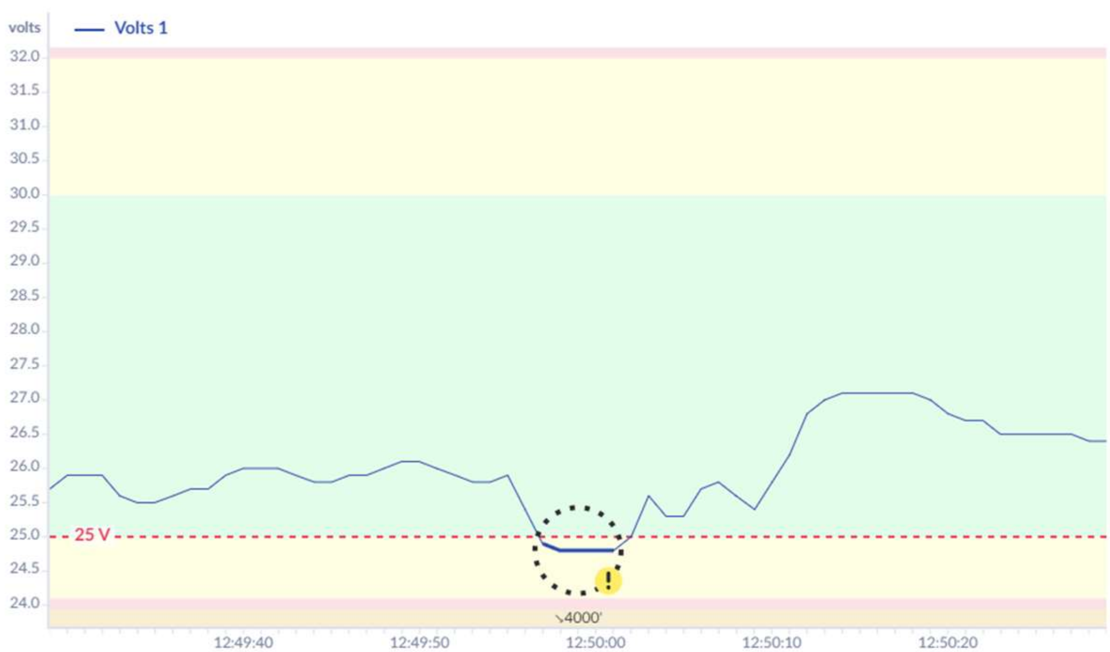
Volts < 25 V for 18 sec in total

Graph | Map


## Volts < 25 V

Volts < 25 V for 5 sec

Graph | Map



These dips are **not real** — the independent VDL48 logger shows the bus voltage is steady at ~28V during these same periods. The G1000 is the only instrument seeing these drops.

## How We Know It's Real

Three independent measurements were taken on the same aircraft, on the same flights. Two agree. One doesn't.

| Source | Where It Measures | Average Reading | Verdict |
|---|---|---|---|
| **VDL48 data logger** (plugged into AUX POWER) | Direct battery voltage | **28.3V** | Correct |
| **ECU battery voltage** (engine computer) | Separate bus and ground path | **27.8V** | Correct |
| **G1000 volt1** | Through instrument panel ground studs | **26.9V** | **Reads low** |

The VDL48 and ECU agree — the bus voltage is normal (~28V with alternator). The G1000 is the only instrument reading low.

### How the Data Was Collected

| Data Source | Collection Method | Sample Rate | Coverage |
|---|---|---|---|
| **G1000 NXi flight logs** | Automatically collected every flight by the **Flight Stream 510 (AirSync)** and uploaded to FlySto.net. CSV source files downloaded from FlySto. | 1 second | **184 flights**, Jul 2023 – Feb 2026 (entire aircraft history since delivery) |

| | | | |
|---|---|---|---|
| **AE300 ECU data logs** | Extracted from the ECU's built-in data logger via USB using **AE300-Wizard** software (Austro Engine's download tool). The encrypted `.ae3` binary log files were then decrypted and parsed into readable CSV using **AustroViewer** (github.com/ingramleedy/AustroViewer, private repo). The ECU records 16 channels including battery voltage (channel 808) every engine run automatically. | 1 second | **265 sessions**, Oct 2023 – Feb 2026 |
| **VDL48 voltage logger** | Triplett VDL48 standalone data logger plugged into AUX POWER plug (HOT BUS, direct battery) | 2 seconds | **2 flights** on Feb 8, 2026 (3.5 hours flight time + 1.4 hours ground idle) |

- The **G1000 logs** `volt1` — the bus voltage displayed on the PFD/MFD, measured by the GEA 71S via its voltage sense input (Pin 46 (ANALOG IN 5 HI) / Pin 47 (ANALOG IN 5 LO)) from the Essential Bus
- The **ECU logs** `Battery Voltage` (channel 808) — the AE300 engine computer's own battery voltage reading, measured through a separate bus (ECU BUS) and separate ground path (GS-RP studs)
- The **VDL48** measures voltage at the AUX POWER plug on the HOT BUS — a direct connection to the battery through only a 5A fuse, no relays or breakers. This gives the cleanest reference of actual bus voltage.

All three sources were time-aligned and compared using paired statistical analysis. The full analysis scripts and raw data are available in the project repository at github.com/ingramleedy/volts.

### Ground Test (Aug 18, 2025 — battery only, no engine)

| Condition | Meter at AUX POWER | G1000 Display | Difference |
|---|---|---|---|
| Master ON, G1000 on, no other loads | **25.2V** | **23.7V** | **-1.5V** |

The offset exists on the ground with battery only. This rules out the alternator, voltage regulator, and charging system entirely.

### Why the Battery Matters (but isn't the cause)

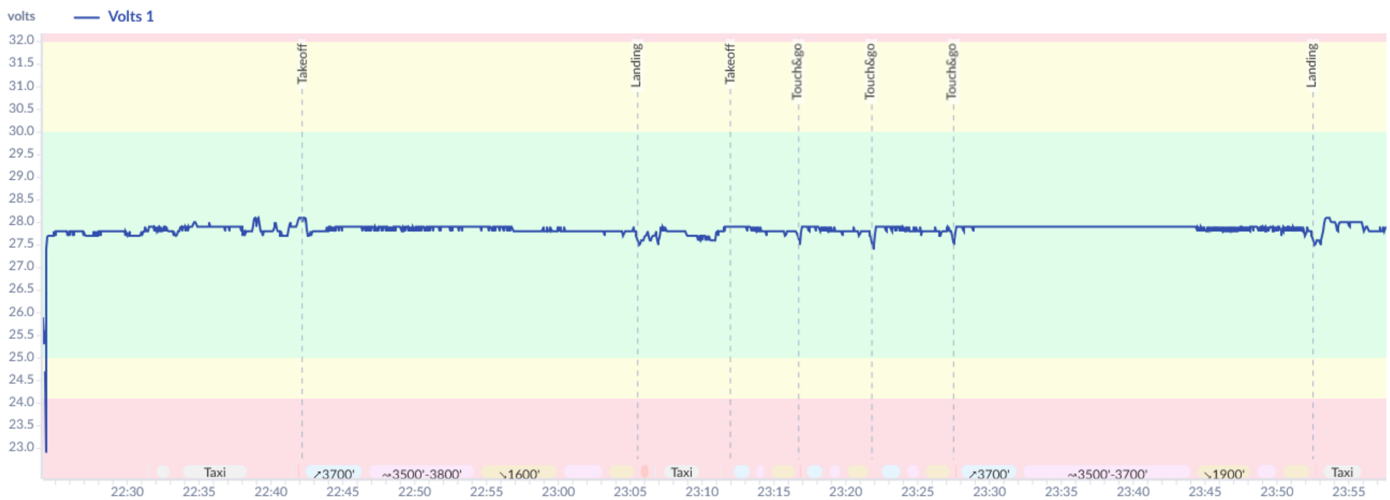
The ground path drops ~1.4V regardless of battery condition. But the higher the starting bus voltage, the more headroom the G1000 has before hitting the 25V LOW VOLTS threshold. A fully charged battery with alternator running keeps the bus at ~28V, so the G1000 reads ~26.6V — above the threshold most of the time. If the battery is weak or undercharged, the bus sits lower and the G1000 dips below 25V more easily.

A **BatteryMinder** trickle charger was installed and keeps the battery fully maintained between flights when returned to the home hangar. However, when away from the home hangar this isn't used. When maintained, this maximizes voltage headroom and keeps the G1000 reading within operational margins most of the time — but it's a workaround, not a fix. High-current transient loads (radio TX, autopilot servos, flaps) still cause dips that break through even that margin, which is what triggers the LOW VOLTS annunciations seen in the FlySto screenshots above.

## When It Started and How It's Getting Worse

### The Problem Existed From Day One

Comparing N238PS to another DA40NG (N541SA) shows something was never right — even from the delivery flight:




N541SA's G1000 reads rock-steady voltage at ~27.8V with barely any fluctuation. N238PS has **never** been this stable:

| Metric | N541SA | N238PS Brand New (Jul 2023) | N238PS Pre-Feb 2024 | N238PS Post-Feb 2024 |
|---|---|---|---|---|
| Mean voltage | ~27.8V | 27.55V | 27.44V | 26.86V |
| Noise | ~0.05–0.10V | 0.36V | 0.38V | 0.51V |
| Peak-to-peak range | ~0.3V | 4.4V | 4.6V | 5.2V |
| Time below 27V | ~0% | 6.2% | 6.2% | **53.5%** |

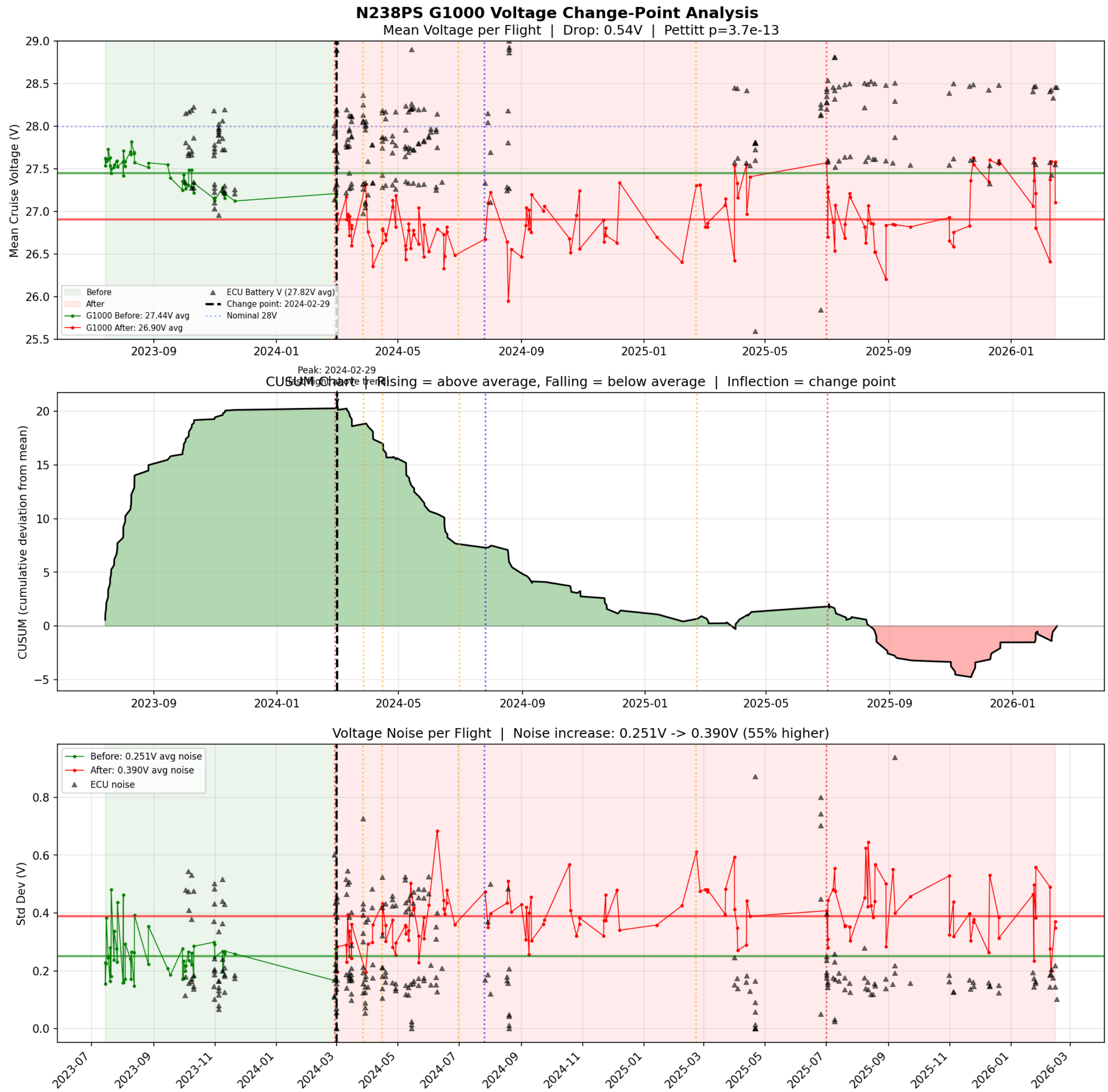
Even from delivery, N238PS was reading **0.25V low** and had **4–5x more voltage noise** than N541SA. This suggests a marginal ground connection has existed since the factory — the Feb 2024 shop visit then made it significantly worse.

### The Change-Point: February 2024

Statistical analysis of **184 flight logs** (Jul 2023 – Feb 2026) pinpoints exactly when the readings shifted. A statistically significant change-point was detected on **February 29, 2024**:

| Period | Mean G1000 Voltage | Voltage Noise |
| --- | --- | --- |
| Before shop visit (53 flights) | 27.44V | 0.25V |
| After shop visit (131 flights) | 26.90V | 0.39V |
| **Change** | **-0.54V** | **+55% noisier** |

The ECU voltage did NOT change — it reads a steady 27.82V throughout the entire period. The problem is G1000-specific. The Feb 2024 shop visit made a pre-existing marginal connection worse, pushing it into LOW VOLTS territory.




**How to read this chart:**

- **Top panel** — Each dot is one flight's average voltage. Green = before Feb 2024, red = after. The ECU dots along the top stay flat at ~27.8V the entire time — the actual bus voltage never changed. Only the G1000 dropped.
- **Middle panel** — A trend line showing the problem is getting progressively worse over time, with a clear inflection at Feb 2024.
- **Bottom panel** — Voltage noise (how much the reading jumps around during each flight). After Feb 2024, noise increased 55% — consistent with a loose or corroded connection that vibration makes worse.

## What Happened During That Shop Visit (Feb 2024)

The engine R&R (oil leak) was not the only work performed. During the same visit:

1. **Engine removed and reinstalled** — oil sump gasket and cylinder head cover (firewall connectors disconnected/reconnected)
2. **Alternator #2 replaced** — the RACC (AC system) wasn't turning on and wasn't getting power to the AUX switch
3. **RACC relay troubleshooting** — relays in the **aft avionics bay** were inspected to diagnose the RACC power issue
4. **GSA 91 pitch servo replaced** — autopilot pitch servo (also in the aft area)

The scope of this visit was extensive — engine R&R, alternator swap, relay troubleshooting in the aft bay, servo replacement. Panels were opened, harnesses were moved, and connectors were handled throughout the aircraft. Something during this visit disturbed a ground connection, and nobody noticed the G1000 was now reading a volt low.

A second engine R&R in Jul 2025 (piston crack) did **not** fix the problem, ruling out the firewall pass-through connectors (which were reconnected during that work). The GSA 91 pitch servo was also replaced a second time — also with no improvement.

## What Has Already Been Tried (and didn't fix it)

| Date | Action | Result |
|---|---|---|
| Feb 2024 | Replaced alternator #2 (RACC) + RACC relay troubleshooting | Fixed RACC — but G1000 voltage problem started here |
| Feb 2024 | Replaced GSA 91 pitch servo | No improvement on voltage |
| Apr 2024 | Replaced voltage regulator | No improvement |
| Jun 2024 | Replaced voltage regulator again + repaired wire at P2208 | No improvement |
| Jul 2024 | Replaced P2413 connector (repinned HSDB harness) | Fixed COM/NAV/GPS cycling issue — no improvement on voltage |
| Feb 2025 | Replaced main alternator AND voltage regulator (3rd time) | No improvement |
| Jul 2025 | Engine R&R #2 + new battery + GSA 91 pitch servo replaced again | No improvement |
| Feb 2026 | Cleaned GDL 69A pins (CH.23) | No improvement — wrong unit |

None of these addressed the ground path. The alternator and regulators were never the problem — the ECU confirms the charging system works correctly.

The Feb 2026 pin cleaning targeted the **GDL 69A** (SiriusXM datalink transceiver, CH.23). The voltage measurement comes from the **GEA 71S** (Engine/Airframe unit, connector P701) — its power ground pins (Pin 20 (POWER

GROUND) and Pin 45 (ANALOG IN 4 LO), wire 77016A22N to **GS-IP-14**) were not inspected, nor were the voltage sense pins (Pin 46 (ANALOG IN 5 HI) and Pin 47 (ANALOG IN 5 LO), wires 31299A22WH/BL to the Essential Bus).

**Note:** This aircraft has a history of connector/pin problems. In May 2023, the G1000 experienced repeated COM/NAV/GPS/AHRS cycling and autopilot disconnects during an IFR flight — that issue was resolved by cleaning pins and reseating the P2413 HSDB harness connector (Jul 2024). Connector issues are a known problem on this airframe. The voltage problem is the same type of issue — a bad connection — just at a different connector/stud that hasn't been addressed yet.

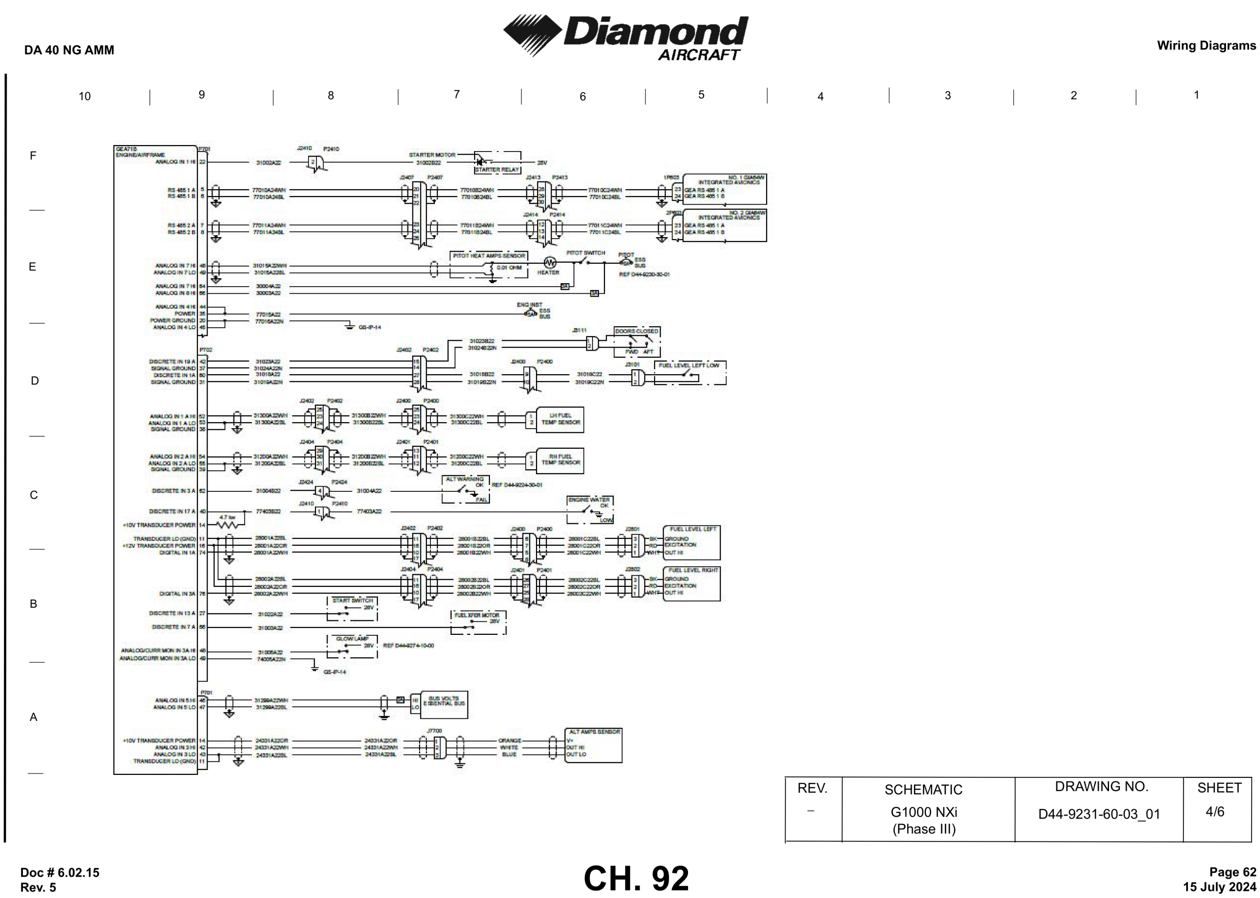
## What's Causing It

**A high-resistance ground connection** somewhere in the GEA 71S's ground return path.

### Where the Voltage Is Actually Measured

The G1000 bus voltage ("volt1") is measured by the **GEA 71S** (Engine/Airframe unit), mounted on the **instrument panel shelf** behind the MFD (AMM 31-40-00, p.985, Figure 6). It is the bottom-left unit on the shelf, accessible by removing the lower instrument panel cover.

**AMM Schematic — G1000 NXi GEA 71S Wiring (D44-9231-60-03, G1000 NXi Phase I & II, Sheet 4/6):**




- Per the AFM (Doc 6.01.15-E, Section 7.10.1, p.7-43): *"The voltmeter shows the voltage of the essential bus. Under normal operating conditions the alternator voltage is shown, otherwise it is the voltage of the main battery."*

- The GEA 71S **senses bus voltage via a dedicated analog input** — Pin 46 (ANALOG IN 5 HI) and Pin 47 (ANALOG IN 5 LO), connected to the **Essential Bus** via shielded wires 31299A22WH/BL. A **3A fuse** protects the HI wire (31299A22WH); its physical location is not identified on the available AMM schematics. This fuse carries essentially no current (high-impedance analog input), so degraded fuse contacts would not cause the observed offset. An open fuse would produce a **0V reading**, not a low reading.
- **GEA power:** Pin 35 (AIRCRAFT POWER) and Pin 44 (ANALOG IN 4 HI) are connected to each other on wire **77015A22**, routed through the **5A ENG INST** breaker on the **Essential Bus**. Pin 44 lets the GEA self-sense its own supply voltage.
- **GEA power ground:** Pin 20 (POWER GROUND) and Pin 45 (ANALOG IN 4 LO) are connected to each other on wire **77016A22N** → ground stud **GS-IP-14**. Pin 49 (ANALOG/CURR MON LO) via wire **74005A22N** also to **GS-IP-14** (glow lamp circuit, probably unrelated)
- The displayed voltage = what Pin 46 (ANALOG IN 5 HI — voltage sense) sees on the Essential Bus, relative to the GEA's ground reference at Pin 20 (POWER GROUND) and Pin 45 (ANALOG IN 4 LO). Any resistance on ground Pin 20 (POWER GROUND), Pin 45 (ANALOG IN 4 LO), or sense low Pin 47 (ANALOG IN 5 LO) shifts the reading down

No software calibration or correction is applied — the G1000 displays exactly what the GEA 71S hardware measures. The offset is a **hardware voltage drop**, not a calibration or firmware problem. Adjusting the software offset would only mask the symptom — the underlying problem would remain and continue to degrade.

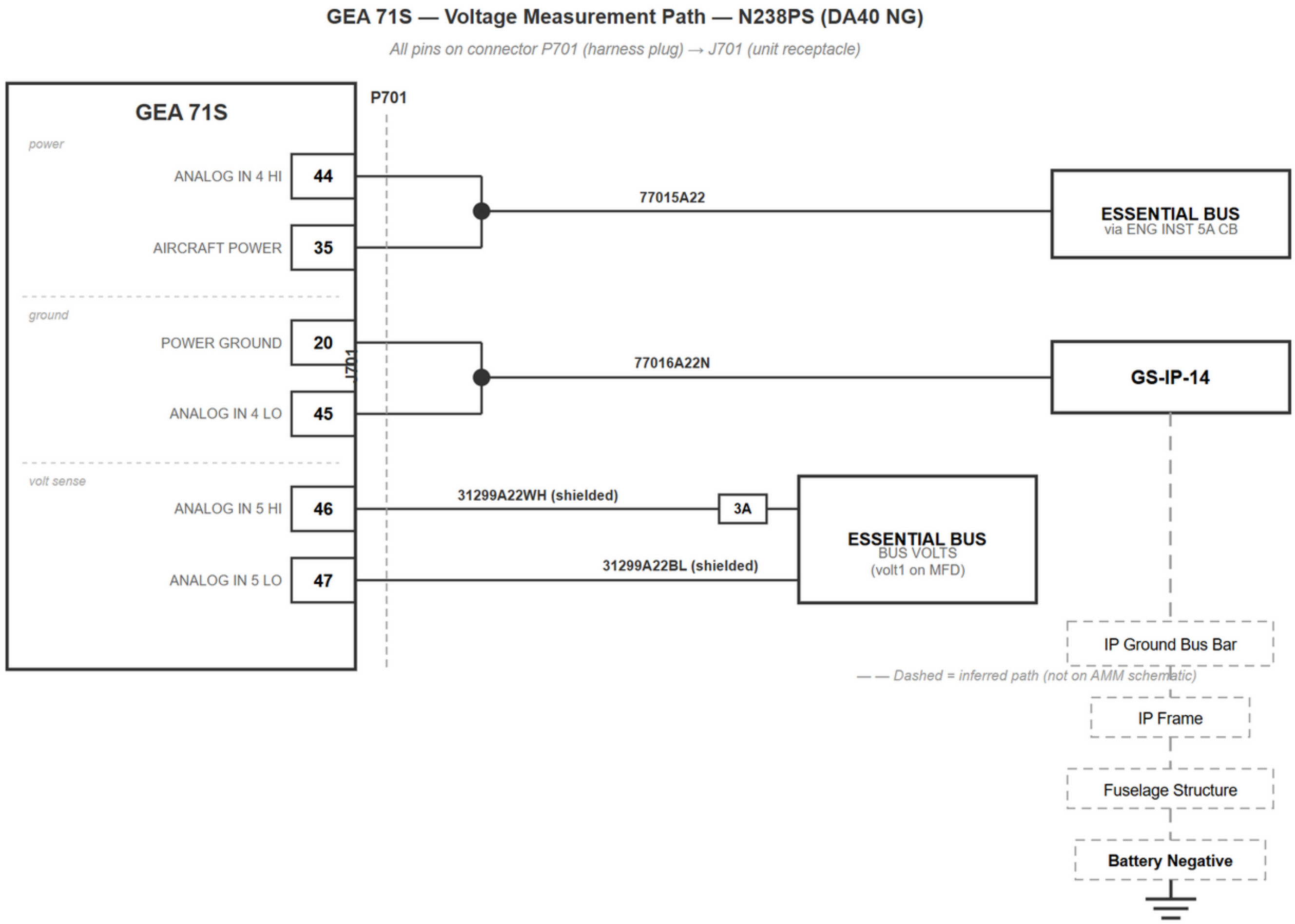
## How a Bad Ground Creates a False Low Reading

If there's extra resistance in the ground path, current flowing through that resistance creates a voltage drop that only the GEA sees:

```
V_displayed = V_actual - (I_load × R_bad_ground)
```

At 20 amps of avionics load, just **0.05 ohms** of extra ground resistance = **1.0 volt** of under-reading. That's all it takes.

## The Voltage Measurement Path




*Solid lines = documented on AMM CH.92 schematics. Dashed lines = inferred path (standard aircraft grounding practice, not shown on available schematics).*

**Connector identification:** The GEA 71S has two receptacles — **J701** and **J702**. The harness plugs that mate to them are **P701** and **P702**. All voltage-related pins (Pin 20 (POWER GROUND), Pin 35 (AIRCRAFT POWER), Pin 44 (ANALOG IN 4 HI), Pin 45 (ANALOG IN 4 LO), Pin 46 (ANALOG IN 5 HI), Pin 47 (ANALOG IN 5 LO)) are on the **P701 / J701** connector. When testing, look for the harness plug labeled **P701** on the instrument panel shelf behind the GEA unit. The AMM schematic splits P701 across multiple drawing sections for clarity, but physically it is one connector.

Both voltage channels share the same ground reference (Pin 20 (POWER GROUND) / Pin 45 (ANALOG IN 4 LO) → wire 77016A22N → **GS-IP-14**). A high-resistance ground shifts **both** readings down equally.

## Why Only the G1000 Reads Low

The GEA 71S grounds through **GS-IP-14** (power ground Pin 20 (POWER GROUND) and Pin 45 (ANALOG IN 4 LO), wire 77016A22N), which must return to the battery negative terminal through the instrument panel ground bus bar, IP frame structure, and fuselage. The exact routing from the GS-IP bus bar to battery negative is not shown on the AMM CH.92 wiring schematics (see Documentation Status below) — but current must complete this circuit, and every joint in the chain adds potential resistance.

The ECU (located under the pilot's seat) grounds through the **GS-RP** (Ground Stud — Relay Panel) studs, which use a separate ground path to battery negative. The ECU reads correctly — its ground path doesn't share the instrument panel's bus bar, frame bonds, or GS-IP studs.

```
GEA 71S → GS-IP studs → IP bus bar → IP frame → fuselage → battery negative (reads low)
^^^^^^^^^^^ ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^ documented inferred — not on
AMM CH.92 schematics ECU → GS-RP studs → separate ground path → battery negative (reads
correctly)
```

### How the Voltage Data Flows to the G1000 Displays

The GEA 71S and ECU are completely independent measurement systems that communicate with the G1000 displays through separate digital data buses (per AMM CH.92 D44-9231-60-03 (G1000 NXi Phase I & II) and Garmin 190-00303-40):

```
GEA 71S ■■RS-485■■→ GIA 63W ■■HSDB■■→ GDU displays (bus voltage, amps, temps) ECU
■■RS-232■■→ GIA 63W ■■HSDB■■→ GDU displays (engine: RPM, fuel, oil, EGT/CHT)
```

- The **GEA 71S** sends airframe measurements (including the voltage reading) to both GIA computers via **RS-485** (P701 pins 5–8, differential pairs)
- The **ECU (AE300)** sends engine parameters to a GIA via **RS-232** (serial, separate connection)
- The GEA does not interface with the ECU — they are independent paths into the GIA
- The voltage displayed on the MFD comes **only** from the GEA, not from the ECU. The ECU's own battery voltage reading (channel 808) is stored in the ECU's internal data log but is never shown on the G1000 displays

This means the G1000 has no way to cross-check the GEA's voltage reading against the ECU's — it simply displays what the GEA reports. The only way to see the ECU's battery voltage is by downloading the ECU data log separately (via AE300-Wizard), which is how we discovered the discrepancy.

## Where to Look

### Instrument Panel

The **GEA 71S** — the unit that actually measures the voltage — is on the **instrument panel shelf** (AMM 31-40-00, p.985). Its harness connector **P701** (mates to receptacle **J701** on the unit) and ground stud **GS-IP-14** are in this area. The GEA also has a second connector pair (**P702 / J702**) but the voltage-related pins are all on P701.

**Inspect:** - **GEA 71S harness plug P701** — is it fully seated with lock engaged on the J701 receptacle? This connector carries all voltage measurement pins. Check Pin 20 (POWER GROUND), Pin 45 (ANALOG IN 4 LO), and Pin 35 (AIRCRAFT POWER) specifically. - **Ground stud GS-IP-14** — this is where the GEA 71S power ground wires (Pin 20 (POWER GROUND) and Pin 45 (ANALOG IN 4 LO), wire 77016A22N) terminate. Check for loose nut, corrosion, or paint under the ring terminals. - All GS-IP ground studs on the IP bus bar (see table below) - Look for anything that appears disturbed, loose, or not fully reconnected

### Ground Stud Locations (GS-IP Series)

All G1000 components ground to the **GS-IP** (Ground Stud — Instrument Panel) group. These are the specific studs and what's connected to each:

| Ground Stud | What's Connected | Priority |
|---|---|---|
| **GS-IP-14** | **GEA 71S Pin 20 (POWER GROUND) + Pin 45 (ANALOG IN 4 LO)** (both wire 77016A22N) + Pin 49 (ANALOG/CURR MON LO) glow lamp (wire 74005A22N) | **CHECK FIRST** — the voltage sensor's power ground (all GEA ground pins terminate here) |
| **GS IP-6** | GIA 63W #1 (wire 23011A20N, 20 AWG) + GIA 63W #2 (wire 23001A20N, 20 AWG) | **CHECK SECOND** — both avionics computers share this one stud |
| **GS IP-4** | GDU 1050 PFD + GDU 1060 MFD + GMA 1360 Audio + COM 1 | Check third — most heavily loaded stud (4 LRUs) but not the voltage sensor ground |
| **GS IP-5** | GRS 79 AHRS #1 + AHRS #2 (via GS AVB bus bar) | Check fourth |
| **GS IP-3** | GPS/NAV 1 + Wx 500 Stormscope (not installed on N238PS) | Check fifth |
| **GS IP-10** | GPS/NAV 2 | Lower priority |

### What to Look For at Each Ground Stud

- Loose nut (vibration loosens over time)
- Corrosion under the ring terminal (green/white buildup)
- Paint, primer, or anodize between the ring terminal and the stud surface
- Cracked or deformed ring terminal
- Multiple ring terminals stacked on one stud not all making good contact
- Lock washer missing or flattened

### LRU Connectors to Inspect

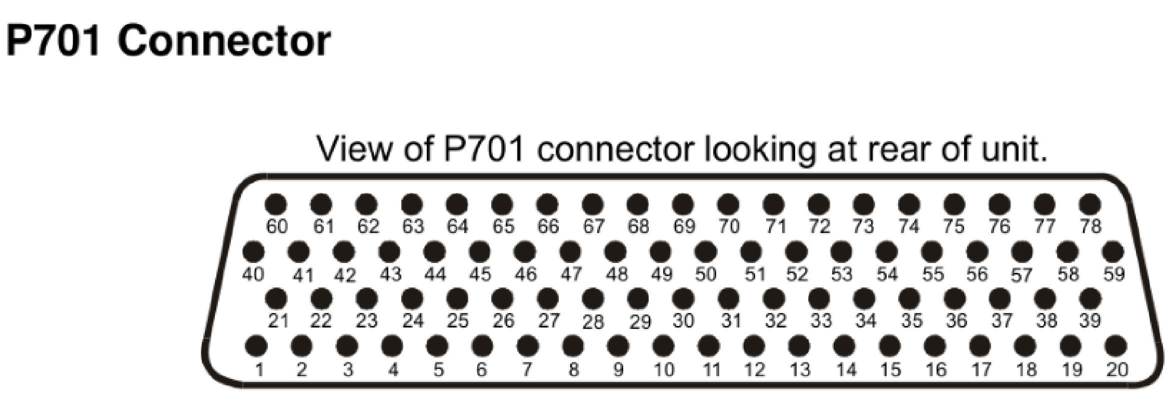
The voltage reading comes from the GEA 71S — its ground pin is the most critical. The displays (GDU) are on the instrument panel and share the same GS-IP bus bar:

| Unit | Harness Plug → Unit Receptacle | Ground Pin | Wire | Ground Stud | What It Does |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| **GEA 71S** | **P701 → J701** | **Pin 20 (POWER GROUND)** | **77016A22N (22 AWG)** | **GS-IP-14** | **THIS IS THE VOLTAGE SENSOR** — power ground reference for all measurements |
| **GEA 71S** | **P701 → J701** | **Pin 45 (ANALOG IN 4 LO)** | **77016A22N (22 AWG)** (tied to Pin 20 (POWER GROUND)) | **GS-IP-14** | **Additional ground pin** — ground return for analog channel 4, same wire as Pin 20 (POWER GROUND) |
| **GDU 1050 PFD** | 1P1600 | Pin 27 (POWER GROUND) | 31106A22N (22 AWG) | GS IP-4 | Primary flight display |
| **GDU 1060 MFD** | 2P1601 | Pin 27 (POWER GROUND) | 31158A22N (22 AWG) | GS IP-4 | Multi-function display |

### GEA 71S P701 / J701 Pin Reference (Garmin 190-00303-40)

**P701 harness plug — view looking at rear of connector:**




Full pin listing: GEA 71 Installation Manual (190-00303-40) — pages 23–26

When you have the GEA 71S connector P701 in hand, these are the pins relevant to the voltage problem:

**Voltage measurement circuit (inspect all of these):**

| Pin | Function | Wire (from AMM CH.92) | Where It Goes | Why It Matters |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **46** | **ANALOG IN 5 HI** | **31299A22WH** (shielded) | **Essential Bus via 3A fuse (HI)** | **Voltage sense high — what's being measured.** A 3A fuse protects this wire. If the fuse were open, the reading would be **0 volts** (no signal), not a low reading — so the fuse is not the cause of our ~1.4V offset. The fuse location is not shown on the AMM schematic. |
| **47** | **ANALOG IN 5 LO** | **31299A22BL** (shielded) | **BUS VOLTS ESSENTIAL BUS (LO)** | **Voltage sense low — reference for the measurement** |
| **44** | **ANALOG IN 4 HI** | **77015A22** (tied to Pin 35 (AIRCRAFT POWER)) | **GEA power supply** (same wire as AIRCRAFT POWER) | **Measures GEA's own supply voltage (Essential Bus)** |
| **45** | **ANALOG IN 4 LO** | **77016A22N** (tied to Pin 20 (POWER GROUND)) | **GS-IP-14** (ground) | **GEA ground pin — same wire as Pin 20 (POWER GROUND), shares ground path** |
| **35** | **AIRCRAFT POWER 1** | **77015A22** | **Essential Bus via ENG INST 5A** | **GEA power supply — affects internal voltage reference** |
| **20** | **POWER GROUND** | **77016A22N** | **GS-IP-14** | **GEA ground reference — if high-R, ALL readings shift** |
| 37 | AIRCRAFT POWER 2 | — | Second power input | Redundant power |

**Other GEA pins (for reference):**

| Pin | Function | Wire | Where It Goes |
|---|---|---|---|
| 48 | ANALOG/CURR MON IN 3A HI | 31006A22 | Glow lamp current monitor |

| | | | |
|---|---|---|---|
| 49 | ANALOG/CURR MON IN 3A LO | 74005A22N | **GS-IP-14** (glow lamp ground — probably unrelated to voltage) |
| 42 | ANALOG IN 3 HI | 24331A22WH | Alt amps sensor OUT HI |
| 43 | ANALOG IN 3 LO | 24331A22BL | Alt amps sensor OUT LO |
| 14 | +10V TRANSDUCER POWER | 24331A22OR | Powers alt amps sensor |
| 11 | TRANSDUCER GROUND | — | Ground return for current sensor |
| 5–8 | RS 485 1A/1B, 2A/2B | 77010/77011 | Digital data bus to GIA computers |

**GEA ground pins summary:** The GEA 71S has two ground connections on the AMM schematic: **Pin 20 (POWER GROUND)** and **Pin 45 (ANALOG IN 4 LO)** — ground return for analog channel 4. Both are tied to the same wire **77016A22N** and terminate at **GS-IP-14**. Pin 49 (ANALOG/CURR MON LO) (glow lamp current monitor LO, wire 74005A22N) also goes to GS-IP-14 but is a separate circuit, probably unrelated to voltage. Pin 36 and Pin 78 (POWER GROUND in Garmin generic manual) are not shown on the DA40NG AMM schematic and are not wired. The amps reading uses a separate **Hall-effect current transducer** (J7700) with its own power (Pin 14 (+10V TRANSDUCER POWER)) and differential output (Pin 42 (ANALOG IN 3 HI) / Pin 43 (ANALOG IN 3 LO)).

**At each connector, check for:** - Backed-out pins (look from the rear of the connector) - Corrosion on pin or socket contacts - Connector not fully seated or lock not engaged - Damaged strain relief (wires pulling on connector)

### Ground Bus Bar

The GS-IP studs connect to a ground bus bar mounted on the instrument panel frame. The bus bar and its connection to the IP frame are not shown on the AMM CH.92 wiring schematics but are standard aircraft construction — visually confirm when panels are open. Check: - Bus bar mounting bolts tight - Clean metal-to-metal contact between bus bar and IP frame - No cracks in the bus bar

### IP Frame to Fuselage Bond

The instrument panel frame connects to the fuselage structure. Check: - Bonding strap present and tight (if required by AMM) - No paint between bonding surfaces - Metal-to-metal contact confirmed

### Documentation Status

The ground return path described in this guide has two levels of documentation:

| Path Segment | Source | Status |
|---|---|---|

| | | |
|---|---|---|
| GEA 71S pins → wire 77016A22N → **GS-IP-14** | AMM CH.92, D44-9231-60-03 (pages 1908-1912) | **Documented on schematic** |
| All G1000 LRU ground pins → GS-IP studs | AMM CH.92, D44-9231-60-03 (pages 1908-1912) | **Documented on schematic** |
| GS-IP vs GS-RP ground stud groups (separate paths) | AMM CH.92, D44-9224-30-01X03 | **Documented on schematic** |
| GS-IP studs → IP ground bus bar | Implied by schematic layout and naming | **Inferred** — not explicitly traced |
| IP ground bus bar → IP frame → fuselage → battery negative | Standard aircraft grounding practice | **Inferred** — not on any AMM schematic we have |

The CH.92 wiring diagrams show the ground symbol at the GS-IP studs and stop there — they do not trace the structural return path from the instrument panel back to the battery negative terminal. The AMM chapters that would document the bonding and structural ground path (CH.51/52 Structures, CH.71 Power Plant) have not been extracted for this project.

**This does not weaken the diagnosis or the test procedure.** The end-to-end resistance measurement (Test 1) measures the actual resistance from GEA Pin 20 (POWER GROUND) to battery negative regardless of how the path is routed. Tests 2–5 then segment that path to isolate where the resistance is. The measurements will find the problem whether or not we have a schematic showing every joint.

## How to Test

### ESS BUS Switch Test (Quick Isolation — No Tools Required)

This test isolates the **power path** from the **ground path** using only a cockpit switch on the ground.

**Background:** The GEA 71S senses voltage from the **Essential Bus** (via Pin 46 (ANALOG IN 5 HI) / Pin 47 (ANALOG IN 5 LO)). In normal operation, the Essential Bus is fed from the Main Bus:

```
Battery → BATT BUS → Power Relay → MAIN BUS → Main Tie → Ess Tie Relay → ESSENTIAL BUS →
GEA Pin 46 (ANALOG IN 5 HI)
```

When the **ESS BUS switch** is activated, the Essential Bus is fed directly from Battery Bus 2, bypassing the Main Bus, Power Relay, Main Tie breaker, and Essential Tie Relay entirely. Per the AFM (Section 7.10.1, p.7-42): *"This separates the essential bus from the main bus. The essential bus is then connected to the battery bus 2."*

```
Battery → BATT BUS 2 → (direct) → ESSENTIAL BUS → GEA Pin 46 (ANALOG IN 5 HI)
```

**Critically, the ground path does not change either way** — the GEA 71S ground pins (Pin 20 (POWER GROUND), Pin 45 (ANALOG IN 4 LO)) still return through the GS-IP studs → structural ground path → battery negative.

**Procedure:** 1. Avionics powered and G1000 running. Engine running is preferred (alternator charging ~28V, higher current loads make the offset more pronounced) but not required — the offset is visible on battery alone (~25V range, lighter loads). Either way answers the question. 2. Note the G1000 voltage reading on the MFD 3. Flip the **ESS BUS switch** ON 4. Observe the G1000 voltage reading for 30–60 seconds 5. Return the ESS BUS switch to normal

**Interpreting results:**

| Result | What It Means | Where to Look |
|---|---|---|
| **Voltage stays the same (still reads low)** | **Ground path confirmed** — the power source changed but the reading didn't, so the drop is on the ground side. | **GS-IP-14** ground stud, GEA P701 ground pins (Pin 20 (POWER GROUND), Pin 45 (ANALOG IN 4 LO)), IP bus bar, IP-to-fuselage bond. Proceed to resistance measurements below. |
| Voltage improves noticeably (reads closer to 28V) | **Power path resistance** — the normal Main Bus → Essential Bus path has degraded contacts. The bypassed components carry all Essential Bus current, so even modest contact resistance produces a measurable drop. | **Essential Tie Relay contacts**, **Main Tie 30A breaker contacts**, **Power Relay contacts**, Main Bus bar connections. Inspect relay contact surfaces for pitting/corrosion. Check breaker resistance (should be < 0.005 Ω across contacts). |
| Voltage improves partially | **Both paths contribute** — resistance on the power side AND the ground side. | Inspect both: relay/breaker contacts in the power path, AND GS-IP ground studs and GEA connector pins. |

Both the ECU and VDL48 bypass the Main Bus → Essential Bus path entirely (ECU is on ECU BUS from Battery Bus 2; VDL48 is on HOT BUS direct from battery), which is why both read higher regardless of whether the problem is power-side or ground-side.

Based on all prior analysis (variable offset with load, elevated noise, worse under vibration), we expect the reading to **stay low** — confirming the ground path. But this test removes the guesswork.

## Resistance Measurements

**Setup:** Battery master OFF, **battery negative cable physically disconnected from the battery post**.

**Why disconnect the battery?** The meter needs to be the only source of current in the circuit. If the battery is still connected, its 28V overwhelms the meter's tiny test signal and readings will be wrong. Battery master OFF alone is not enough — the HOT BUS and BATT BUS remain live. Physically disconnecting the negative cable is the only way to fully isolate the circuit.

**Recommended meter:** Fluke 289 or similar DMM with 0.01Ω resolution and **REL (relative) mode** for auto-zeroing lead resistance. Set the meter to the lowest ohm range (600Ω range on the Fluke 289 gives 0.01Ω resolution).

**Practical setup for long-distance measurements:** The GEA 71S is on the instrument panel shelf (front) while the battery is in the aft bay — too far apart for standard 1-meter test leads. To reach both points:

1. Get a length of **heavy gauge wire** (12–14 AWG, 4–5 meters) with alligator clips on each end
2. Clip one end to the **black DMM lead**
3. Clip the other end to the **red DMM lead**
4. **Zero the leads:** Press **REL** on the Fluke 289 — this zeros out the red lead + extension wire + black lead. The display should read 0.00Ω. The aircraft is not in the circuit during zeroing.
5. Unclip the extension wire from the **red DMM lead**. Lay the extension wire through the cabin from instrument panel to aft bay. Clip the free end to the **disconnected battery negative cable lug** — this is the cable end you just pulled off the battery post. It's still connected to the aircraft's ground network. Do NOT clip to the battery post itself (it's isolated once the cable is removed).
6. Place the red probe on the test point (e.g., P701 Pin 20 (POWER GROUND)) — the meter current flows from the red probe through the aircraft's ground wiring to the cable lug. The reading is the true ground path resistance with lead resistance already zeroed out.

| Test | From | To | Expected | If High |
|---|---|---|---|---|
| **1. End-to-end** | GEA 71S ground pin (P701 Pin 20 (POWER GROUND)) | Battery negative cable lug | **< 0.050** Ω | Confirms ground path problem — continue testing |
| **2. Fuselage path** | Bare fuselage metal near IP | Battery negative cable lug | < 0.010 Ω | Check battery cable, fuselage ground point |
| **3. IP-to-fuselage** | IP frame metal | Bare fuselage metal | < 0.005 Ω | Check bonding strap, IP mounting |
| **4. Each GS-IP stud** | Each GS-IP stud terminal | IP frame metal | < 0.005 Ω | Clean and retorque that stud |
| **5. Each LRU ground** | LRU ground pin (at connector) | Its GS-IP stud | < 0.010 Ω | Check connector pin, harness wire, crimp |

## Where to Put the Probes (Step by Step)

**Test 1 — End-to-End (most important, do this first):** - **Black probe:** Connected via extension wire to the **disconnected battery negative cable lug** in the aft bay (see setup above). REL should already be set from the zeroing step. - **Red probe:** Touch the back of **Pin 20 (POWER GROUND)** on harness plug **P701** (the aircraft-side plug that mates to J701 on the GEA 71S, located on the instrument panel shelf). This is the power ground pin — the ground reference for all voltage measurements. If P701 is mated to the unit, you'll need to back-probe or disconnect it from J701 to access the pin. - This measures the entire ground path at once. If it reads good (< 0.050 Ω), the ground path is fine and the problem is elsewhere. If high, continue with Tests 2–5 to find which segment has the resistance.

**Test 2 — Fuselage Path:** - **Black probe:** Still connected via extension wire to **disconnected battery negative cable lug** (REL still active). - **Red probe:** Bare/scraped fuselage metal **near the instrument panel** — find an unpainted screw head or lightly sand a small spot to get bare metal contact. - Tests the fuselage structure itself as a conductor from front to back.

**Tests 3–5** are all at the instrument panel — no extension wire needed. Disconnect the extension, touch the standard leads together, and press REL again to re-zero with just the standard leads.

**Test 3 — IP Frame to Fuselage:** - **Red probe:** Bare metal on the **instrument panel frame** — the structural part the ground studs are mounted to. - **Black probe:** Bare **fuselage metal** nearby (same spot from Test 2). - If this reads high, the bonding strap between the IP frame and fuselage is the problem.

**Test 4 — Each GS-IP Ground Stud:** - **Red probe:** The **nut/terminal surface** of each GS-IP stud — where the ring terminals are stacked. - **Black probe:** Bare **IP frame metal** right next to that stud. - Test each stud individually: **GS IP-14** (GEA voltage sensor ground — most critical), GS IP-6, GS IP-4, GS IP-5, GS IP-3, GS IP-10. If one reads high while others read near-zero, that's your culprit — clean all surfaces and retorque.

**Test 5 — Each LRU Ground Wire:** - **Red probe:** The **ground pin** at the aircraft-side harness plug — start with **P701 Pin 20 (POWER GROUND)** (the harness plug for the GEA 71S — mates to J701 on the unit). - **Black probe:** The **GS-IP stud** that wire runs to — **GS-IP-14** for the GEA 71S. - Tests the wire, crimp, and connector pin between the LRU and its ground stud. Repeat for each connector on the instrument panel.

## Isolation Strategy

Start with **Test 1**. If high, the bad segment will stand out — everything else reads near-zero while the problem connection shows the bulk of the resistance. Work through Tests 2–5 in order to narrow down which segment carries the extra resistance.

**Important: Don't stop after finding one bad connection.** The data shows the ground path was never as clean as other DA40NGs — even from the factory. There may be more than one marginal connection. Clean and retorque **all** GS-IP ground studs and reseat **all** G1000 LRU connectors while the panels are open.

## What the Numbers Mean

| End-to-End Resistance | Voltage Drop at 20A | What It Means |
|---|---|---|
| < 0.010 Ω | < 0.2V | Normal — clean ground path |
| 0.010 – 0.025 Ω | 0.2 – 0.5V | Marginal — may worsen with vibration |
| 0.025 – 0.050 Ω | 0.5 – 1.0V | Degraded — consistent with the ~1.4V average offset we measured |
| 0.050 – 0.100 Ω | 1.0 – 2.0V | Failed — consistent with the -5.6V worst-case dips |
| > 0.100 Ω | > 2.0V | Severe |

**We estimate the total ground path resistance is approximately 0.05–0.09 ohms** based on the observed voltage offsets and typical avionics current draw.

## How to Verify the Fix

A ground test alone cannot reproduce the problem reliably. The offset is worse in flight due to vibration and thermal effects on the bad connection.

**After repair:** 1. Repeat the end-to-end resistance measurement — should be < 0.010 Ω 2. Power on avionics and check G1000 voltage reads within 0.3V of a meter at the AUX POWER plug 3. **Flight test** — fly at least 30 minutes with varied loads (radio TX, autopilot, flaps), then compare: - **Option A — ECU data (easiest):** The AE300 ECU logs battery voltage every flight automatically. Download the ECU session log and compare against the G1000 log. No extra equipment needed. - **Option B — VDL48 (independent reference):** Install VDL48 on AUX POWER plug, same setup as the Feb 8 analysis. - **Pass criteria:** G1000 vs reference mean offset < 0.3V, no dips > 1.0V, noise < 0.30V - The analysis scripts in this repository can process either data source automatically

## AMM References

| Reference | Content |
|---|---|
| AFM Doc 6.01.15-E, Section 7.10.1 | Electrical system description, bus architecture, voltmeter/ammeter (pp. 7-39 to 7-43) |
| AMM 24-60-00 | Bus structure, power distribution, troubleshooting table |
| AMM 31-40-00, p.985-986 | GEA 71S location (instrument panel shelf), Figure 6 |
| AMM CH.92, D44-9224-30-01X03 | Electrical system wiring diagram — **N238PS configuration**: p1859. Other variants: p1857 · p1858 · p1861 |
| AMM CH.92, D44-9231-60-03 | G1000 NXi wiring diagrams (Phase I & II, Sheets 2-6): p1908 · p1909 · p1910 · p1911 · p1912 |
| AMM CH.31 | GDU 1050/1060 connector pinouts |
| AMM CH.34 | GIA 63W connector pinouts |
| AMM CH.23 | GMA, GTX, GDL connector pinouts |
| Garmin 190-00303-40 | GEA 71 Installation Manual — P701/P702 connector pin function lists (pages 23-26) |
| Concorde 5-0324 Rev G | RG-series battery manual — State of Charge vs Open Circuit Voltage table (p.13): 24V battery at 25.8V+ = 100% SOC, 25.2V = 75%, 24.6V = 50%, 24.0V = 25%, 23.4V = 0% |

## Summary

The G1000 reads low because of a high-resistance ground connection — not a calibration issue, not a charging system issue, not a firmware issue. The voltage was never as stable as other DA40NGs (even from delivery), and it got significantly worse after the Feb 2024 shop visit. Three voltage regulators, two alternators, and two pitch servos have been replaced — none fixed it because the ground path was never addressed. Start at the **instrument panel shelf** with GEA 71S connector P701 (Pin 20 (POWER GROUND) and Pin 45 (ANALOG IN 4 LO), wire 77016A22N) and ground stud **GS-IP-14** (where both GEA power ground pins terminate). Clean and retorque **all** GS-IP ground studs and reseat **all** G1000 connectors on the instrument panel. Don't stop after finding one bad connection — the data shows there may be more than one marginal joint.

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## Appendix A — DA40 NG Electrical System (AFM)

*Source: DA40 NG AFM, Doc 6.01.15-E, Rev. 3, Section 7.10.1 — Electrical System (pp. 7-39 to 7-43)*

### Power Generation

The DA 40 NG has a 28 Volt DC system. Power generation is provided by a 70 Ampere alternator (generator) which is mounted on the bottom left side of the engine. The alternator is driven by a flat belt.

The power output line of the alternator is connected to the ENG ECU bus via a 100 A fuse, which is installed in the instrument panel. The power output line also runs through the current sensor, which provides an indication of the power being supplied to the electrical system by the alternator including the current for battery charging.

In the event of a main battery failure the field of the alternator is energized by two 12 V, 7.2 Ah sealed-lead-acid batteries (ECU backup batteries) which are installed behind the first ring frame. The ENGINE MASTER switch connects the ECU backup battery to the alternator voltage regulator via a 10 A fuse.

### Storage

Main battery power is stored in a 24 V, 13.6 Ah lead acid battery mounted behind the baggage compartment frame. The main battery is connected to the battery bus via the battery-relay which is installed in the relay junction box behind the baggage compartment frame.

The battery relay is controlled with the ELECTRIC MASTER key switch which is located in the center of the instrument panel.

In addition, two 12 V, 7.2 Ah sealed lead-acid batteries (ECU backup-batteries) are installed behind the first ring frame as a further source of electrical power for the Engine Control Unit (ECU B only).

Under normal operating conditions the ECU backup batteries are charged by the ECU bus. In the event of an alternator failure and a depleted main battery the ECU backup batteries automatically supply electrical power to ECU B via a 32 A fuse. This prevents the engine from stopping in the unlikely event of an alternator failure and a totally discharged main battery.

### Distribution

Electrical power is distributed via the hot battery bus, the battery bus 1, the battery bus 2, the ECU bus, the main bus, the essential bus and the avionic bus.

**Hot Battery Bus:** The hot battery bus is directly connected to the main battery, installed in the relay junction box and cannot be disconnected from the main battery. The hot battery bus provides power to the accessory power plug and ELT which are protected by their own fuses.

**Battery Bus 1:** The battery bus 1 is connected to the main battery via the battery-relay which can be controlled by the ELECTRIC MASTER key switch. The battery bus 1 provides power to the battery bus 2 and heavy duty power to the starter. The battery bus 1 is also connected to the power input line of the external power plug.

**Battery Bus 2:** The battery bus 2 is connected to the battery bus 1 via a 100 A fuse and provides power to the ECU bus via a 80 A fuse. It also provides power to the main bus via the power-relay which can be controlled by the ELECTRIC MASTER key switch and the ESSENTIAL BUS switch. The ELECTRIC MASTER key switch must be set to ON and the ESSENTIAL BUS switch must be set to OFF to connect the battery bus to the main bus.

**ECU Bus:** The ECU bus is connected to the battery bus 2 via a 80 A fuse and provides power for the ECU A and ECU B and their fuel pumps. It is also connected to the power output line of the alternator via a 100 A fuse. It also provides power for charging the ECU backup battery. The ENGINE MASTER switch must be set to ON to activate the ECU A and ECU B via the ECU bus.

**Main Bus:** The main bus is connected to the battery bus via the power-relay. It provides power to the consumers directly connected to the main bus and the avionic bus via the avionic master-relay. The AVIONIC MASTER switch must be set to ON to connect the main bus to the avionic bus. Under normal operating conditions the main bus is also connected to the essential bus via the essential tie-relay. In the event of an alternator failure the pilot must switch ON the ESSENTIAL BUS switch (refer to Section 3.4 - FAILURES IN THE ELECTRICAL SYSTEM). This separates the main bus from the battery bus and the essential bus and the equipment connected to the main bus no longer has power.

**Essential Bus:** Under normal operating conditions the essential bus is connected to the main bus via the essential tie-relay. The essential bus provides power to the consumers connected to the essential bus. The AVIONIC MASTER switch must be set to ON to connect the essential bus to the avionic bus. In the event of an alternator failure the pilot must switch ON the ESSENTIAL BUS switch (refer to Section 3.4 - FAILURES IN THE ELECTRICAL SYSTEM). This separates the essential bus from the main bus. The essential bus is then connected to the battery bus 2 which provides battery power for a limited time to the equipment essential for safe flight and landing.

## Consumers

The individual consumers (e.g. radio, electrical fuel transfer pump, position lights, etc.) are connected to the appropriate bus via automatic circuit breakers.

## Voltmeter

The voltmeter shows the voltage of the essential bus. Under normal operating conditions the alternator voltage is shown, otherwise it is the voltage of the main battery.

## Ammeter

The ammeter displays the intensity of current which is supplied to the electrical system by the alternator, including the current for battery charging.

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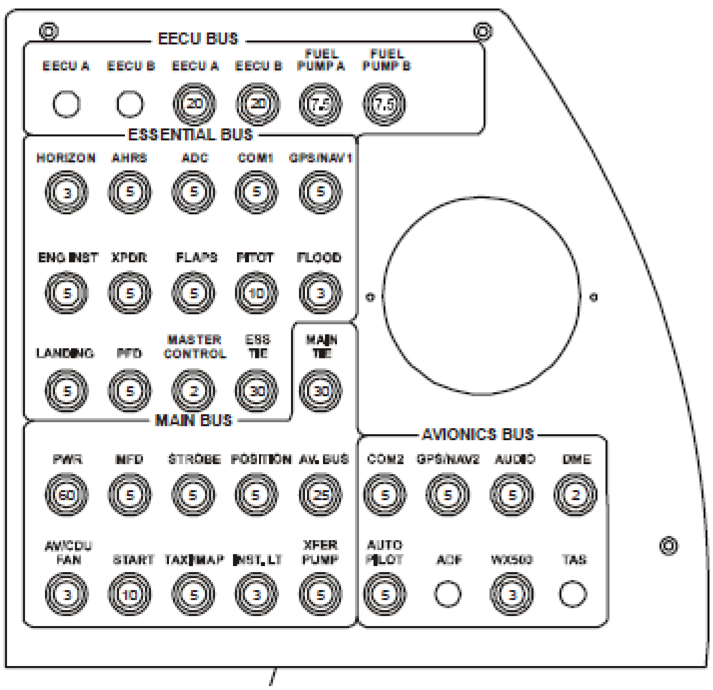
## Appendix B — Instrument Panel Circuit Breaker Layout (AFM)

*Source: DA40 NG AFM, Doc 6.01.15-E, Rev. 3, Section 7.10, p.361 — Instrument Panel*




The circuit breakers are physically grouped by bus on the instrument panel. This layout shows which bus each breaker belongs to:

### EECU BUS (Top Row)

| Breaker | Rating | Circuit |
|---|---|---|
| EECU A | — | Engine Control Unit A |
| EECU B | — | Engine Control Unit B |
| EECU A | — | Engine Control Unit A (backup) |
| EECU B | — | Engine Control Unit B (backup) |
| FUEL PUMP A | — | Fuel Pump A |
| FUEL PUMP B | — | Fuel Pump B |

## ESSENTIAL BUS (Second Group)

| Breaker | Rating | Circuit | Relevance |
|---|---|---|---|
| HORIZON | — | Standby horizon | |
| AHRS | — | Attitude/Heading Reference | |
| ADC | — | Air Data Computer | |
| COM 1 | 5A | COM 1 transceiver | GPS/NAV 1 ground → GS IP-3 |
| GPS/NAV 1 | 5A | GPS/NAV 1 | Ground → GS IP-3 |
| **ENG INST** | **5A** | **GEA 71S — airframe sensors (bus voltage, alt amps, pitot heat, fuel level/temp, doors, fuel lever, start switch, fuel xfer, glow lamp, engine water, alt warning)** | **Powers the GEA 71S, which is the unit that measures bus voltage** |
| XPDR | — | Transponder (GTX 33) | |
| FLAPS | — | Flap motor | |
| PITOT | — | Pitot heat | |
| FLOOD | — | Flood lights | |

## MAIN BUS (Lower Group)

| Breaker | Rating | Circuit |
|---|---|---|
| PWR | 60A | Power Relay (Main Bus power) |

| | | |
|---|---|---|
| MFD | — | GDU 1060 Multi-Function Display |
| STROBE | — | Strobe lights |
| POSITION | — | Position lights |
| AV BUS | 25A | Avionic Bus (through Avionic Relay) |
| AV/CDU FAN | — | Avionics cooling fan |
| START | — | Starter |
| TAXI/MAP | — | Taxi/map lights |
| INST. LT | — | Instrument lights |
| XFER PUMP | — | Fuel transfer pump |
| AUTO PILOT | — | Autopilot servos |
| ADF | — | ADF (if installed) |
| WX500 | — | Stormscope |
| TAS | — | Traffic Advisory System |

## AVIONICS BUS (Right Group)

| Breaker | Rating | Circuit | Relevance |
|---|---|---|---|
| COM 2 | 5A | COM 2 transceiver | |
| GPS/NAV 2 | 5A | GPS/NAV 2 | Ground → GS IP-10 |
| AUDIO | — | GMA 1360 Audio Panel | |
| DME | — | DME (if installed) | |

## Center Controls

| Control | Type | Function |
|---|---|---|

| | | |
|---|---|---|
| MASTER CONTROL | Key switch | Electric Master — controls battery relay + power relay |
| ESS BUS | Toggle switch | Emergency — connects Essential Bus directly to Battery Bus 2 |
| MAIN TIE | Breaker (30A) | Connects Main Bus to Essential Bus via Essential Tie Relay |
| LANDING | — | Landing light |
| PFD | — | GDU 1050 Primary Flight Display |

## Key Observation

The **ENG INST** breaker (which powers the GEA 71S voltage sensor) is physically located in the **Essential Bus** group on the instrument panel, confirming the GEA 71S is powered from the Essential Bus — not the Avionic Bus. This means:

1. The GEA 71S stays powered even when the Avionic Master is OFF
2. When the ESS BUS switch is activated (emergency mode), the GEA 71S switches to direct Battery Bus 2 power along with all other Essential Bus loads
3. The GEA 71S power path is: Main Bus → Main Tie 30A → Ess Tie Relay → ESS TIE 30A → Essential Bus → ENG INST 5A → GEA 71S