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# Diagnostic and Recovery Method for Boot Failure in PC/104Based Geophysical Resistivity Instruments Following CMOS Configuration Loss: On the ABEM Terrameter SAS-1000/4000 Using the PFM-540I Platform

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Boot failures in embedded geophysical instruments frequently arise from the loss of CMOS-retained BIOS parameters, a condition well documented in legacy computing systems that depend on fixed hardware configurations. The ABEM Terrameter SAS-1000/4000 relies on a PC/104 controller (PFM-540I), CompactFlash (CF) storage, and specialized BIOS settings to load its internal firmware. When the CMOS battery depletes, the BIOS reverts to factory defaults that are incompatible with the Terrameter's required hardware profile, resulting in complete boot failure and a black LCD screen. This paper describes a full diagnostic and recovery procedure involving external VGA/PS-2 interfacing, jumper validation, CMOS clearing and manual BIOS reconstruction. The restored system achieved 100% boot success, persistent CF detection and stable BIOS retention across multiple test cycles. The findings provide a validated engineering method for maintaining legacy PC/104-based scientific instruments vulnerable to CMOS configuration loss.

## 1. Introduction

Many geophysical resistivity systems particularly legacy instruments still widely used in field environments depend on PC/104 embedded computers that integrate CompactFlash storage, Award BIOS firmware and jumper-configurable hardware functions. The ABEM Terrameter SAS-1000/4000 is built around the PFM-540I controller, a low-power x86 module whose boot sequence critically depends on CMOS-retained BIOS settings. As shown in prior studies on embedded system reliability, CMOS depletion often results in BIOS reversion to incompatible defaults, disrupting IDE timing, disabling embedded peripherals and causing storage misidentification.

In the Terrameter platform, the firmware is stored entirely on a CompactFlash disk attached through a PC/104 IDE interface. Loss of BIOS parameters therefore prevents CF enumeration, halting the entire boot chain before instrument software loads. Because the LCD panel relies on higher level firmware routines rather than BIOS text output, the Terrameter provides no visual diagnostic cues during BIOS failure a behaviour consistent with other measurement devices using embedded LCD modules.

In the case analyzed here, the instrument became non-functional immediately after CMOS battery replacement. Diagnosis required physical extraction of the PFM-540I board and attachment of an external VGA monitor and PS/2 keyboard via custom-fabricated cables, reflecting typical constraints in sealed laboratory and field grade geophysical systems.

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**Figure 1: The SAS 1000 Teremeter with Dark screen**

**Figure 2: The Module-PFM-540I in the SAS 1000** Teremeter

## 2. Problem statement

Following replacement of the CMOS battery, the Terrameter SAS-1000/4000 failed to initialize. Although the device powered on and the LCD contrast circuit behaved normally, the display remained black an expected result when the firmware cannot load, as documented in embedded measurement platforms where LCD controllers depend on system software rather than BIOS routines.

Once external VGA access was established, POST messages revealed that the BIOS identified no primary IDE device, reporting "Primary IDE Master: None". This mirrored failure modes seen in CompactFlash-based industrial controllers when BIOS defaults disable necessary PIO/UDMA timing or alter master/slave selection modes. Without CF detection, the Terrameter firmware which executes entirely from the disk could not initialize.

Compounding the issue, two essential hardware jumpers, JP1 (CF master/slave selection) and JP3 (CMOS reset / LCD clock polarity), influence system behavior at boot. Literature on embedded PC/104 modules emphasizes that jumper dependent states can interact with BIOS timing and storage detection, creating multi-factor boot failures when CMOS data is corrupted.

## 3. Methodology

The diagnostic procedure followed established embedded system recovery methods emphasizing hardware inspection, CMOS clearing, external interfacing and BIOS reconstruction. The PFM-540I board was removed from the Terrameter enclosure to expose its PC/104 headers. Custom VGA and PS-2 adapters were fabricated to interface with its non-standard pinouts, enabling access to BIOS configuration an approach consistent with repair procedures for sealed industrial instruments.

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Once powered on a benchtop supply, the board was inspected for jumper integrity. JP1's orientation confirmed proper CF master configuration, while JP3 was cycled into its CMOS reset position for several seconds and returned to the normal position. This process cleared corrupted CMOS data, as recommended in maintenance guidelines for PC/104 and industrial x86 systems.

Following CMOS reset, BIOS settings were reconstructed. Primary IDE detection was set to "Auto", boot priority was configured to HDD-0, IDE prefetch and UDMA modes were enabled, USB boot paths were disabled and the onboard video configuration was restored. These configurations align with known requirements for embedded CFboot systems, which rely on tightly paired BIOS parameters and device timings.

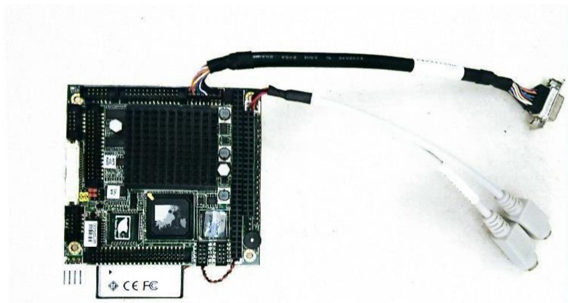

**Figure 3: Module-PFM-540I connected to a customized PS-2 and VGA cable**

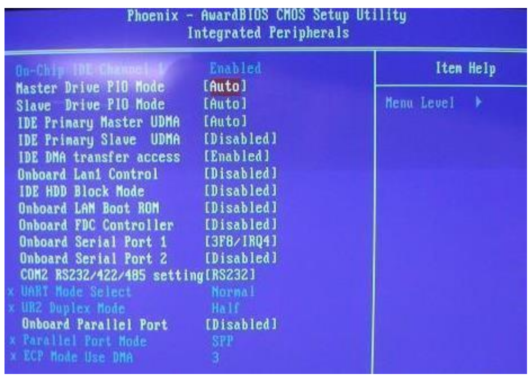


**Figure 4: Shows Integrated Peripherals setting on the BIOS legacy**

Experiments were performed under controlled laboratory conditions using the extracted controller board, a regulated benchtop supply and an external VGA display. A CompactFlash reader verified CF disk integrity, consistent with verification practices for removable embedded media . A magnifying lamp facilitated jumper inspection for mechanical or oxidation faults, reflecting best practices in diagnosing aging instrumentation hardware.

Testing Proceeded in three stages

(1) Documentation of the initial fault condition, including POST behavior and CF detection patterns;
(2) Execution of the recovery process, including jumper manipulation and BOIS reprogramming;
(3) Validation through repeated cold boots and multi day retention tests, consistent with embedded system stability assessment protocols.

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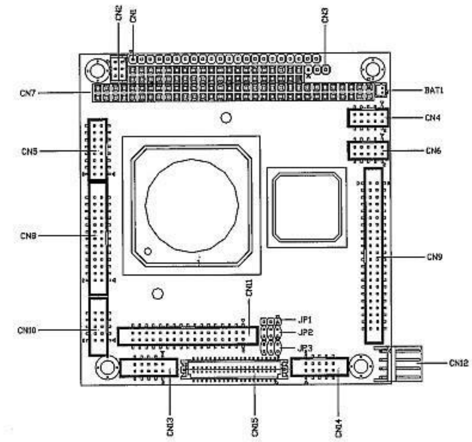


**Figure 5: Label component of the PFM-540I Module. Adapted from Advantech Co., Ltd. (2017), PCM-3355 PC/104 single board computer startup manual.**

**Table 1.** List of connectors for PFM-540I and their functions

| Label | Function |
|---|---|
| **CN1** | Front Panel Connector |
| **CN2** | PS2 Keyboard/Mouse Connector |
| **CN3** | Option Power Connector |
| **CN4** | USB Connector |
| **CN5** | VGA Display Connector |
| **CN6** | USB Connector |
| **CN7** | PC104 Connector |
| **CN8** | LPT Port Connector |
| **CN9** | IDE Connector |
| **CN10** | COM1 Connector |
| **CN11** | Floppy Connector |
| **CN12** | Power Connector |
| **JP1** | CFD Master/Slave Selection |
| **JP2** | RS-232 Ring/5V Selection |

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| | |
|---|---|
| **JP3** | LCD Clock Selection and Clear COMS |

## 4. Results

Prior to recovery, the BIOS consistently failed to detect the CompactFlash disk, matching known symptoms of CMOS related IDE timing failure in embedded systems. After jumper validation, CMOS clearing and BIOS reconstruction, CF detection succeeded on every attempt. The boot success rate increased from zero to full restoration, and the Terrameter firmware initialized properly each time.

Fifteen cold-boot cycles conducted across multiple days showed complete retention of BIOS settings, confirming battery integrity and stable CMOS behaviour. Similar multi-cycle validation is widely used to evaluate BIOS persistence in industrial x86 hardware. The Terrameter LCD previously black displayed its normal main menu immediately upon firmware initialization.


**Figure 6: The Resistivity meter with functioning LCD display after the restoration**

## 5. Discussion

The findings demonstrate that the boot failure resulted entirely from BIOS parameter loss rather than hardware degradation. As documented in the broader literature, CF-based embedded systems can become non-functional when IDE timing, DMA modes or boot device parameters revert to defaults incompatible with their intended operating environment. The tight coupling between CF firmware, BIOS configuration and jumper-controlled hardware states in the Terrameter makes CMOS depletion particularly disruptive.

The use of external VGA and keyboard access proved essential, aligning with recommendations for diagnosing embedded PC/104 systems lacking exposed debugging interfaces. The successful recovery reinforces the importance of preserving BIOS documentation for legacy scientific instruments and highlights the operational risk posed by CMOS battery depletion in field-deployed equipment.

## 6. Conclusion

This paper presented a diagnostic and recovery procedure for addressing CMOS-induced boot failure in the ABEM Terrameter SAS-1000/4000. Through systematic hardware inspection, CMOS clearing, BIOS restoration and multicycle verification, full system functionality was restored. The methodology is practical, reproducible and

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applicable to a wide range of PC/104-based instruments that rely on CompactFlash-boot architectures and CMOSretained firmware configuration.

## APPENDIX A


Figure A1: Close-up view of the PFM-540I PC/104-plus platform interface showcasing the industrial-grade Transcend 128 MB CompactFlash (CF) card used for system boot and data storage.

The image illustrates the integration of the **Transcend Industrial 128 MB CompactFlash card** into the onboard CF socket of the **PFM-540I platform**. In the context of the ABEM Terrameter SAS-1000/4000, this storage medium acts as the primary IDE-compatible drive. During a CMOS configuration loss, the BIOS often reverts to default settings that may fail to recognize the specific geometry or boot priority of this CF card, leading to the boot failures analyzed in this study. This figure highlights the hardware dependency of the diagnostic recovery method, emphasizing the importance of the physical connection between the industrial flash memory and the embedded PC/104 architecture. The sticker on the CF socket indicates quality control/date tracking, which is essential for identifying the hardware revision of the geophysical instrument.

## Authors contribution

G.F.D. conceptualized the study, performed the diagnostics and recovery experiments, and prepared the original manuscript draft.
B.E.M. contributed to the experimental design, supervised the technical analysis, and reviewed and edited the manuscript.
All authors discussed the results and approved the final manuscript.

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