ULTRA | Energy

CURTISS-WRIGHT

High integrity digital to analogue converter recovery programme

Summary

High integrity digital to analogue converters (HIDAC) were a key component within the safety systems at a customer's nuclear power plant. They had been in service for more than 25 years and were no longer supported by the original equipment manufacturer. Increasing failure rates in recent years had caused concern to be raised over their continued safe and reliable operation. The investigation and recovery program implemented improved equipment reliability and projected end of life by more than 10 years.

Scope of work

Ultra undertook a multiphase programme of work that provided investigative engineering recovery and refurbishment works across the complete HIDAC unit. Investigations centred on the sub assembly within the chassis, including the 11 analogue data acquisition boards, a high integrity processor board, IEEE interface board, motherboard and two power supplies.

Systems outline

The HIDAC converts analogue thermocouple signals into a digitised representation that is used to trigger a shutdown of the reactor in the case of a temperature transient. The equipment functions are implemented in transistor-transistor logic (TTL) and using programmable logic (PLD and PLA) in MIL-STD-883 CERDIP packages with embedded firmware.

Initial investigations

We assessed the condition and supportability of the HIDAC equipment, by testing and fault-finding on a typical failed unit to identify the root cause of the

failures and the impacts of aging on components. Review was also undertaken on the available spares, parts obsolescence and quality, and completeness of test equipment, manuals and specifications.

Key findings of the investigation:

- Product support data was incomplete
- Firmware was not available
- Factory automated test system was not available
- Data acquisition cards had faults due to semiconductor aging
- Programmable logic devices in use are obsolete
- Connectors and cables had become brittle
- Dry joints on circuit boards were apparent throughout
- Significant noise was being generated by the power supply units due to aging electrolytic capacitors

Recovery actions schedule

The recovery actions implemented focused on making the units reliable and supportable for longer than 10 years. Initial work focused on establishing the definitive equipment design and configuration using customer available information supplemented with reverse engineering and research. The work culminated in the development of parts and component lists, circuit diagrams, as used configuration details, history files, repair and diagnostics test specifications, calibration procedures, and periodic maintenance procedures.

Firmware functionality information for the EPROMs, 5 different PAL and three different field devices were derived from available HIDAC units by functional testing and supported by data mining.

A custom computer based automated functional and soak test system was developed that operates on Shell core test software driving a GPIB unit to control test instrumentation and data recorders.

Twelve component alternatives were considered where form, fit and function, equivalence analysis and availability were used for a replacement power supply. The assessments considered functional performance, environmental, qualification and regulatory constraints to ensure the change would have no detrimental effect on safety or performance.

A refurbishment programme was developed to replace components and remake dry joints.

Refurbishment

Twenty HIDACs were refurbished within a specifically developed process and programme that included point to point shipping on dedicated transport, receipt, inspection and documentation of condition, diagnostic testing, repair and refurbishment, test, soak test and history file completion. The works included replacement of power supplies, connectors, electrolytic capacitors, wiring, fans, EPROMs and mains filter. Improving the general condition through tin whisker remediation, cleaning and replacement of missing or broken fasteners.

About Ultra Energy

Organisations working with nuclear technologies have a responsibility to safeguard people, the environment and infrastructure. We provide solutions that give our customers complete, long-term protection and control of safety critical systems, while helping them increase the net value derived from nuclear investments over their total lifespan.

Part of Curtiss-Wright, Ultra Energy has worked with nuclear customers for over 60 years. We're embedded in strategic national infrastructure and helping organisations develop future nuclear applications. We support continuous operation of nuclear sites with protection and control solutions that monitor and manage factors such as radiation, neutrons, temperature and pressure within safety critical systems.

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