Case Study

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Digital Signal Processing Line Replacement Unit

Introduction

The Digital Signal Processing Line Replacement Unit (DLRU) is one of the sub-systems in an Aerostat, which provides resources for radar signal processing, data capturing, data recording with other radar control functions.

The Case Study highlights Mistral's expertise in the architecture and design of a custom hybrid system that supports two industry standard bus architectures VME and VPX, to meet the requirements of input/output signals, communication links, processing capability and high-speed data transfer capability.

> "This case study showcases Mistral's expertise in the architecture and design of a custom hybrid system that supports two industry standard bus architectures VME and VPX."

The Customer

A leading Defense Lab selected Mistral to design, build and integrate a system capable of functioning as a DSP Line Replaceable Unit.

The Requirement

The customer's requirement was to design and integrate a solution that addressed their overall functional and performance criteria while adhering to SWaP (Size, Weight, and Power), the longevity, product lifecycle management and subsystem integration norms.

The key requirements for the proposed solution included:

- Mechanical design of the Digital Signal Processing Line Replacement Unit with structural and thermal analysis
  - The DLRU unit had to be housed in a sheltered space on an Aerostat
  - The unit had to be designed to comply with Environmental Stress Screening Test as per MIL-HDBK2164, Safety of Flight Test (SOFT) as per MIL-STD-810E and EMI/EMC test as per MIL-STD-461E
- Design and Fabrication of the hybrid backplane (VPX and VME)
- Custom Design and Fabrication of three VPX based Processor Boards and four VME based channel receiver boards
- Generation of Wiring Charts, ICD (Inter Connection Document) and cable harness diagrams as per the ICD

- The unit had to be equipped with:
  - FPGA based processing system
  - High Speed Fiber Optical Module capable of communication using sFPDP protocol
  - High speed Gigabit Ethernet Ports for inter communication
  - RF input and output through SMA connectors
  - RS232 Serial Ports from for debugging
  - RS422 level based line sports from processor cards to front panel for communication and debugging
  - I/O Debug ports
  - Provision of Redundant Power
  - Power Supplies to cater for the entire unit. Circuit breakers and protection circuitry to be provided to prevent damage to the electronics housed in the unit
  - LED's to indicate the health of the power supplies.

The Solution

Mistral is a professional design services company with extensive experience in embedded hardware and software development for Mil-Aero applications. This capability, in conjunction with partnerships with leading embedded solution providers like Curtiss Wright Controls Defense Solutions, enabled Mistral to provide a complete solution to meet the customer expectations.

Mistral developed an air cooled Digital Signal Processing Line Replacement Unit, comprising of the following components:

- Custom Hybrid Backplane supporting VME and VPX technologies
- Three VPX based processing boards based on Xilinx Virtex-5 FPGA
- Four Quad Channel VME based Receiver Modules
- Single channel sFPDP high Speed Fiber Optical Module mounted on VPX board capable of communication using sFPDP protocol
- VPX based Data Recorder card
- 7 Gigabit Ethernet Ports on VPX based processor cards through Quadrax connectors
- Xilinx Virtex-6 FPGA based VME I/O board
- Six RS232 Serial Ports on the front panel for debugging
- 156 RS422 level based linesports on front panel
- Debug ports on the three VPX based processing cards
- Input power Supply range 16-32V
- 16 SMA connectors (4 Per Quad channel receiver for RF input or output)
- Custom designed Front Panel Board, which consists of all the Circular connectors for I/Os, Quadrax circular connectors for Gigabit Ethernet, LED's, Power switch and reset switch
- Two Fans housed on the rear of the unit for efficient heat transfer which can be controlled through software
- Necessary EMI filters, fuse voltage, current monitor and Sense circuit for automatic output voltage regulation.

Backplane Chassis

The VPX based unit provided consists of 6U VPX and VME cards. To accommodate this, the unit was equipped with a custom hybrid backplane, designed by Mistral and its solution partner adhering to VPX and VME standards. The backplane has three VPX slots and eleven VME slots.

Design Services and System Integration:

Mistral was involved in the design and development of the entire system from the initial phase of system designing, to component selection, system engineering and validation. The solution offered included:

System Design

- System Study with report generation to ensure all the operational environmental conditions and performance requirements were met. This included the complete 3D computer modeling of the system, system power consumption calculations, system cooling calculations, system structural analysis, system thermal analysis, signal integrity analysis and external/ internal cable harness

- Hardware Design
  - Design and development of:
    - Rugged Air cooled Rack
    - Hybrid Backplane having 14 slots (3 VPX and 11 VME)
    - Redundant Power supplies
    - Complete cable harness design
    - Front panel design

- Integration
  - Integration of all boards within the system; and establishing functional capabilities of base card, inter- and intra-system communication, GigE network establishment, Inter Processor Communication with inter- and intra-system dependencies
  - Integration and testing of custom designed hardware
  - Integration and testing of software modules for Xilkernel

- Verification and Validation
  - Design and validation of unit for high-power application, with thermal management
  - Rugged systems adherence to ground based application - All boards supplied cater to the requirements of MIL-HDBK2164, MIL-STD-810E and MIL-STD-461E.

The Challenges

- Design and fabrication of 14-slot hybrid backplane comprising of VPX and VME bus architecture
- VPX backplane had to incorporate full mesh fabric connection between the VPX slots while maintaining high level of signal integrity
- Conformance to environmental conditions including thermal management, structural rigidity, EMI/EMC standards. conformance.

Key Achievements

- Complete integration of the customized hardware that used two industry standard bus architectures VPX and VME. The system realized with two different operating platforms (Linux and XilKernel)
- Power ON sequencing, Remote power ON/OFF, Remote Power monitoring and temperature monitoring system
- Establishing optical links for sFPDP and Fiber Channel and Gigabit ethernet network for external and internal network
- The integrated DLRU unit is qualified i.e. EMI / EMC tests and environmental tests carried out as an integrated system instead of qualifying the individual sub-systems. System designed meets requirements of MIL-HDBK2164, MIL-STD-810E and MIL-STD-461E Specifications
- Inter Board communication between the VPX based processor board and Controller board using SRIO (4 channels) and Aurora (8 channels) protocol and tested for speeds up to 3.125Gbps.

Customer Benefits

- A multi-vendor selection of best-of-breed sub-systems was made available as an integrated system through a single system integrator; who not only provided the solution but would also provide support and maintenance for the coming years
- Shortens customer's end-to-end product development cycle and ensured on-time deployment schedule
- A fully integrated deployable solution, compliant with functional and environmental standards was made available.

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