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HARDWARE DESIGN DOCUMENT
for <LRU/SYSTEM Name>
for
<Platform Name>

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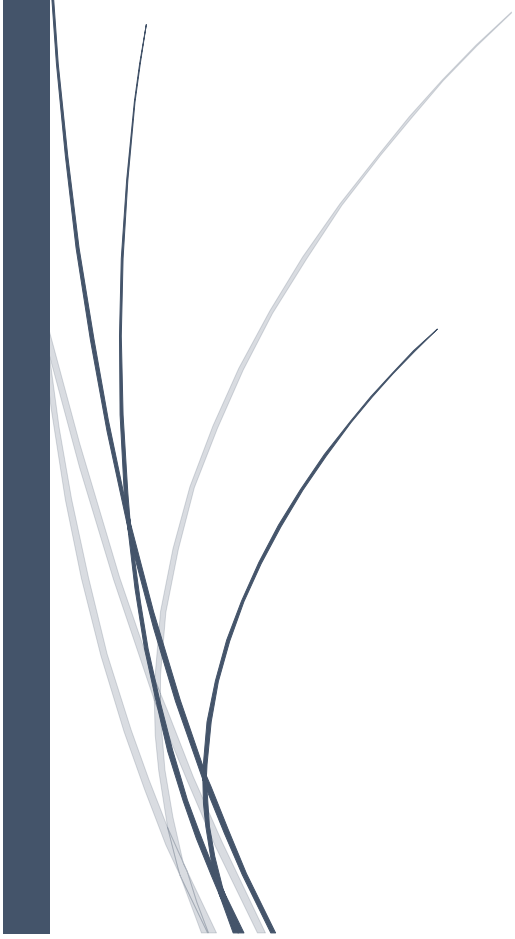

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HARDWARE DESIGN DOCUMENT for <LRU/SYSTEM Name>for <Platform name>	< Project/System Name>
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Disclaimer:

This document is a guidance document. Applicable section / table rows may be considered. Any additional details may be added. Any not applicable section/ table rows may be deleted. The template is very general and vary with process to process followed by Development Agency. The document may be fine-tuned with the TAA for finalization.

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Amendment History

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1 Introduction

1.1 Scope

<Mention the Purpose and scope of the hardware design document with identification of the system. Ex: This document provides the detailed design of the hardware for *the <System Name> <Part No.> for use on the <Platform Name>.*

1.2 Definitions and Acronyms

<Give all the list of Acronyms used in the specification Alphabetically. Any special/non-generic definitions if applicable can be given here>

1.3 Applicable/Reference Documents

Mention Reference to Technical specs document, BOM, MDI, Standards and any other relevant document.

<All the applicable documents of the system and the standards to which the system should conform to, should be given here along with the Title, document number, issue number & date of issue..>

Reference to the hardware and software standards with issue and date to be provided

1) MIL-STD-704 : Aircraft electrical power supply characteristics

2) MIL-STD-810 : Environmental test methods and engineering guidelines

3) MIL-HDBK-217: Reliability prediction for electrical equipments

Any MIL/ IPC/ IEEE/ JSS/ ICAO/ ARINC/ DO/ STANAG/ TSO/ SAE standards as applicable

2 System overview

Give brief functional description of the LRU. (1-2 pages)

3 Principle of Operation

Explain the theory/ concept based on which the system hardware is designed. Explain how the hardware will be able to support all the functionalities required by the specification using this principle of operation. If some functionalities are accomplished by Software, mention them at the top level only. (At system level. Do not go to individual card or component level)

4 Design alternatives

- Give the available choices for hardware design – in terms of architectures, components, technology etc.
- Explain the advantage of the chosen design and major components (like Processors, FPGA, NVRAM, DPRAM, Sensors, ASICs) over other options in terms of expertise, previous experience, availability, reliability, cost, schedule, ease of use, design optimization, robustness, portability, future expansion etc.

- Bring out the limitations/ compromises in the selected design with justifications and calculations.
- Mention any new test facilities that are required to be established for verification and validation of the system.
- Give the estimates of design margins available in terms of processing, memory, IO load, spare pins etc for future expansion.

5 Hardware Architecture

- Give overall block diagram of the system showing the architecture & interconnections
- Architecture details depicting the sub modules considered for implementing all functionality given in the technical specification to be made. Each block shall indicate the inputs required, control signals required, outputs generated and inter connection of these with internal modules. The range of signals inputs and outputs may be mentioned wherever possible. This diagram will also indicate inputs received from external environment (i.e system inputs) and output generated by systems.
- Describe how the requirement is distributed amongst the cards giving details of the PCBs/modules used in the LRU along with their interfaces. Where inter-chip/ inter-card bus data exchange is planned, give the details of the bus protocol.
- Give details of external IO and conditioning/ conversion of the signals, for the cards that interface with external systems like Bus controller, antenna, sensors, other electronic systems etc. Include all types of IO such as discrete, analog, pulses, RF, video, audio etc.
- Give the signal flow path from Connector(s) inputs to the Connector(s) outputs through various cards including flow of the data between the modules.
- If the system consists of multiple LRUs, the apportionment of responsibilities and interconnectivity between the LRU subsystems are to be covered.
- Input and output signal ranges to be indicated in engineering values and corresponding voltage/ current/ pulses equivalents.
- Communication protocol between internal modules to be clearly indicated
- Describe any special design provisions to take care of rain drip, arrestor landing etc.
- Sketch the grounding and shielding scheme used.
- Describe the POST/ CBIT/ IBIT plan and coverage.
- Plan for data recording/ fault code storage for later analysis to be described.
- Interchangeability of cards, any dependency on other cards/ software etc to be brought out.
- Descriptions of computer processors shall include manufacturer name and model number, processor speed/capacity, identification of instruction set architecture, applicable compiler(s), word size (number of bits in each computer word), character set standard (such as ASCII, EBCDIC), and interrupt capabilities.
- Descriptions of memory shall include manufacturer name and model number and memory size, type, speed, and configuration (such as 256K cache memory, 16MB RAM (4MB x 4)).
- Descriptions of input/output devices shall include manufacturer name and model number, type of storage, amount of installed storage, and storage speed.
- Descriptions of auxiliary storage shall include manufacturer name and model number, type of storage, amount of installed storage, and storage speed.
- Descriptions of communications/network equipment, such as modems, network interface cards, hubs, gateways, cabling, high speed data lines, or aggregates of these or other components, shall include, as applicable, manufacturer name and model number, data transfer rates/capacities, network topologies, transmission techniques, and protocols used.

- Each description shall also include, as applicable, growth capabilities, diagnostic capabilities, and any additional hardware capabilities relevant to the description.
- For programmable/ configurable items the configuration settings of the item are to be recorded.
- Each resource (such as memory, IO, processor) description shall, identify the configuration items that will use the resource and describe the allocation of resource utilization

5.1 Power Supply module/ card

5.1.1 Power Supply Design

The Power Supply module required to meet MIL-STD-704, MIL-STD-461 and MIL-STD-810 and other applicable MIL standard requirements.
Explain the Power supply design. No. of outputs, voltage regulation, ripple/ distortion avoidance and other add-ons as per the circuitry, such as, EMI filter and transient suppressor, Line conditioning module etc. should be mentioned.
Design shall ensure the power consumption within the required limit specified in the technical requirement document, suitable design margin and future growth potential.
The list of secondary voltages generated along with estimated output current requirements and the provision in the design with sufficient margin, to be added in tabular form.

5.1.2 Protection features

Provisions and scheme for reverse voltage protection, power supply hold features, under/ over voltage surge, lightning protection, ESD protection etc should be explained.
Safety aspects include the requirements related to safety of hardware and intended platform for which the system is to be developed with applicable standard. For example provision for ground terminal which connect to internal chassis by means of conductor, provision for fuses/ switches for disconnecting the equipment from electrical power system, provision for safety marking if any etc. The guideline of MIL-HDBK-454 may be followed for safety design criteria and personnel hazard aspects.

Lightning protection of power supply module and other individual module which are directly interfaced to the external connector/platform shall be provided.

5.2 Motherboard/ Backplane

- Explain the interconnectivity and signal transfers between cards/ connectors etc.
- If any functional circuit is implemented on motherboard, explain the requirement for such placement of functionality.
- If flexi or flexi-rigid boards/ cable looms are used for interconnectivity, explain how robustness and long term maintainability and ease of use are ensured.
- Mention speed and throughput of the backplane. If any standard protocols are used, explain them.

5.3 <Card 1>

- Explain the various circuits implemented in this card and each circuit logic, with block diagrams such as, signal conditioning, Schmitt trigger, filter and protection, amplifier etc.
- Specify the IO details (signals, levels and timing) applicable to the card. These IO signals should cover both those received from external environment and internally generated by other interfacing cards.

Origin/ Destination	Signal name	Type (DI/DO, AI/AO, FI/FO, bus, audio, video)	Signal Levels	Data availability (Periodicity)	Data location	Processor Data read mechanism
Connector C2, Pin 45	PLA	DI	28V/0V	50 ms	DPRAM 0x2345	Poll
Timer IC U25 Within Card1	Timer1	Interrupt		100ms	RAM 0xABCD	ISR
Connector C1, Pins 12 and 35	N1	FI	±5V 0-2000 Hz	10 ms	DPRAM 0x1234	Poll
DAC U12 in Card2	BrPr1	AO	0-20 mA	50 ms		Asynch
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- Mention the isolation, buffering, protection etc for inputs as applicable.
- Provide details of interface protocol between this PCB and motherboard/ other PCBs/ connector wiring.
- Explain other provisions or special features in the PCB such as temperature monitoring, probe points for diagnosis/ monitoring and other testability features.
- Coverage of the POST, CBIT and IBIT to be included for the cards.
- If there is a microprocessor, DSP, microcontroller, FPGA, PLD or any other programmable device in the card, give the significant and relevant specifications of the device, explain the functionality assigned to the device, its peripherals, IP cores used, programming scheme (in-situ or otherwise) etc.
- Describe various clocks available for the devices and various operating voltages of the devices. Mention whether there are any reference voltages/ currents used for any device in the system and how monitoring/ control of these voltage/ current is done.
- If the card is enclosed in a module or cassette, describe the requirement for the enclosure and justify the additional weight, assembly procedure etc.
- If the card is a backplane, give the throughput expected, maximum throughput catered by design without compromising correctness of signals and the data transfer scheme between the connected cards. Details of the high speed digital signals and their routing may be included.

- For analog/ RF cards, mention if any additional provisions are made to prevent signal distortion.
- Provide impedance characteristics of the load, propagation delays, optimization of track length and width etc in the card.
- De-Rating analysis of the components and how the values are arrived at. De-rating analysis report shall be given in the tabular form with following information. (This can be either an appendix to this document or a separate document)

Sl.no.	Component name	Ckt reference	Parameter to be derated	Comp. Rating (R)	Load in the ckt (L)	Derating factor (L/R)

- Include module edge connector details.
- PCB details such as size, material, no. of layers, certification standard to be mentioned.
- PCB level EMI/EMC ANALYSIS shall be covered
- PCB level POWER INTEGRITY ANALYSIS shall be covered
- If any special process is required for the card or any of the components of the card, describe it in brief referring applicable standard.

5.4 <Card2>

<…… And so on for all the cards. If the design consists of modules/ cassettes, the tree structure with final assembly to card level may be included in the beginning. If Bought out cards/ modules are part of the hardware, a brief write-up with data sheet of the card also to be included. However, interfaces of the bought out module to other parts of the design have to be covered in full.>

5.5 External Interfaces

5.5.1 Bus Interfaces

- Give details of communication Interfaces like MIL-STD-1553B, RS-422, ARINC 429 etc, the expected delays in read/write, analysis of resources (memory, speed) and their utilization percentage.

5.5.2 Other Interfaces

- Give details of Discrete analog, frequency, RF, temperature, pressure etc interfaces to the system from external environment Interfaces. Cover the input reading, engineering unit conversion mechanisms and formulas, output conversions etc.

6 Mechanical design

- Brief description of the Mechanical design of LRU and its Mounting tray.
- The dimension of the individual module, mounting of the interface connector in the module, mounting details of module within the LRUs, mechanical interface of module shall be provided.
- Specify the mechanical aspects of the LRU like connectors, chassis, shock absorbers, handles, mounting tray, Name plate, fixtures, gaskets etc, including cooling/ heating requirements with suitable Figures/Diagrams (Mechanical Structure, Exploded view, Front view, Rear view, Inside view etc.). 3D-model of the LRU & Mounting tray.
- Give the pin-out details of connectors including test connectors.
- Include structural analysis report to prove the adequacy of the mechanical design to withstand the operational environment throughout equipment lifetime.
- Care taken for removal and re-fitment mechanism of the module from the LRU for easy maintenance.
- Heat transfer mechanism details (use of heat shunt , wedge lock, thermal pad etc.,)

7 Thermal analysis

- Explain the thermal management scheme. Prove the adequacy of the scheme during high/ low temperature operation, storage conditions. Any warning/ auto-shutdown planned at adverse thermal conditions?
- Bring out the effect of temperature variations on the components and thereby on the overall system parameters.
- Bring out details of cooling/ heating required or any other design strategy, to mitigate/ compensate effects due to thermal variations.
- The maximal thermal dissipation allowable in watts for LRU shall be provided
- Thermal analysis shall be carried out at ambient and maximum operating temperature, by using the following inputs.
  a. Active components
  b. Power dissipation of these components
  c. Enclosure details and properties
  d. PCB Layout and component placement details

8 Reliability Estimation

Enclose Parts Stress Reliability Estimation report for all the Cards/Modules. In the conclusion section, bring out any high failure rate component/ sub assembly, possible effects on the system and mitigation plan.
Analysis shall be done using standard reliability analysis tools. Guidelines given in MIL-HDBK-217 shall be followed.

9 Structural Analysis

Include report and conclusion of vibration, acceleration and mechanical shock analysis to confirm that the design conforms to the platform requirements.

10 Signal integrity

Explain the signal integrity for each of the PCBs including the backplane/ motherboard with cross talk, reflection waveform, propagation delay and timing analysis.
Signal Integrity analysis for the high speed digital circuits shall be provided. Signal integrity analysis may be carried out for all nets, but it is mandatory for the critical nets. (i.e PCB trace which carries high speed signals. Following type of signal integrity analysis needs to be carried out and corresponding report shall be generated.

a. Reflection wave form analysis.
b. Cross –talk analysis
c. Propagation delay and timing analysis
d. Eye diagram analysis.

11 Maintainability and Testability

Explain if any periodic or condition-based maintenance activity is necessary for proper functioning of the system. This may include battery charging/ replacing, calibration of the sensors, refilling of the compounds, replacing the gaskets, replacing lifed components, updating of data at regular intervals (such as WGS, WMM) etc.
Explain the plans for I-level, O-level and D-level test facilities with test coverage.
Explain system level, LRU level, module level and card level test facilities to be developed. Include FPGA/ ASIC/ CPLD level testing requirements.
Provide the test points details and critical parameters to be monitored and ensured for Troubleshooting purpose.

12 Simulation studies

Explain the studies, calculations, assumptions, modeling and other basis for theoretical confirmation of design objective achievement. For ex., end-to-end computational accuracy through algorithms, choice of ADC/ DAC to meet specific timing and LSB requirements, propagation delays, EMI effects of co-situated transmitters, Radiations from Unfriendly aircraft, antenna pattern perturbations etc.
Circuit level simulation analysis shall be performed and results shall be recorded. Hardware failures which can be simulated shall be described.

13 Data sheets

Enclose data sheets of important components (like processors, sensors, FPGAs, Non-volatile memory, bus chip, holdup module, DC-DC converter, EMI-EMC filter etc).