PCB Fabrication, Assembly & Testing of PCI Express based SPARC boards

Work Details and Terms & Conditions

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Abbreviations and Acronyms

- **SPARC**: Satellite data Processing & Acquisition Reconfigurable Card
- **PCB**: Printed Circuit Board
- **PCIe**: Peripheral Component Interconnect Express
- **FPGA**: Field programmable gate array
- **BGA**: Ball Grid Array
- **FCBGA**: Flip Chip Ball Grid Array
- **FTBGA**: Fine-Pitch Thin Ball Grid Array
- **LFCSP**: Lead Frame Chip Scale Package
- **UBGA**: Ultra-Fine Ball Grid Array
- **SOIC**: Small Outline Integrated Circuit
- **SOT**: Small Outline Transistor
- **QFN**: Quad Flat No-leads
- **TSSOP**: Thin Shrink Small Outline Package
- **BBT**: Bare Board Test
- **BOM**: Bill Of Materials
- **DDR3**: Double Data Rate 3
- **SDRAM**: Synchronous Dynamic Random Access Memory
- **SODIMM**: Small Outline Dual In-line Memory Module
- **ENIG**: Electroless Nickel / Immersion Gold
- **EDA**: Electronic Design Automation
- **EMI/EMC**: Electro Magnetic Interference / Electro Magnetic Compatibility
- **LDO**: Low Drop Out (voltage regulator)
- **QA/QC**: Quality Assurance / Quality Control
- **SI**: Signal Integrity
- **SMA**: Sub Miniature version A
- **JTAG**: Joint Test Action Group
- **ADC**: Analog to Digital Converter
- **IRIG**: Inter Range Instrumentation Group
- **LVDS**: Low Voltage Differential Signaling
- **LVCMOS**: Low Voltage Complementary Metal Oxide Semiconductor
- **NECL**: Negative Emitter Coupled Logic (-5.2V)
- **LVPECL**: Low Voltage Positive Emitter Coupled Logic
- **MEMS**: Micro Electro Mechanical Systems
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1. Introduction

**NRSC** receives remote sensing satellite data from Indian Remote Sensing (IRS) satellites and processes the data. In order to meet the demand for ingest and processing of existing and upcoming IRS missions, NRSC has designed & developed new ingest hardware card and is named as **SPARC** (Satellite data Processing & Acquisition Reconfigurable Card). NRSC proposes to invite qualified vendors for PCBs fabrication, components procurement, assemble the components on PCBs and functional testing.

It should be clearly understood that the work pertains to earth station’s real time data acquisition & processing hardware, where highest quality and reliability is expected to be built into the system. For this purpose, the vendor shall follow all necessary internationally accepted guidelines (as per section 4).

Each activity related to the PCB fabrication, part procurement, final assembly and testing is to be carried out by the vendor. It is essential for evaluation of offer, vendor should include sufficient technical details of capabilities to meet work requirement in the proposed approach.

2. Product Overview

**SPARC** will be used for data acquisition and processing in real-time environment at earth stations. Figure 1 shows the photo of SPARC card. It is based on Virtex-6 FPGA. The card interfaces to computer system through PCIe Gen-1, x8 interface and can handle data rates up to 800 Mb/Sec.

The card accepts 3 data and 1 clock lines (differential). Additionally, the card also accepts IRIG time code signal. These signals enter the card through SMA connectors.

This PCB is 12 layer, Thickness 1.57mm (+/- 10% tolerance), Length 167mm, Breadth 106 mm, 8-lane PCIe card containing different types of programmable devices like FPGAs, memories etc. The component packages are FCBGS(786 pin), FTBGA(64 pin), LFCSP (16/32 pin), SOIC, SOT, TSSOP, EQFP, QFN, SMD devices and PTH components.

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![Figure 1: SPARC board](image)
3. **Scope of Work**

Scope of work is for Production and supply PCI Express based SPARC cards of quantity 25 nos. Vendor needs to fabricate PCBs, procure components, and assemble components on PCBs. These cards are to be thoroughly tested by vendor with NRSC provided software utilities and Test data generator hardware (mentioned in Section 7.0) before delivering to NRSC. The Test data generator hardware shall be issued to the vendor against submitting of a bank guarantee for an amount of Rs 1,00,000/ valid for a period of six months from the date of delivery.

4. **Reference Documents/Standards**

1. IPC-A-600F or higher : Acceptability of Printed Boards
2. IPC-A-610E : Acceptability of Electronic Assemblies
3. IPC/JEDEC J-STD-033 : Handling, Packing, Shipping and use of Moisture/Reflow sensitive Surface Mount Devices

5. **Work Details**

The work to be carried out by vendor involves

- Components procurement - Components should be procured as per Bill of Materials (BOM) from authorised dealers. The BOM list (excel file) is attached. Certificate of Compliance should be provided by Vendor.
- PCB fabrication - PCBs should be fabricated by using NRSC-provided Gerber files. The fabricated PCBs should be compliant with IPC-A-600F standard (or higher).
- PCB assembly - Components should be assembled on PCBs and should meet IPC-A-610E standard.
- Functional testing - Loading of programming files provided by NRSC into FPGA. Testing the functionality of the card with PC/Work station (Linux RHEL / CentOS 7.0 or above) by using NRSC provided device driver and application software.

5.1. **Typical Production Stages**

The production work involved is defined in different stages

5.1.1. **Stage-1: Components Procurement**

- Vendor should procure the components listed in BOM from authorized vendors. He has to provide Certificate of Compliance for the components.
- He should maintain a part list per PCB, which includes
  - Part number and type
  - Screening details (date code/ batch no.)
5.1.2. **Stage-2: PCB Fabrication**
- Shall be fabricated from reputed PCB fabricator.
- PCB base material shall be FR4 glass epoxy with high Tg and ENIG surface finish.
- Board warpage to be less than 1% of largest dimension of PCB and free from Bow and Twist.
- PCBs to be free of blistering, de-lamination and smooth without wrinkles and bumps.
- PCBs should be compliant with IPC-A-600F standard.
- Inspection of the bare PCBs, and BBT report for each board should be given to NRSC.
- Record the non-conformity, if any and re-fabrication should be done.

5.1.3. **Stage-3: PCB Assembly**
It is categorized in following sub-stages:
- Component mounting stage:
  - PCB cleaning and baking
  - Inspection and rework if required, followed by inspection
  - Component Mounting
  - Inspection
  - Rework if required, followed by inspection
- Component soldering stage:
  - Soldering
  - Inspection
  - BGA assembly correctness to be verified
  - Rework if required, followed by inspection

5.1.4. **Stage-4: Cooling Solution**
- Vendor must provide heat-sink with fan for providing cooling to Virtex-6 FPGA.

5.1.5. **Stage-5: Functional Testing**
- Programming of the devices shall only be done by the files provided by NRSC.
- Testing the functionality of the card with PC/Work station (RHEL OS 7.0 or above) by using NRSC provided device driver and application software. The input will be from NRSC provided Pattgen (Test Pattern Generator) unit.
- Test the card completely as per test plan document provided by NRSC.

5.2. **Record maintenance/documentation**
- Maintain production file for each card which covers
  - Part list prepared in Stage-1.
  - PCB fabrication and assembly check list.
  - BBT report.
  - The non-conformance identified in each of the stage shall be addressed along with rework record if any.
6. Test reports from Stage-5.

QC (Mechanical and Electrical) clearance report.

6. Details of the card
This will be PCI Express interface based PC/server add-on card.

- **PCB dimension**: Length 167mm X Breadth 106mm
- **Type of PCB**: FR4 glass epoxy with high Tg and ENIG surface finish
- **Number of layers**: 12 layers
- **Thickness of the PCB**: 1.57mm (within +/- 10% tolerance)

6.1. Major Components
The major components of SPARC are as follows. Detailed BOM is provided in separate excel sheet.

- **XC6VLX240T-2FFG784C**
  - Description: Virtex-6 FPGA
  - Make: Xilinx
  - Density: 240K logic cells
  - Speed grade: -2
  - Package: 784-pin FCBGA
  - Authorized dealers: Avnet India, Digikey

- **XCF128XFTG64C**
  - Description: Platform Flash configuration device
  - Make: Xilinx
  - Capacity: 128 Mb
  - Package: 64-pin FTBGA
  - Authorized dealers: Avnet India, Digikey

- **AD7626BCPZ**
  - Description: 16-bit 10 MSps differential ADC
  - Make: Analog Devices
  - Package: 32-pin LFCSP
  - Authorized dealers: Avnet India, Arrow Electronics, Digikey

- **ADA4932-1YCPZ-R2**
  - Description: Differential ADC driver
  - Make: Analog Devices
  - Package: 16-pin LFCSP
  - Authorized dealers: Avnet India, Arrow Electronics, Digikey

- **M471B5773DH0-CH9**
  - Description: DDR3 SDRAM SODIMM
- Make: Samsung  
  - No. of pins: 204  
  - Capacity: 2 GB  

- **2-2013289-1**  
  - Description: DDR3 SDRAM SODIMM connector  
  - Make: TE Connectivity  
  - No. of pins: 204  
  - Authorized dealers: Avnet India, Arrow Electronics, Digike

- **10M08SCE144C7G**  
  - Description: Max10 FPGA  
  - Make: Altera  
  - Density: 8K logic elements  
  - Package: 144 pin EQFP  
  - Dimensions: 22mm X 22mm  
  - Authorized dealers: Arrow Electronics, Cytech Global, Digike

- **MC100EP90**  
  - Description: Triple ECL-to-LVPECL translator  
  - Make: ON Semiconductor  
  - Package: 20-pin TSSOP  
  - Authorized dealers: Arrow Electronics, Avnet India, Cytech Global, Digike

- **Power Regulators**  
  - Check BOM for details  

- **874001AG1-05LFT**  
  - Description: PCI Express jitter attenuator  
  - Make: IDT  
  - Package: 20-pin TSSOP  
  - Authorized dealers: Avnet India, Cytech Global, Digike

- **553S**  
  - Description: Low skew 1-to-4 clock buffer  
  - Make: IDT  
  - Package: 8-pin SOIC  
  - Authorized dealers: Avnet India, Cytech Global, Digike

- **R125.680.000**  
  - Description: Right-angle metallic female SMA connector  
  - Make: Radiall  
  - Plating: Gold  
  - Authorized dealers: element14, Mouser Electronics
7. Inputs provided by NRSC
NRSC will provide the following inputs to the successful bidder, as and when required.

- Gerber files
- Programming bit-stream files for Virtex-6 FPGA and Max10 FPGA
- PCIe SPARC Device Driver
- Functional and application software for verification & validation of SPARC boards
- Pattgen: Test Pattern Generator unit for giving input to the card and testing the functionality. This unit will be provided to the successful bidder once the cards are assembled, and should be returned in working condition to NRSC after the Testing Stage of all 25 SPARC cards.
- Test plan document for checking functionality of the card

8. Selection criteria of Vendor
NRSC reserves the right to cross-check the facilities of the vendor. Vendor should fulfil all the requirements mentioned below:

8.1. Essential Requirements from Vendor side

- Digital hardware development and production experience.
- ISO-9001 certified company.
- The vendor should have experience in designing boards with PCIe system interface, and DDR3 high-speed memory interface.
- Vendor is expected to share copies of Purchase Orders showing his past experiences in handling PCIe based boards with high-density FPGAs (> 200 pins in BGA package), DDR3 memory, etc.

8.2. Environment and infrastructure required at Vendor site

- Store PCBs horizontally in sealed dry packaging to maintain solderability.
- ESD safe environment for components, bare PCBs and assembled PCBs.
- Required tools and equipment list is attached as Annexure-1.

9. Terms and Conditions

- Component procurement shall be done from authorised vendors and while procuring, vendor should ensure that correct components with proper specifications, functionality is ascertained.
- High quality soldering practices to be followed. Soldering quality shall be as per IPC-A-600F standard. RoHS compliant assembly by using SAC305 lead-free alloy, no clean and aqueous fluxes.
- Assembly verification report and QA report to be submitted with each assembled board. Finished products will undergo inspection with NRSC’s QA division also.
• NRSC provides testing procedures and required functional testing programs. Vendor shall submit functional test report with each board. Vendor shall support for final functional testing of boards at NRSC which will be carried out by NRSC designers.
• The maximum number of reworks shall be limited to 3 times only.
• Inspection can be carried out by NRSC team at any stage of design & production, to ensure adherence to the guidelines, quality levels and procedures, if required.
• Non Disclosure Agreement (NDA) to be signed by vendor.

10. Acceptance of Assembled & Tested SPARC cards
• Bare Board Testing (BBT) has to be done with 100% coverage of each PCB. BBT report for each PCB should be submitted to NRSC. PCBs should be compliant to IPC-A-600F standard.
• Assembled cards should meet IPC-A-610E standard. QA inspection report should be submitted to NRSC.
• Fully assembled cards will be accepted only after successful completion of functional tests as per test plan document provided by NRSC.
• NRSC will be the final authority for acceptance of the SPARC cards.
• After successful completion of functional testing at NRSC, all the cards will be subjected to Burn-in test for 192 hours under room temperature. In case of any failure during Burn-in test, vendor has to repair/replace component/card without any additional cost.

11. Rejection of SPARC card
• Non-conformance of quality (based on QA/QC inspection report).
• Non-conformance of functionality (based on Test report).
• Any deviation from the provided specifications of the card.
• Not meeting our terms & conditions as per section 9.0 / acceptance procedures as per section 10.0.

If any SPARC card has any of the above issues, then it will result in rejection of that SPARC card. The root cause of rejection shall be analyzed and corrective action shall be implemented by vendor. Rejected SPARC cards shall be re-fabricated by the party without any extra cost and to be supplied within 30 days after receiving information from NRSC. The rejected material will be handed over to the party against replacement.
### Checklist for Acceptance/Rejection of Assembled & Tested FEH cards

<table>
<thead>
<tr>
<th>S. no.</th>
<th>Description</th>
<th>Observation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Any Non-conformance based on mechanical QC inspection report.</td>
<td>![Yes] ![No]</td>
<td>![Yes] ![No]</td>
</tr>
<tr>
<td>2.</td>
<td>Any Non-conformance based on electrical QC inspection report.</td>
<td>![Yes] ![No]</td>
<td>![Yes] ![No]</td>
</tr>
<tr>
<td>3.</td>
<td>Any Non-conformance of functionality (based on Test reports)</td>
<td>![Yes] ![No]</td>
<td>![Yes] ![No]</td>
</tr>
<tr>
<td>4.</td>
<td>No. of reworks should be less than 3 times</td>
<td>![Yes] ![No]</td>
<td>![Yes] ![No]</td>
</tr>
<tr>
<td>5.</td>
<td>Any deviation from the provided specifications of the card</td>
<td>![Yes] ![No]</td>
<td>![Yes] ![No]</td>
</tr>
<tr>
<td>6.</td>
<td>Any deviations from terms &amp; conditions as per para 9.0</td>
<td>![Yes] ![No]</td>
<td>![Yes] ![No]</td>
</tr>
<tr>
<td>7.</td>
<td>Check list for Stage-I to IV submitted</td>
<td>![Yes] ![No]</td>
<td>![Yes] ![No]</td>
</tr>
<tr>
<td>8.</td>
<td>All the NRSC property returned back</td>
<td>![Yes] ![No]</td>
<td>![Yes] ![No]</td>
</tr>
</tbody>
</table>

Note: NRSC will be the final authority for acceptance/rejection of the FEH cards.

### 12. Assembled PCB Packaging
Assembled PCB shall be properly sealed along with silica gel & humidity indicator to avoid the damage during transportation from rough handling, heat, humidity, dust, mechanical shock, vibration and storage.

### 13. Confidentiality
The party is prohibited from further utilizing or passing on any of the design details or details of the drawing in whatever form to any third party for use by them for any exploitation, commercial or otherwise without written permission from NRSC. If any digression from confidentiality will be found at any stage, agreement will no longer be valid.
and appropriate action against vendor will be initiated.

14. Warranty: One year
In case of any malfunction of the card during the warranty period due to fabrication/manufacturer/component defects/failures, vendor has to repair/replace the card without any additional cost.

15. Delivery of Jobs

15.1. Delivery Schedule
Delivery of the finished products within 100 days from the date of receipt of inputs / Purchase Order from NRSC, whichever is later.

15.2. Deliverables
Vendor is required to submit following deliverables:

- Finished (assembled and tested) SPARC cards
- Photo films of SPARC card.
- BBT report
- Pattgen unit provided by NRSC for testing the SPARC cards.
- Individual inspection and functional test reports corresponding to each assembled PCB:
  - Mechanical Measurement Report.
  - QA report for visual inspection.
  - Functional test Report.
  - Non conformance report if any.

16. Annexure-1
The following EDA Tools and Equipments will be required at Vendor side for PCB assembly, programming and testing. NRSC will not provide these tools and equipments.

- Oscilloscope
- Logic analyzer
- Visual inspection systems for PCBs
- Temperature control and ESD protective soldering stations
- EDA tools:
  - Altera QuartusII Programmer
  - Xilinx iMPACT tool
- Programming equipments:
  - Altera USB Blaster
  - Xilinx Platform Cable USB
- All types of precision tools required for PCB assembly
- PC/Server with PCIe interface and Linux RHEL / CentOS 7.0 or above