TECHNOLOGY DEVELOPMENT FUND SCHEME

TECHNOLOGY
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Project Definition Document (PDD)

Design and Development of Multi-Band RFSoC for Proximity Sensor (MB RPS) Application

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1 Brief description of the Project

Radars are core of the any defence engagement scenario and operates by transmitting a RF signal towards a target. The receiver of the radar uses the reflected information form the target for determining its relative position/speed etc. These radars are used for varieties of the application in the military operations such as target detection, tracking, fuzing, surveillance, weapon control and missile guidance etc.

Among these applications, proximity sensor radar is one of the most widely used in all the avionics system such as missiles, rockets and stores for the fuzing application. Considering the frequent usage of the proximity sensors, it is required that they should be realized in the miniaturized form factor with economical cost of production. Therefore, the design and development of proximity sensors with superior size, weight, area, power and cost (SWAP-C) performance parameters in comparison to the existing discrete component-based proximity sensors is the focus of this project.

1.1 Name of Project

Design and Development of Multi-Band RFSoC (RF System on Chip) for Proximity Sensor (MB-RPS) application

1.2 Introduction

Proximity sensor is an integrated RF system and mechanically fits into the avionics system such as missile and stores. These proximity sensors are configured for radio

proximity fuze (RPF) and radio-altimeter application. The main function of these proximity sensors is to accurately and precisely detect the target irrespective of the operating scenarios and target attack.

- DRDO has done the design and development of proximity sensors for various strategic application.
- These proximity sensors operate at C-, X- and Ku-band of frequency and realized using various industrial grade components
- Most of these proximity sensor systems are already gone through various qualification stages and are flight worthy.
- However, the above approach has following constraints
  - ***Component obsolescence*** from the import sources is leading to reiteration of the complete design cycle, qualification and testing.
  - ***Import dependency***, since most of components used in the realization of Radio-altimeter and RPFs are from the multiple import sources. So, there is a huge dependency on source of these components.
  - ***Multiple design*** for the proximity sensor operating at same as well as different frequency bands.
  - Possibility to reduce size, cost, weight and volume.

Therefore, considering the advancements in the state of art chip design development, it is proposed to do the design and development of a Single Multi-

Band CMOS/BiCMOS RFSoC and system for C- and Ku-band Proximity Sensor (MB-RPS) application.

1.3 Objective of the project:

To design and develop multi-band RFSoC and system for miniaturized reconfigurable FMCW (Frequency modulated continuous wave)/PN (pseudo random) Coded Radar, with following features:

- Single RFSoC for C- and Ku-band FMCW/PN-Coded Radar system
- RFSoC based system radio proximity fuze (RPF) and radio-altimeter
- Overcome component obsolescence and import dependency
- Miniaturized Hardware
- Possibility to extend application to imaging.

1.4 Description of the major system / subsystem:

The outcome of this project is Single Multi-Band RFSoC and system for C- and Ku-band Proximity Sensor (MB-RPS) application. RF proximity sensor configured in radio proximity fuze (RPF) or radio-altimeter mode are used is all the airborne system such as missile, bombs, rocket etc. Typically, these proximity sensors operate at C- and Ku-band frequencies. Therefore, proposed multi-band RFSoC and system based on it, will meet the large-scale requirement of these strategic system and be a single reconfigurable solution to these the large number of system requirement.

Proposed system for the use of proposed technology: Airborne system such as missile, bombs, rocket etc

Further, the details of the application system shall be shared on the successful development and evaluation of the RFSoC.

2 Project Categorization (Sensitive/ Non-Sensitive)

Non-Sensitive

3 Shortcomings of existing system and capabilities sought in system/ product

To analyze the shortcomings of the existing radio-altimeter and radio proximity fuze (RPF) proximity sensor their details have been studied at following levels

- Design specifications
- Realization plan
- Life cycle management

Based on the analysis carried the shortcomings of existing system and capabilities sought in the proposed system/ product are explained in the subsequent sub-sections.

3.1 Shortcomings of existing system

In the existing airborne system such as missile, bombs, rocket etc, proximity sensors are configured as radio-altimeter and radio proximity fuze (RPF).

Currently, these systems are being realized using discrete components source from multiple manufacturers. However, this approach has following constraints:

- ***Component obsolescence*** from the import sources is leading to reiteration of the complete design cycle, qualification and testing.

- ***Import dependency***, since most of components used in the realization of Radio-altimeter and RPFs are from the multiple import sources. So, there is a huge dependency on source of these components.
- ***Multiple design*** for the proximity sensor operating at same as well as different frequency bands.
- Possibility to reduce size, cost, weight and volume.

3.2 Capabilities sought in system/ product

To overcome these constraints, it is proposed to do the design and development of Single Multi-Band RFSoC and system for C- and Ku-band Proximity Sensor (MB-RPS) application. The utility and improvement brought by this development to system are:

- The RFSoC and system designed during this development will be fully owned by DRDO. Therefore, it will address the ***Component obsolescence*** and its associated challenges such as re-development and re-qualification. Apart from, these it will be easy to upgrade/modify the design as per DRDO future needs
- Since, this development is an indigenous development, it will address the **import dependency** constraint adequately.
- The proposed RFSoC and system is a multi-band reconfigurable design, operating across C- and Ku-band. Therefore, this single RFSoC and system will be adequate for all the current and future requirements, hence will adequately address the ***Multiple designs*** constraint.

- Also, this RFSoC is proposed to design using highly integrable CMOS/BiCMOS technologies, which is having well established commercial eco-system from design to production. Therefore, this RFSoC will led to the reduction in size, weight and volume of the system. Also, the cost of system is also likely to be reduced by a factor 5 to 10 times.

4 System requirements and functionalities

This project is for the design and development of BiCMOS/CMOS based multi-band RFSoC and qualify its performance at the system level as radio-altimeter or radio-proximity fuze (RPF). The tentative block diagram of proposed Multi-Band BiCMOS RFSoC for the proximity sensing is shown in Fig. 1. This RFSoC shall be configured in the radio-altimeter or RPF configuration application The block of proposed single channel system configured at C- or Ku-band for radio-altimeter application is shown in Fig. 2. Similarly, proposed three channel system configured at C- or Ku-band for RPF application is shown in Fig. 3. **The details of the system requirements and functionalities are given in Appendix I (Refer Appendix I To be shared with development partner on Signing the NDA)**

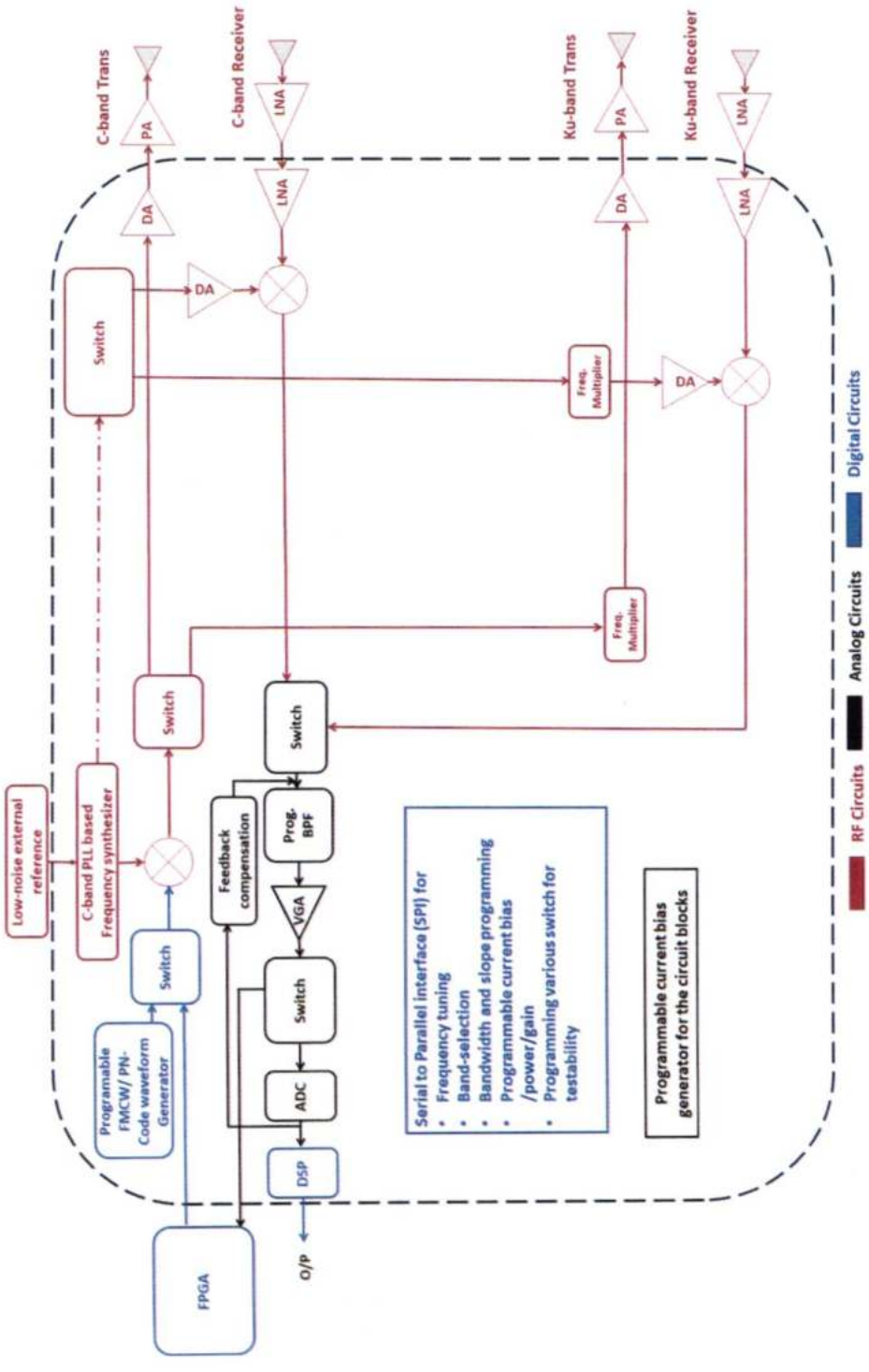

Fig. 1. Block diagram of proposed Multi-Band BiCMOS RFSoC for Proximity Sensor (MB-RPS)

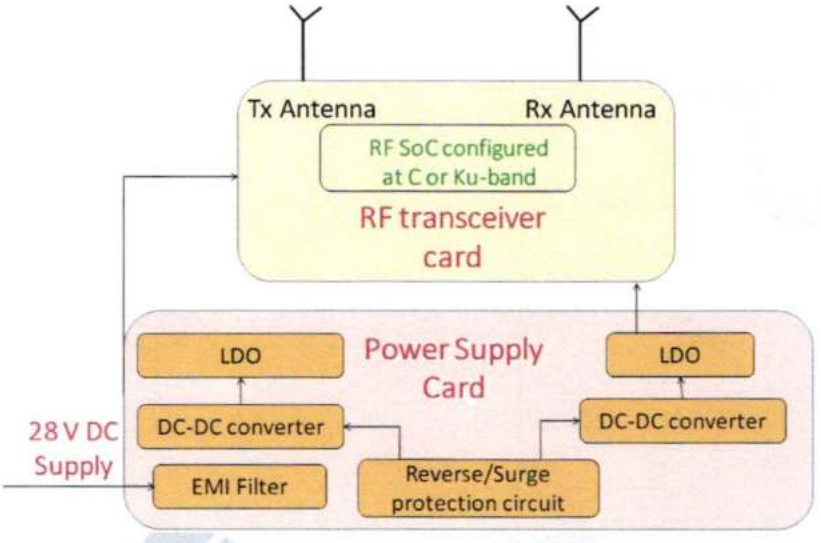

Fig. 2. Proposed single channel system configured at C- or Ku-band for radio-altimeter application

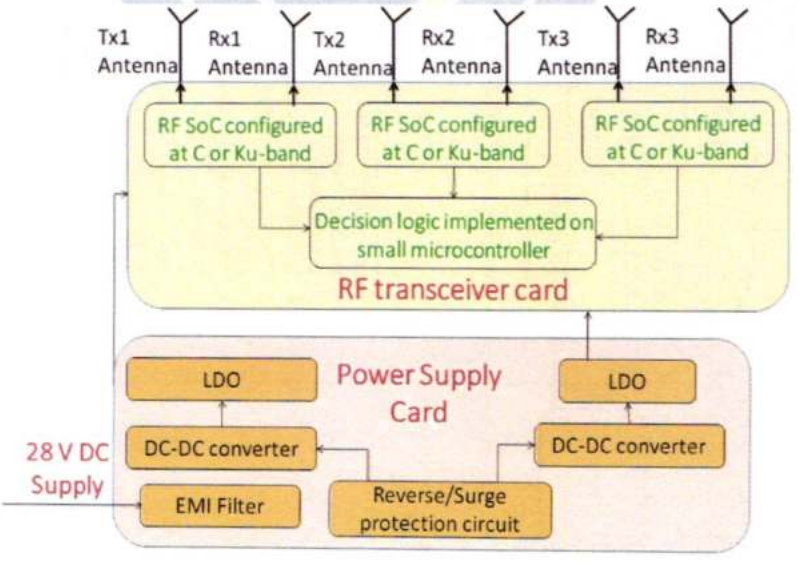

Fig. 3. Proposed three channel system configured at C- or Ku-band for RPF application

5 Operational requirements

This RFSoC chip and proximity sensor realized using this RFSoC should demonstrate the respective performance at their respective operational conditions.

5.1 RFSoC operational requirement

For the evaluation board, RFSoC should qualify the standard industrial grade environmental constraints applicable for semiconductor chips/components.

5.2 Proximity sensor system level operational requirement

On the successful completion of the PDR, DRDO shall provide the ENTEST and QAP document of the intended application. Development agency must incorporate these spcifications starting from the design stage of RFSoC, so that performance at the system level is achieved

6 Critical activities and milestones

This project involves the design and development of CMOS/BiCMOS multi-band RFSoC and proving its performance in one/three channels system at C/Ku-band in radio-altimeter system and RPF configuration. The complete execution task is carefully divided in various critical activities and milestones for the successful execution as given in the following subsections.

6.1 List of critical activities

i. **Preliminary Design**

- Preliminary Design Review
- Finalization of RFSoC specification and link budget design

- Completion of RFSoC schematic design
- Release of Approved PDR Documents including compliance

ii. **Pre-fabrication layout finalization**

- Layout Design Review
- Completion of the RFSoC layout design and post-layout simulation
- Release of approved pre-silicon verification document and it compliance with finalized RFSoC specifications in MS1
- Tape-out of the RFSoC

iii. **RFSoC Evaluation board design**

- Integrated RFSoC layout and Evaluation PCB board design
- Design of RFSoC evaluation board, its simulation with RFSoC and generation of 3-D model
- Release of approved PCB schematic and layout files for fabrication

iv. **Critical Design review**

- Completion of Design, Development & testing of identified Critical technology and component
- Release of Approved CDR Document including compliance of simulation and measurement results of RFSoC at industrial grade

v. **System Design**

- Design and development of 3-channels proximity sensor system for RPF application and 1-channel proximity sensor system for radio-altimeter application

- Testing and evaluation of RFSoC based system

vi. Qualification of proximity sensor

- Acceptance and Qualification test of 3-channels proximity sensor system for RPF application and 1-channel proximity sensor system for radio-altimeter application.
- Release of approved documents and its compliance with targeted Environmental specifications supplied by user.

vii. Production and Supply

- Final production plan of deliverables
- Documentation and ToT /IPR

6.2 List of milestones

Based on these critical activities and TDF guidelines a list of milestones is:

Milestone No.	*Phase*	*Activities*	*Payment*
MS1	*Preliminary Design*	***Preliminary Design Review*** ▪ *Finalization of RFSoC specification and link budget design* ▪ *Completion of RFSoC schematic design* ▪ *Release of Approved PDR Documents including compliance* ***Layout Design Review***	***15%***

		▪ *Completion of the RFSoC layout design and post-layout simulation* ▪ *Release of approved pre-silicon verification document and it compliance with finalized RFSoC specifications in MS1* ▪ *Tape-out of the RFSoC*	
MS2	*Critical Design review*	***Critical Design review*** ▪ *Integrated RFSoC layout and Evaluation PCB board design* ▪ *Design of RFSoC evaluation board, its simulation with RFSoC and generation of 3-D model* ▪ *Release of approved PCB schematic and layout files for fabrication* ▪ *Completion of Design, Development & testing of identified Critical technology and component* ▪ *Release of Approved CDR Document including compliance of simulation and measurement*	***25 %***

		results of RFSoC at industrial grade	
MS3	*System Design review*	***System level design and testing*** ▪ *Design and development of 3-channels proximity sensor system for RPF application and 1-channel proximity sensor system for radio-altimeter application* ▪ *Testing and evaluation of RFSoC based system*	***20%***
MS4	*Qualification*	***Qualification of proximity sensor*** ▪ *Acceptance and Qualification test of 3-channels proximity sensor system for RPF application and 1-channel proximity sensor system for radio-altimeter application* ▪ *Release of approved documents and its compliance with targeted Environmental specifications supplied by user.*	***20%***

MS5	*Production plan and Documentation*	▪ *Final production plan of deliverables* ▪ *Documentation and ToT /IPR*	***20 %***

7 Feasibility study details as per current scenario

User has done the detailed feasibility study as per current scenario. The details of the report can be shared with development agency at the appropriate time. However, development agency should carry-out an independent feasibility of the project and shall submit the peer reviewed report of the same at the start of project.

8 Phases of implementation

Complete scope of work for this project can divided into following 5 phases as per the Milestones of the project

i. Preliminary design review
ii. *Critical design review*
iii. System level design and testing
iv. Qualification
v. *Production plan and documentation*

9 Testing and analysis

*i. **RFSoC evaluation and characterization: Bench level testing for the evaluation board***

a. Development partner should demonstrate the functionality of RFSoC against specification derived from overall specification, which are wetted by DRDO at start of the project.

b. The RFSoC evaluation and characterization shall be carried out by Development partner at their premises as well as at the designated DRDO lab

ii. System level test

a. ***For fuzzing application***

The development partner needs to design a 3-channel system using 3 RFSoC, as per the mechanical casing, fitment and section details provided by DRDO and need to establish the system level perform in the following scenario at frequency-band i.e., C- and Ku-band

- Bench-level test
- Anechoic chamber
- Open air test at the site specified by user in the gun firing scenario
- Development agency should carry-out test for demonstrating the functional capability in presence of jamming signal.

b. ***For Radio-altimeter application***

The development partner needs to design a 1 channel system using 1 RFSoC, as per the mechanical casing, fitment and section details provided by DRDO and need to establish the system level perform in the following scenario at frequency-band i.e., C-and Ku-band

- Bench-level test
- Anechoic chamber
- Tower-top test

- Development agency should carry-out test for demonstrating the functional capability in presence of jamming signal.

10 Integration

This RFSoC will be used to realize one/three-channel radio altimeter system and RPF i.e., C-band single channel radio-altimeter, Ku-band single channel radio-altimeter, C- band three-channel RPF and Ku-band three-channel RPF. For demonstrating the system level performance, user will supply the 4 sets of antenna/RF cables and mechanical fixture of the targeted applications for respective configuration. Development partner needs to integrate all the four types accordingly and prove the system level performance accordingly.

11 Certification Requirements

a. *For RFSoC evaluation board*

DR&QA of the nodal DRDO lab

b. *For system level*

RCMA, co-located with nodal DRDO lab

12 Trials and Performance evaluation

- Development partner needs to carry-out the Radio altimeter trails and performance evaluation in captive flight test (CFT) environment and establish the performance against the target specifications. The details of the CFT to be decided at the time of PDR.

- Development partner needs to carry-out the RPF trails and performance evaluation in dynamic fuzing environment by means of detecting the projectile fired from a Bofors gun and establish the performance against the target specifications.
- During both these, DRDO will assist the partner technically and obtaining the necessary permission.

13 Time frames for execution of the project

36 Months

14 Cost Estimation clause

- To realize the final qualified product a lot of tasks need to be carried out. It includes the all activities to be carried-out at development agency (DA) as well as nodal lab end. **The detailed responsibility matrix in this regard in Appendix II**
- Therefore, while estimating the cost DA should consider complete development in total. DA should support the DRDO nodal lab in terms of manpower/logistics etc. as per the requirement during the execution and should quote accordingly.

15 Safety and security aspects

15.1 Safety Aspects

The maximum power level (2 W) of the RF radiations transmitted by the proximity sensor bare minimal and within in the permissible limit of standard operating scenario. Therefore, it does not need any operational safety precautions.

15.2 Security Aspects

The technology development is at the very initial stage of development and specifications are very much generic. Therefore, at this stage of development there are no security concerns

However, for the IP protection, vendor needs to comply to:

- IP rights of all the designs, final RFSoC and system shall be jointly owned by DRDO and development agency
- DRDO should have perpetual ownership of all the designs, final RFSoC and system
- Database of GDS generated of RFSoC and PCBs etc., shall be uploaded from designated DRDO lab.
- Development agency should have license or agreement with process design kit (PDK) foundry for of producing RFSoCs in bulk on successful delivery.

16 Exit Criteria and Risk management

16.1 Exit Criteria

- All the milestone stages interlinked to the next milestone stage in the series fashion and have associated payment commitment. Thus, without completing one stage of development next stage of development cannot be taken up.
- Therefore, non-compliance to the task and deliverables associated with each milestone are the potential exit criteria.

- Therefore, each milestone shall be treated as stage closure. Completion of first 3 milestone (Milestone 1, Milestone -2 and Milestone 3) i.e., system level design and testing shall be treated as partial closure/partial development,
- Accordingly, relevant experts shall be invited for reviewing the performance on the completion of milestone targets and hence the payment shall be made accordingly.

16.2 Risk management

- Fabricated RFSoC is susceptible to process variation, hence enough EM simulation need to be done before tape-out.
- Difficult to debug if proper testability is not included during the design. Therefore, proper testability to be planned during the design phase.
- Development agency should address these technology gap/risks during the design and chalk-out the risk mitigation plan at the start of design.

17 Final Deliverables and documents

17.1 System -level deliverable

i. **System -level deliverable**

S.No	System	Proto/testing samples	AT qualified	QT qualified
1	3-channel proximity sensor system for RPF application at Ku-band	2	2	1
2	3-channel proximity sensor	2	2	1

	system for RPF application at C-band			
3	1-channel proximity sensor for radio-altimeter application at Ku-band	2	2	1
4	1-channel proximity sensor for radio-altimeter application at C-band	2	2	1

ii. **RFSoC:** 50 packaged chips from the lot that has qualified for system-level AT/QT

iii. **All the cables and accessories:** 20 sets (5 set for each type of system)

iv. **Mechanical fixtures** for all the mechanical tests such as random vibration, thermal, shock and acceleration: 8 sets (2 for each type of system)

v. **Coupon Cards with test zigs**: 2 sets for all the evaluation boards

17.2 Design and Documentation deliverables

The development agency must mandatorily disclose all the project related information with DRDO through various documents or design files and other details for RFSoC, 3-channel for RPF application and 1-channel proximity sensor for radio-altimeter application separately:

a. *Inter-mediatory deliverables* documents/design files

At each milestone and review development partner should supply following documents (editable soft copy as well as hardcopy) and design files (editable soft copy)

i. Design document covering all the conceptual, design details and results
ii. Soft copy of the editable schematic and layout files of the circuit, PCBs, mechanical design.
iii. Softcopy of the digital logic written in Verilog/VHDL etc
iv. Qualification report

b. **Final deliverables documents/design files**

On successful completion of the project, following approved documents (editable softcopy as well hardcopy) must be submitted to DRDO nodal lab

Complete set of following documents/design files

i. A detailed design document covering all the conceptual, design details and results.
ii. The simulation results of the integrated RFSoC should include, the simulation across the process corner and temperature
iii. Soft copy of the final editable schematic and layout files of the circuit, PCBs, mechanical design
iv. Softcopy of the final digital logic written in Verilog/VHDL etc
v. Electrical and software interface control document
vi. Integration process document (Electrical and mechanical)

vii. BOM documents

viii. Master drawing index (MDI) (Electrical and Mechanical)

ix. Signal integrity and analysis report.

x. ATP, QTP and QAP documents with all the test, corresponding targeted and achieved results

xi. All the test data-sets

xii. Complete thermal analysis report

xiii. Editable 3-D model of the RFSoC and final system

xiv. Vendor must submit 3 sets of following approved documents

S. NO.	Documents Name
1	Operational Requirement Document
2	Preliminary Design Document
3	Detailed Design Document
4	Preliminary Design Document
5	Detailed Design Document
6	Critical Design Document
7	Post Flight Analysis Document
8	Pre-fabrication Design Analysis Report
9	De-rating Analysis Report
10	Power Integrity Analysis
11	Thermal Integrity Analysis
12	Structural Dynamic Analysis

13	3D EM Package Analysis [Electronics Block]
14	Failure Mode, Cause & Effect Analysis
15	Reliability Analysis
16	Thermo-structural Analysis
17	Kinetic Heating Analysis Report
18	Set of SQAD Document
19	Software Requirement Specifications
20	Software Design Document
21	Software Test Procedure
22	Software Test Report
23	Quality Assurance Plan
24	Environmental Test Plan
25	Acceptance Test Plan
26	Qualification Test Plan
27	Safety of Flight Test Plan
28	Test Setup Calibration Report
29	Individual evaluation board Test Report
30	Functional Test Report
31	Acceptance Test Report
32	Qualification Test Report
33	Safety of Flight Test Report
34	Technical Specifications
35	Bill of Materials

36	Kit Inspection Report
37	Master Drawing Index
38	Integration Process Document
39	Interface Control Document
40	Checkout Procedure Document

18 List of applicable standards

- RFSoC in the standard evaluation board shall be qualified for the standard industrial grade ENTEST specifications.
- Development agency should adapt the following standards for the design and development of the system.

S. NO.	Standard	Applicability of Standard
1	MIL-STD-810 G *31 Oct. 2018*	Environmental Engineering Considerations & Laboratory tests
2	JSS-0256-01: *1992* *REV. NO.: 1*	Environmental Test Methods for Missile System
3	JSS 55555: *2012* *REV. NO.: 3*	Environmental Test Methods for Electronic and Electrical Equipment
4	MIL-HDBK-2164A *19th JUN. 1996*	Environmental Stress Screening (ESS) Process for Electronic Equipment
	MIL-HDBK 344A REV. A *16th AUG., 1993*	
5	MIL-STD-461 E *20TH AUG., 1999*	Requirements for the control of Electromagnetic Interface Characteristics of Subsystems & Equipment.
	MIL-STD-461 G *11TH DEC., 2015*	

6	MIL-STD-704 F *12TH MAR. 2004*	Department of Defense Interface Standard for Aircraft Electric Power Characteristics
7	IPC-A-600F *NOV. 2004*	Acceptability of Printed Boards
8	IPC-A-610F	Acceptability of electronic assemblies
9	MIL-I-46058C *7TH JULY, 1972*	Military Specification for Conformal Coating of Printed Circuit Assemblies
10	MIL-STD-454N 30 June 1992	General requirements for Electronic equipment

- However, the exact environmental specifications and quality assurance plan document of the intended application, shall be provided on the successful completion of PDR.

19 Life cycle management

- An avionic sub-system usually has operational life cycle of over 20 years. Therefore, development partner should ensure that life cycle of this RFSoC is minimum twenty years for the final deliverable and subsequent ten years on every upgradation.
- Vendor should provide the life cycle assessment of the RFSoC based system considering manufacturing process, power emissions, environmental factors and operating scenario.
- The fabricated RFSoC should be easy to maintain and handle. Vendor should provide the detailed manual for better life cycle and maintainability of the proposed RFSoC hardware.

20 Estimated Future Quantity Requirements

- Since RFSoC is likely to be used for proximity sensing application of the present and future avionics or air-borne system, the requirement will to be continuous over the time-period.
- The estimated requirement shall be a large number for the DRDO application for which order will be placed by the user upon successful completion of TDF project. However, this RFSoC is likely to have other commercial application as well

21 Broad Acceptance Criteria

- The development partner must timely comply to all the milestones specified by the DRDO
- The development partner must deliver all the documents, design files, hardware at each milestone as well as on the completion of project.

22 Any other Applications including Spin-off Applications

Apart from strategic applications proximity sensing radar has applications in various other domains

- **Commercial and military aircraft**: For reliable lending
- **Space:** For reliable lending
- **Automotive industry**: For vehicle collision avoidance system / automatic driver assistance system (ADAS)

- **Drones:** For reliable navigation and collision avoidance

23 Vendor qualification criteria

The RFSoC design and development is a very costly exercise, need highly qualified and experience manpower to meet the targeted goal in 1 iteration. Therefore, development agency should meet following criteria to execute the task.

i. **Design experience**

a. Development agency must have design experience of executing at least 5 different CMOS/BiCMOS RFSoCs and successful delivery to the customer through present entity and must provide the proofs for the verification in this regard.

b. These delivered CMOS/BiCMOS RFSoCs must have RF (minimum at S-band and above), analog and digital circuitry.

c. Typically, the experience may include CMOS/BiCMOS RFSoCs for commercial mobile communication radio, FMCW radar or beamforming RFSoC and system based on the RFSoC.

ii. **Manpower**

Vendor must deploy following set of dedicated man-power for timely execution of task

a. **System Design** (1 Design lead with 10 Yr + experience, 2 Design engineers with 5 Yr+ design experience)

b. **RF Design** (1 Design lead with 10 Yr + experience, 2 Design engineers with 5 Yr+ design experience, 1 layout engineer with 5 yr+ experience)

c. **Analog Design** (1 Design lead with 10 Yr + experience, 2 Design engineers with 5 Yr+ design experience, 1 layout engineer with 5 yr+ experience)

d. **Digital Design** (1 Design lead with 10 Yr + experience, 1 Design engineer with 5 Yr+ design experience, 1 layout engineer with 5 yr+ experience)

iii. **Software tools**

Vendor should have well established software tools setup for the following from RFSoC chip design to system delivery:

a. IC design and simulation: Industry standard software tools from Cadence/Synopsys/Mentor etc

b. EM simulation: ADS/HFSS etc

c. Mechanical tools: Ansys etc

d. IC packaging and thermal analysis tools

iv. **Equipment**

Vendor should have well established integrated RFSoC characterization facility till Ku-band

v. **Turn-over**

Since RFSoC design and development activity is a capital-intensive activity and need well established eco-system and experienced/trained manpower to execute the task on -time. Therefore, total turn-over of the development agency should be minimum equal to the half of project cost over last 2 years

24 **IP right clause**

- IP rights of all the designs, final RFSoC and system shall be jointly owned by DRDO and development agency
- DRDO should have perpetual ownership of all the designs, final RFSoC and system

25 **Responsibility Matrix**

To ensure the successful execution and utility of the final project outcome, a detailed matrix has been prepared. **The detail of tasks and along with responsibility assigned is available in Appendix II.**

26 **Essential equipment's/Infrastructure needed from the Development Agency (DA)**

i. **Software tools**

Vendor should have well established software tools setup for the following from RFSoC chip design to final demonstration:

e. IC design and simulation: Industry standard software tools from Cadence/Synopsys/Mentor etc

f. EM simulation: ADS/HFSS etc

g. Mechanical tools: Ansys, CST etc

h. IC packaging and thermal analysis tools

ii. **Equipment**

Vendor should have well established integrated RFSoC characterization facility till Ku-band

27 **Other Details, if any:**

- Development agency should involve the designated DRDO Scientist from the Nodal DRDO lab and should share all the details
- Development is allowed to collaborate with any other vendor with necessarily approval from DRDO.
- Database of GDS generated of RFSoC and PCBs etc., shall be uploaded from designated DRDO lab. However, payment related to fabrications shall be made be development agency.
- Nodal DRDO lab shall share knowledge gained during the development of existing discrete components-based proximity sensor on the need basis and recommendation by appropriate committee on signing the NDA
- Nodal DRDO lab shall share the final testing details only after the establishment of RFSoC evaluation board for industrial grade environmental/reliability specifications.

- Development agency shall take the approval of Nodal DRDO lab, before going ahead for any fabrication or capital-intensive activity or any design changes from the approved design
- Development agency should have license or agreement with process design kit (PDK) foundry for of producing RFSoCs in bulk on successful delivery.
- Development agency should address the technology gap/risks during the design and chalk-out the risk mitigation plan at the start of design.

28 Keywords

CMOS, BiCMOS, RFSoC, Miniaturized Radar, Proximity sensor, multi-band transceiver, RPF, Radio-altimeter

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Appendix II

RESPONSIBILITY MATRIX

Project: Multi-band RFSoC for proximity sensing application

S.No	Task	User agency	Development Agency (DA)
1.	Review of the existing proximity sensor at C- and Ku-band transceiver architectures by DA and review by user agency	✓	✓
2.	Preparation of common specifications for proximity sensor at each frequency band by DA and review by user agency	✓	✓
3.	Literature review of CMOS/BiCMOS based proximity sensor by DA (mentoring by user agency)	✓	✓
4.	Conceptual block diagram of the multi-band RFSoC for C- and Ku-band proximity sensing application by DA and review by user agency	✓	✓
5.	Feasibility review of the multi-band RFSoC by DA and mentoring by user agency	✓	✓
6.	Study of system level block diagram finalized by user and suggested detail amendments		✓

RESPONSIBILITY MATRIX

Project: Multi-band RFSoC for proximity sensing application

S.No	Task	User agency	DA
7.	Finalization of the detailed system level block diagram for C-and Ku-band proximity sensing application along with off-chip components as per DA inputs and review by nodal lab	✓	✓
8.	Finalization of process design kit (PDK) as per the design experience and availability to DA in consultation with Nodal lab		✓
9.	Preliminary specifications of all circuits block as per PDK capability by DA		✓
10.	Finalization of block level specifications of complete RFSoC by DA & review by user	✓	✓
11.	Schematic design of LNA and driver amplifier of for C-and Ku-band receiver		✓
12.	Schematic, layout design and simulation of receiver RF chain (LNA + Mixer + driver amplifier) for C-and Ku-band		✓

RESPONSIBILITY MATRIX

Project: Multi-band RFSoC for proximity sensing application

13.	Integrated receiver RF chain schematic and post-layout simulation verification and review for C- and Ku-band	✓	
S.No	**Task**	**User agency**	**Development Agency (DA)**
14.	Design of schematic, layout and Simulation of RF transmitter chain (Driver amplifier+ mixer + coupler + multiplier) for C-and Ku-band		✓
15.	Integrated transmitter RF chain schematic and post-layout simulation verification for C-and Ku-band by DA and review by user agency	✓	✓
16.	Design of schematic, layout and simulation of exciter/frequency synthesizer for C-and Ku-band		✓
17.	Integrated exciter/frequency synthesizer schematic and post-layout simulation verification by DA and review by user agency	✓	✓

RESPONSIBILITY MATRIX

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18.	Design of schematic, layout and simulation of common baseband chain (Filter+AGC+DC offset cancellation circuit)		✓
S.No	**Task**	**User agency**	**DA**
19.	Integrated baseband chain schematic and post-layout simulation verification by DA and review by user agency	✓	✓
20.	Design of schematic, layout and simulation of ADC		✓
21.	Integrated ADC simulation verification by DA and review by user	✓	✓
22.	Schematic, layout integration and simulation of RF and analog circuits		✓
23.	Integrated analog and RF schematic and post-layout simulation verification by DA and review by user agency	✓	✓
24.	Preliminary digital algorithm based on the existing proximity sensors by DA and review by user agency	✓	✓

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25.	Digital logic design and synthesis for ASIC and external FPGA		✓
26.	Finalization of digital logic design & verification of the results by DA & review by user	✓	✓
S.No.	**Task**	**User Agency**	**DA**
27.	Planning of the reconfigurability & programmability of RFSoC by DA & review by user	✓	✓
28.	Implementation of the reconfigurability and programmability of RFSoC		✓
29.	Generation of PDR document on completion of schematic design		✓
30.	Conducting the PDR review and finalization of minutes by DA and review by user	✓	✓
31.	Incorporating the PDR committee review comments in RFSoC design		✓
32.	Identification of external PA, LNA C-and Ku-band by DA and review by user	✓	✓
33.	Floor planning for the layout integration at RFSoC level by DA and review by user	✓	✓
34.	Integrated RFSoC level schematic, layout design and simulation		✓

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35.	Integrated RFSoC schematic & post-layout simulation by DA and review by user	✓	✓
36.	Release of approved pre-silicon verification document and it compliance with finalized RFSoC specifications		✓
S.No.	**Task**	**User Agency**	**DA**
37.	Generation of final GDS-II and addressing the fabrication related queries		✓
38.	Tapeout of the final GDS from user agency office	✓	
39.	Design of package and fabrication		✓
40.	Design of evaluation board schematic and layout		✓
41.	Finalization of evaluation board BoM by DA and review by user	✓	✓
42.	Generation of 3D model for integrated RFSoC, package, PCB and EM simulation		✓
43.	Review of integrated 3D model	✓	
44.	Fabrication and testing of evaluation board at vendor premises		✓
45.	Testing of evaluation board at Nodal lab premises review by user	✓	✓

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46.	Compilation of the measurement results		✓
47.	Generation of CDR document and compliance of measurement results with simulation results		✓
S.No	Task	User agency	Development Agency (DA)
48.	Conducting the CDR review and finalization of minutes by DA and review by user	✓	✓
49.	Incorporating the CDR committee review comments in design if any		✓
50.	Qualification of RFSoC evaluation board for industrial grade environmental and reliability specifications by DA and review by user	✓	✓
51.	Review and validations of results during qualification		✓
52.	Design and development of RFSoC based system at C- and Ku-band as per form factor required by nodal lab		✓

RESPONSIBILITY MATRIX

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53.	System level test for fuzzing application: Bench-level test, Anechoic chamber, open air test		✓
54.	System level test for radio-altimeter application: Bench-level test, Anechoic chamber, tower-top test		✓
S.No.	**Task**	**User Agency**	**DA**
55.	Review and validations of system level tests for fuzzing and radio-altimeter application		✓
56.	Qualification RFSoC based RPF and altimeter system at C- and Ku-band as per AT and QT level specified by nodal lab		✓
57.	Validations of RFSoC system results during qualification by DA and review by user	✓	✓
58.	Preparation of AT,QT,MDI,BoM and TS documents as per the requirement of DR&QA of nodal lab		✓
59.	Approval of qualification documents		✓

RESPONSIBILITY MATRIX

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60.	Release of approved documents and it compliance with targeted specifications	✓	
61.	Final deliverable hardware, documents and design files		✓
62.	Preparation of ToT document		✓
63.	Approval and release of ToT document	✓	