QUALIFICATION FILE – Standalone NOS

Essentials of Python for RTL Verification

☐ Horizontal/Generic ☐ Vertical/Specialization

☒ Upskilling ☐ Dual/Flexi Qualification ☐ For ToT ☐ For ToA

☐General ☐ Multi-skill (MS) ☐ Cross Sectoral (CS) ☒Future Skills ☒ OEM

NCrF/NSQF Level: 5

Submitted By:

NATIONAL INSTITUTE OF ELECTRONICS AND INFORMATION TECHNOLOGY (NIELIT)

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Section 1: Basic Details

1.	**NOS-Qualification Name**	**Essentials of Python for RTL Verification**	
2.	**Sector/s**	Electronics	
3.	**Type of Qualification ☒ New ☐ Revised**	**NQR Code & version of the existing /previous qualification: NA**	**Qualification Name of the existing/previous version: NA**
4.	**National Qualification Register (NQR) Code & Version** *(Will be issued after NSQC approval.)*	NG-05-EH-02911-2024-V1-NIELIT	**5. NCrF/NSQF Level: 5**
6.	**Brief Description of the Standalone NOS**	The standalone (NOS) on Python for RTL Verification with cocotb and pyuvm explores essential verification methodologies using Python and its libraries. It begins by covering Python fundamentals including conditions, loops, data structures, strings, modules, functions, classes, inheritance, and design patterns such as factory patterns. The module then dives into verification using cocotb, focusing on coroutines, efficient data handling with cocotb Queue, hardware simulation, and implementing basic and class-based test benches, including practical applications like TinyAluBfm for functional verification. This module equips students to proficiently validate complex hardware systems using Python-based verification approaches.	
7.	**Eligibility Criteria for Entry for a Student/Trainee/Learner/Employee**	**a. Entry Qualification & Relevant Experience:**	

S. No.	Academic/Skill Qualification (with Specialization - if applicable)	Relevant Experience (with Specialization - if applicable)
1	2nd year of UG in Electronics and Communication Engineering/ Electrical Engineering/CS/IT/Physics/Electronics and allied branches	NA
2	3 Years of Diploma in Electronics and Communication Engineering/ Electrical Engineering/CS/IT/Physics/Electronics and allied branches after class 10th	1.5 Years
3	2 Year of diploma in Electronics and	NA

	Communication Engineering/ Electrical Engineering/CS/IT/Physics/Electronics and allied branches after class 12th	
4	NSQF Level 4.5 in Electronics and Communication Engineering/ Electrical Engineering/CS/IT/Physics/Electronics and allied branches	1.5 Years
5	NSQF Level 4 Electronics and Communication Engineering/ Electrical Engineering/CS/IT/Physics/Electronics and allied branches	1.5 Years

b. Age: 18 Years

8.	**Credits Assigned to this NOS-Qualification, Subject to Assessment** *(as per National Credit Framework (NCrF))*	2 Credits	**9. Common Cost Norm Category (I/II/III)** *(wherever applicable)***:** Category-I
10.	**Any Licensing Requirements for Undertaking Training on This Qualification** *(wherever applicable)*	NA	
11.	**Training Duration by Modes of Training Delivery** *(Specify **Total Duration** as per selected training delivery modes and as per requirement of the qualification)*	☒**Offline** ☐ **Online** ☐ **Blended**	

Training Delivery Mode	Theory (Hours)	Practical (Hours)	Total (Hours)
Classroom (offline)	30	30	60

The mode of delivery shall be based on the regional demand and can be offered in anyof the above modes mentioned.
(Refer Blended Learning Annexure-V for details)

12. Assessment Criteria

Theory (Marks)	Practical (Marks)	Project (Marks)	Viva (Marks)	Total (Marks)	Passing %age
100	60	20	20	200	50

The centralized online assessment is conducted by the Examination Wing, NIELIT Headquarters.

13.	**Is the NOS Amenable to Persons with Disability**	☒ **Yes** ☐ **No** **a)** Locomotor Disability: Leprosy Cured Person, Dwarfism, Muscular Dystrophy and Acid Attack Victims **b)** Visual Impairment: Low Vision	
14.	**Progression Path After Attaining the Qualification, wherever applicable** *(Please show Professional and Academic progression)*	Python Verification Trainee-> Junior Verification Engineer-> Senior Verification Engineer ->Verification Architect->Project Manager	
15.	**How participation of women will be encouraged?**	Participation by women can be ensured through Government Schemes. Occasionally, exclusive batches for women would be run for the proposed courses. Funding is available for women's participation under other schemes launched by the Government from time to time.	
16.	**Other Indian languages in which the Qualification & Model Curriculum are being submitted**	Qualification files available in English & Hindi Language	
17.	**Is similar NOS available on NQR-if yes, justification for this qualification**	☐ **Yes** ☒ **No** **URLs of similar Qualifications:**	
18.	**Name and Contact Details Submitting / Awarding Body SPOC** *(In case of CS or MS, provide details of both Lead AB & Supporting ABs)*	Name: Jayaraj U Kidav Email: jayaraj@nielit.gov.in Website: https://nielit.gov.in/ Name: Ishant Kumar Bajpai Email: ishant@nielit.gov.in Website: https://nielit.gov.in/ Name: Deepam Dubey Email: deepamdubey@nielit.gov.in Website: https://nielit.gov.in/ Name: Sreejeesh S.G Email: sreejeesh@nielit.gov.in Website: https://nielit.gov.in/	
19.	**Final Approval Date by NSQC: 25.07.2024**	**20. Validity Duration: 3 years**	**21. Next Review Date: 25.07.2027**

Section 2: Training Related

1.	**Trainer's Qualification and experience in the relevant sector (in years)** *(as per NCVET guidelines)*	B.E./B. Tech in Electronics/ Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation / Instrumentation & Control /Computer Science/Information Technology Minimum 2 year of experience in the field of VLSI Design
2.	**Master Trainer's Qualification and experience in the relevant sector (in years)** *(as per NCVET guidelines)*	B.E./B. Tech in Electronics/ Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation / Instrumentation & Control /Computer Science/Information Technology Minimum 3 years of experience in the field of VLSI Design
3.	**Tools and Equipment Required for the Training**	☒Yes ☐No Available at Annexure-II
4.	**In Case of Revised NOS, details of Any Upskilling Required for Trainer**	NIL

Section 3: Assessment Related

1.	**Assessor's Qualification and experience in relevant sector (in years)** *(as per NCVET guidelines)*	B. Tech or Equivalent as per NCrF + 3 years relevant experience
2.	**Proctor's Qualification and experience in relevant sector (in years)** *(as per NCVET guidelines), (wherever applicable)*	The assessor carries out theory online assessments through the remote proctoring methodology. Theory examination would be conducted online and the paper comprises MCQ. Conduct of assessment is through trained proctors. Once the test begins, remote proctors have full access to the candidate's video feeds and computer screens. Proctors authenticate the candidate based on registration details, pre-test image captured and I-card in possession of the candidate. Proctors can chat with candidates or give warnings to candidates. Proctors can also take screenshots, terminate a specific user's test session, or re-authenticate candidates based on video feeds.
3.	**Lead Assessor's/Proctor's Qualification and experience in relevant sector (in years)** *(as per NCVET guidelines)*	External Examiners/ Observers (Subject matter experts) are deployed including NIELIT scientific officers who are subject experts for evaluation of Practical examination/ internal assessment / Project/ Presentation/ assignment and Major Project (if applicable). Qualification is generally B.Tech.

4.	**Assessment Mode** *(Specify the assessment mode)*	Centralized online examination will be conducted
5.	**Tools and Equipment Required for Assessment**	Same as for training ☒ Yes ☐ No

Section 4: Evidence of the Need for the Standalone NOS

Provide Annexure/Supporting documents name.

1.	Government /Industry initiatives/ requirement (Yes/No): Yes, Available at Annexure-A: Evidence of Need
2.	Number of Industry validations provided: 7
3.	Estimated number of people to be trained: 500 persons per year shall be trained.
4.	Evidence of Concurrence/Consultation with Line/State Departments (In case of regulated sectors): NIELIT is recognized as AB and AA under Government Category. NIELIT is an HRD arm of MeitY, therefore, the Line Ministry Concurrence is not required.
5.	Latest Skill Gap Study (not older than 2 years) (Yes/No): Yes, Available in Annexure-A: Evidence of Need
6.	Latest Market Research Reports or any other source (not older than 2 years) (Yes/No): Yes, Available at Annexure-A: Evidence of Need

Section 5: Annexure & Supporting Documents Check List

Specify Annexure Name / Supporting document file name

1.	**Annexure:** NCrF/NSQF level justification based on NCrF/NSQF descriptors *(Mandatory)*	*Available at* Annexure-I: Evidence of Level
2.	**Annexure:** List of tools and equipment relevant for NOS *(Mandatory, except in case of online course)*	*Available at* Annexure-II: Tools and Equipment

3.	**Annexure:** Industry Validation	*Available at* Annexure-III: Industry Validation
4.	**Annexure:** Training Details	*Available at* Annexure-IV: Training Details
5.	**Annexure:** Blended Learning *(Mandatory, in case the selected Mode of delivery is Blended Learning)*	*Available at* Annexure-V: Blended Learning
6.	**Annexure/Supporting Document:** Standalone NOS-Performance Criteria Details Annexure/Document with PC-wise detailing as per NOS format (Mandatory- Public view)	*Available at* Annexure-VI: Standalone NOS- Performance Criteria details
7.	**Annexure:** Performance and Assessment Criteria *(Mandatory)*	*Available at* Annexure-VII: Detailed Assessment Criteria
8.	**Annexure:** Assessment Strategy *(Mandatory)*	*Available at* Annexure-VIII: Assessment Strategy
9.	**Annexure:** Acronym and Glossary *(Optional)*	*Available at* Annexure-IX: Acronym and Glossary
10.	**Supporting Document:** Model Curriculum	*Available at* Annexure-C: Model Curriculum

Annexure- I: Evidence of Level

NCrF/NSQF Level Descriptors	Key requirements of the job role/ outcome of the qualification	How the job role/ outcomes relate to the NCrF/NSQF level descriptor	NCrF/NSQF Level
Professional Theoretical Knowledge/Process	• Candidates should have a strong grasp of Python fundamentals, including data structures (e.g., lists, sets, tuples), control flow, and object-oriented concepts like classes, inheritance, and design patterns, ensuring they can develop and manage efficient codebases for system verification. • Candidates must be proficient in verification tools such as cocotb and Pyuvm, including their usage for simulating and testing hardware	• The job role requires a strong theoretical understanding of Python programming, particularly in utilizing data structures and object-oriented principles to design efficient verification systems. • It also involves applying formal verification methodologies like cocotb and Pyuvm, emphasizing testbench creation, debugging, and simulation for hardware verification.	5

	systems, developing testbenches, and debugging with tools like ConfigDB(), enabling robust verification processes.		
Professional and Technical Skills/ Expertise/ Professional Knowledge	• Candidates must demonstrate a strong understanding of Python programming concepts, including data types, control structures (conditions and loops), and object-oriented programming principles such as classes and inheritance. • Familiarity with design patterns, particularly factory patterns, is important for building scalable and maintainable code. Candidates should apply these patterns in their programming tasks to enhance code reusability and facilitate collaboration within development teams.	• The job role outcomes related to Python programming and verification methodologies reflect a deep integration of professional and technical skills essential for success in the field. • Candidates are expected to possess comprehensive knowledge of Python concepts, verification frameworks like cocotb and PyUVM, and design patterns, which are critical for developing robust software solutions.	5
Employment Readiness & Entrepreneurship Skills & Mind-set/Professional Skill	• Candidates should demonstrate strong programming skills in Python, including working with data structures, modules, classes, inheritance, and design patterns, ensuring readiness for tasks like software development, algorithm design, and automation. • Candidates must be capable of creating efficient testbenches and simulations using cocotb and Pyuvm, equipping them for roles in hardware verification and validation, and enabling them to contribute to high-quality product development in the semiconductor industry.	The outcomes ensure candidates are equipped with the technical expertise needed to develop, test, and verify complex systems using Python and verification tools like cocotb and Pyuvm, preparing them for immediate contribution in industry roles.	5
Broad Learning Outcomes/Core Skill	• Ability to write modular, reusable, and object-oriented Python code, including the implementation of advanced concepts like inheritance, the super() function, and design patterns. This ensures a strong foundation for	• The job role/outcomes align with Broad Learning Outcomes/Core Skills by enhancing candidates' ability to develop structured, object-oriented Python programs for advanced applications. Mastery in cocotb enables the creation of coroutine-driven,	5

	applying Python in verification environments. • Demonstrate the capability to simulate hardware designs using cocotb by developing coroutine-driven testbenches, managing cocotb queues, and utilizing BFMs (Bus Functional Models) for effective verification.	class-based test benches for efficient hardware verification.	
Responsibility	• Candidates must ensure high standards of code quality by implementing best practices in Python programming, including proper use of functions, classes, and design patterns. • It is essential for candidates to take responsibility for developing robust verification environments using cocotb and PyUVM. This involves creating comprehensive test benches, debugging issues effectively, and ensuring that all components function as intended through rigorous testing protocols.	• The job role/outcomes related to Python programming and verification methodologies underscore the responsibility of ensuring high-quality code development and verification processes. Candidates must be accountable for creating efficient test benches and debugging complex systems, which directly impacts the reliability and performance of digital designs.	5

Annexure-II: Tools and Equipment (lab set-up)

LIST OF EQUIPMENT

(For a batch of 30 students)

	Description	Qty	Specifications
1	Classroom	1	30 Sq.m
2	Student Chair	30	
3	Student Table	30	
4	LCD Projector	1	

5	Trainer Chair & Table	1	
6	Pin up Boards	1	
7	White Board	1	
	VLSI Design Lab		60 Sq. m
1	Desktop computer with accessories	30	Processor: Intel Core i5 (sixth generation newer) or equivalent Memory: 16GB RAM, Internal Storage: 500GB Xilinx Zynq Series FPGAs
2	Desk jet printer	1	A4
3	CADENCE/Synopsys frontend and backend university bundle	5 user licenses	Server-based floating licenses.
4	Xilinx Vivado design suite	30 user licenses	Server-based floating licenses.

Annexure-III: Industry Validations Summary

S. No	Organization Name	Representative Name	Designation	Contact Address	Contact Phone No	E-mail ID
1	Inditech Software Wizard Pvt. Ltd.	Sandip Ghosh	Course Coordinator	Mohiari Chanpiritala, Po: Andul Mouri, PS: Domjur, Distt: Howrah, West Bengal-711302	9230027415	swizardrecruitment@gmail.com
2	Aajivika Global Skill Private Limited	Mukesh Kumar Verma	Director	Beside Vishal Trade, dasmile chowk, Khunti Road Ranchi, Jharkhand-835221	9507952882	aajivikaglobal@gmail.com
3	AISECT Ltd.	Teena Panthi	Assistant Manager	AISECT Ltd. 1-1-387, 3rd floor, Flat No. 403/404, GNR Heights,	7879982075	teena.panthi@aisect.org

				Above SBI,Bakaram Road, Musheerabad, Hydrabad-500020		
4	B. G. Infotech	Amal Das	Centre Head	Kakdihi, Mecheda, Purba, Medinipur	9434996748	bginfotech2007@gmail.com
5	Surekha IT Services	Anjani K	Manager	8-3-191/84/302, Sharan Residency, Vengalrao Nagar, Hyderabad-500038, Telangana	8125134134	info@surekhaitservices.com
6	Sidhi Vinayak Academy	Neha Verma	Director	Shiv Narayan Kunj, B Block, Shivaji Nagar, Hethu, Ranchi, JH-834002	8789837772	sidhiacadmey@gmail.com
7	Prasanthi Polytechnic	D. Prasad	Principal	Duppituru (Vill), Atchutapuram (Md). Visakhapatnam (Dist), Andhara Pradesh-531011	9849952573	prasadreddy.1279@gmail.com

Annexure-IV: Training Details

Training Projections:

Year	Estimated Training # of Total Candidates	Estimated training # of Women	Estimated training # of People with Disability
2024-25	500	200	20
2025-26	500	200	20
2026-27	1000	200	20

Data to be provided year-wise for next 3 years.

Annexure-V: Blended Learning

Blended Learning Estimated Ratio & Recommended Tools:

S. No.	Select the Components of the Qualification	List Recommended Tools – for all Selected Components	Offline : Online Ratio
1	☐Theory/ Lectures - Imparting theoretical and conceptual knowledge	Online interaction platforms like JitSi Meet, Bharat VC, Google Meet, MS Teams, etc.	20:80
2	☐Imparting Soft Skills, Life Skills, and Employability Skills /Mentorship to Learners	Online interaction platforms like JitSi Meet, Bharat VC, Google Meet, MS Teams, etc.	20:80
3	☐Showing Practical Demonstrations to the learners	Through Virtual Design Software (Cadence & Xilinx) and Online interaction platforms like JitSi Meet, Bharat VC, Google Meet, MS Teams, etc.	20:80
4	☐Imparting Practical Hands-on Skills/ Lab Work/ workshop/ shop floor training	Through Virtual Design Software (Cadence & Xilinx) and Online interaction platforms like JitSi Meet, Bharat VC, Google Meet, MS Teams, etc.	20:80
5	☐Tutorials/ Assignments/ Drill/ Practice	Online interaction platforms like JitSi Meet, Bharat VC, Google Meet, MS Teams, etc.	20:80
6	☐Proctored Monitoring/ Assessment/ Evaluation/ Examinations	NIELIT Remote Proctored Software	Online: 100% Theory Offline: 100% Practical
7	☐On the Job Training (OJT)/ Project Work Internship/ Apprenticeship Training	Design Software	Either 100% online in a virtual environment Or 100% offline in the Industry.

Annexure-VI: Standalone NOS- Performance Criteria details

1. Description:

This standalone NOS encompass a comprehensive exploration of Python programming fundamentals, covering essential concepts such as conditions, loops, data structures (sequences, tuples, ranges, strings, lists, and sets), modules, functions, classes, inheritance, and advanced topics like the Super() function, design patterns, and Factory Patterns. It also includes practical skills in hardware verification using cocotb, focusing on coroutines, simulating with cocotb, utilizing the cocotb Queue, and implementing both basic and class-based test benches. Additionally, the module delves into verification methodologies with Pyuvm, highlighting the importance of UVM (Universal Verification Methodology), components of UVM, creating test benches in a UVM environment, debugging techniques using ConfigDB(), and specialized test bench implementations such as Analysis ports, Sequence testbench, Fibonacci testbench, and Virtual sequence testbench.

2. Scope:

The scope covers the following:

The scope of this module includes mastering foundational Python programming concepts such as conditions, loops, data structures, and modules, along with more complex features like classes, inheritance, and the Super() function. It delves into design patterns with a focus on Factory Patterns, enhancing object-oriented programming skills.

3. Elements and Performance Criteria

To be competent, the user/individual on the job must be able to:

Overview of Python Programming

- Demonstrate proficiency in Python concepts including conditions, loops, and data structures (sequences, tuples, ranges, strings, lists, and sets).
- Apply object-oriented programming principles with Python classes, inheritance, and the Super() function.
- Implement design patterns and Factory Patterns in Python programming projects.

Veriifcation with cocotb

- Utilize coroutines effectively in cocotb for hardware verification.
- Implement cocotb Queues for efficient data handling in test benches.

● Develop and simulate basic and class-based test benches using cocotb.

Verification with Pyuvm

● Explain the rationale for incorporating UVM in hardware verification processes.
● Construct testbenches within a UVM environment using uvm_component and ConfigDB().
● Design and implement specialized test structures including Analysis ports, Component communication, Sequence testbench, Fibonacci testbench, and Virtual sequence testbench.

4. Knowledge and Understanding (KU):

The individual on the job needs to know and understand:

- Gain foundational knowledge in Python, covering essential concepts such as conditions, loops, sequences, modules, functions, classes, inheritance, and advanced topics like design patterns and factory patterns.
- Gain proficiency in hardware verification using cocotb, focusing on coroutines and cocotb Queue for effective data management. Develop simulation expertise using both basic and class-based test benches to achieve thorough functional verification with TinyAluBfm.
- Acquire proficiency in hardware verification with Pyuvm, including understanding the significance of UVM, developing UVM-based test benches, debugging with ConfigDB(), and implementing advanced verification strategies like analysis ports and sequence test benches.

5. Generic Skills (GS):

User/individual on the job needs to know how to:

GS1. Proficiency in Python fundamentals including conditions, loops, sequences (tuples, ranges, strings, lists, sets), modules, functions, classes, inheritance, and advanced topics like the Super() function, design patterns, and factory patterns.

GS2. Acquire advanced skills in utilizing coroutines and cocotb Queue for streamlined data management, employ cocotb for robust simulation in functional verification, and demonstrate proficiency in implementing both basic and class-based test benches.

GS3. Understanding the rationale behind using UVM (Universal Verification Methodology), implementing test benches in a UVM environment, debugging with ConfigDB(), utilizing UVM factory for testbench configuration, analyzing data through analysis ports, and developing comprehensive test sequences including Fibonacci and Virtual sequence testbenches.

Annexure-VII: Assessment Criteria

Detailed PC-wise assessment criteria and assessment marks for the NOS are as follows:

NOS/Module	Assessment Criteria for Performance Criteria	Theory Marks	Practical Marks	Project Marks	Viva Marks
Essentials of Python for RTL Verification	**Overview of Python Programming**	30	20		6
	● Demonstrate proficiency in Python concepts including conditions, loops, and data structures (sequences, tuples, ranges, strings, lists, and sets).	-	-	-	-
	● Apply object-oriented programming principles with Python classes, inheritance, and the Super() function	-	-	-	-
	● Implement design patterns and Factory Patterns in Python programming projects.	-	-	-	-
	Veriifcation with cocotb	30	20		7
	● Utilize coroutines effectively in cocotb for hardware verification.	-	-	-	-
	● Implement cocotb Queues for efficient data handling in test benches.	-	-	-	-
	● Develop and simulate basic and class-based test benches using cocotb.	-	-	-	-
	Verification with Pyuvm	40	20		7
	● Explain the rationale for incorporating UVM in hardware verification processes.	-	-	-	-
	● Construct testbenches within a UVM environment using uvm_component and ConfigDB().	-	-	-	-
	● Design and implement specialized test structures including Analysis ports, Component communication, Sequence testbench, Fibonacci testbench, and Virtual sequence testbench.	-	-	-	-
	Total Marks -200	**100**	**60**	**20**	**20**

Annexure-VIII: Assessment Strategy

This section includes the processes involved in identifying, gathering, and interpreting information to evaluate the Candidate on the required competencies of the program.

Assessment of the qualification evaluates candidates to ascertain that they can integrate knowledge, skills and values for carrying out relevant tasks as per the defined learning outcomes and assessment criteria.

The underlying principle of assessment is fairness and transparency. The evidence of the outcomes and assessment criteria. competence acquired by the candidate can be obtained by conducting Theory (Online) examination.

About Examination Pattern:

1. The question papers for the theory exams are set by the Examination wing (assessor) of NIELIT HQS.

2. The assessor assigns roll number.

3. The assessor carries out theory online assessments. Theory examination would be conducted online and the paper comprise of MCQ

4. Pass percentage would be 50% marks.

5. The examination will be conducted in English language only.

Quality assurance activities: A pool of questions is created by a subject matter expert and moderated by other SME. Test rules are set beforehand. Random set of questions which are according to syllabus appears which may differ from candidate to candidate. Confidentiality and impartiality are maintained during all the examination and evaluation processes.

Annexure-IX: Acronym and Glossary

Acronym:

Acronym	Description
AA	Assessment Agency
AB	Awarding Body
NCrF	National Credit Framework
NOS	National Occupational Standard(s)
NQR	National Qualification Register
NSQF	National Skills Qualifications Framework

Glossary:

Term	Description
National Occupational Standards (NOS)	NOS define the measurable performance outcomes required from an individual engaged in a particular task. They list down what an individual performing that task should know and also do.
Qualification	A formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards
Qualification File	A Qualification File is a template designed to capture necessary information of a Qualification from the perspective of NSQF compliance. The Qualification File will be normally submitted by the awarding body for the qualification.
Sector	A grouping of professional activities on the basis of their main economic function, product, service or technology.