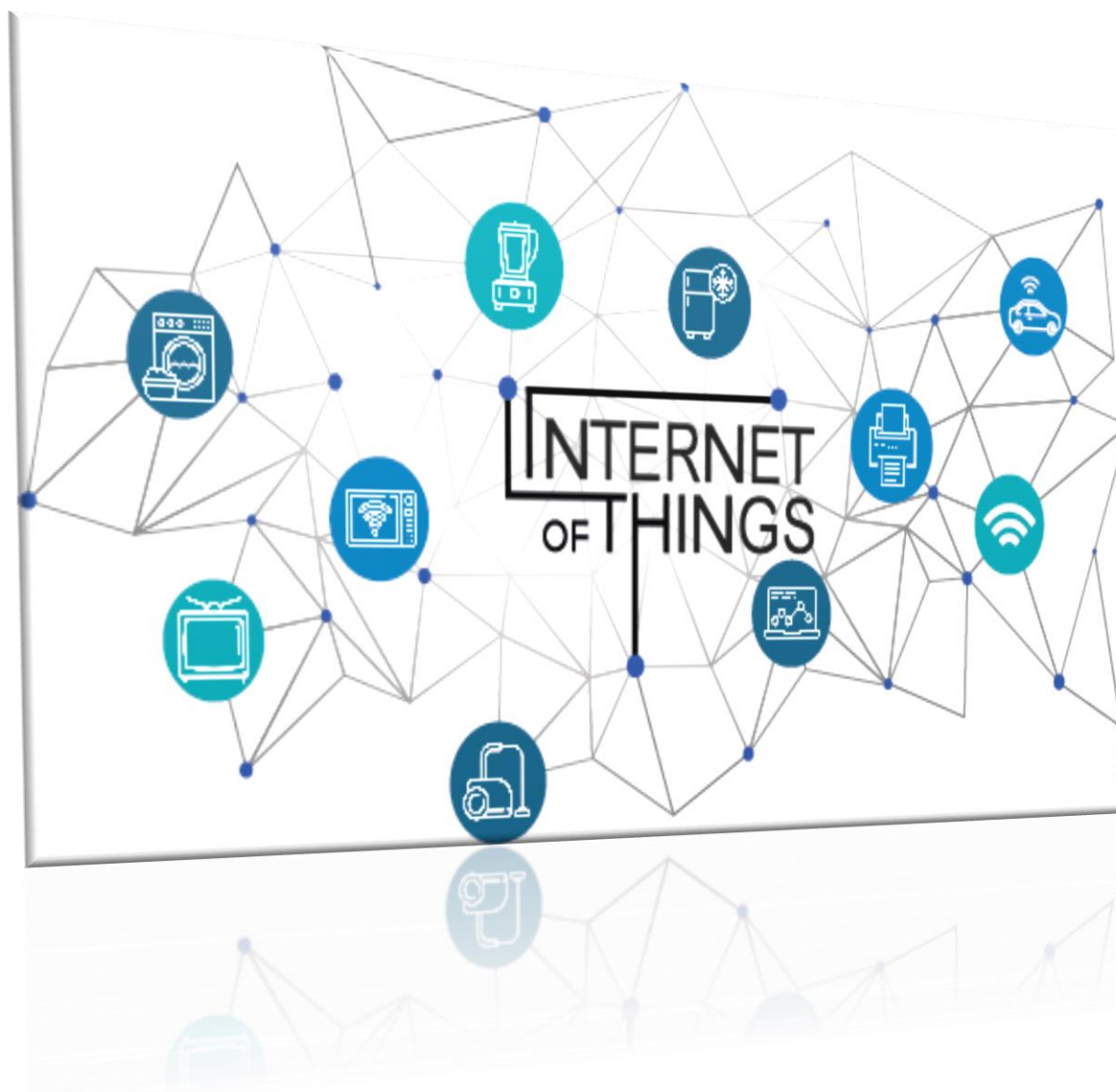




National Competency Standards for “Internet of Things (IoT)”



**National Vocational and Technical Training Commission (NAVTTTC),
Government of Pakistan**



ACKNOWLEDGEMENT

National Vocational and Technical Training Commission (NAVTTTC) extends its gratitude and appreciation to representatives of business, industry, academia, government agencies, provincial TEVTAs, sector skill councils and trade associations who spared time and extended their expertise for the development of National Vocational Qualifications for the trade of **Internet of Things (IoT)**. This work would not have been possible without the technical support of the above personnel.

NAVTTTC initiated development of CBT&A based qualifications for 200 traditional / hi-tech trades under the Prime **Minister’s Hunarmand Pakistan Program**, focusing on Development & Standardization of 200 Technical & Vocational Education & Training (TVET) Qualifications. NAVTTTC efforts have received full support from the Ministry of Federal Education and Professional Training which highly facilitated progress under this initiative.

It may not be out of place to mention here that all the experts of Industry, Academia and TVET experts of TEVTAs, BTEs and PVTC work diligently for making this qualification worthy and error free for which all credit goes to them. However, NAVTTTC accepts the responsibility of all the errors and omissions still prevailing in the Qualification document.

It is also noteworthy that development of Skill Standards is a dynamic and ongoing process, and the developed skill standards needs periodic review and updating owing to the constant technological advancements, development in scientific knowledge, and growing experience of implementation at the grass root level as well as the demand of industry. NAVTTTC will ensure to keep the qualifications abreast with the changing demands of both national and international job markets.

**Dr. Nasir Khan,
Executive Director,
NAVTTTC**



Table of Contents

1. Introduction	4
2. Purpose of the Qualification.....	5
3. Date of Validation	6
4. Date of Review.....	6
5. Codes of Qualifications	6
6. Members of Qualification Development Committee	7
7. Members of Qualification Validation Committee.....	8
8. Entry Requirements	9
9. Regulation of the Qualification and Schedule Of Units	9
10. Summary of Competency Standards	10
11. 10	
12. Detail of Qualification and its Competency Standards.....	12
LEVEL 3: Jr. IOT ASSISTANT	12
0714-E&A-1. Develop program and Frontend using framework	12
0714-E&A-2. Develop and Integrate Database with Web Applications	15
0714-E&A-3. Make Rectifier Using Diode	17
0714-E&A-4. Use of Bipolar Junction Transistor (BJT) and MOSFET in Circuits	19
0714-E&A-5. Apply Thyristors (Uni Junction Transistor, Silicon Control Rectifier, Diac and Triac) in Various Application.....	21
0714-E&A-6. Verify Truth Tables of Digital Gates.....	24
0714-E&A-7. Construct & Verify Combinational Logic Circuit	27
0714-E&A-8. Construct and Verify Function of Flip Flops	30
0714-E&A-9. Use 555 IC as Multivibrator.....	32
0714-E&A-10. Construct Shift Registers and Counters with The Help of Flip Flops.....	34
0714-E&A-11. Configure Arduino.....	36
0714-E&A-12. Configure NodeMCU.....	38
0714-E&A-13. Configure Raspberry Pi	40
0714-E&A-14. Configure ESP-32 with LORA.....	42



1. Introduction

The Internet of Things (IoT) is a network of resource constrained nodes being capable of automating an existing manual procedure. This IoT network is also connected to the internet to enable ease of access and user-friendly configuration and monitoring. An IoT developer is an expert who completely understands the IoT network, its different components and their working. IoT developer is capable of programming sensor and hardware devices. IoT developer is capable of developing a hardware and software for IoT edge devices. He is also trained of sending the data to the cloud server. IoT developer is a specialist in utilizing resource constrained devices. IoT cloud developer is an expert who can install and configure Virtual machines on the cloud. While IoT Data scientist is the one who utilizes the data received on the cloud and saves it efficiently in the databases to train Machine Learning algorithms. IoT security is one of the hot research topic nowadays which will create many skill based jobs in the near future. An IoT developer is incomplete without the understanding and hands on experience of security protocols. In a nutshell, IoT is the start of art technology to automate the industrial, commercial and domestic procedures and there is a need to develop the resources with the required IoT skills which will not only benefit the industry but also create job opportunities for the individuals.

IoT is an ever-changing field. The number of IoT nodes are increasing each day and hence their monitoring, upgrading and security needs. Therefore, industry requirement for skilled workforce is increasing which can only be managed through setting relevant competency standards in collaboration with the leading industries.

Being cognizant of this fact, National Vocational & Technical Training Commission (NAVTTTC) developed competency standards for IoT system development under National Vocational Qualifications Framework (NVQF). These competency standards have been developed by a Qualifications Development Committee (QDC) and validated by the Qualifications Validation Committee (QVC) having representation from the leading IoT development houses and research labs of the country.



2. Purpose of the Qualification

The competency based NVQ has been developed to train the unskilled men and women of Pakistan on the technical and entrepreneurial skills to be employed / self-employed and inevitably set sustainable impact on their lives by enhancing their livelihood income.

The purpose of these qualifications is to set highly professional standards for IoT Experts in order to complete local and international job market. Who will serve as key elements enhancing quality of Pakistan’s IoT development sector. The specific objectives of developing these qualifications are as under:

- Improve the professional competence of IoT Hardware and Software development
- Capacitate the local community and trainers in modern CBT trainings, methodologies and processes as envisaged under NVQF
- Provide flexible pathways and progressions in IoT development houses
- Enable the trainees to perform their duties in efficient manner
- Establish a standardized and sustainable system of training in IoT industry in Pakistan
- Enabling the youth with greater employment opportunities



3. Date of Validation

The level 5 IoT qualification has been validated on 20th – 24th July 2020 at PITAC, Lahore, by the qualification validation committee (QVC) members.

4. Date of Review

The level 5 IoT qualification has been reviewed on _____, by the qualification validation committee (QVC) members.

5. Codes of Qualifications

The International Standard Classification of Education (ISCED) is a framework for assembling, compiling and analyzing cross-nationally comparable statistics on education and training. ISCED codes for these qualifications are assigned as follows:

ISCED Classification	
Code	Description
0714-E&A(1)	1 st Level National Certificate of level-5, in “ Internet of Things”
0714-E&A(2)	2 nd Level National Certificate of level-5, in “ Internet of Things”
0714-E&A(3)	3 rd Level National Certificate of level-5, in “ Internet of Things”
0714-E&A(4)	4 th Level National Certificate of level-5, in “ Internet of Things”



6. Members of Qualification Development Committee

The following members participated in the qualification development process of the IoT qualification at PITAC, Lahore.

Date:08 to 12 June 2020

S#	Name	Designation
1.	Dr. Adnan Noor Mian	Associate Professor – ITU, Lahore
2.	Ali Hammad	Associate Professor – UET, Lahore
3.	Sanaullah Manzoor	Research Associate & PHD Fellow – ITU, Lahore
4.	Muhammad Anghus Jamil	Managing Partner – Techno Desert
5.	Mughees Butt	Co-founder – Techno Desert
6.	Salman Shahid	Embedded Developer – Techno Desert
7.	Amir Amin	HOD – City Polytechnic
8.	Muhammad Umair	Lecturer, UET Lahore
9.	Hina Khalid	Assistant Professor – UET, Lahore
10.	Muhammad Yasir	Deputy Director - NAVTTC
11.	Muhammad Hassaan	Daccum Facilitator / BCS



7. Members of Qualification Validation Committee

The following members participated in the qualification validation process of **IoT** at PITAC, Lahore.

Date: 20th -24th July, 2020

S#	Name	Designation
1.	Dr. Ahmad Mustafa	Chief Instructor, GSTC, Murree
2.	M. Abbas Khan Abbasi	HOD, KP Tevta, GPI, Mansehra
3.	Hina Khalid	Assistant Professor, UET, Lahore
4.	Danish Khan	Calibration & Testing Engineer, PCSIR, Islamabad
5.	Muzammil Hassan	AM Research, KICS-UET, Lahore
6.	Muhammad Umair	Lecturer, UET, Lahore
7.	Sanaullah Manzoor	Research Associate, PHD Fellow, ITU, Lahore
8.	Faisal Sarwar	PBTE Representative
9.	Muhammad Nouman	
10.	Muhammad Yasir	Deputy Director, NAVTTC
11.	Muhammad Hassaan	Daccum Facilitator



8. Entry Requirements

The entry requirement for this qualification would be Matric with science.

9. Regulation of the Qualification and Schedule Of Units

Not Applicable



10. Summary of Competency Standards

Sr No	Competency Standards	Occupation	NVQF Level	Category	Estimated Contact Hours			Cr Hr
					Th	Pr	Total	
Level 3 Jr. IoT Assistant								
1	Develop program and frontend using framework		Level 3	Technical	9	39	48	4.8
2	Develop and integrate database with web applications		Level 3	Technical	8	36	44	4.4
3	Make rectifier using Diodes		Level 3	Technical	11	39	50	5
4	Use of bipolar junction transistor (BJT) and MOSFET in circuits		Level 3	Technical	8	36	44	4.4
5	Apply Thyristors (Uni Junction Transistor, Silicon Control Rectifier, Diac and Triac) in various Applications		Level 3	Technical	9	33	42	4.2
6	Verify Truth table of Digital Gates		Level 3	Technical	9	39	48	4.8
7	Construct and Verify Combinational Logic Circuits		Level 3	Technical	10	39	49	4.9
8	Construct and Verify Function of Flipflops		Level 3	Technical	7	36	43	4.3
9	Use 555 IC as multi Vibrators		Level 3	Technical	9	33	42	4.2
10	Construct Shift Register and counters with the help of flip flop		Level 3	Technical	8	30	38	3.8
11	Configure Arduino		Level 3	Technical	8	24	32	3.2
12	Configure NodeMCU		Level 3	Technical	8	30	38	3.8
13	Configure Raspberry Pi		Level 3	Technical	8	33	41	4.1
14	Configure ESP-32 with LORA		Level 3	Technical	8	33	41	4.1
Total					120	480	600	60

11.



National Competency Standards for “Internet of Things (IoT)”





12. Detail of Qualification and its Competency Standards

LEVEL 3: Jr. IOT ASSISTANT

0714-E&A-1. Develop program and Frontend using framework

Overview: After this competency standard candidate will be able to;

- Develop a responsive Dashboards using HTML, JS, CSS and bootstrap.
- Develop interactive screen for IoT web control panels
- Design a mockup according to the SRS document
- Make a form validation in JS

Competency Unit	Performance Criteria
CU1. Collect Requirement to develop front end	P1. Organize interview sessions for clients. P2. Prepare Software Requirement specification (SRS) Document. P3. Prepare Prototyping or visuals based on SRS. P4. Gather information regarding storage spaces. P5. Verify the completeness of SRS
CU2. Create and Optimize responsive web page for different device	P1: Design mockups using different components of web pages P2: Design responsive web page for different screen sizes P3: Implement the mockups to all screen sizes through frontend frameworks P4: Apply media queries to the layouts
CU3. Create PHP based web app	P1. Configure environment for PHP development P2. Write basic PHP program P3. Create web page using PHP
CU4. Perform testing of application	P1: Perform User interface testing P2: Perform Unit testing P3: Perform Compatibility testing P4: Perform security testing P5: Perform performance testing
CU5. Debug application	P1: Debug code using debugger P2: Perform validation and verification testing P3: Collaborate with teams to fix and improve products



P4: Check software is up-to-date with latest technologies

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Explain the modes of Interviews: formal or informal, in person or virtually.
- Explain different Surveys or Questionnaires.
- Explain How to get feedback and input from end users. Workshops or Focus Groups
- What is meant by Prototyping? Describe in detail.
- How to clarify the client requirements
- Describe the components of SRS Document
- Explain different components of web pages.
- Describe the Design Layouts / mockups design process.
- Explain how to communicate the Designers to Design the mockups according to the functional and non-functional requirements,
- Explain different types of screens sizes in pixels
- Describe the tags of HTML, List them.
- the the code (HTML, CSS, JS and frameworks) to generate the frontend layouts using frameworks according to mockups
- Adopt the skills to implement the right framework to achieve the responsiveness on all the screens
- Explain the CSS classes, selector types in CSS
- Explain Saas, Preprocessor, and css functions
- Explain the concept of media queries
- Explain Bootstrap and its usage
- Explain different components of bootstrap. Enlist them.
- Explain Javascript events, and actions
- Describe JS loops, objects, and DOM
- How to implement security on database
- Understand and describe the need for testing
- Understand the describe user interface testing
- Understand and describe compatibility Testing
- Understand Unit Testing techniques
- Understand and describe the Unit testing
- Understand and describe the need of Security Testing

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1.	IDE, editors like Notepad ++ , VSCode Editor etc
2.	Bootstrap, JQuery, HTML, CSS, Javascript



National Competency Standards for “Internet of Things (IoT)”



3.	Firefox, chrome, internet explorer, etc
4.	Search Engines like google
5.	Adobe photoshop, fireworks, and other designing tools

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

- Develop a web based Interactive screen to control switches for IoT system
- **Prepare an SRS Document** of a model software development



0714-E&A-2. Develop and Integrate Database with Web Applications

Overview: After this competency standard candidate will be able to

- Install Database
- Design, program, manipulate, test and Run the database
- Take backup and restore backups

Competency Unit	Performance Criteria
CU1. Manipulate the Database	<p>P1. Create database and entities</p> <p>P2. Specify primary keys</p> <p>P3. Set up the table and relationships among database entities</p> <p>P4. Create and manage database reports, visualizations, and dashboards.</p>
CU2. Adminstrate the Database	<p>P1. Install and maintain the database servers.</p> <p>P2. Develop processes for optimizing database security.</p> <p>P3. Manage database access rights and controls.</p> <p>P4. Diagnose and troubleshoot database errors.</p> <p>P5. Create automation for repeating database tasks</p> <p>P6. Export the database backups</p> <p>P7. Restore database backups</p>

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes

- Differentiate DBMS and Database
- Introduce the concept of a relational database.
- Briefly Describe Early Database Models
- Explain the concept of Hierarchical Database Model
- Explain the Network Database Model
- Explain the term Primary key, Foreign Key
- Describe the term integrity constraint



National Competency Standards for “Internet of Things (IoT)”



- Explain Views in Relational Database
- Describe different types of join, explain one by one
- Explain database design process
- What is the term Database Normalization?
- How to design database through Normalization
- Explain the term ACID: Concurrency Control with Transactions
- How to ensure data integrity.
- How to get Backup of database, routine and manual
- What is DDL?
- What is DML?
- What is DCL?

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1.	DBMS like MySQL, SQL / SQL Management tool, PGADMIN
2.	Database server, like mysql server, sql server etc
3.	Query Browser tools like SQL management tool, phpmyadmin, Workbench
4.	MS access
5.	Excel, and connector/driver for OS

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

- Prepare ERD diagram for a given scenario
- Convert Logical Design to physical design
- Design Database of eCommerce site
- Write store procedures for multiple applications



0714-E&A-3. Make Rectifier Using Diode

Overview: This competency standard covers the skills and knowledge required to Identify Various Diodes, Identify Resistors in circuit, Identify Capacitor in circuit, identify Inductor in circuit and Identify IC's Packages. After this competency standard the candidate will be able to identify variety of basic electronic components and their usage in industry

Competency Units	Performance Criteria
CU1. Identify basic electronic components	P1. Identify Resistors and its resistance P2. Calculate the resistance in Series & Parallel circuit P3. Identify Capacitor & its capacitance P4. Calculate the capacitance in Series and Parallel circuit. P5. Identify an Inductor and its inductance P6. Check the inductance in Series and Parallel circuit. P7. Identify the Diodes as per polarity P8. Identify IC's and its Packages
CU2. Construct half wave and Full Wave center tapped Rectifier	P1. Construct circuit Diagram of half wave Rectifier P2. Construct circuit Diagram of Full Wave Rectifier P3. Calculate the ripple Factor P4. Calculate output voltage using proper formulas
CU3. Make voltage regulator using Zener diode	P1. Draw the voltage Regulator circuit P2. Select the Zener diode and components as per requirement for voltage regulator P3. Install the components for voltage regulator circuits. P4. Vary the input voltage and note down the effects on output. P5. Record the difference between input and output
CU4. Make Seven Segment Display Using Light Emitting Diode	P1. Draw the Seven Segment Display Circuit P2. Construct Seven Segment Display Circuit using components. P3. Verify the numeric digits on Seven Segment Display by providing proper input to its terminal

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:



National Competency Standards for “Internet of Things (IoT)”



- Describe the diodes, polarities & their applications in circuits
- Explain the uses of multi-meter & power Supply
- Explain the data sheets
- Explain Resistor & their applications in Parallel & Series circuits
- Describe Capacitor & their applications in circuits
- Describe the Inductor & their applications in circuits
- Understand the data sheets
- Describe the basics of IC Packages
- Learn to use oscilloscope & power Supply
- Learn basic knowledge of LED & its applications
- Learn knowledge of components
- Learn to use power Supply
- Understand the data sheets
- Learn to Solder the Components

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1	Multimeter
2	Power supply
3	Trainer
4	Resistor
5	Inductor
6	ICs
7	Capacitor
8	Source of data sheets
9	Zener Diode
10	Bread Board
11	Wires
12	Oscilloscope
13	Digital Trainer Kit
14	Leds
15	DC Supply

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

Identify variety of basic electronic components in a circuit



0714-E&A-4. Use of Bipolar Junction Transistor (BJT) and MOSFET in Circuits

Overview: This competency standard covers the skills and knowledge required to Perform the Biasing of Transistors, Implement Transistor as an amplifier using CB Configuration, Implement Transistor as an amplifier using CC Configuration, Implement Transistor as an amplifier using CE Configuration, Design the circuit of Class A Power Amplifier and Implement BJT and MOSFET as a switch After completion of this competency standard the student will be able to regulate the current or voltage flow and implement a switch for electronic signals.

Competency Unit	Performance Criteria
CU1. Use BJT as an operational amplifier	P1: Identify the type of transistor. P2: Identify the base collector & Emitter of transistors. P3: Perform the standard Biasing of PNP & NPN Transistor
CU2. Implement MOSFET as a switch	P1: Identify the Gate, Drain & Source of FET. P2: Perform the standard Biasing of (N-Channel, P Channel) FET. P3: Measure the Gate-Source voltage (V_{GS}) & Threshold Voltage (V_{th}) P4: Draw switching circuit of MOSFET. P5: Construct switching circuit using MOSFET P6: Verify switching operation of MOSFET using LED.

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Study the datasheet of transistor
- Learn basic concepts & working principles of transistor
- Study semiconductor theory
- Learn Doping Procedure.
- Learn basics of Coupling Capacitor.
- Learn basic concepts of transistor
- Learn the basics of FET
- Learn the concept of FET Biasing
- FET Biasing
- Learn the power rating of FET
- Study The datasheet of FET
- Learn the Switching theory
- Learn the behavior of current and voltage in FET's
- Learn biasing mechanism and basic formulae of FET's
- Understand Multimeter & power Supply
- Knowledge of basic electronics
- Study the basics of Transistors, ICs, Capacitors, Resistors, Op-Amp & their applications in circuits
- Explain the basics of electronics & its applications



National Competency Standards for “Internet of Things (IoT)”



- Understand Multimeter, Oscilloscope, power Supply& their applications

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1	Power Supply
2	Oscilloscope
3	Trainer
5	Resistors
6	Datasheets
7	Transistors
9	MultiMeter
10	Capacitors
11	MOSFET
12	Digital Trainer Kit
13	Bread Board
14	Led

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

- Construct the circuit of Class A Power Amplifier



0714-E&A-5. Apply Thyristors (Uni Junction Transistor, Silicon Control Rectifier, Diac and Triac) in Various Application

Overview: This competency standard covers the skills and knowledge required to Implement the UJT in electronic circuits as switch, Implement the SCR in electronic circuits as switch and Construct the dimmer circuit using Diac & Triac. After the completion of this standard the candidate will be able to install Uni junction Transistor (UJT), Silicon-controlled rectifier (SCR) in power Control Application.

Competency Unit	Performance Criteria
CU1. Construct relaxation oscillator using UJT	P1. Select the components for relaxation oscillator. P2. Construct the relaxation oscillator circuit on bread board using given diagram. P3. Vary the value of input resistor and record the effect on output.
CU2. Construct switching circuit using SCR	P1. Select the components for SCR switching circuit. P2. Construct the SCR switching circuit on bread board P3. Verify switching operation by triggering the SCR
CU3. Construct the dimmer circuit using DIAC & TRIAC	P1. Construct the dimmer circuit using given TRIAC & DIAC diagram. P2. Connect the circuit with AC supply. P3. Vary the potentiometer and record the effect on load (Fan or Lamp)
CU4. Construct full wave converter and observe natural commutation.	P1. Make connection as per diagram. P2. Apply triggering pulse at the gate of SCR. P3. Connect oscilloscope across the load resistor and record the output wave shape

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Learn the basics of UJT
- Learn the uses of oscilloscope and power Supply
- Introduction of DIAC and TRIAC
- Concept of Triggering
- Knowledge of Potentiometer
- Understand the data sheets
- Learn adequate knowledge of hand tools
- Define Reverse breakdown voltage
- Define junction potential
- Define SCR
- Describe the operation of SCR



National Competency Standards for “Internet of Things (IoT)”



- Define phase control rectifier
- Define triggering of SCR
- Describe the use of SCR
- Define VAK
- Define commutation and its types
- Define natural commutation.
- Define force commutation
- Name the methods of force commutation

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1	Oscilloscope
2	UJT,
3	Resistor
4	Variable DC power supply,
5	Multimeter
6	Soldering iron, wire
7	Breadboard or trainer
8	Supply
9	Trainer/Breadboard
10	Multimeter
11	SCR, Diodes, Resistors, Inductors, Capacitors & connecting wire
12	Basic electronic trainer kit
13	LED
14	TRIAC
15	DIAC
16	Potentiometer

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

- Draw schematic diagram of relaxation oscillator using UJT.



National Competency Standards for “Internet of Things (IoT)”



- Identify the anode, cathode and gate terminals of a SCR.
- Differentiate between DIAC and TRIAC
- Draw schematic diagram of SCR as phase control rectifier.
- Draw characteristic curve of SCR.



0714-E&A-6. Verify Truth Tables of Digital Gates

Overview: This competency standard covers the skills and knowledge required to Verify the truth table of AND gate, Verify the truth table of OR gate, Verify the truth table of NOT gate, Verify the truth table of NAND gate, Verify the truth table of NOR gate, Verify the truth table of XOR gate and Verify the truth table of XNOR gate. Verify the truth table of AND gate, OR gate, NOT gate, NAND gate, NOR gate, XOR gate and XNOR gate.

Competency Units	Performance Criteria
CU1. Verify the truth table of AND gate	<p>P1. Place (AND gate IC) on bread board.</p> <p>P2. Identify the input, output, Vcc and ground pin.</p> <p>P3. Connect LED to the output pin of IC and apply different logics and input pins.</p> <p>P4. Record & verify the output result against each given input.</p>
CU2. Verify the truth table of OR gate	<p>P1. Place (OR gate IC) on bread board.</p> <p>P2. Identify the input, output, Vcc and ground pin.</p> <p>P3. Connect LED to the output pin of IC and apply different logics and input pins.</p> <p>P4. Record & verify the output result against each given input.</p>
CU3. Verify the truth table of NOT gate	<p>P1. Place (NOT gate IC) on bread board.</p> <p>P2. Identify the input, output, Vcc and ground pin.</p> <p>P3. Connect LED to the output pin of IC and apply different logics and input pins.</p> <p>P4. Record & verify the output result against each given input.</p>
CU4. Verify the truth table of NAND gate	<p>P1. Place (NAND gate IC) on bread board.</p> <p>P2. Identify the input, output, Vcc and ground pin.</p> <p>P3. Connect LED to the output pin of IC and apply different logics and input pins.</p> <p>P4. Record & verify the output result against each given input.</p>
CU5. Verify the truth table of NOR gate	<p>P1. Place (NOR gate IC) on bread board.</p> <p>P2. Identify the input, output, Vcc and ground pin.</p> <p>P3. Connect LED to the output pin of IC and apply different logics and input pins.</p> <p>P4. Record & verify the output result against each given input.</p>



CU6. Verify the truth table of X-OR gate	<p>P1. Place (X-OR gate IC) on bread board.</p> <p>P2. Identify the input, output, Vcc and ground pin.</p> <p>P3. Connect LED to the output pin of IC and apply different logics ant input pins.</p> <p>P4. Record & verify the output result against each given input.</p>
CU7. Verify the truth table of X-NOR gate	<p>P1. Place (X-NOR gate IC) on bread board.</p> <p>P2. Identify the input, output, Vcc and ground pin.</p> <p>P3. Connect LED to the output pin of IC and apply different logics ant input pins.</p> <p>P4. Record & verify the output result against each given input.</p>

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Study logic gates Logic gates. AND, OR, NAND, NOR, NOT, XOR and XNOR.
- Study the Boolean expression of AND, OR, NAND, NOR, NOT, XOR and XNOR, gate and its equivalent electrical circuit
- Define Universal gate and enlist its types.
- Knowledge of different number system and conversion between them (binary, octal, decimal and hexadecimal).
- Knowledge of compliments (1's and 2's)
- Knowledge of binary operators (Addition, subtraction, multiplication and division)

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1	AND gate (7408 2-input Quad)
2	OR gate (7432 2-input Quad)
3	NOT gate (7404 Hex)
4	NAND gate (7400 2-input Quad)
5	NOR gate (7402 2-input Quad)
6	X-OR gate (7486 2-input Quad)
7	X-NOR gate (74266 2-input Quad)
8	Bread board
9	DC supply (5 V)



National Competency Standards for “Internet of Things (IoT)”



10	LED
11	Connecting leads
12	Logic probe

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

- Verify the truth table of XNOR gate



0714-E&A-7. Construct & Verify Combinational Logic Circuit

Overview: This competency standard covers the skills and knowledge required to, Apply Karnaugh mapping & Boolean algebra to simplify logic expressions, Construct & verify the truth table of Half adder, Construct & verify the truth table of Full adder, Construct & verify the truth table of Half Subtraction, Operate seven segment display with seven segment decoder, Construct & verify the truth table of Full Subtraction, Verify Encoder, Verify Encoder and Verify multiplexer and DE- multiplexer Construct & verify the truth table of Half adder, full adder and Half Subtraction

Competency Unit	Performance Criteria
CU1. Apply Karnaugh mapping & Boolean algebra to simplify logic expressions	<p>P1. Apply Boolean algebra & Karnaugh mapping to simplify SOP & POS.</p> <p>P2. Construct logic circuits with simplified SOP & POS.</p>
CU2. Construct & verify the truth table of Half adder/subtractor	<p>P1. Place (AND gate IC) & (XOR gate IC) on bread board.</p> <p>P2. Connect LED to the output pin of IC and apply different logics at input pins.</p> <p>P3. Record & verify the output result against each given input</p> <p>P4. Design, Construct, and test a half-adder circuit using one XOR gate and two NAND gates.</p>
CU3. Construct & verify the truth table of Full adder/subtractor	<p>P1. Place (AND gate IC) & (XOR gate IC) on bread board.</p> <p>P2. Connect LED to the output pin of IC and apply different logics at input pins.</p> <p>P3. Record & verify the output result against each given input</p> <p>P4. Design, Construct, and test a full-adder circuit using two ICS, &7486 and &7400.</p>
CU4. Verify Decoder	<p>P1. Connect LED to the output pin of IC and apply different logics at input pins.</p> <p>P2. Record & verify the output result against each given input.</p>
CU5. Operate seven segment display with seven segment decoder	<p>P1. Insert (7 segment decoder IC) and 7 segment display on bread board.</p> <p>P2. Connect segment display with seven segment decoder input output pins.</p>



	P3. Record & verify the output result against each given input.
CU6. Verify Encoder	P1. Connect LED to the output pin of IC and apply different logics at input pins. P2. Record & verify the output result against each given input.
CU7. Verify multiplexer and DE- multiplexer	P1. Perform multiplexing P2. Perform DE-multiplexing

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Describe the laws and rules of Boolean algebra.
- Understanding of commutative, • And distributive expiration. That is, $A \cdot (B + C) = (A \cdot B) + (A \cdot C)$ and $A + (B \cdot C) = (A + B) \cdot (A + C)$.
- Study the combinational logic circuit. (Half adder, Full adder, Half subtraction, Full subtraction, Binary Multiplier, Magnitude
- Comparator)
- Study the Product-of-Sums& SOP Simplification
- Knowledge of Don't-Care Conditions
- Introduction to half adder and full adder.
- Introduction to half adder and full subtractor.
- Understanding of Karnaugh Map of four Variable.
- Understanding of Decoders & Encoders& Multiplexers.
- Knowledge of Pin configuration of iCs
- Knowledge of 7 segment display.
- Explain pin 7 segment display and common cathode 7 segment display.
- Define limiting resistor
- Understanding how to implement functions using multiplexers.
- To study DE multiplexer

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1	AND gate (7408 2-input Quad)
2	OR gate (7432 2-input Quad)
3	NOT gate (7404 Hex)



National Competency Standards for “Internet of Things (IoT)”



4	NAND gate (7400 2-input Quad)
5	NOR gate (7402 2-input Quad)
6	X-OR gate (7486 2-input Quad)
7	X-NOR gate (74266 2-input Quad)
8	Bread board
9	DC supply (5 V)
10	LED
11	Connecting leads
12	Bread board
13	Resistances (1K ohm)
14	Connecting leads
15	DC supply (5 V)
16	Mux KL-33006 block e
17	Seven segment display
18	74LS47 IC
19	Mux KL-33006 block

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

- Operate seven segment display with seven segment decoder.



0714-E&A-8. Construct and Verify Function of Flip Flops

Overview: This competency standard covers the skills and knowledge required to Construct and verify the truth table of RS latch using NAND gate, Construct and verify the truth table of clocked RS latch using NAND gate, verify function of D flip flop, verify function of JK/T flip flop construct and verify the truth table of RS latch using NAND gate, clocked RS latch using NAND gate, D flip flop and JK flip flop.

Competency Unit	Performance Criteria
CU1. Construct and verify the truth table of RS latch using NAND gate	P1. Connect LEDs to outputs pins. P2. Apply different logic inputs to Record & verify the output result against each given input.
CU2. Construct and verify the truth table of clocked RS latch using NAND gate	P1. Connect LEDs to outputs pins. P2. Apply different logic inputs to Record & verify the output result against each given input.
CU3. Verify function of D flip flop.	P1. Connect LEDs\ Scope to outputs pins. P2. Apply different logic inputs to Record & verify the output result against each given input.
CU4. Verify function of JK/T flip flop	P1. Connect LEDs\ Scope to outputs pins. P2. Apply different logic inputs to Record & verify the output result against each given input.

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Define Latch
- How many inputs are given to SR Latch?
- Which IC is used for NAND and NOR gate?
- What is clocked RS flip flop.
- What is difference between Latch and flip flop?
- Symbols for Combinational Elements (Symbols for Flip-Flops.)
- Define D flip flop.
- Define clock pulse.
- What is difference between synchronous & asynchronous input
- Define JK/T flip flop.
- Draw the symbol of JK flip flop
- Which IC is used for JK flip flop



Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1	AND gate (7408 2-input Quad)
2	OR gate (7432 2-input Quad)
3	NOT gate (7404 Hex)
4	NAND gate (7400 2-input Quad)
5	NOR gate (7402 2-input Quad)
6	X-OR gate (7486 2-input Quad)
7	X-NOR gate (74266 2-input Quad)
8	Digital clock
9	DC supply (5 V)
10	LED
11	Connecting leads
12	Bread board
13	JK Flip Flop (74112 Dual

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

Verify function of JK/T flip flop



0714-E&A-9. Use 555 IC as Multivibrator

Overview: This competency standard covers the skills and knowledge required to. Construct 555 IC as A-stable Multivibrator, Construct 555 IC as Mono-stable Multivibrator, and Construct 555 IC as Bi-stable Multivibrator and verify its set and reset conduction.

Competency Unit	Performance Criteria
CU1. Construct 555 IC as A-stable Multivibrator	P1. Draw circuit diagram for A-stable Multivibrator P2. Place 555 IC on bread board/trainer P3. Make connection as per diagram. P4. Apply voltage to circuit. P5. Record the output signal wave shape from oscilloscope.
CU2. Construct 555 IC as Mono-stable Multivibrator	P1. Draw circuit diagram for Mono-stable Multivibrator P2. Place 555 IC on bread board/trainer. P3. Make connection as per diagram. P4. Apply voltage to circuit and give triggering pulse at input pin. P5. Record the output signal wave shape from oscilloscope.
CU3. Construct 555 IC as Bi-stable Multivibrator and verify its set and reset conduction	P1. Draw circuit diagram for Bi-stable Multivibrator P2. Place 555 IC on bread board/trainer. P3. Make connection as per diagram. P4. Apply voltage to circuit and give triggering pulse at input pin. P5. Record the output signal wave shape from oscilloscope.

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Describe basic elements of 555 timer IC.
- Name pins of 555 timer IC.
- What is function of voltage control input?
- What is a stable Multivibrator?
- What is nonstable Multivibrator?
- What is beatable Multivibrator

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1	DC supply (5 V
2	Connecting leads
3	555 Timer IC



National Competency Standards for “Internet of Things (IoT)”



4	Capacitor 0.1 μ F
5	Resistors 10 K Ω
6	dual trace Oscilloscope 0-20MHZ
7	Capacitor 0.01 μ F
8	Bread board

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

Construct 555 IC as Bi-stable Multivibrator and verify its set and reset conduction



0714-E&A-10. Construct Shift Registers and Counters with The Help of Flip Flops

Overview: This competency standard covers the skills and knowledge required to Construct a 4-bit shift register by Using Flip Flops, construct a 4-bit binary counter Using Flip Flops, Construct 4-bit synchronous Counter with D flip-Flops, Repair & Troubleshoot combinational logic circuits

Competency Unit	Performance Criteria
CU1. Construct a 4-bit shift register by Using Flip Flops	<p>P1. Draw circuit diagram 4-bit register.</p> <p>P2. Make connection of D-Flip Flop as per diagram to construct 4-bit shift register.</p> <p>P3. Apply data at the input of register and give clock pulse</p> <p>P4. Recode the output according to the input.</p>
CU2. Construct a 4-bit binary counter Using Flip Flops	<p>P1. Draw circuit diagram counter.</p> <p>P2. Make connection of JK-Flip Flop as per diagram to construct 4-bit binary counter.</p> <p>P3. Connect LEDs to the outputs pins.</p> <p>P4. Apply the clock pulse and record the output.</p>
CU3. Construct 4-bit synchronous Counter with D flip-Flops	<p>P1. Draw circuit diagram synchronous counter.</p> <p>P2. Make connection of JK-Flip Flop as per diagram to construct 4-bit synchronous counter.</p> <p>P3. Connect LEDs to the output pins.</p> <p>P4. Apply the clock pulse and record the output.</p>
CU4. Troubleshoot different combinational logic circuits.	<p>P1. Identify faults in different combinational logic circuits IC's.</p> <p>P2. Troubleshoot the faults.</p>

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Symbols for Combinational Elements (Symbols for Registers, Counters, RAM.)
- understand the function of registers, and counters in digital circuits
- Knowledge of basic computer memories and its types.
- Explain precautions when handling components.
- Demonstrate proper use of ESD equipment.
- Explain how to distinguish hardware from software issues



National Competency Standards for “Internet of Things (IoT)”



- Show how pulsars are used for digital signal tracing and how logic probes are used to verify states in digital equipment.

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1.	Software Simulator and IDE's.
2.	DLD trainer
3.	Multimeter
4.	IC's and Components
5.	Logic tester

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

Troubleshoot different combinational logic circuits



0714-E&A-11. Configure Arduino

Overview: This competency unit covers the skills and required knowledge to Configure Arduino. It provides an introduction to the main theories and activities associated with Arduino being applied in industry.

Competency Unit	Performance Criteria
CU1. Embed Code in Arduino	P1: Install Arduino IDE P2: Select Serial Port on which Arduino is connected P3: Select the relevant board from tools. P4: Verify the connectivity of board from computer P5: Select and Run Basic Example Project as guided by instructor P6: Burn the code on Arduino P7: Identify that code is uploaded successfully. P8: Troubleshoot configurations of Arduino IDE (If required)
CU2. Control LED with Arduino	P1: Connect LED to digital pin P2: Burn blink code from example projects P3: Check LED is blinking. If not, check its connection and rectify P4: Connect LED to PWM pin P5: Burn fade code from example projects P6: Verify LED is fading.

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Basic Understanding of Arduino and Arduino IDE Configurations
- Difference between PWM pin, Analog pin and Digital pin
- Basic Understanding of Block Diagram
- Differentiate Different Microcontrollers

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1	Arduino UNO
2	Arduino IDE
3	Laptop/Desktop



National Competency Standards for “Internet of Things (IoT)”



4	LED
5	Mini USB Cable
6	Internet Connection
7	Jumper Wires
8	PWM

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:



0714-E&A-12. Configure NodeMCU

Overview: This competency unit covers the skills and required knowledge to configure NodeMCU. It provides an introduction to the main theories and activities associated with NodeMCU being applied in industry.

Competency Unit	Performance Criteria
CU1. Embed Code in NodeMCU	P1: Connect NodeMCU board with computer P2: Install NodeMCU Library in IDE (ESP-8266) P3: Select and Run Basic Example Project as guided by instructor P4: Burn the code on NodeMCU P5: Verify that code is uploaded successfully P6: Troubleshoot configurations of Arduino IDE (if required)
CU2. Control LED with NodeMCU	P1: Connect LED to digital pin P2: Burn blink code from example projects P3: Verify LED is blinking. P4: Connect LED to PWM pin P5: Burn fade code from example projects P6: Verify LED is fading. P7: Connect NodeMCU with your WIFI Router P8: Check its output on Serial Monitor

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Basic Understanding of NodeMCU
- Difference between PWM pin, Analog pin and Digital pin
- Basic Understanding of Block Diagram
- Differentiate Different Microcontrollers

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1	NodeMCU
2	Arduino IDE
3	Laptop/Desktop
4	LED



National Competency Standards for “Internet of Things (IoT)”



5	Mini USB Type B Cable
6	Internet Connection
7	Jumper Wired

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

- Embed Code in NodeMCU
- Control LED with NodeMCU



0714-E&A-13. Configure Raspberry Pi

Overview: This competency unit covers the skills and required knowledge to demonstrate the understanding of Raspberry Pi. It provides an introduction to the main theories and activities associated with Raspberry Pi being applied in industry.

Competency Unit	Performance Criteria
CU1. Set-up Raspberry Pi	P1: Download Raspberry Pi OS on your Desktop. P2: Burn Raspberry Pi OS in SD Card. P3: Insert SD card in Raspberry PI. P4: Attach Input Output devices required (Mouse, Keyboard) P5: Install Raspberry Pi OS in Raspberry Pi. P6: Write startup script for Raspberry Pi P7: Execute Basic Linux Terminal commands (make directory, change path)
CU2. Set-up Programming Environment	P1: Download GCC compiler through Terminal P2: Install GCC compiler through Terminal. P3: Compile and Run “Hello World” Example available on Internet.

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Basic Understanding of Linux OS
- Basic Linux Commands
- Basic use of Raspberry Pi
- Understanding of GCC Compiler
- Understanding of Raspberry Pi 3 Board
- Difference between PWM pin, Analog pin and Digital pin
- Differentiate Different Microcontrollers

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1	Raspberry Pi 3
2	Monitor/LCD/LED
3	Laptop/Desktop
4	Raspberry Pi Power Supply
5	Keyboard



National Competency Standards for “Internet of Things (IoT)”



6	Mouse
7	SD Card
8	SD Card Reader
9	Internet Connection
10	UPS

Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

- Set-up Raspberry Pi
- Set-up Programming Environment



0714-E&A-14. Configure ESP-32 with LoRa

Overview: This competency unit covers the skills and required knowledge to demonstrate the understanding of ESP-32 with LoRa. It provides an introduction to the main theories and activities associated with ESP-32 with LoRa being applied in industry.

Competency Unit	Performance Criteria
CU1. Perform connection of ESP-32 with LoRa Transceiver Module	P1: Connect ESP-32 and LoRa Transceiver Module P2: Compare your connections with the circuit diagram provided by your Instructor P3: Select the appropriate Serial Port
CU2. Perform embedding Code in ESP-32	P1: Install LoRa Library (An Arduino library for sending and receiving data using LoRa Radios) in IDE. P2: Select and Run Basic WAN Project on Sender and Receiver (ESP-32) as guided by instructor P3: Burn the code on both ESP-32 P4: Verify that code is uploaded successfully. P5: Troubleshoot Arduino IDE and rectify

Knowledge & Understanding

The candidate must be able to demonstrate underpinning knowledge and understanding required to carry out tasks covered in this competency standard. This includes:

- Basic Understanding of LoRa and ESP-32
- Understanding of Pin Configuration
- Difference between sender and receiver
- Knowledge of Packets Transfer

Tools and Equipment

The tools and equipment required for this competency standard are given below:

S. No.	Items
1	ESP-32, LoRa Transceiver Module
2	Arduino IDE
3	Laptop/Desktop
4	Led Bulb
5	USB Type B Cable



Critical Evidence(s) Required

The candidate needs to produce following **Critical Evidence(s)** in order to be competent in this competency standard:

- Perform connection of ESP-32 with LoRa Transceiver Module
- Perform embedding Code in ESP-32