

ELECTRONIC CIRCUITS FABRICATION

UNIT CODE: 0714 451 10A

TVETCDACC UNIT CODE: ENG/CU/TLE/CR/04/5/MA

Relationship to Occupational Standards

This unit addresses the unit of competency: Fabricate Electronic Circuits

Unit duration: 180 Hours

Unit Description: This unit covers the competencies required in Fabrication of electronic circuits. These competencies include; preparing electronic components, fabricating digital logic circuits, fabricating analogue circuits and fabricating PCB circuits.

Summary of Learning Outcomes

By the end of the unit the trainee should be able to:

S/NO	LEARNING OUTCOME	DURATION (HRS)
1.	Prepare Electronic Components	20
2.	Fabricate analog circuits	60
3.	Fabricate digital logic circuits	60
4.	Fabricate PCB circuits	40
	TOTAL HOURS	180

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods
1. Prepare Electronic Components	1.1.Introduction to Electronic Communication Systems 1.1.1. Overview of basic electronic components and their characteristics 1.1.1.1.Resistors 1.1.1.2.Capacitors 1.1.1.3.Inductors 1.1.1.4.Diodes 1.1.1.5.Transistors 1.1.1.6.ICs: Op-amps, counters, multivibrators, amplifiers 1.1.2. Reading component values	1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence

	1.1.3. Polarity-sensitive components 1.1.4. ESD precautions and component storage 1.1.5. Active and passive components 1.1.6. Power suppliers 1.1.7. Linear 1.1.8. Switching 1.2. Radio frequency fundamentals 1.2.1. Introduction to radio frequency (RF) signals 1.2.1.1. Definition of Electromagnetic waves 1.2.1.2. Frequency spectrum concepts 1.2.1.3. Significance of Impedance matching 1.2.2. Role of RF components 1.2.2.1. Antennas 1.2.2.2. Filters and their applications. 1.2.2.3. Amplifiers	
2. Fabricate digital logic circuits	2.1. Introduction to Digital Logic 2.1.1. Number Systems and Codes 2.1.2. Boolean Algebra and Logic Gates 2.1.3. K-map 2.1.4. Logic Gates Implementation 2.1.4.1. Transistor-level 2.1.4.2. ICs 2.2. Combinational Circuit Design 2.2.1. Multiplexers and Demultiplexers 2.2.2. Encoders and Decoders 2.2.3. Adders and Subtractors 2.2.4. Arithmetic Logic Units (ALUs) 2.2.5. Combinational Circuit Design and Analysis Techniques	1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence

	2.2.6. Introduction to Programmable Logic Devices (PLDs) 2.3. Sequential Circuit Design 2.3.1. Latches and Flip-Flops (SR, D, JK, T) 2.3.2. Registers 2.3.3. Counters: Asynchronous and Synchronous 2.3.4. Shift Registers 2.3.5. Finite State Machines (FSMs) 2.3.6. Sequential Circuit Design and Analysis Techniques 2.4. Digital Logic Circuit Design and Simulation Tools 2.4.1. Introduction to a specific CAD tool: EAGLE, Logisim 2.4.2. Basic operations: project creation, file management, simulation setup 2.4.3. Introduction to Circuit Simulation Software: SPICE, LTSpice 2.4.4. Producing Printed Circuit Boards (PCBs) 2.5. Digital Logic Circuit Implementation 2.5.1. Breadboarding Techniques 2.5.2. Prototyping Boards and Kits 2.5.3. Soldering techniques 2.5.4. Introduction to PCB Design 2.5.5. Using Digital Logic ICs 2.5.6. Interfacing with Microcontrollers and 2.6. Digital electronic circuit tests 2.6.1. Importance of testing 2.6.2. Types of digital circuit tests 2.6.2.1. Functional testing	
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	2.6.2.2.Input/Output Verification 2.6.2.3.Truth Table Testing 2.6.2.4.Sequential Logic Testing 2.6.3. Reporting and Documentation 2.6.3.1.Results, and observations	
3. Fabricate Analog circuits	3.1. Foundational Concepts 3.1.1. Semiconductor Physics 3.1.1.1.Energy bands, doping, PN junctions 3.1.1.2.Diode characteristics, applications 3.1.1.3.Bipolar Junction Transistors (BJTs): structure, operation, biasing 3.1.1.4.Field-Effect Transistors (FETs): MOSFETs, JFETs, operation, biasing 3.1.2. Operational Amplifiers (Op Amps) 3.1.2.1.Ideal op-amp model 3.1.2.2.Inverting, non-inverting, and summing amplifiers 3.1.2.3.Differential amplifiers 3.1.2.4.Filters: low-pass, high-pass, band-pass 3.1.2.5.Oscillators 3.1.2.6.Comparators 3.1.3. Signal Analysis 3.1.3.1.Signal types: DC, AC, sinusoidal, square, triangular 3.1.3.2.Noise sources and their effects 3.2. Analog Circuit Design	1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence

	3.2.1. Amplifier Design 3.2.1.1.Small-signal amplifiers: common emitter, common source 3.2.1.2.Power amplifiers: class A, B, AB 3.2.1.3.Feedback amplifiers 3.2.1.4.Stability and oscillation 3.2.2. Filter Design 3.2.2.1.Active filters: using op-amps 3.2.2.2.Passive filters: using RLC components 3.2.2.3.Switched-capacitor filters 3.2.3. Data Converters 3.2.3.1.Analog-to-Digital Converters (ADCs): sampling, quantization, resolution 3.2.3.2.Digital-to-Analog Converters (DACs) 3.2.4. Oscillator Design 3.2.4.1.LC oscillators 3.2.4.2.Crystal oscillators 3.2.4.3. 3.3. Testing and Measurement 3.3.1. Measurement Instruments 3.3.1.1.Oscilloscope 3.3.1.2.Function generator 3.3.1.3.Multimeter 3.3.1.4.Spectrum analyzer 3.3.1.5.Network analyzer 3.3.2. Testing Procedures 3.3.2.1.DC and AC measurements 3.3.2.2.Noise and distortion measurements 3.3.2.3.Frequency response measurements	
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	3.3.2.4.Troubleshooting techniques 3.3.2.5.Automated test equipment (ATE)	
4. Fabricate PCB circuits	4.1. PCB Materials & Components 4.1.1. Types of boards and copper cladding 4.1.1.1.Single-sided, double-sided, multilayer 4.1.1.2.Overview of fabrication steps 4.1.2. Identifying electronic components 4.1.3. Understanding datasheets and packaging types 4.2. Tools and Equipment 4.2.1. Soldering iron, desoldering pump, hot air station 4.2.2. Magnifier, tweezers, multimeter, test jigs 4.2.3. Safety gear and ESD protection 4.3. PCB Material Preparation 4.3.1. Handling blank PCBs 4.3.2. Cleaning PCBs before assembly 4.3.3. Applying solder mask 4.3.4. Silkscreen usage 4.4. Assembly Process 4.4.1. Through-hole mounting techniques 4.4.2. Surface mount (SMD) techniques 4.4.3. Using tweezers, magnifiers, and reflow stencils 4.4.4. Reflow soldering overview 4.4.5. Wire harnessing and header alignment 4.5. Soldering & Rework Techniques 4.5.1. Lead and lead-free solder differences	1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence

	4.5.2. Temperature control & tip care 4.5.3. Manual and hot-air soldering 4.5.4. Soldering fine-pitch ICs and connectors 4.5.5. Heat-sensitive component handling 4.5.6. Desoldering and component replacement 4.5.7. Preventing cold solder joints & solder bridges 4.5.8. Desoldering and rework best practices 4.6. Assembly of Full Circuit Boards 4.6.1. Interpreting BOM (Bill of Materials) and layout 4.6.2. Populating and assembling a functional circuit 4.7. Inspection & Testing 4.7.1. Cleaning agents and techniques 4.7.2. Visual inspection standards (IPC-A-610 basic intro) 4.7.3. Electrical continuity and functionality testing 4.8. Maintenance & Troubleshooting 4.8.1. Diagnosing common fabrication faults 4.8.2. Replacing and re-soldering components 4.8.3. Record keeping and quality logs	
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Suggested Delivery Methods

- Practical
- Project
- Demonstration
- Discussions
- Direct instruction
- Industry visits

List of Recommended Resources for 25 trainees

S/No.	Category/Item	Description/ Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	Learning Materials			
1.	Textbooks	Digital Design by M. Morris Mano and Michael D. Ciletti Digital Fundamentals by Thomas L. Floyd	5 pcs 5 pcs	1:5 1:5
B	Learning Facilities & infrastructure			
2.	Lecture/theory room	60m ²	1	1:25
3.	Workshop	160m ² With ventilation system of specifications: Fume extractor with HEPA filter, adjustable airflow With fire extinguishers, first aid kits, ESD mats, grounding straps With workbenches of specifications: ESD-safe, adjustable height, 1500mm x 750mm With soldering stations Specifications: Adjustable temperature control (200°C - 480°C), ESD-safe With hot air rework stations	1 25 pcs 25 pcs 10 pcs	1:25 1:1 1:1 1:2.5
4.	Projector	3000 lumens	1 pc	1:25
5.	Interactive display screen	75 inches	1 pc	1:25

6.	Computers with internet access	Processor: Intel Core i5/i7 or equivalent RAM: 8GB or higher Storage: 256GB SSD or higher	25 pcs	1:1
7.	PCB prototyping machine	Specifications: CNC router for PCB, precision $\pm 0.01\text{mm}$, spindle speed 20,000 RPM	1 pc	1:25
8.	Printed Circuit Boards	Single-sided, double-sided, and multi-layer PCBs Specifications: FR4 material, 1.6mm thickness, copper thickness 1oz	100 pcs each category	4:1
9.	Oscilloscope	Specifications: Digital, 100MHz bandwidth, 4 channels	5 pcs	1:5
10.	Multimeter	Specifications: Digital, true RMS, auto-ranging, measure voltage, current, resistance, capacitance	25 pcs	1:1
11.	Function generator	Specifications: Frequency range 0.1Hz to 10MHz, various waveforms (sine, square, triangle)	10 pcs	1:2.5
12.	Power supply	Specifications: Dual output, 0-30V, 0-5A, adjustable	10 pcs	1:2.5
13.	Component tester	Specifications: Test resistors, capacitors, inductors, diodes, transistors	5 pcs	1:5
14.	Microscope	Specifications: 10x - 40x magnification, LED illumination	5 pcs	1:5
15.	Magnifying lamps	Specifications: 5x magnification, adjustable arm	25 pcs	1:1

16.	PCB etching tank	Specifications: 300mm x 200mm, temperature control, bubble agitation	5 pcs	1:5
17.	Etching solution	Specifications: Ferric chloride or sodium persulfate	20 litres	1:1.25
18.	Drilling machine	Specifications: Precision PCB drill, drill bits 0.8mm - 1.5mm	5 pcs	1:5
19.	Tweezers	Specifications: ESD-safe, various tips (straight, angled)	25 pcs each category	1:1
20.	Cutters	ESD-safe, flush cutters	25 pcs	1:1
21.	Pliers	ESD-safe needle-nose pliers	25 pcs	1:1
22.	Screwdrivers	Specifications: Precision set, various sizes (Phillips, flathead)	5 sets	1:5
23.	ESD mats	Specifications: Workbench and floor mats, grounding cords	10 pcs	1:2.5
24.	Wrist straps	Specifications: Adjustable, grounding cord with 1M Ω resistor	25 pcs	1:1
25.	Logic analyzer	Specifications: 16 channels, 100MHz sampling rate, USB interface	5 pcs	1:5
C	Consumable materials			
26.	Resistors	Specifications: 1/4 watt, 1%, various values (10 Ω - 1M Ω)	100 pcs each category	4:1
27.	Capacitors	Specifications: Ceramic, electrolytic, tantalum, various values (1pF - 1000 μ F)	100 pcs each category	4:1
28.	Inductors	Specifications: Various values (1 μ H - 10mH)	100 pcs each category	4:1

29.	Diodes	Specifications: 1N4001, 1N4148, Zener diodes of various voltages	100 pcs each category	4:1
30.	Transistors	Specifications: NPN (2N2222), PNP (2N2907), MOSFET (IRF540N)	100 pcs each category	4:1
31.	Integrated Circuits	Specifications: Op-amps (LM741), Timers (NE555)	100 pcs each category	4:1
32.	Connectors and headers	Specifications: Male and female headers, USB connectors, screw terminals	Enough	
33.	Solder wire	Specifications: Lead-free, 0.8mm diameter, Sn63/Pb37 composition	25 rolls	1:1
34.	Soldering Flux	Specifications: Rosin flux, liquid and paste	Enough	
35.	Cleaning reagents	Isopropyl of 99% purity	20 litres	1:1.25
36.	Brushes	Specifications: Anti-static, soft bristles	25	1:1
37.	Solder wires	Red and black	5 rolls each category	1:5
38.	Bread boards	Specifications: 830 tie-points, solderless, multiple power rails	50 pcs	1:2
39.	Strip boards		200	1:8
40.	Logic gates ICs	Specifications: 74HC series (7400, 7402, 7404, 7408, 7432)	100 pcs each category	4:1
41.	100 Light Emitting Diodes	Red/yellow/green/white	100 pcs each category	4:1
42.	Flip-flops IC	Specifications: 74HC series (7474, 7476)	100 pcs each category	4:1
43.	Counters and register ICs	Specifications: 74HC series (7490, 7493, 74161, 74164)	100 pcs each category	4:1
44.	Multiplexers and demultiplexers ICs	Specifications: 74HC series (74151, 74154)	100 pcs each category	4:1

45.	Encoders and Decoders ICs	Specifications: 74HC series (74138, 74147)	100 pcs each category	4:1
46.	Analog-to-digital converters	Specifications: 8-bit, 10-bit, 12-bit resolution, various interfaces (I2C, SPI)	50 pcs each category	2:1
47.	Digital-to-analog converters	Specifications: 8-bit, 10-bit, 12-bit resolution, various interfaces (I2C, SPI)	50 pcs each category	2:1
48.	Microcontrollers	Specifications: 8-bit (ATmega328), 16-bit (MSP430), 32-bit (ARM Cortex-M)	25 pcs each category	1:1
49.	Development boards	Specifications: Arduino, Raspberry Pi, STM32 Nucleo, including necessary accessories (sensors, shields)	25 sets each category	1:1
D	Software			
50.	PCB design software	Eagle, KiCad, Altium Designer Specifications: Ability to design schematic diagrams and PCB layouts	Installed in 25 computers	1:1
51.	Simulation software	LTSpice, Proteus and Multisim Specifications: Simulate electronic circuits, support for various components and models	Installed in 25 computers	1:1
52.	Programming tools Arduino IDE	Specifications: Integrated development environment for Arduino boards	Installed in 25 computers	1:1
53.	Keil uVision	Specifications: IDE for ARM microcontroller programming	Installed in 25 computers	1:1