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Capacity Building within the Field of Higher Education

eACCESS Project

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EU-Asia Collaboration for aCcessible Education in Smart Power Systems

WP 1	PREPARATION
TASK	Preparation of the detailed technical specifications for the physical laboratories (Automation and Power Electronics)
LEAD PARTNER	TUL (Lodz University of Technology, Poland)
PARTICIPATING PARTNERS	KEC(Kantipur Engineering College)

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Comments from the QAC chairperson

This document fulfils the required need of pillar III of eACCESS project. Kantipur Engineering College (KEC) seems to lack basic engineering laboratories to enable practical demonstration of its available theoretical curricula. It is also evident that KEC will need to reconsider that modernization of power system is still missing which will be next stage development alternatively. The modernization of power system directly refers to new generation energy sources such as solar, wind, biomass and hydro. This energy sources faces the reliability challenges to be brought into market maturity where university still has bigger role to play in terms of stable power supply, over-come intermittence nature and their control measures. For the time being the Asian power market is yet to progress on 100% renewable energy strategy which will require both capacity development and technological skill set development, which KCE seems to have been lacking as of now. The current laboratory procurement request suggests the foundation for the 100% renewable energy vision a global target towards SDG7-clean and affordable energy initiatives for all.

With the above note considered the current document suffice the proposed plan. The final quality check however in such deliverables will require physical verification of the set up. Therefore, the quality team suggest a field visit is necessary after the laboratories are fully established at KCE.

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EXECUTIVE SUMMARY

Under Pillar III in eACCESS project, Kantipur Engineering College (KEC) have proposed to install Power Electronics and Industrial automation laboratory. As a member of eACCESS project supported by Erasmus+, KEC proposes a laboratory that focused on power electronics and industrial automation. Nepal is a developing country with very few progess on industrial sector. The development of lab is important for KEC as Nepal deficits the capable manpower on industrial automation. Most of the graduates from universities lacks the understanding of logical controller used in automated industries so the proposed laboratory will be capable to support the same. In this document, the existing laboratory of KEC and the proposed laboratory under the support of eACCESS are described.

Automation laboratory will consist of four set of PLC training kit with HMI and different training modules. Also, four set of two Delta brand of PLC set will be assembled at KEC for low power and high power VFD. Required power supply and backup power supply for the protection of equipment will also be installed in the laboratory.

The Power electronics laboratory will consist of four set of power electronic trainer kit for the study of characteristics of Power diodes, thyristor, IGBT, TRIAC, rectifier and choppers.

Automation laboratory will help to enrich the knowledge and understanding of undergraduates on the field of automation. The laboratory will also be used to conduct the professional courses for the graduates and technical professionals which will be beneficial for the developing countries like Nepal. Power Electronics laboratory will help us to introduce the Power Electronic course for engineering students of KEC. The same laboratory will also help us to complete the laboratory task for the course Advance Electronics.

AL&PEL (Automation Laboratory and Power Electronics Laboratory)

Kantipur Engineering College - eACCESS

1. INTRODUCTION

Kantipur Engineering College (KEC) is one of the best engineering colleges of Nepal in terms of quality engineering education, peaceful and pollution free environment, and international linkage. KEC actively encourages and facilitates collaborations between its researchers within the University and with researchers external to it. KEC serves the people of Nepal by producing competent engineering manpower, by imparting quality engineering education and carrying applied research which will ultimately help to enhance the infrastructure development of the country.

Among three pillars of eACCESS project, under Pillar III KEC has proposed to install Power Electronics and Industrial Automation laboratory. As a member of eACCESS project supported by Erasmus+, KEC proposes two laboratories focusing on Power Electronics and Automation. Nepal is a developing country with very little progress in smart power system and industrial sector. There is a strong demand for hands-on knowledge in Automation by students, electricians and academics. A PLC, HMI and SCADA laboratory would suffice this need in the future. Under the support of Erasmus+ “eACCESS '' project, Kantipur Engineering College (KEC) intends to install a latest advanced state of art PLC, HMI and SCADA laboratory at its college premises for training and education of future engineers, technicians, and researchers. KEC also aims to conduct some professional training courses as well for technicians who want to get familiarized with, get in depth knowledge and enhance their technical capability on industrial automation.

1.1 Automation Laboratory

Automation is the use of control systems such as computers to control industrial machinery and processes, reducing the need for human intervention. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provided human operators with machinery to assist them with the physical requirements of work, automation greatly reduces the need for human sensory and mental requirements as well.

A PLC is an industrial computer or control system that continuously monitors the state of input devices and makes decisions based upon a custom program to control the state of output devices. A PLC or programmable controller is a digital computer used for automation of power system network, electromechanical processes, such as control of machinery or lighting fixtures. PLCs are used in many power system, industries and machines. PLCs are also used in many "real world" applications.

Human-machine interface or HMI is the apparatus which presents process data to a human operator, and through this, the human operator, monitors and controls the process. SCADA stands for supervisory control and data acquisition. As the name indicates it is not a full control system, but rather focuses on the supervisory level. As such, it is a purely software package that is positioned on the top of hardware to which it is interfaced in general via PLC's, or other commercial hardware modules. Experiments on the courses like Automation, Instrumentation, Power Plant Equipment and Utilization of Electrical Energy can be conducted on the laboratory.

1.2 Power Electronics Laboratory

Under Pillar I, KEC is developing course module of Power Electronics for Bachelors in Electrical Engineering. Power Electronics is also an elective course for the fourth-year students of both Computer and Electronics Engineering. So, we need to establish a completely new laboratory in the college. After the installation, this elective course can be offered to the students in near future. Also, the laboratory exercise of Advance Electronics for Electronics Engineering Student will be conducted in this laboratory. Also, in future students from Electrical Engineering will conduct all the experiments of the core subject Power Electronics in this laboratory.

2. DESCRIPTION OF EXISTING LABORATORIES

KEC has following laboratory for undergraduate Program related to electrical engineering.

2.1 Electronics Laboratory:

This physical laboratory space hosts practical activities for two subjects: Basic Electronic engineering and Electronic Devices and Circuit. The objective of the Electronics laboratory is to give students the opportunity to conduct practical experiments with basic electronic components, learn operational characteristics of basic electronic circuits, as well as acquire skills in the design, assembly and testing of electronic devices.

2.2 Electrical Laboratory:

This laboratory hosts the practical for two subjects: Basic Electrical Engineering and Electric Circuit Theory. The objective of the basic electrical Laboratory is to convert the theory into hands-on experience with simple electrical circuits (DC and AC) and experimental verification of the fundamentals of Ohm's, Kirchhoff current and voltage laws. Here, student can demonstrate the transient and frequency response of the passive electrical components.

2.3 Electrical Machine Laboratory:

The objective of this laboratory is to familiarize students with designs and operational characteristics of the basic electrical machines, which are key components of the generation, transmission and distribution of power. The students validate in practice operational characteristics of various electrical machines including DC separately excited machine, different types of DC generators. Students learn how to determine with practical tests technical parameters of the single-phase transformer and induction motors.

2.4 Instrumentation Laboratory:

The objective of this laboratory is to familiarize students with instrumentation, measurement techniques and data analysis and allow them to perform laboratorial work in the other electrical laboratories and workshops. Students will be familiarized with different techniques for analogue to digital and digital to analogue converters.

2.5 Control System Laboratory:

In this laboratory students have their hands-on experience regarding control system including, P, PI, PD and PID controller design, settings and operation.

2.6 Workshop:

The objective of this workshop is to give students the opportunity to develop practical skills necessary for the implementation and maintenance of electrical and mechanical systems.

3. Automation laboratory

3.1 Introduction

The industrial automation laboratory will be set up at Kantipur Engineering College with the support from eACCESS project. Automation laboratory will include hardware and software for PLC, HMI and SCADA. Development of the laboratory is important for KEC as Nepal lacks capable manpower in field of automation. Even Most of the graduates from universities lack the understanding of logical controller used in smart power system, and automated industries and the proposed laboratory will be capable to support the same.

3.2 Experiments and training courses

The PLC Trainer Kit with HMI gives an idea regarding the basics of programmable Logic Controllers & their applications. The laboratory will be used to perform the laboratory exercises on automation. Beside automation, different professional training packages will be developed for the undergraduate students, academicians, and professionals from different industries. The training

The following are the laboratory exercises that will be covered from the laboratory.

1. Operating a simple load using relays, switches and pushbuttons
2. PLC Digital Input - Output Methods
3. PLC Analogue Input- Output methods
4. Interfacing of lamp and button with PLC for ON/OFF operation.
5. Combination of Counter & Timer for Lamp ON/OFF operation
6. Programming the PLC Via Ladder logic
7. HMI and its Interface
8. PLC based traffic light control
9. PLC based water level control
10. PLC based elevator control
11. PLC based hydro dam monitoring
12. PLC based induction Motors starter Via Star-Delta Starter
13. PLC based motor control
14. PLC based servo motor control (Robotic arm)
15. PLC based pump control
16. Parameter reading of PLC in SCADA.
17. Reporting and Trending in SCADA System.

Detail manual for the lab experiments can be developed only after installation of the laboratory.

The following are the list of topics that will be included in the training and experiments.

1. Switch-Gear Automation
2. Electric Panel & it`s Wiring

3. Introduction to PLC, Sensors & Actuators
4. PLC & it`s Wiring
5. Communication and Networking
6. Drives & motion Control
7. SCADA & Its Implementation
8. HMI and its interface
9. PLC Programming
10. PLC and VFD based motor control
11. Manual & Automatic Light Control System
12. Temperature Control
13. Other Application control

3.3 Detail specification of Equipments

The major equipment of Automation laboratory is divided into the following four different categories. Switchgear Automation and Accessories, PLC trainer Kit with HMI, UPS supply and Computer for PLC, and Three phase bench power supply. All the equipment is subjected to safety standard.

The detail of each category of equipment is listed below.

1. Switchgear Automation equipment and Accessories:

Under the section switchgear automation and accessories, three subsections: a) switchgear automation equipment, b) assembly equipment and c) connectors are mentioned as follows.

a. Switchgear Automation Equipment

S.N.	Particular	Description	Qty
1	Push button Switch (NO and NC combination)	Industrial grade, Metal base	200
2	Relay with base	Coil Voltage 220VAC, 5A, DPDT, Industrial grade	50
3	Relay with base	Coil Voltage 380VAC, 10A, DPDT, Industrial grade	10
4	Relay with base	Coil Voltage 24VDC, 5A, DPDT, Industrial grade	50
5	Emergency Switch	Normally Close	10
6	Auto cable	Roll 25Mtr	50
7	Timer (Sec, Min)	ON Delay time Coil voltage 220VAC	15
8	Timer (Sec, Min)	OFF Delay time Coil voltage 220VAC	15
9	Timer (Sec, Min)	Real time monitoring Coil voltage 220VAC	15
10	UP counter	Digital display 0 to 99999 Count	10

11	Down counter	Digital display 99999 to 0 Count	10
12	Indicator	220VAC (Multi colour)	50
13	Indicator	24VDC (Multi colour)	50
14	Proximity Sensors Capacitive	10-30VDC Sensing Range:1.5mm-35mm	25
15	Proximity Sensors Inductive	10-30VDC Sensing Range:15mm	25
16	Proximity Sensors Optical	10-30VDC,250mA Detection Range:100mm	25
17	MCBs Triple Pole(32A)	240/440V AC,50HZ,10KA	5
18	MCBs Single Pole(6A)	220/240 V AC,50 Hz, 10KA	10
19	MCBs Double Pole(16A)	220/240 AC,50HZ,10KA	5
20	Star Delta Timer	230,50HzSupply Output: 2 Relay O/P Time Range: 0-60 Sec. Pause Time : 50ms or 100ms	5
21	Contactor 10A	Operational Voltage:400-440 Rated current: 10A Ith:25A Coil voltage:220 NO/NC Contact: Each 2	15
22	Contactor 16A	Operational Voltage:400-440 Rated current: 16A Ith:25A Coil voltage:220 NO/NC Contact: Each 2	15
23	Temperature controller	Input sensor type = Thermocouple (J,K,T,R,S), RTD (Pt100), Current, Voltage Communication: Rs485	4
24	Panel Developing Materials	MS with anti-corrosion paint electrical panel box bush, cable tray, bus bar, connector, cable shoe, spiral	4

b. **Assembly Equipment:**

The details and quantity of Assembly equipment are listed in the following table.

S.N.	Particular	Description	Qty
1	PLC	Digital Inputs – 8 Digital Outputs - 4 Input/Output Led indication Power: 24VDC Digital inputs: 8x 24VDC	4Pcs

		Digital outputs: 4x transistor or relay outputs Memory: 100kB Utility program: Step 7 Basic (LAD, FBD) PID controller with auto tuning Ethernet - PROFINET card Communication extensions: RS-232, RS-485 Example Delta Ex2	
2	HMI	Screen type: STN-LCD Screen size: 7.0 inch Resolution: 800x480 Communication: RJ45, USB-A, USB-B Touch plate: Yes, 4-wire Serial communication : RS-232, RS-422, RS-485 External input power: 24V (1.7W Max.)	4pcs
3	Single phase VFD	Input Range VAC: 200 to 240 Volts AC HP: 1HP Amps (CT): 5 Amps Input Phase: 1 Operator Controls: Keypad Included Max. Frequency: 400 Hertz,	2 PCS
4	Three phase VFD	Nominal Input VAC: 480 Volts AC Input Range VAC: 380 to 480 Volts AC HP: 3 HP Input Phase : 3 PH Keypad included Max. Frequency: 1500 Hz	1 Pcs
5	Three phase Motor with mount	Power:0.373KW Horsepower: 0.5 HP Speed: 1500 rpm Phase: 3PH No. of Poles: 4 Voltage: 440 V Mounting Type: Foot Frequency: 50 Hz IP Rating: IP55 Ambient Temperature: 50 °C	2 Pcs
6	Three-phase motor with mount	Power: 1.5 KW Horsepower: 2HP Speed: 1400 rpm Phase: 3PH No. of Poles: 4 Voltage: 440 V Mounting Type: Foot Frequency: 50 Hz	1 Pcs

		IP Rating: IP55 Ambient Temperature: 50 ◦C	
7	Control Panel for VFD	control panel, 4P MCB, Contractor 16A, BUS	3 Pcs
8	Robotic Arm	Build material: Aluminium Motor type: anti-blocking servo Supply voltage: 12/24VDC Power consumption: 180W Number of rotation axis: 6 Max. holding width: 98mm Max. torque: 15kgcm Control Board: AVR Based control with PLC compatible Communication type: RS485 or DI/DO	1 Pc
8	PLC card Analogue input	4 points of analogue input voltage (-10V~+10V)/ current (-20mA~+20mA) Input resolution: 14-bit Built-in RS-485 interface Differential input Compatible with PLC series	2 Pcs
9	PLC card Analogue output	4 points of analogue output voltage (0V~+10V)/ current (0mA~+20mA) Output resolution: 12-bit Built-in RS-485 interface Compatible with PLC series	2 Pcs
10	Frame and stand for automation kit	Metal frame with anti-rusting paint and all wooden material	4
11	PLC software	Compatible software for ladder programming, life time floating licence	4

c. Connectors:

All the connectors must have a safety plug. Following table shows the details of connectors.

S.N.	Leads Colour	Diameter (mm)	Quantity (No)	Length (cm)	Section (sq. mm)	Unit Price	Total Price (Euro)
1	Red	4	100	50	0.75	1	100
2	Black	4	100	50	0.75	1	100
3	Red	4	100	100	0.75	1.5	150
4	Black	4	100	100	0.75	1.5	150

						Total	500

2. PLC trainer Kit with HMI and Software:

S.N	Description	No.
1	PLC trainer Kit with HMI	4
2	PLC software	4
3.	SCADA software	1

Following is the technical specification of PLC trainer kit with HMI, PLC and SCADA software are mentioned in the following table.

S.N.	Particular	Specification
1	PLC	Digital Inputs – 14 Digital Outputs - 10 Analogue Input - 2 Analog Output - 2 Input/Output Led indication Power: 24VDC Digital inputs: 14x 24VDC Digital outputs: 10x transistor outputs Analog Inputs: 2x 0...10VDC (10 bit resolution) Analog Outputs: 2x 0...20mA (10 bit resolution) Memory: 100kB Utility program: Step 7 Basic (LAD, FBD) Fast counters: max 3 (100kHz) PID controller with auto tuning Integrated Ethernet - PROFINET Communication extensions: RS-232, RS-485 Example Siemens S7-1200 1215C
2	Power Supply for PLC	24VDC, 5A Power Source
3	Electrical Control panel with input/output simulating device	**For simulation of digital inputs** switches - Selector switch - 1 No., Push button - 4Nos (2NO & 2NC), Emergency switch - 1 No, toggle switch - 3 Nos, proximity sensors - 1 No., Optical Sensor – 1 No., miniature float switch - 1 No., Limit switch - 1No., Front panel for display of digital input/output status: Lamps (24 Nos.),

		For Digital Output Solenoid valve 1 no. Small DC electric motor - 1 no. Audio Indicator- 1 no. **For Analog output simulation** Voltmeter **Analog input simulation** Temperature sensor module - 1 No.
4	Mains Voltage Source	230VAC
5	PLC panel dimension	48” (L) x 15” (W) x 35” (H)* (size may be slightly varied)
6	HMI Display	Screen size: 7.0 inch Resolution: 800x480 Communication: RJ45, USB-A, USB-B Touch plate: Yes, 4-wire Power supply: 24V Serial communication: RS-232, RS-422, RS-485 PLC and SCADA software compatible Example Omron NB7W-TW00B or Compatible Equivalent
7	Output Relay	Relay Compatibility to Loads like Solenoid valves, Electric Motor and for future. (10Nos.)
8	Voltmeter	Supply: 230VAC, Input Range: 0-20VDC
9	Safety Features	MCB 6A, and Fuse 2A.
10	PWM output	High-Speed PWM output for stepper motor module or servomotor
11	Hardware Module	Each module should be provided with safety feature. Water level control module- 4 no. Traffic Light Module- 4 no. Elevator control Module- 4 no. Star-delta starter Module- 4 no. Forward and reverse induction AC motor control module- 4no. Dam water monitoring module-2 no. Standby dual pump control module-4 no.
12	Communication	Communication Port RS232 / RS 485 / Ethernet
13	Networking (Modbus based communication,	10/100Mbps auto-negotiation RJ45 ports with auto MDI/MDIX supported- 5 Specifications:

	TCP/IP Ethernet communication)	- Basic switching RJ-45 Ethernet ports quantity: 5. -Basic switching RJ-45 Ethernet ports type: Fast Ethernet (10/100) - Full duplex. Switching capacity: 1 Gbit/s. - Network standard: IEEE 802.3, IEEE 802.3u, IEEE 802.3x. - Power connector: DC-in jack
	SCADA Software	Feature: Should support HMI software Should have proper communication system like Ethernet Should obtain data from remote location and display in real time Should control device located at remote Should have alarm function for alerting in case of issue like system fail, jamming etc Should support minimum 128 tag Should be configurable Should support common available PLCs like Allen Bradley, Omron, Siemens S7 series, Mitsubishi, Delta etc. Should support Modbus, DNP3, BACnet etc. Should have developer licence i.e. unlimited programming hour Example Siemens Wincc RC
14	PLC Software	PLC programming on PC using IEC programming languages Software for configuring and programming PLC, Floating license for lifetime eg. Simatic Step 7 (TIA Portal)

3. UPS supply, Computer and Laptop for PLC

The following table shows detail specification, number and cost of the equipment.

S.N.	Particular	Description	Qty
1	UPS power supply for PLC and PC	Line interactive UPS Capacity: 1500VA Nominal output voltage: 230VAC Input voltage range: 140 - 300 VAC +/-5% Voltage regulation: +/-10% Max. Transfer time: 6ms Battery charging type: Super-fast Protection: Over Temperature, Surge, Early shutdown warning, Over load	4

2	UPS power supply for PLC	Line interactive UPS Capacity: 1200VA Nominal output voltage: 230VAC Input voltage range: 140 - 300 VAC +/-5% Voltage regulation: +/-10% Max. Transfer time: 6ms Battery charging type: Super-fast Protection: Over Temperature, Surge, Early shutdown warning, Over loadwarning, Over load	4
3	PC for PLC trainer kit	CPU: Intel i7, 8th Generation or Ryzen 7 RAM: 12 GB Motherboard: MSI B450 Tomahawk MAX II or equivalent Storage: 256Gb SSD + 500 Hdd Cooling system: Fan PSU: 600 watt CPU case with proper vent for sufficient airflow Onboard Graphic Monitor: Full HD, 19 inches with HDMI	4
4	Laptop for PLC	Display: 14.0-inches IPS panel Resolution: FHD (1920 x 1080), Processor: i7 or Ryzen 7 5700U or equivalent RAM: 8GB DDR4 Storage: 256GB NVMe SSD + 1TB HDD or 500 SSD GPU: Radeon (AMD) or equivalent Ports: 2x USB 3.2 Gen 1 Type-C, 1x USB 2.0 Gen 1 Type A, 1x Ethernet, 1x HDMI 1.4, 1x 3.5mm headphone jack	4

4. Three Phase Bench Power Supply:

Following table shows the number and estimated cost of variable power supply.

S.N.	Particular	Qty
1	Bench power supply	2

Following is the technical specification of three phase bench power supply.

S.N.	Particular	Description
1	Variable AC Output Voltage	0VAC to 240VAC, 5A
2	Fixed AC Output Voltage	Standard fixed AC230V, 8A, 1ph Standard fixed AC380V, 8A, 3ph

3	Variable DC	0VDC to 30VDC, 0A to 5A 5 step memory Over voltage protection Over current protection Constant current Constant voltage
4	Protection	MCB for both input and output and fuse Easily replaceable
5	Emergency Stop switch	Yes
6	Input power supply	380VAC + N and 230VAC at 50Hz
7	Indication	Yes, Segment display and LED

3.4 Sustainability of laboratory

Students from the Electronics Engineering and Computer Engineering will enrich their hands-on and practical knowledge on this laboratory. Laboratory exercise and demonstration of automation for the course of Instrumentation will be carried out for those students. Similarly interested technical personal and different professionals related to electrical engineering will be trained on the field of automation and smart power system. Even the academic professionals also lack the proper understanding on PLC, HMI and SCADA. The training courses will be developed for undergraduates, graduates, academics and professionals depending upon the finding of google form-based need assessment survey. This laboratory is thus sure to fulfil the present need of the whole nation.

KEC has a dedicated wings known as Research, Consultancy and Training Division (RTCD) for the development of research and enhancement of training activities at KEC. Each year RTCD provides several trainings to third and fourth-year students related to their career and interest. Thus, in addition to laboratory task, KEC in collaboration with RTCD, will assure to conduct Automation training to its third-year students each year. Up to the date here in Nepal, it is very rare to have automation lab in colleges, so MOU with other university will be done so that other student from whole nation can access the laboratory.

The following table illustrates about the scope of laboratory on different engineering subject area and trainings at the Automation laboratory.

S.N.	Stream		Subjects
1	Electrical Engineering	Subject	Power Plant Equipment Utilization of Electrical Energy

			Instrumentation I Instrumentation II
		No. of student (Average)	48 (Proposed)
		Course type	Core
2	Electronic Engineering	Subject	Instrumentation
		No. of student (Average)	20
		Course type	Core
3	Computer Engineering	Subject	Instrumentation I Instrumentation II
		No. of student (Average)	90
		Course type	Core
4	Professional training packages	For Students	Yes
		For Academics	Yes
		For Graduates and Professionals	Yes

For the sustainable operation of the laboratory, KEC will assign Academic staff and technical staff for the Automation laboratory. Mr. Bishal Rimal and Mr. Ishwor Maharjan will be the Academic and technical staff at automation laboratory respectively. The operation, maintenance, and planning regarding the laboratory will be conducted by these assigned staffs. The continuous effort of responsible dedicated staff will assure the sustainable operation of the laboratory.

4. Power Electronics Laboratory

4.1 Introduction

The Power Electronics laboratory aims at imparting practical knowledge of Power Electronics to the students. It will be well equipped with equipment's and trainer kits to teach practical from fundamentals to high level concepts to the students.

4.2 Experiments

The laboratory will be used for performing following experiments. The experiment resembles with the developed course of power electronics under pillar I.

1. To study the basic I-V characteristics of power transistors, diodes, thyristors (SCRs)
2. To study Single phase, full wave and bridge rectifiers with resistive load
3. To study Single phase SCR controller
4. To study Three phase bridge rectifiers with diodes and with SCRs
5. Study on Rectification for inductive loads
6. To study operation of Choppers

Detail manual for the lab experiments will be developed only after installation of the laboratory.

4.3 Detail specification of Equipment

Four set of Power Electronics trainer kit with the following cost and specification detail will be installed at power electronics laboratory.

S.N	Description	No.
1	Power Electronics trainer Kit	4

The power electronics trainer kit should be a compact, ready-to-use experiment workbench. It should be designed in a vertical position and with sufficient space for working. This workbench should be available with a table. The technical specification of power electronics trainer kit is tabulated below. The following table shows the estimated cost under each category.

S.N	Particular	Specification

1	Digital Storage Oscilloscope (DSO)	Bandwidth: 100MHz Real-time Sample Rate: 1GS/s (Single Channel) Number of Channels: 2 CH +1 Ext Memory Depth: 25 Kpts (Single Channel) Acquisition Modes: Normal/Average/Peak Detect Average: Selectable from 4 to 256 Vertical Sensitivity: 2mV/div - 20V/div Time Base Range : 5ns/div-50s/div Input Impedance: 1 MΩ ±2% II 17 pF ±3 pF Input Coupling: DC, AC, and GND Display: 7 Inches 64K Colour TFT LCD (800 x 480) Maximum Input Voltage: ±400Vpp Number of waveform parameter: 32 All measurement device are subjected to the Accuracy: +/- 5%
2	AC voltmeter	0-500V AC Voltage Measurement (Deflection type)
3	AC Ammeter	0-25A AC Current Measurement (Deflection type)
4	DC Voltmeter	0-650V DC Voltage Measurement (Deflection type)
5	DC Ammeter	0-25A DC Current Measurement (Deflection type)
6	SCR Module	On board AC source: 0 V - 18V On board firing circuits: R Triggering Circuit RC Half Wave Triggering Circuit RC Full Wave Triggering Circuit Firing angle variation: Gradually variation using firing control (2M-ohm) SCR: 400V/2A
7	IGBT character module	Internal supply : +35 V, +15 V Interconnection : 2 mm socket Gate voltage variation : 0 to 15 V Collector to Emitter voltage Variation: from 0 to 35 V IGBT : 600V/ 10 A

		Power Supply : 110V - 260V AC, 50/60Hz
8	Series Inverter	Circuit DC supply: +5 V, +12 V On board firing circuits: Square wave Generator. Logic circuit for two get signals output. Frequency variation: Gradually variation SCR : 2 SCRs 2P4M, 400V/2A Mains Supply : 220V/110V, 50 Hz / 60 Hz
9	Single phase controlled rectifier	Circuit DC supply: 0 V - 15 V,18 V - 0 V - 18 V On board firing circuits: Ramp comparator firing scheme SCR : 4 SCRs 2P4M, 400 V/ 2 A Mains Supply : 220V/110V, 50 Hz / 60 Hz
10	Universal Power electronics kit	VI characteristics of power devices Study of Single Phase Thyristor Firing Scheme Single Phase Controlled Rectifiers DC to DC Chopper Single Phase Inverter
11	Single phase cycloconverter	On board firing circuits: Ramp comparator firing scheme SCR : 4 SCRs 2P4M, 400 V/ 2 A Pulse transformer: PT4503 Firing angle variation: 0 to 180 degree Load: 279E, 5W Mains Supply : 220V/110V, 50 Hz / 60 Hz
12	Single phase bridge inverter	Variable DC voltage section Single Phase Bridge Inverter with resistive - capacitive load Single Phase Bridge Inverter with inductive - capacitive load Single Phase Bridge Inverter with resistive inductive & capacitive load

13	MOSFET, IGBT, Transistor and SCR based Step up Chopper	On board PWM circuit : Triangular wave comparator scheme Frequency variation : 27 Hz to 5 KHz (approx.) PWM variation : 0-50% MOSFET : MOSFET IRFZ44N, 55 V, 49 A IGBT : IGBT G4BC20S, 600 V, 10 A Transistor : Transistor TIP122, 100 V, 5 A SCR : SCR TYN 616, 600 V, 16 A
14	MOSFET, IGBT, Transistor and SCR based Step down Chopper	On board PWM circuit : Triangular wave comparator scheme Frequency variation : 27 Hz to 5 KHz (approx.) PWM variation : 0-50% MOSFET : MOSFET IRFZ44N, 55 V, 49 A IGBT : IGBT G4BC20S, 600 V, 10 A Transistor : Transistor TIP122, 100 V, 5 A SCR : SCR TYN 616, 600 V, 16 A
15	Load Modules	R load Inductive load Capacitive load
16	Connecting Leads	Sufficient
17	Protection	MCB and Fuses if required

4.4 Sustainability of the laboratory

Power Electronics is a core subject for Electrical Engineering undergraduate's students. Similarly, as an elective subject for Computer Engineering, and Electronics & information engineering but due to lack of Power Electronics laboratory, KEC is not being able to propose Power Electronics as an elective course for its student. After the installation of laboratory student will have option to choose Power Electronics as an elective subject. We know, Nepal is a developing country in the field of industry and power electronics is important subject for those who are interested in industrial area, so KEC can at least conduct the power electronics course for some students of Computer and Electronics Engineering each year. Beside power electronics, students of Electronics Engineering will perform the laboratory task of the core subject Advance Electronics in the same laboratory each year.

The following table illustrates about the scope of Power Electronics laboratory on different engineering subject area.

S.N	Stream		Subjects
1	Electrical Engineering	Subject	Power Electronics
		No. of student engaged (Average)	48*
		Course type	Core
2	Electronic Engineering	Subject	a. Power Electronics b. Advance Electronics
		No. of student (Average)	20
		Course type	a. Elective b. Core
3	Computer Engineering	Subject	Power Electronics
		No. of student (Average)	90
		Course type	Elective

For the sustainable operation of the laboratory, KEC will assign a dedicated Academic staff and technical staff for the Automation laboratory. Mr. Sushil Paudel and Mr. Ishwor Maharjan will be the Academic and technical staff at Power Electronics laboratory respectively. The operation, maintenance and planning regarding the laboratory will be conducted by these assigned staffs.

5. Location and Layout of the Laboratory

Both the laboratories will be installed at ground floor of Academic building A of KEC. The photo of the building is shown in the figure below. KEC has its own transformer of 250kVA at its premises. The main distribution board of the building is located under the ladder near to the room 101. Three phase four wire can be connected from main distribution panel to the laboratory room at installation. The laboratory will be installed with sub-distribution panel incorporating protection feature and safety guidelines.

Figure: Academic block A

The Room 104 with an area of 72 square meter will be used for Automation laboratory. The layout of the planned laboratory is shown in the figure below.

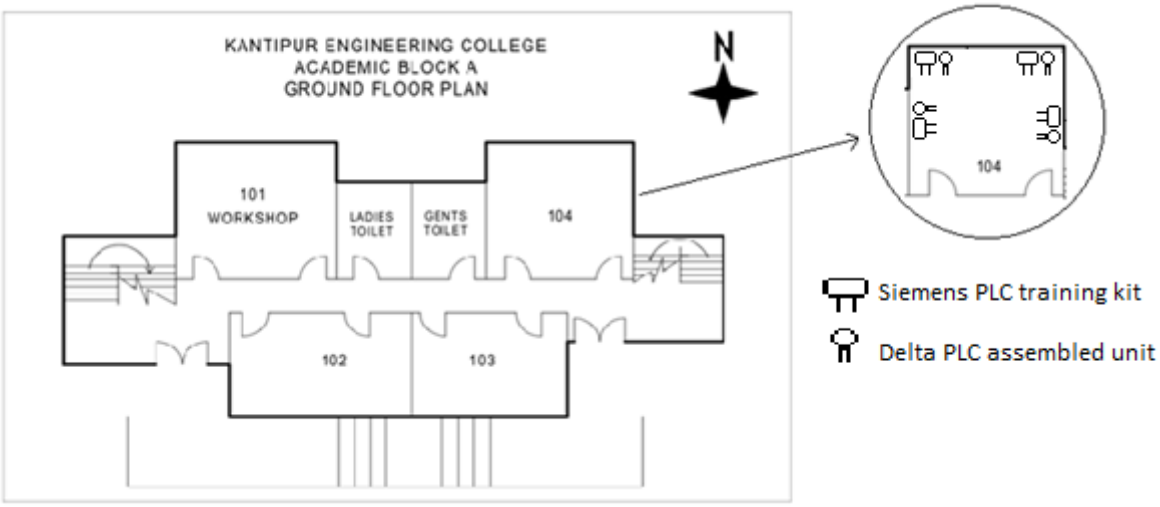

Figure: Ground floor plan with layout of Automation laboratory

The room 103 with area of 65 square meter will be used for Power Electronics laboratory. The plan on layout of the Power Electronics laboratory is shown in the figure below.

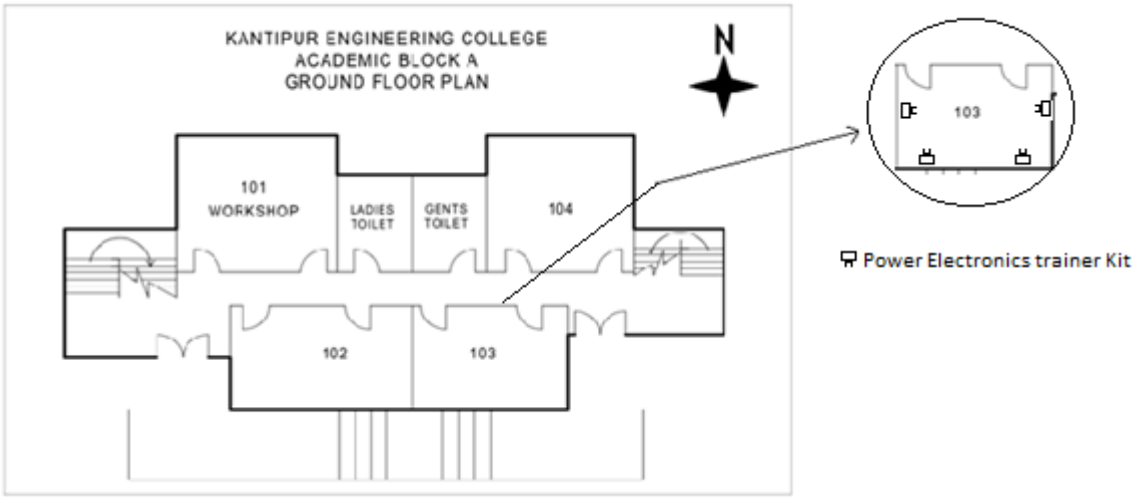

Figure: Ground floor plan with layout of Power Electronics Laboratory

6.Electrical Installation and Safety

Both the proposed laboratory room will follow the local electrical installation guidelines ensuring the safety of the equipment and user. During the installation the sub-distribution board will be installed which will consist of MCB, ELCB, and measurement devices. SP and TP MCBs of proper rating will be installed which can discontinue electrical supply in the laboratory in case of any electrical faults. In order to be ensure zero leakage current, ELCB will be installed. These devices will ensure the safety of the user and equipment. In order to measure the current and voltages, current transformer and voltmeter will be used which can be supervised on the respective meter. All wiring and joints from sub distribution board will be properly installed in appropriated conduit and PVC casing. Suitable insulation will be provided on all the live part of the laboratory. In order to avoid fire hazards, smoke detector and alarm will be installed in the laboratory. Safety equipment like fire extinguishers will also be made accessible in the laboratory.

In order to ensure the safety of the students, proper safety guidelines will be made. A safety protocols that must be followed by the students will be plotted on the flex board and will be kept at the visible place at the laboratory. Proper warning signs will be postered on the appropriate places.

All the laboratory equipment mentioned on chapter 3 and 4 will be provided with proper safety features like fuses, short circuit protection, overload protection etc. All the mechanical equipment, training kits and modules will be properly fixed on the stable surface and ground with sufficient working space.

7. Final Remarks

After the installation of the laboratory, KEC can offer the course Power Electronics to its students. The same lab will be used to conduct the experiments of Advance Electronics. The Automation lab will enhance the understanding the concept of PLC, HMI and SCADA. In addition to the experiments, each year final year students will be trained about automation in collaboration with RTCD at KEC. Coordination and MOU with other university will help other students to perform experiments in the laboratory. Different professional courses will be developed for graduates, professionals and academics. Upgradation of the laboratory facilities with additional equipment will be done in future by KEC.