

EXPO
engineering ▲ design



INDUSTRIAL CONTROL SYSTEM LAB EXERCISES

TEAM CONTROL SYSTEMS



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INDUSTRIAL CONTROL SYSTEMS

- Continuously controls or monitors an industrial process.
- Applications:
 - Manufacturing
 - Power System Protection
 - Telecommunicaiton



TEAM OBJECTIVES

1. Design industrial control system lab exercises.

2. Document exercises in the form of lab guides.

3. Propose method of delivery for outreach students.

VALUE STATEMENT

1

ICS Lab curriculum
will expedite
student learning.

2

Labs will help
students better
understand ICS
concepts.

3

Labs will utilize
current industry
equipment
and standards.

PROJECT REQUIREMENTS



Duration

Complete in
Under 2.5 Hours



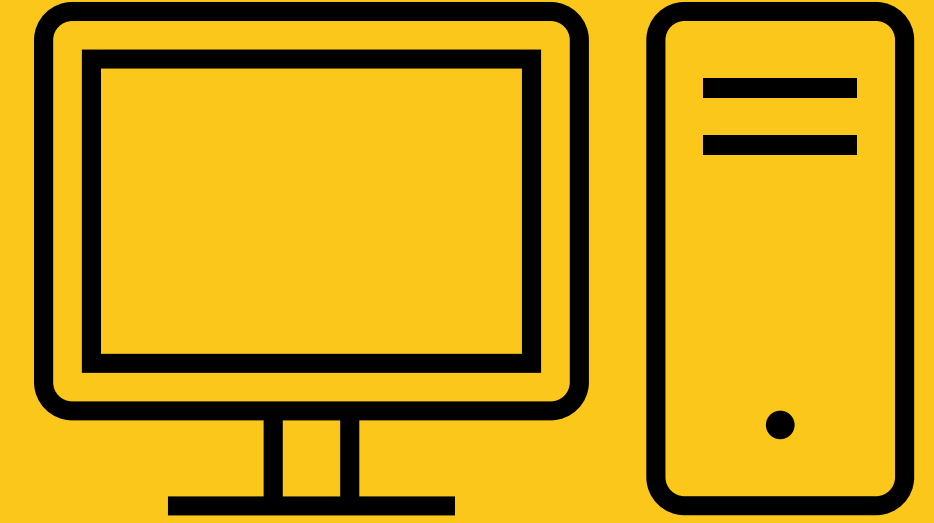
Documentation

TA and Student
Lab Guides



Progression

Cumulative Lab
Progression



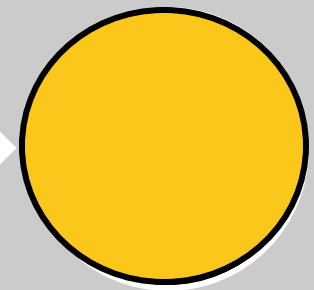
Equipment

Use Existing
or Donated
Equipment

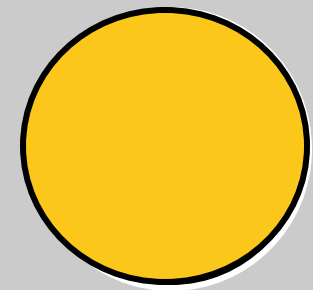


PROJECT DEVELOPMENT

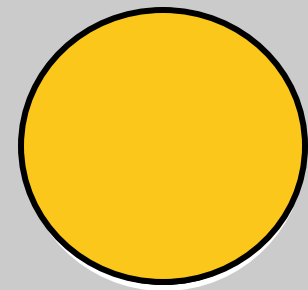
**Review
Current
Lab Materials**



**Identify
Important
ICS Concepts**



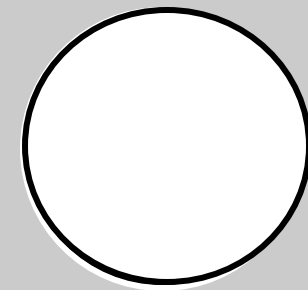
**Design Lab
Exercises**



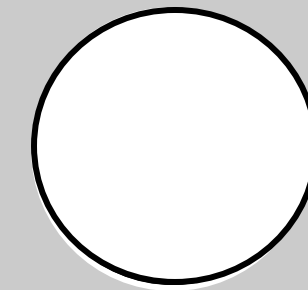
**Campus
Closes**



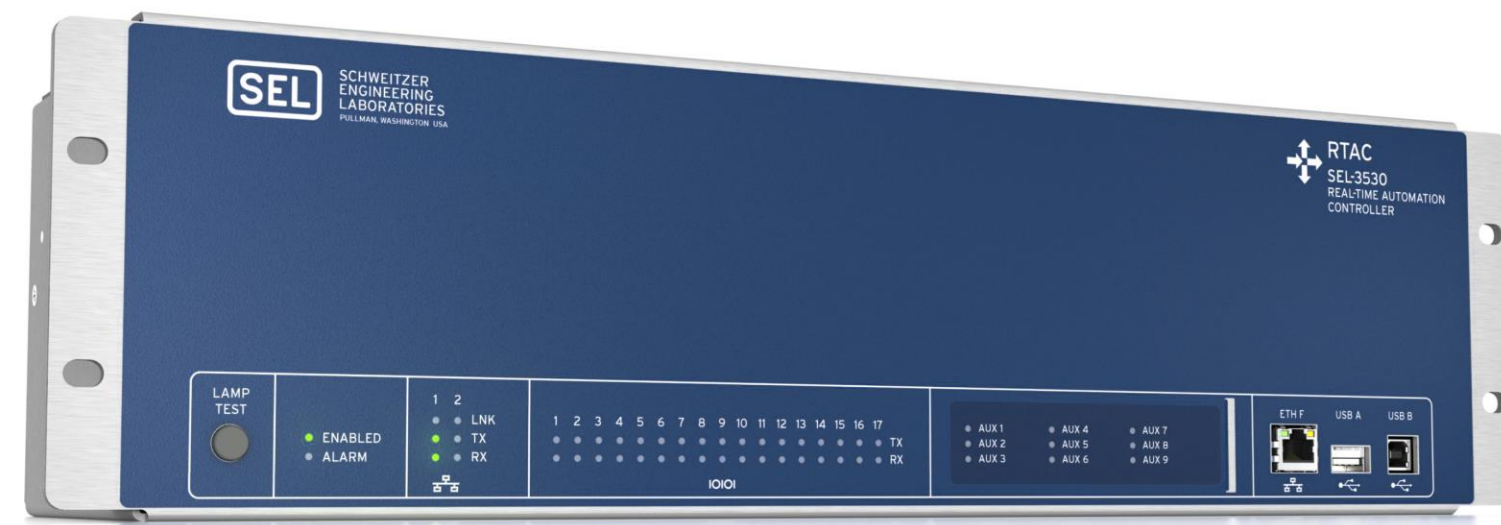
**Quality
Assurance
Testing**



**Build
Equipment
Rack**



IMPORTANT LAB EQUIPMENT



SEL RTAC

- Real Time Automation Controller.
- Manages communication and receives information from connected devices.
- Used in substation automation.



SEL-351

- Protective relay.
- Trips circuit breaker in response to fault conditions.
- Used in distribution feeder protection.

IMPORTANT LAB EQUIPMENT



SEL-849

- Motor management relay.
- Provides overcurrent and overvoltage protection to three phase motors.



KoCoS ARTES 460

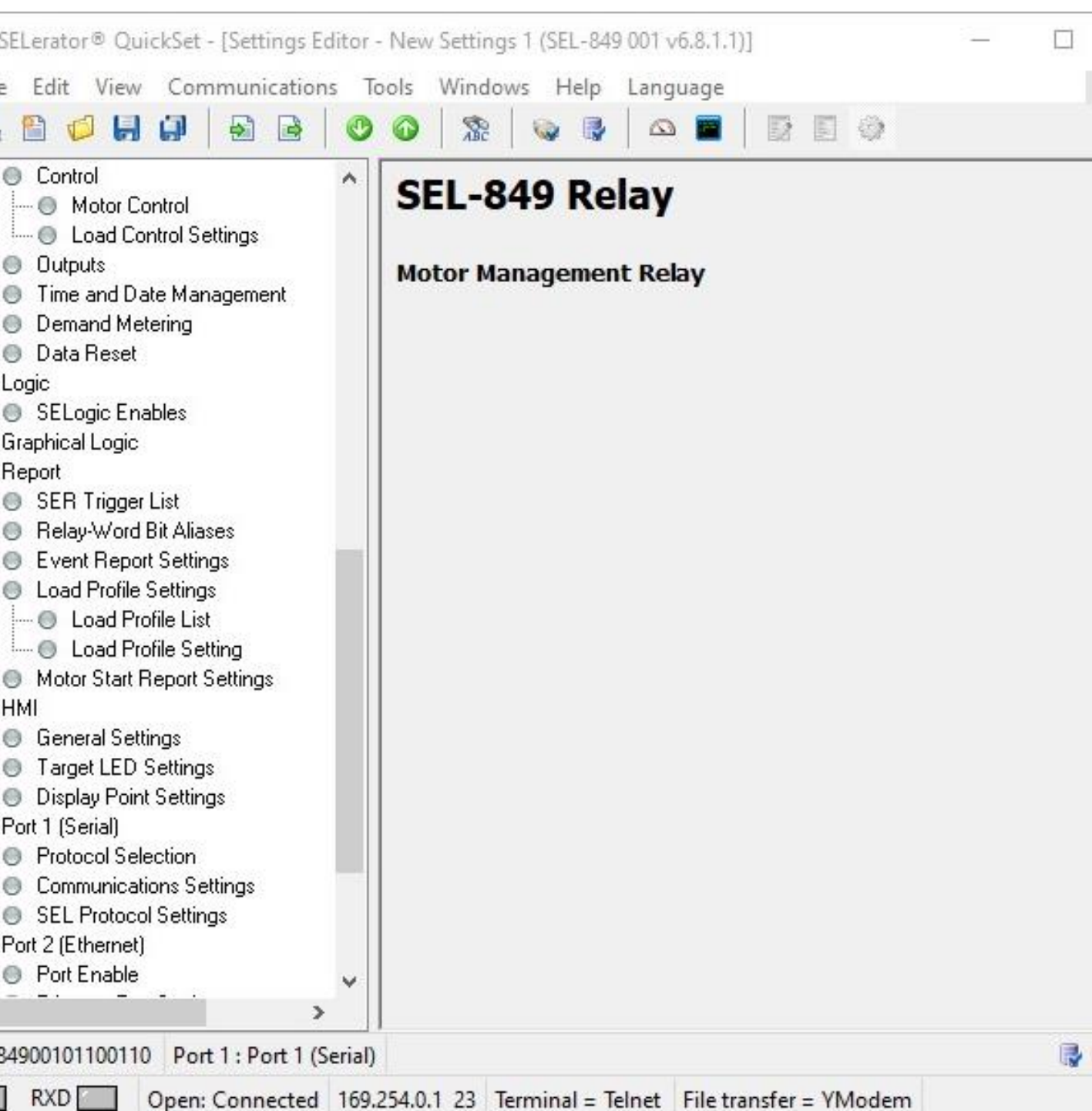
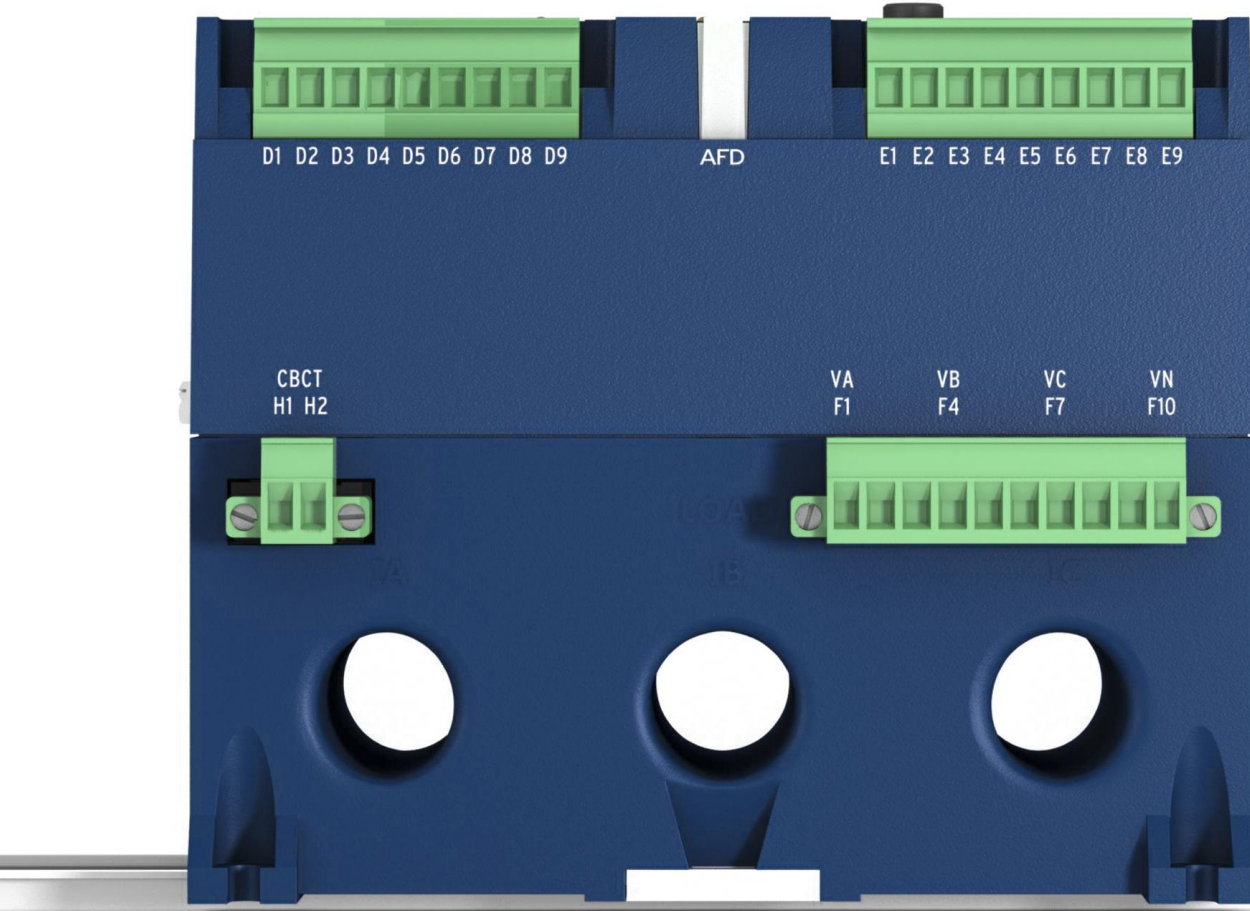
- Provides voltage and current to test protective relays.
- Can be operated manually or through software.



SEL-3622 Security Gateway

- Provides proxy services for secure access.
- Used primarily for password management.

LABORATORY EXERCISES



```

TERMINAL SERVER
ACC
Password: ? *****

SEL-849                               Date: 04/28/2020   Time: 19:25:27.327
Team CS (31)                           Time Source: Internal

Level 1
=>2AC
Password: ? ****

SEL-849                               Date: 04/28/2020   Time: 19:25:31.634
Team CS (31)                           Time Source: Internal

Level 2
=>>SHO PORT 2

Port 2 Settings
Port Enable
EPORT := Y

Ethernet Port Settings
IPADDR := 169.254.0.1/16
DEFRTN := 0.0.0.0
ETCPKA := N           NETMODE := FAILOVER   FTIME := 1.00
NETPORT := A         NETASPD := AUTO       NETBSPD := AUTO

Telnet Configuration
EテルNET := Y           MAXACC := 2           TPORT := 23
TCBAN := TERMINAL SERVER
TIDLE := 15           AUTO := N           FASTOP := N

FTP Configuration
EFTPSEV := Y           FTPACC := 2
FTPUSER := FTPUSER
FTPCBAN := FTP Server
FTPIDLE := 5

```

• LAB 1 – IEDs

- IEDs
 - Intelligent Electronic Devices.
- Lab Goals
 - Introduce the concept of IEDs.
 - Connect to and communicate with an IED.
- Future Work
 - Connect to an IED using AcSELERator QuickSet.

• LAB 2 – RTUs

- RTUs

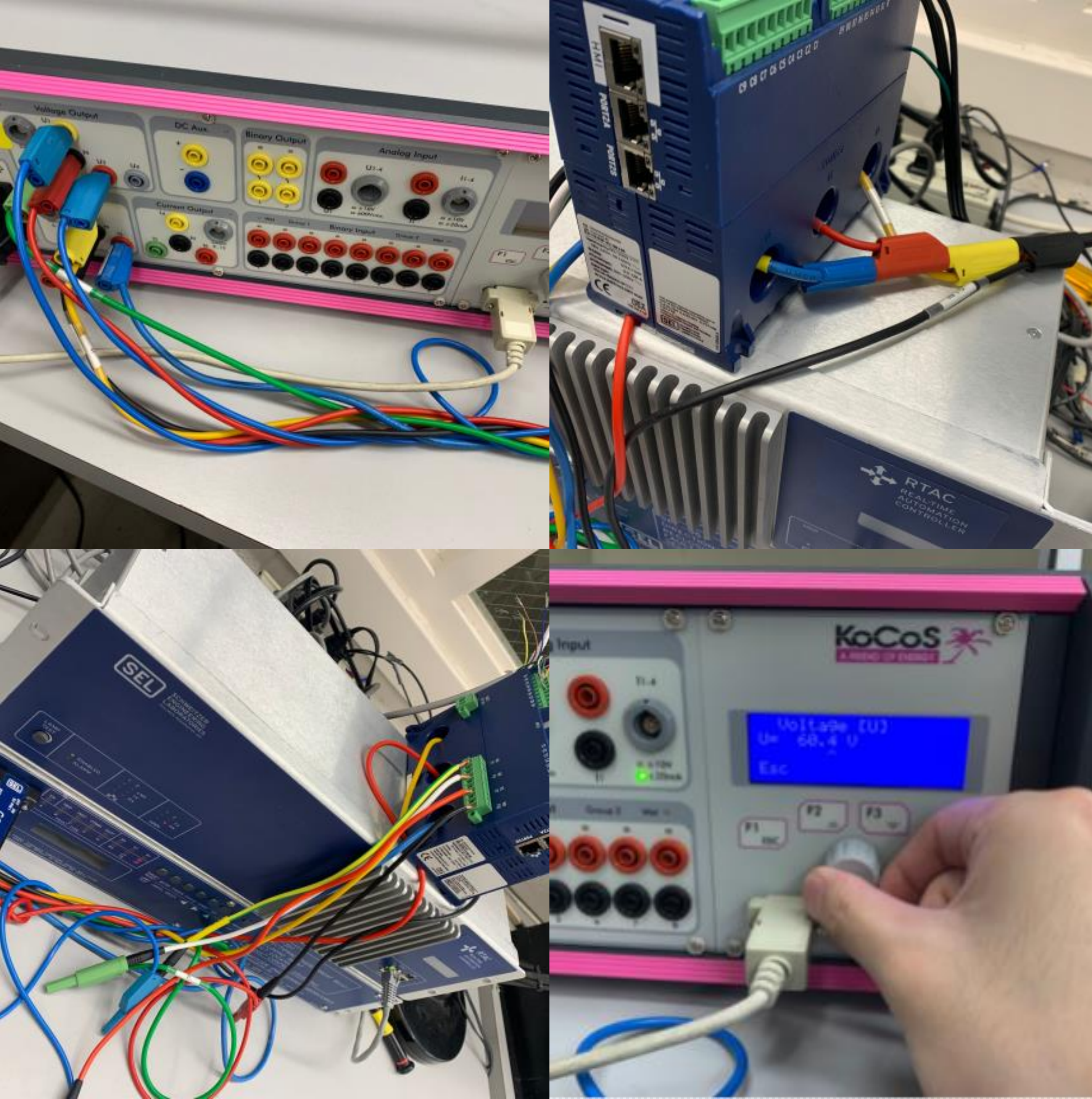
- A microprocessor-based device that monitors and controls other devices.

- Lab Goals

- Provide deeper understanding of IEDs.
- Introduce RTUs.
- Demonstrate communication between RTU and IED.

- Future Work

- Replace KoCoS with a functioning three-phase motor for realistic conditions.
- Operate KoCoS through ARTES Software.



• LAB 3 – HMI DESIGN

• Human Machine Interface

- Provides ability to view data from device or remotely control through interactive interface.

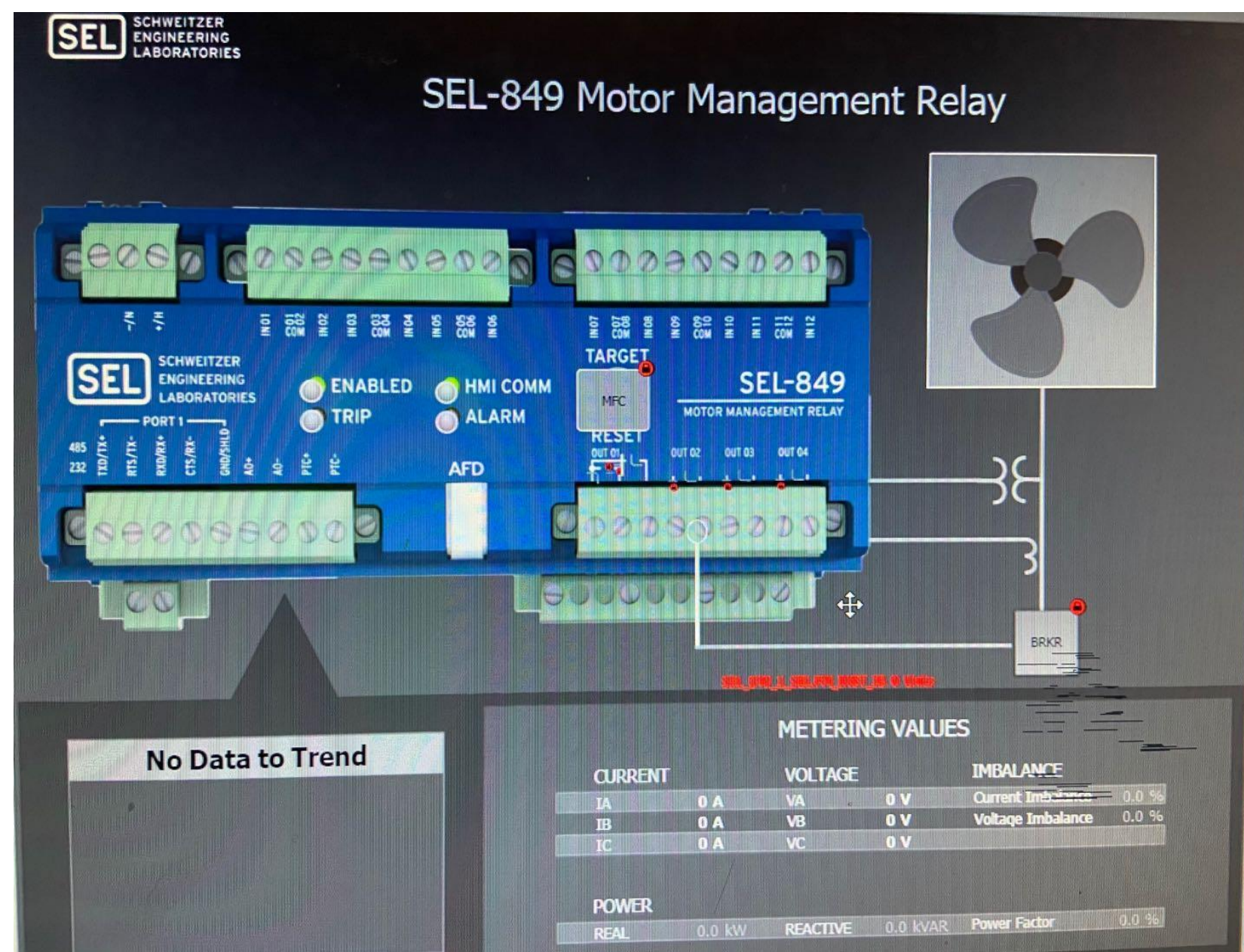
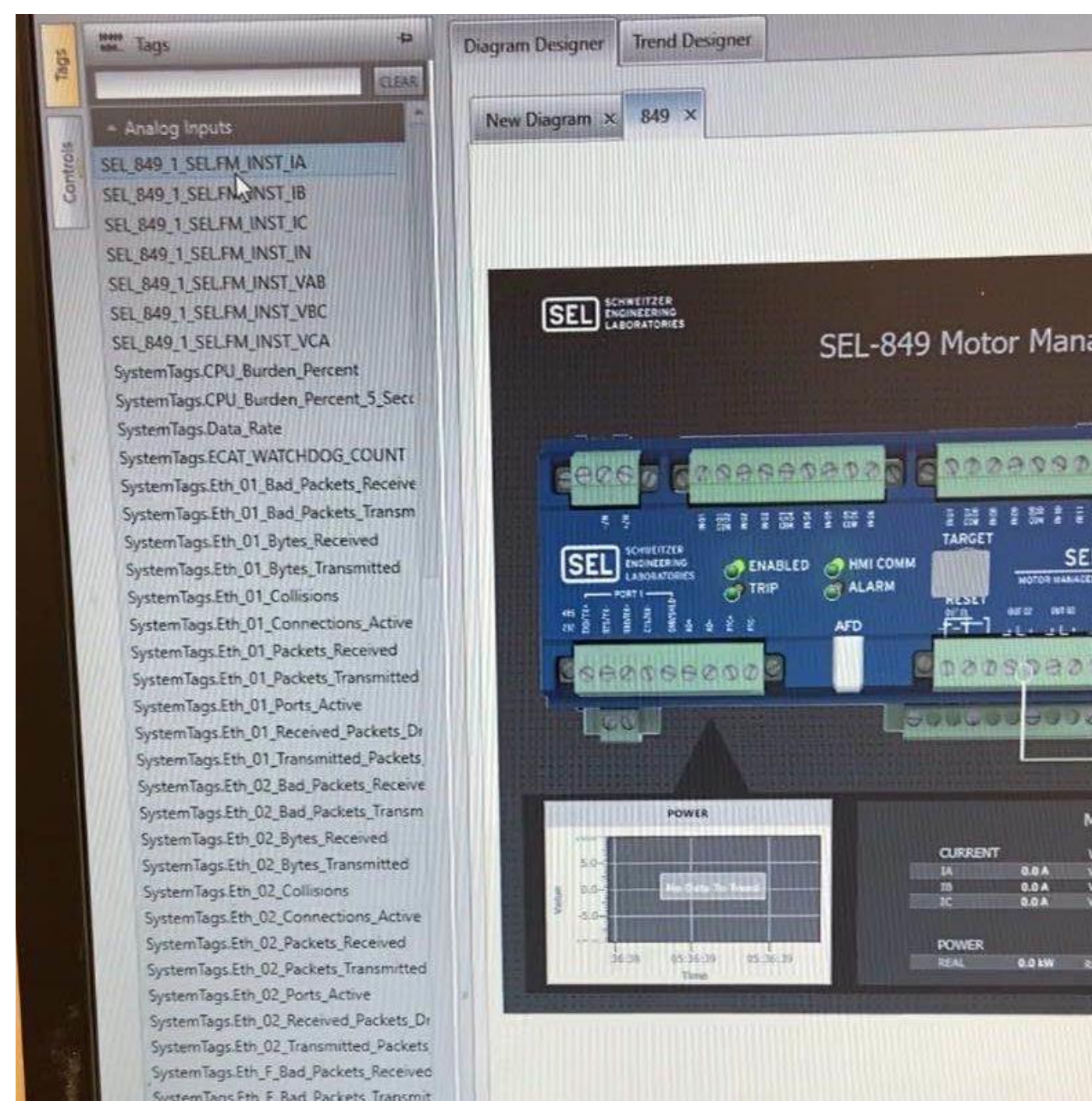
• Lab Goals

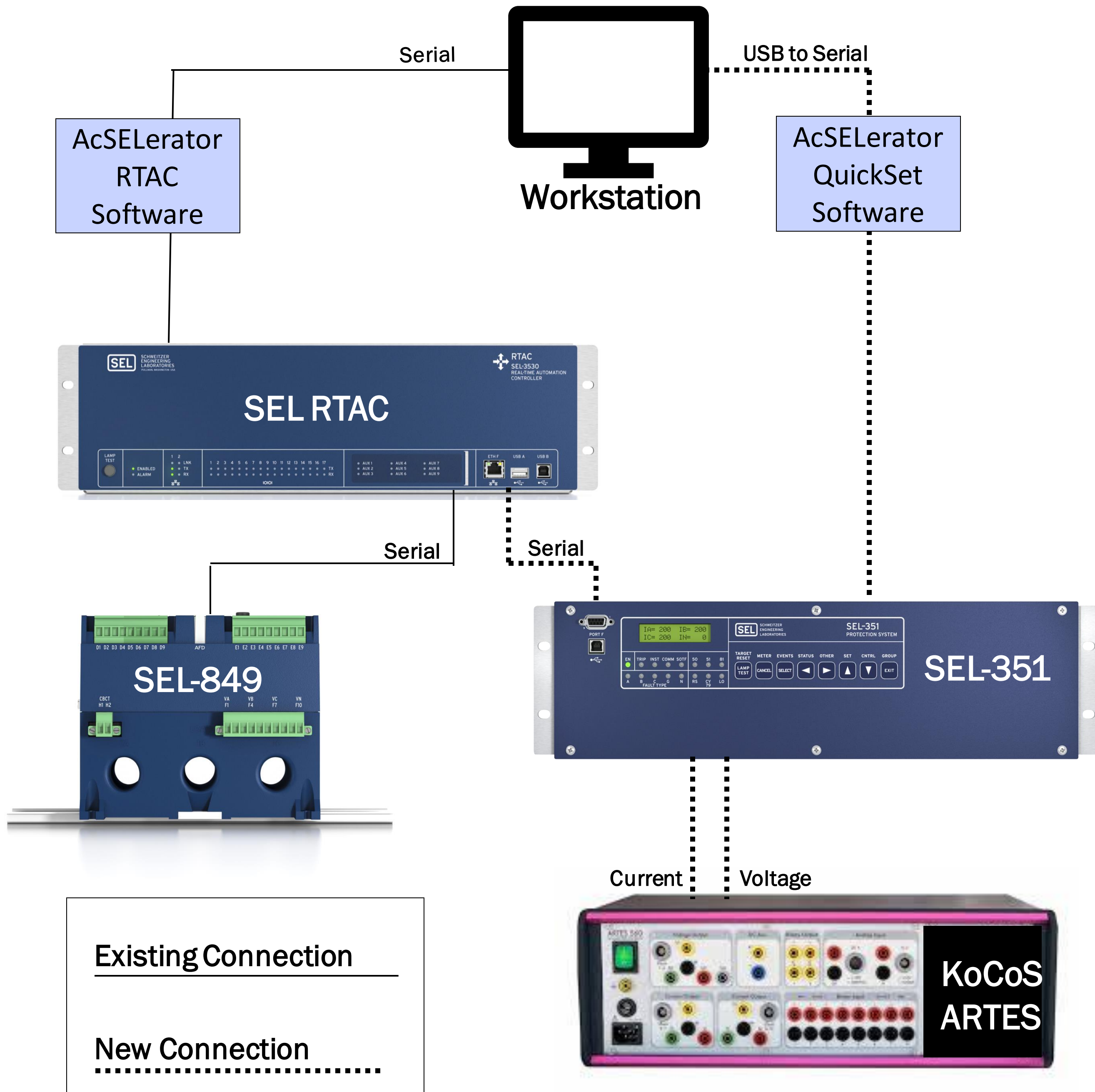
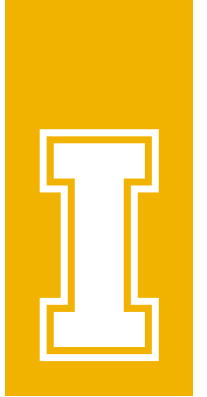
- Introduce HMI functions and characteristics.

- Create HMI using SEL Diagram Builder Software.

• Future Work

- Shift lab progression to incorporate SEL-351 device introduced in Lab 4.





• LAB 4 – COMMISSIONING

- Commissioning
 - Installing a device into an existing system.
- Lab Goals
 - Commission SEL-351 protective relay.
 - Complete commissioning guide.
 - Reference miniature instruction manual.
- Future Work
 - Determine communication and device settings based on provided diagrams and materials.

• LAB 5 – CYBERSECURITY

• Proxy Server


- Acts as a third party between IEDs.

• Lab Goals

- Introduce the SEL-3622: Security Gateway.
- Set up password management.
- Show proxy and direct access differences.

• Future Work

- Connect the Security Gateway to RTAC.
- Set up a server for centralized user password management.



```

login as: supervisor1
Pre-authentication banner message from server:
| This system is for the use of authorized users only. Individuals using this s
> ystem without authority, or in excess of their authority, are subject to havi
> ng all their activities on this system monitored and recorded by system perso
> nnel. Anyone using this system expressly consents to such monitoring and is a
> dvised that if such monitoring reveals possible evidence of criminal activity
> , system personnel may provide the evidence of such monitoring to law enforce
> ment officials.
> End of banner message from server
supervisor1@192.168.1.2's password:

*who

Available Devices:
1      SEL-849_SER1

*sel 1

=acc

=>2ac

=>>sho port 1
      sho port 1

Port 1 Settings

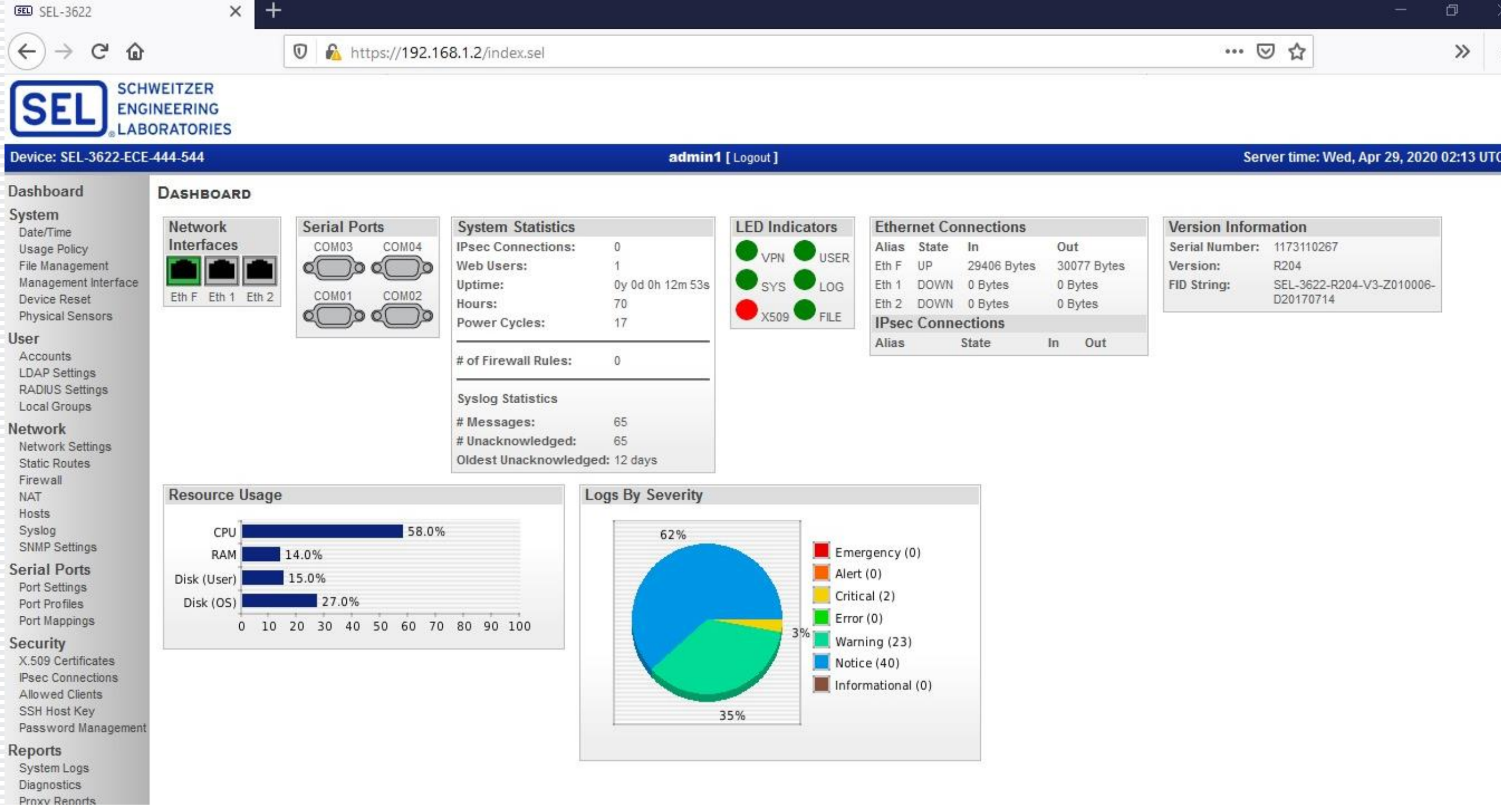
Protocol Selection
PROTO := SEL      COMMINF := 232

Communications Settings
SPEED := 9600      BITS := 8      PARITY := N
STOP := 1          RTSCTS := N      T_OUT := 15

SEL Protocol Settings
AUTO := N          FASTOP := N

=>>>

```



SEL-3622 Web Management Interface Dashboard (admin1 [Logout], Server time: Wed, Apr 29, 2020 02:13 UTC)

System Statistics

- IPsec Connections: 0
- Web Users: 1
- Uptime: 0y 0d 0h 12m 53s
- Hours: 70
- Power Cycles: 17
- # of Firewall Rules: 0

Syslog Statistics

- # Messages: 65
- # Unacknowledged: 65
- Oldest Unacknowledged: 12 days

Resource Usage

Resource	Usage
CPU	58.0%
RAM	14.0%
Disk (User)	15.0%
Disk (OS)	27.0%

Logs By Severity

Severity	Count
Emergency	0
Alert	0
Critical	2
Error	0
Warning	23
Notice	40
Informational	0



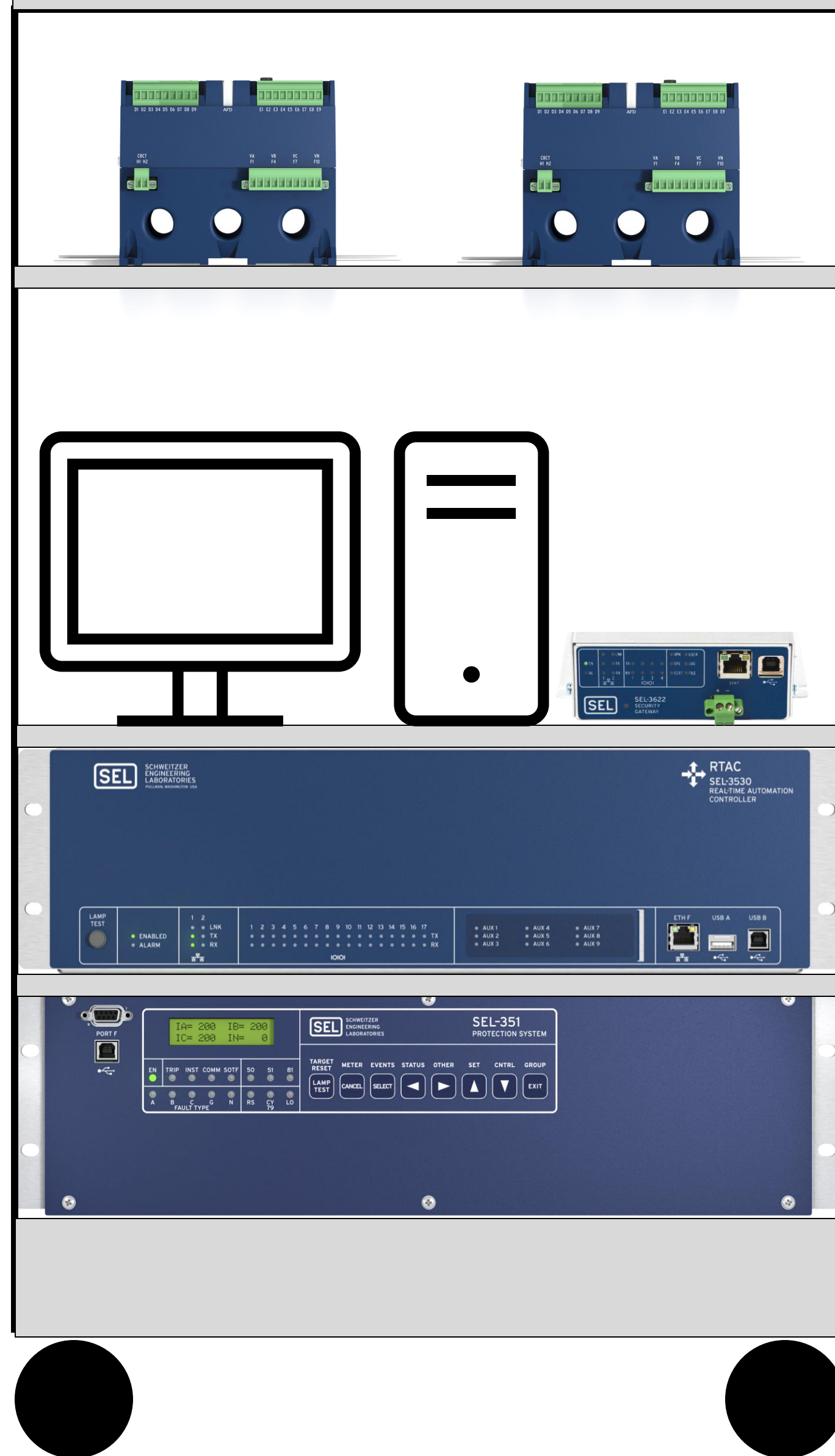
FUTURE RECOMMENDATIONS

TESTING AND VERIFICATION

- Planned to validate lab exercises by recruiting students for quality assurance testing.
- Impacted by closure of campus.
- Documentation allows for testing to be conducted by future group of students.



Industrial Control System Exercises



CONSTRUCTING A RACK

- Equipment used in the field to physically secure devices.
- Provide storage for equipment used in lab exercises.
- Provide organization for device wiring.

ACKNOWLEDGEMENTS

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