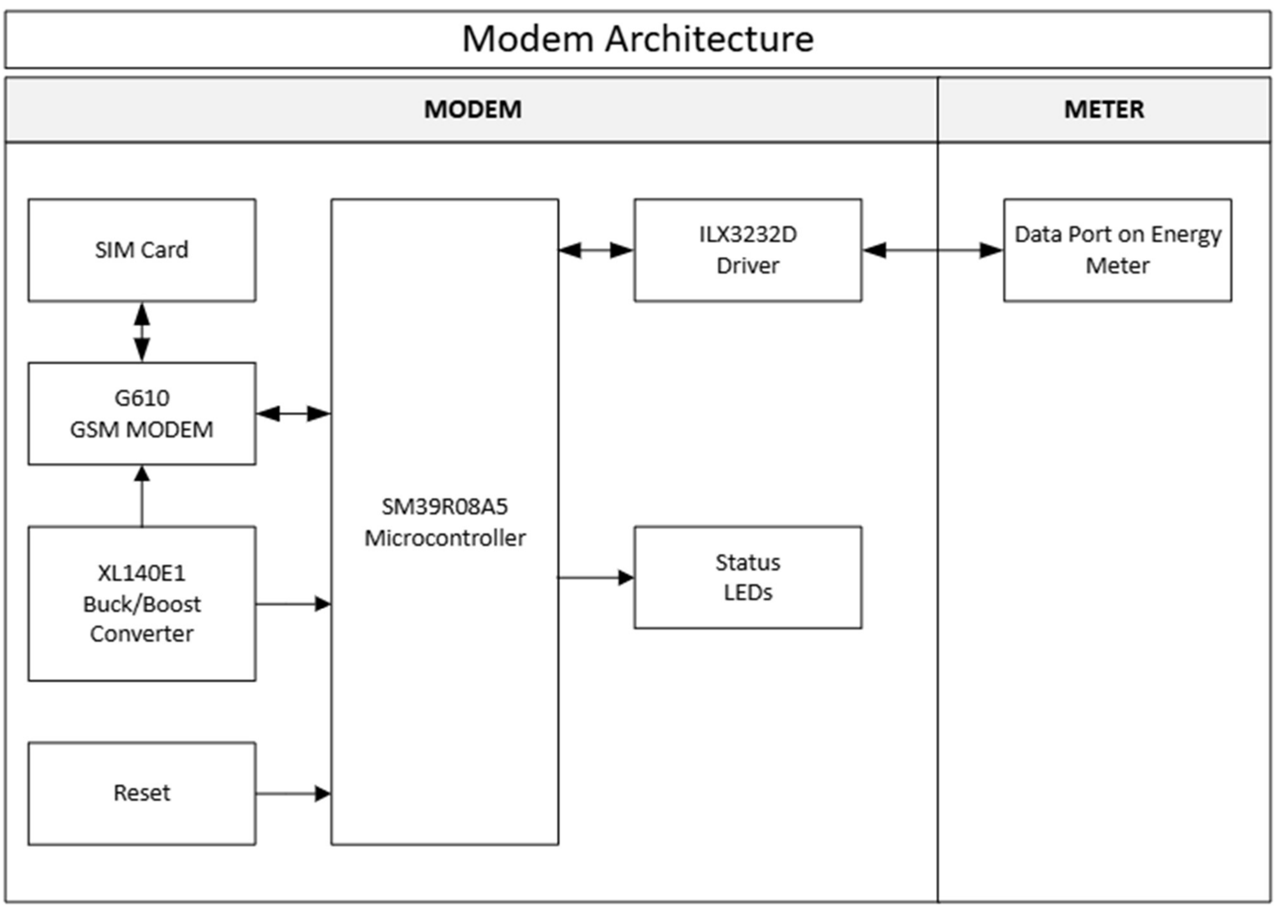
HackAP Hackathon – Power Distribution

Problem Statements

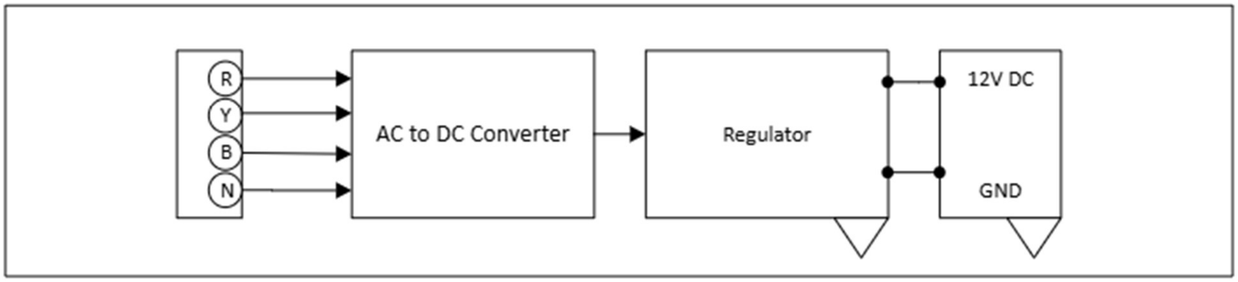
1. **Problem Statement:**
   Seamless functioning of communication modems installed for Feeders.

   Description:
   There are 7,530 modems installed at HT Services and 11 kV Feeders to facilitate real-time communication of data with APEPDCL's servers. However, it has recently been observed that the communication consistency of these modems is poor. This inconsistency adversely affects the efficiency of the Outage Management System (OMS) and leads to inaccurate reporting on the National Feeder Monitoring System (NFMS).

   Block Diagrams:



Power Supply Architecture



The Modem is also equipped with a 3.7V battery.

Desired Outcomes:

Participants are expected to:

- Study the existing modems' Network Interface Card (NIC) firmware, rewrite the firmware on the existing hardware.
- Modify the data acquisition software (MQTT Protocol)
- Ensure the acquired data is integrated to the APEPDCL database.
- The solution must have a considerable impact on the communication consistency of the modems.

Data Sets Provided:

1. Sample Modem
2. Sample Meter (DLMS)
3. Existing Modem Data Sheet
4. Details of existing Meter Data Acquisition Software
5. Required information on database structure for integration
6. List of parameters expected to be captured, along other required details such as frequency of communication.

Note:

The source code shall be created under an open-source license like MIT, Apache, or GPL, allowing unrestricted use, modification, and distribution, while safeguarding against proprietary restrictions. The source code shall be available on a public GitHub repository.

2. **Problem Statement:**
   Enhance Quality Control Management in APEPDCL's New Projects to Ensure Reliable Power Distribution

   Description:

   APEPDCL distribution network is vast and robust and is responsible for transferring electricity between both the power grid and end consumers. APEPDCL in its network has distribution lines of 33kV, 11 kV, and 440V voltages across 11 districts of Andhra Pradesh.

   APEPDCL undertakes new projects to meet the growing power demand through installing new substations, HT and LT lines. These installations include erection of substations, laying of poles, x-arms, insulators, conductors, jumpers, transformers, etc. Field contractors undertake these works as per the construction standards stipulated by APEPDCL. However, field contractors often deviate from construction standards, compromising the quality of installations. This can lead to:

   - Heavy damage during natural disasters (cyclones, floods)
   - Premature failures during normal operations
   - Power interruptions affecting consumers
   - Increased maintenance costs, resource allocation, and financial losses
   - Decreased customer satisfaction

   Desired Outcomes:

   To identify anomalies/ deviations in the components of new installations (Lines & associated equipment) w.r.t construction standards.

   Note:

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3. **Problem Statement:**
Defect Detection and Analysis in Power Distribution Components using Image Processing

Description:

Power distribution companies face significant challenges in maintaining and repairing their infrastructure, with faulty components being a major contributor to power outages and equipment failures. Currently, defect identification relies heavily on manual visual inspections, which can be time-consuming, prone to human error, and often delayed. The increasing availability of defect component photographs from various sources (e.g., field technicians, drones, and cameras) presents an opportunity to leverage image processing techniques to extract valuable insights.

To identify anomalies/ deviations/defects in the installations (Lines & associated equipment)– With the use of AI/ML/ Image Processing

Desired Outcomes:

Develop an image processing-based system to detect, classify, and analyse defects in power distribution components (e.g., transformers, switchgear, insulators, poles, conductors, insulators, x-arms, capacitor banks, etc.) from photographs, enabling:

1. Early defect detection and prevention of potential failures
2. Reduced manual inspection time and increased efficiency
3. Improved accuracy and consistency in defect identification
4. Data-driven insights for predictive maintenance and asset management

Data Sets Provided:

1. Images from field team
2. Sample Details of equipment present in the system

Note:

It is to be noted that the defective/ doubtful component photographs sent by the field team may subjected to variability in image quality, lighting, and camera angles, Diversity of defect types and appearances, complexity of power distribution component structures, etc. By addressing these challenges, the proposed system aims to revolutionize the maintenance and inspection processes.

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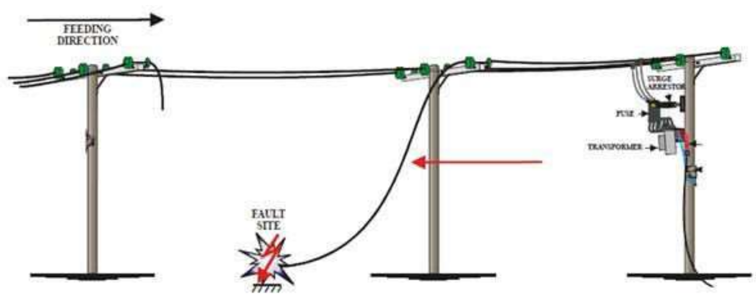
4. Problem Statement:

Accurate detection of Open Circuit faults during broken/ open conductor which poses a serious threat of electrocution to passersby human or animal and a potential fire hazard

Description:

The open circuit fault is when a conductor physically breaks and falls to the ground. The break in the conductor will usually result in either a drop in load on the affected feeder or possibly a momentary over-current condition as the falling conductor briefly comes in contact with a solidly grounded object. Once on the ground, the resulting electrical signature is very much a function of the contacted surface. Surfaces such as concrete, grass, dirt, and wet surfaces in general will result in an “arcing fault” with RMS fault currents in the range of 10 to 50 amps.

Open circuit faults are the faults that do not produce enough fault current to be detectable by conventional over current relays. The traditional protection is designed to protect the power system, open circuit fault protection is primarily focused on the protection of people and property.



The possible scenarios for open circuit fault are detailed below:

- A broken feeder conductor does not fall on the ground but remains suspended, resulting in no fault current at all (i.e. an open circuit fault)
- Conductor falls on a high resistivity ground surface (asphalt road, rocky terrain, etc.) causing a very low amount of fault current, due to which conventional earth fault relay at the substation end fails to trigger the circuit breaker at the substation

Existing relays have the feature of detecting % unbalanced current (I2/ I1) crossing a predetermined threshold limit with some time delay (46BC). But facing the following limitations:

- Unbalanced current detection feature doesn’t work for unbalanced loads
- More difficult with increase of prosumers feeding power into the grid
- APEPDCL existing feeder protection relays are of tier-2 brand make, which do not effectively act for 46BC feature.

Desired Outcomes:

Participants are expected to propose a cost-effective "Open Circuit" fault detection method/ provision for the existing low-end OEM make feeder relays in APEPDCL (Must work for unbalanced load situations, 2/3, 1/3 Agri-Supply)

Data Sets Provided:

- Existing OEMs relays
- Historical faults data
- Relay settings (Sample data)

5. **Problem Statement:**
   Use of Optical Character Recognition (OCR) for accurate conversion of meter display information from image to text

Description:

APEPDCL conducts monthly billing for all Low Tension (LT) services through a Spot Billing system. These services are equipped with either IR-Port or Non-IR Port energy meters. A mobile application has been developed for billing purposes, which can be installed on any Android device. The IR-Port Scanner (Reader) is externally connected to the mobile device through a USB port, enabling the billing of all IR-Port energy meters by scanning the meter. The bill is generated on the spot based on the captured reading, and it adheres to a Two-Part Tariff system—one part based on energy consumption (kWH/kVAH) and the other based on either the Maximum Demand recorded during the month or the Contracted Load. A physical bill is printed on the spot using a Bluetooth printer.

For Non-IR Port meters, the Spot Billing personnel manually input the meter reading and Maximum Demand (MD). However, there have been instances where IR-Port meters could not be scanned due to defective IrDA ports. In such cases, manual input is required, which can lead to billing errors, either intentional or unintentional, causing inaccurate billing for consumers.

Desired Outcomes:

The objective of this project is to develop a comprehensive model that enhances the accuracy and reliability of the billing process by incorporating the following functionalities that:

- **Image Extraction**: The model should be capable of extracting data from captured images of the meter display using Optical Character Recognition (OCR) technology. This includes the cumulative kWH, cumulative kVAH, and Maximum Demand (MD) readings. The feature should function effectively both online and offline to accommodate various field conditions.
  - When the display is not visible, and
  - When the LCD screen is visible with the corresponding output
- **Data Extraction:** Retrieves data displayed on the LCD screen.
- **Image-to-Text Conversion:** Accurately and reliably converts the extracted image data into text format.

Data Sets Provided:

Images of various displays, showing various readings, including unclear and partly damaged displays.

Note:

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6. **Problem Statement:**
   Prevention of explosion of Current transformers (CTs) used in APEPDCL network

   Description:
   Current transformers in distribution system are used for metering and protection. In APEPDCL, there is a high share of oil filled CTs installed. The CTs fail due to various reasons such as overloading, short circuits, overheating, aging and high voltage surges. In some instances when the CTs fail, they tend to explode causing the spillage of oil at high pressure and temperature and ignition of oil leading to fire etc.

   The explosion of CTs have severe and far-reaching consequences which can cause the serious injury or even death to personnel who are working in the vicinity of the CTs. Further the blast and fire can damage or destroy adjacent equipment such as transformers, switchgear, and transmission lines, leading to extended power outages.

   Desired Outcomes:
   The participants are required to provide a cost-effective retrofitting solution to restrict the explosion of existing CTs in APEPDCL during its failures.

   Data Sets Provided:
   - Type and make of the CT and any other details if required

7. **Problem Statement:**
   Identification or detection of failure of insulators (polymer and porcelain) during night

Description:

In power distribution lines, it is necessary to isolate the conductors under voltage from the towers, and insulators are used for this purpose. These insulators have two main tasks. One of the significant tasks of insulators is to isolate (insulate) the line conductor from the body of the tower. The insulators must be able to isolate the high voltages of the lines from the body of the tower without having a leakage current. On the other hand, the insulators must withstand the mechanical forces resulting from the weight of the conductors and the applied forces caused by wind. Also, leakage current is one of the important parameters for condition monitoring of insulators in power grid lines.

Failure to inspect the insulation for contamination and health conditions will lead to insulator failure and cause electrical system faults. Failure of insulators on HT lines is one of the major reasons for power supply interruptions. It is difficult to identify failure of insulators (porcelain and polymer) in the lines especially during nighttime. The APEPDCL personnel may need to perform sectionalized troubleshooting to identify the faulty section and isolate a specific section of the electrical line to identify the faulty insulator. This process requires careful planning, coordination, and execution to ensure safety.

Sectionalizing and inspecting the failure in insulators is a tedious and time-consuming process. It requires careful planning, attention to detail, and a methodical approach to ensure accuracy and safety.

Hence APEPDCL is looking for a tool which can identify/detect the insulator failure from ground during the nighttime.

Desired Outcomes:

The participants are required develop an innovative tool/ device which can identify / detect the polymer insulator failure from the ground level during nights.

Data Sets Provided:

- Sample healthy Polymer and porcelain Insulators
- Sample defective polymer and porcelain Insulators