Field study of agricultural distribution systems for Electrical Engineers

First Edition

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A project funded by the Department of Higher and Technical Education, Government of Maharashtra

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Preface

1. Motivation

There are two main motivations for this book. One is to orient engineering education towards development issues of the state. The other is to teach engineering through current regional problems, field examples, and data. The case studies and field examples are from agricultural feeders,i.e., the grid distribution system for irrigation pumps. The engineering concepts are based on the electrical engineering curriculum and especially useful to electrical students. However, they can be studied and used in practical cases by all engineering disciplines.

The material in this book was developed along with a group of faculty from electrical departments across the state. A series of workshops were conducted which included field visits, concept development, and take-home assignments.

Useful outcomes achieved through this book:

- Case studies that can be implemented through the farmer community, MSEDCL, or the Department of Agriculture, thus contributing to development goals
- Fieldwork and community engagement aspects required in the New Education Policy are covered
- Students learn to apply concepts related to material from core electrical courses to real world problems. Some of these courses are Electrical Measurements, Power Systems, Power flow modeling, Motors.
- The case studies and other ideas arising from this material, can be structured as micro, major, and course projects.

The section on ‘Recommended coverage’ details out ways to include the material in the academic program.

2. Content

Chapter One provides an overview of the irrigation status and systems in Maharashtra. It gives a brief overview of the current status and government policy..

Chapter two provides an overview of the agricultural distribution system. Chapters three to six cover the relevant electrical analysis and application to agricultural feeders such as: overview of three-phase systems, analysis of low-tension networks using simple to more complex modeling techniques, Distribution Transformer loading, and capacitors.

Chapters seven to nine cover irrigation pumping such as: basics of the pumpsets, estimation of flow rate, irrigation depth etc. with examples from typical conditions in the state, usage of drip and sprinkler. And appropriate pump selection for different irrigation methods like drip and sprinkler.

Chapter 10 includes a tutorial for network analysis using power flow modeling using Matpower

Chapter 11 is on how to conduct fieldwork.

Section 2 contains case studies. These case studies can be used for projects (mini projects, BTech and MTech projects)and also as teaching case studies as a part of courses. These will be connected to existing courses in the curriculum.

List of case studies:

1. Analysis of the network of one Distribution Transformer
2. Capacitor usage on irrigation pumps
3. Loading on agricultural feeders as connected to cropping
4. Operational efficiency and appropriate selection of irrigation pumps

Each case includes (i) Objectives (ii) Methodology for data collection (iii) Steps in how to conduct the analysis (iii) Broad format for presenting results (iv) Pointers on which chapters should be covered before various steps in the conduct of the case study (v) Instruments that may be useful. if any, expected travel and time on the field.

3. Recommended coverage

The book may be used for (a) Complete course(s) (b) To provide field examples for related material in core courses (c) As micro, major, and course projects and field work.

The book has enough material to cover two semester-long courses. It may be taught in the second semester of the second year and the first semester of the third year. The chapters in the book correspond roughly to the core courses listed in the tables below.

Table 1. Analysis of agricultural feeder

Disciplinary Subject and year	Analysis to be conducted / Case study to be documented	Disciplinary concepts included in the case study	Related chapters in this book
Electrical Measurements, First year	Measurement of power consumption of agricultural pumps. Measuring the effect of a capacitor on power drawn. Conducting surveys on capacitor usage in the field. Find the MSEDCL rule of capacitor usage with irrigation pumps. Analyze the capacitor ratings specified by the rule.	Measurement of Power: Active & reactive power measurement in three-phase system for balanced loads	1,5,7
Power Systems - I, Second year	An analysis of a feeder, and connecting the requirements of the distribution system to irrigation requirements.	Related to a substation/feeder / Distribution Transformer: Different factors such as Connected load, Maximum demand, Demand factor, Average load, Load factor, Diversity factor, Load curve, and Load duration curve.	1, 5
Power Systems - I, Second year	Representing an agricultural feeder, at the High Tension and Low-Tension level. Collecting conductor data from MSEDCL. Connecting the available data to textbook material on inductance, resistance and capacitance. Conducting some measurements on the field to estimate the regulation and efficiency of the feeder.	Transmission line parameters, Representation of power system components: Introduction, single-phase solution of balanced three-phase networks, One-Line diagram and Impedance or reactance diagram, Per Unit(P.U.)system, an advantage of Per Unit system, p.u. Impedance diagram, representation of load. Classification of short, medium and long lines. Modeling of short, medium, and long lines. Regulation and efficiency of short lines.	2,3,4
Power Systems - II, Third Year	Analyzing the performance of an agricultural feeder at the High Tension and Low-Tension level.	Introduction to power flow analysis, power-flow equations, generalization to n-bus systems, and classification of buses. Regulation and efficiency of short lines.	3,4,5, 10

Section One

1. Energized irrigation

1.1 Introduction

55% of the population of India is engaged in farming, and about 50% of the land is irrigated, mostly through energized irrigation. In other words, gravity-based irrigation through canals is a small proportion. There are 14.16 crore land holdings in the country (Jadhav et al, 2020) , using 1 crore 56 lakh grid-connected electric pumps (CEA, 2019), and 55 lakhs diesel pumps (MI, 2016). 18 % of the total electricity consumption is used in irrigation pumps or 2 lakh GWh (MOSPI. 2019).

Since our work is in Maharashtra, the material in the rest of the chapter only refers to the state.

In Maharashtra, a much smaller proportion of the land is irrigated ~20-25%, and the number of irrigation connections is ~1/3 of the land holdings in the state.

Current Status

Groundwater is the most common source of irrigation in Maharashtra with open wells being predominant, followed by a much smaller fraction of borewells. Surface water sources such as dams, rivers, irrigation tanks, and farm ponds are also used. Most of the irrigation is through pumping, with a small proportion, which may be ~10% or less, by canal / gravity-based irrigation. Most of the pumps are of 3 HP and 5 HP ratings. The total number of electricity pumps in the state has been steadily increasing with a total of ~44 lakhs in 2024.

Diesel pumps are not very common and may be used when there is a breakdown in a Distribution Transformer with no supply for many days, or in villages where the voltage is frequently very low. However, diesel is expensive and so not used by many farmers.

Since 2018 there have been some schemes for solar photovoltaic pumps however the number of such pumps is less than 1 lakh.

Government Policy in the sector

The state government has placed a significant importance on energized irrigation as may be deduced from the substantial number of new connections given out each year, and the subsidy on energy.

The government supplies electricity to farmers at the average tariff of Rs. 1.76 / kWh. This is highly subsidized since the cost to supply this energy is Rs. 7.25 / kWh. For some farmers, the basis of payment is a fixed monthly rate which depends on the HP of their pump. Tariffs may be obtained from the Mahadiscom website(https://www.mahadiscom.in/consumer/en/tariff-details/).

There are 44 lakh electrical pump connections and about 1 lakh new connections are given out each year, as shown in table 1. The farmer has to pay ~ Rs.5000 for a new connection.

Table 1: Annual count of new pump connections in each Financial year

Sr. No	Financial Year	No. of connections
1	FY 13 - 14	1,24,769
2	FY 14 - 15	1,47,993
3	FY 15 - 16	1,30,000
4	FY 16 - 17	1,25,522
5	FY 17 - 18	66,174

Source: MERC, 2019

Several new technical approaches to agricultural connections have been introduced by the government over the last few years since 2018. These are off-grid solar photovoltaic pumps, High Voltage Distribution Systems (HVDS), and Solar Agricultural feeders. A Government Resolution is passed to approve each new policy. More about these technical approaches and the GRs are given in the chapter 'Electricity supply infrastructure for irrigation pumps'.

A government resolution gives the reasoning and provision for the operationalising the policy, the agency that introduced the policy, and how it will be financed. All relevant officials who are expected to take some action due to the GR are listed on the GR.

GRs are available at the https://gr.maharashtra.gov.in/1145/Government-Resolutions website. The GRs related to the electricity supply are listed under the 'Energy, Industry and Labour' sector.

1.2 Problems with electricity supply

Even though the government places importance on energy for irrigation it is commonly known that the quality of supply to agriculture is very poor. Distribution Transformer failure is a major problem, especially in the rabi season when maximum energy drawl takes place. Frequent tripping of pumps and DT, failure of pumps, and low flow rates are some problems farmers need to deal with. Another major issue faced by farmers is the night-time supply of electricity for at least half the day. Night-time irrigation is problematic since farmers need to be in the field to manage the irrigation. Working in the dark is difficult due to poor visibility, and also unsafe.

Many of these issues may be reduced through technical and operational solutions. In this course, we touch upon some solutions.

1.3 Summary

This chapter provided an overview of the irrigation status and systems in Maharashtra. Some data was provided. References and sources to look up data, and documents in the sector were also given.

References

1. Jadhav et al, 2020; Jadhav, Priya & Sawant, Namita & Panicker, Athira. (2020). Technical paradigms in electricity supply for irrigation pumps: Case of Maharashtra, India. Energy for Sustainable Development. 58. 50-62. 10.1016/j.esd.2020.07.005.
2. MOSPI, 2019; Energy Statistics, Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India. 2019.https://www.mospi.gov.in/sites/default/files/publication_reports/Energy%20Statistics%202019-finall.pdf
3. CEA, 2019; Annual Pumpset Energisation Report 2018. New Delhi, India: Central Electricity Authority, Government of India; 2019.

Figure 1. An area of Walwa taluka in Sangli district. The red circles indicate the habitation clusters with larger area surrounded by agricultural field

2.2 Schematics of 11 kV network (or High Tension) of Ag feeder

A schematic of an Ag feeder (Agricultural feeder) is shown below figure 2. The starting point for an agricultural feeder is the distribution substation. The main function of a distribution substation is to house a step-down transformer. An incoming line from a transmission substation carries power to a distribution substation.

A power transformer in the substation steps down the voltage from the incomer feeder of 33 kV to one or more outgoing Ag feeders of 11 kV. These Ag feeders cover one to six villages extending over 10 to 40 km. The feeder has a number of Distribution Transformers connected to it, in the various villages. There may be 20 to 50 Distribution Transformers (DT).

Figure 2 illustrates the network diagram of a sample Ag feeder. We see this incomer carrying power at a voltage of 33 kV into the substation - marked as '33 kV incomer'. There are usually more than one feeder outgoing from the substation. In this figure only one Ag feeder has been illustrated as an example. It is marked in the figure as '11 kV outgoing feeder'. The substation has a step down transformer which steps down the voltage from 33 kV to 11 kV.

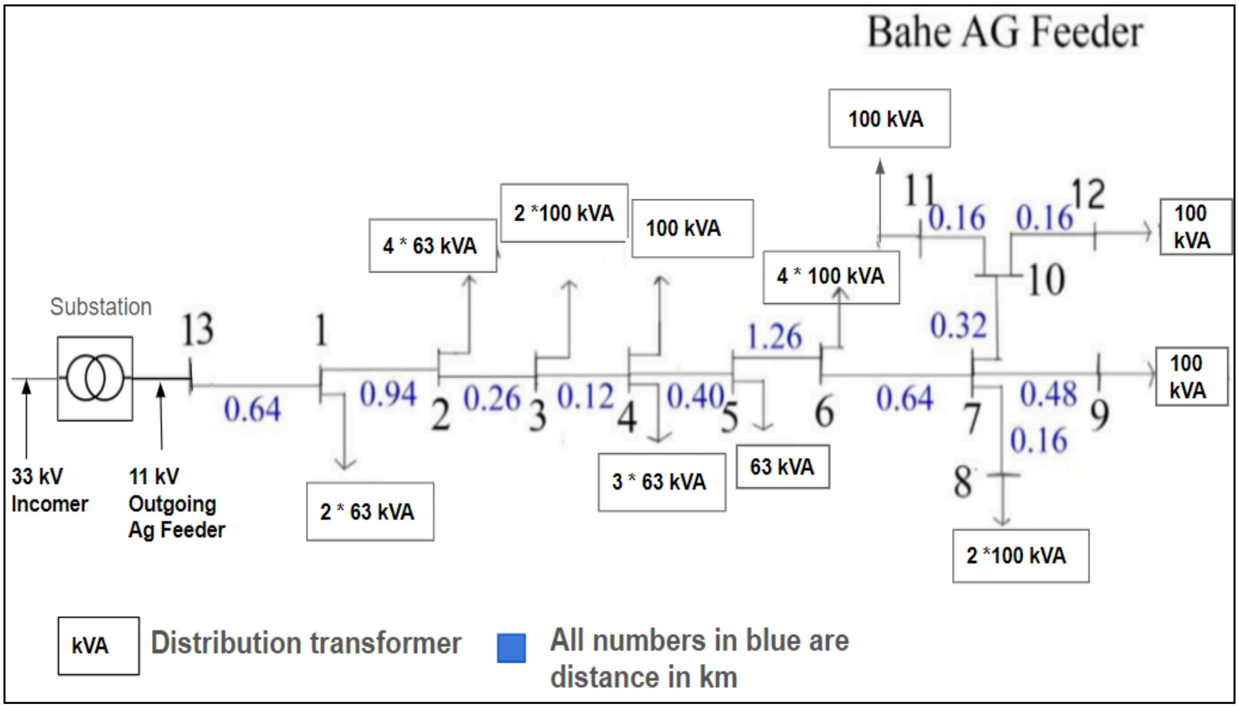

Figure 2: Network diagram of Bahe Agricultural feeder from Walwa taluka, Sangli district (Raghavan, 2015)

The length of the 11 kV outgoing Ag feeder is shown in the schematic. There are a number of DTs connected to it. The numbers in blue show the length of the Ag feeder in km. There are some numbers from 1 to 13, these are buses. A bus is a node which is defined at a DT, a load (in this case a pump), or at a branching of conductors.

The start of the feeder at the substation has been numbered as bus no.13. At a distance of 0.64 km from bus no. 13, there are two DTs of 63 kVA connected to the feeder. This is indicated by a box with the notation '2 * 63 kVA'. This bus is numbered 1. This diagram is at a high level, hence the more detailed 11 kV lines for each transformer are not indicated here, but instead both DTs are shown at bus no. 1.

We see that there are a number of 63 kVA and 100 kVA DTs connected along the feeder. The 11 kV voltage from the Ag feeder is supplied to the Distribution Transformers which steps down the

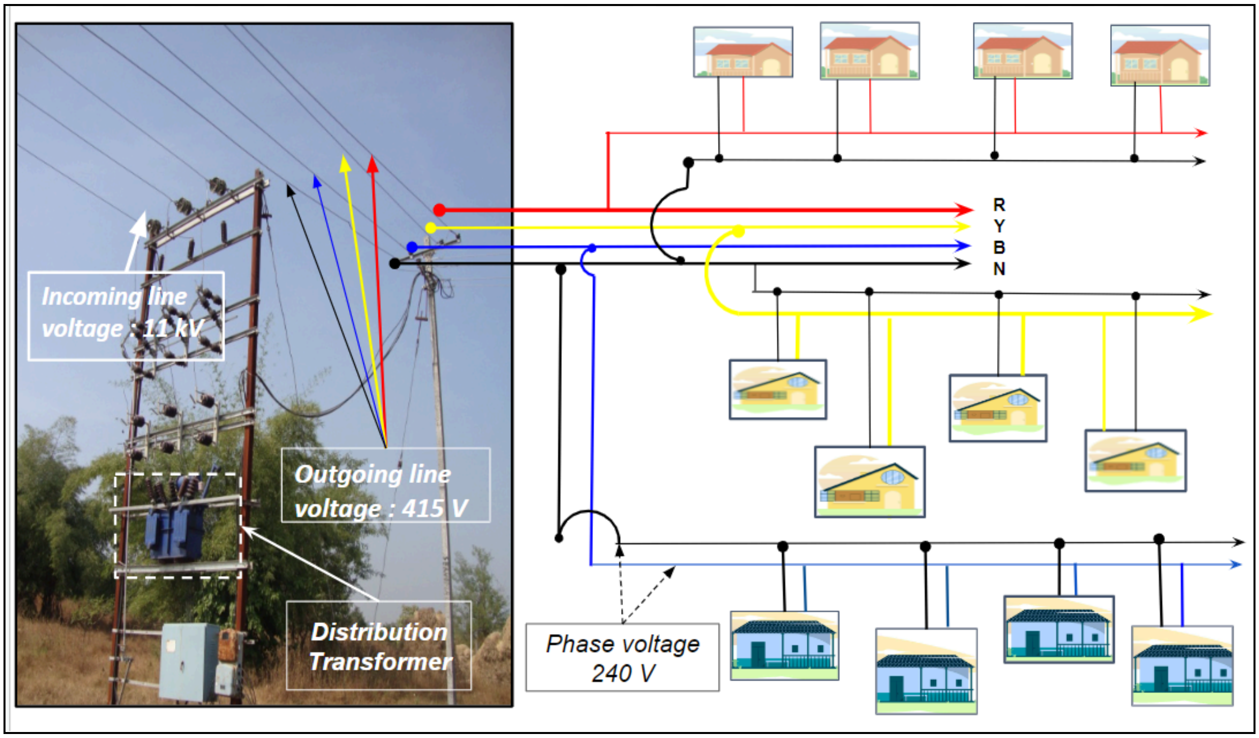

Figure 11. Residential homes receiving single phase voltage supply from the Distribution Transformer

Generally in power systems, there is no neutral wire at higher voltages,however homes need a neutral. So a neutral is created for the Low Tension side of the Distribution Transformer. In figure 11, you can see there are only three wires on the High Tension side, the 11 kV incomer side, of the DT, but 4 wires on the outgoing LT side.

In the case of a three phase agricultural distribution system, there may not be a neutral in the Low tension network, because the loads - agricultural pumps are usually delta connected and do not require a neutral. Also, they are expected to be balanced three-phase loads with zero neutral current.

3.11 Summary

This chapter gave an overview of three-phase systems. It explained basic concepts of both single-phase and three-phase electricity, using examples to build up from Kirchoff's law to single line diagram in a three-phase system. In the next chapter, we will learn how three-phase electricity is distributed to agricultural fields, specifically to pumps.

While others are more complex, needing a greater number of input parameters but also providing a more accurate estimate. Which model we select depends on how accurate we want the output.

We will learn the following models for LT network analysis:

I. Resistance-only model of conductors
II. R/X model of conductors for lagging load
III. Power flow modeling

The third model power flow modeling will be dealt with in a later chapter

4.3 Resistance only model of conductors

We analyze a low tension network connected to one Distribution Transformer (DT) starting with the ‘Resistance only model of conductors‘, which is a very simple and approximate model. This is a good starting point. The complexity builds up slowly in each subsequent model. We learn how to do this, by using an example.

Figure 1 shows the single-line diagram of a low-tension network of one DT. First, we want to find the voltages at the pumps. The consumer should get appropriate voltage within a certain limit as specified by the standard. We want to know what service the consumer will get in this network structure. Secondly, we want to find the loss in the conductors, which is a loss to the distribution company and which should be minimized.

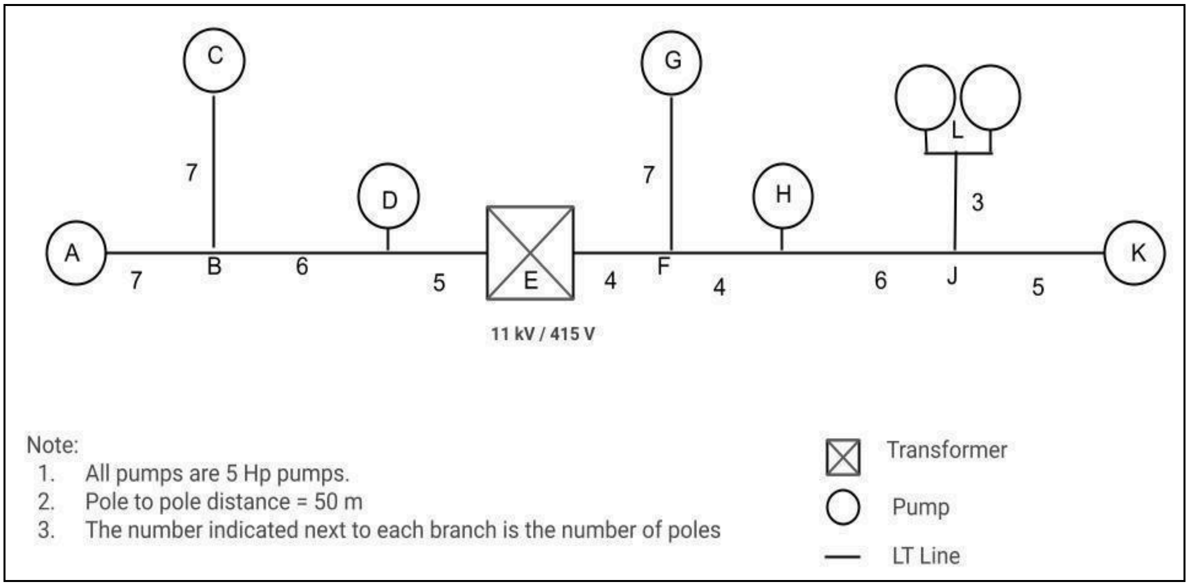

Figure 1. Single line diagram of the Low Tension network of one Distribution Transformer. The buses are designated by the letters of the alphabet. The Distribution Transformer is at bus E. All the pumps have a rating of 5 HP.

We see the Distribution Transformer(DT) at bus E. This is the power source in the network. Current flows from E to the pumps. The resistance in the Low-tension conductors results in a voltage drop. Hence to find the voltage at the pumps we need to know: (i) the voltage at the DT (at E) (ii) the current drawn by the pumps, and (iii) The resistances of the LT conductors.

(i) Voltage at the DT:

Assume that the line voltage at the transformer is 415V, since that is the standard voltage on the LT side of the DT. And in a well-designed system, the voltage should be very close to the standard.

(ii) The current drawn by the pumps, I :

We can find some sample values of I from field measurements. We can also look up some vendor data to find the current drawn by 5 HP pumps. For now assume that the current drawn is approximately 10 A. This is typical of field conditions.

(iii) The resistance of the conductors, *R:*

$$V_{EC} = V_{ME} + V_{BM} + V_{CB}$$

$$= 3.75 + 3.0 + 1.75$$

$$\boldsymbol{V_C} = V_E - V_{EC} = 240 - (3.75 + 3.0 + 1.75) = 231.5$$

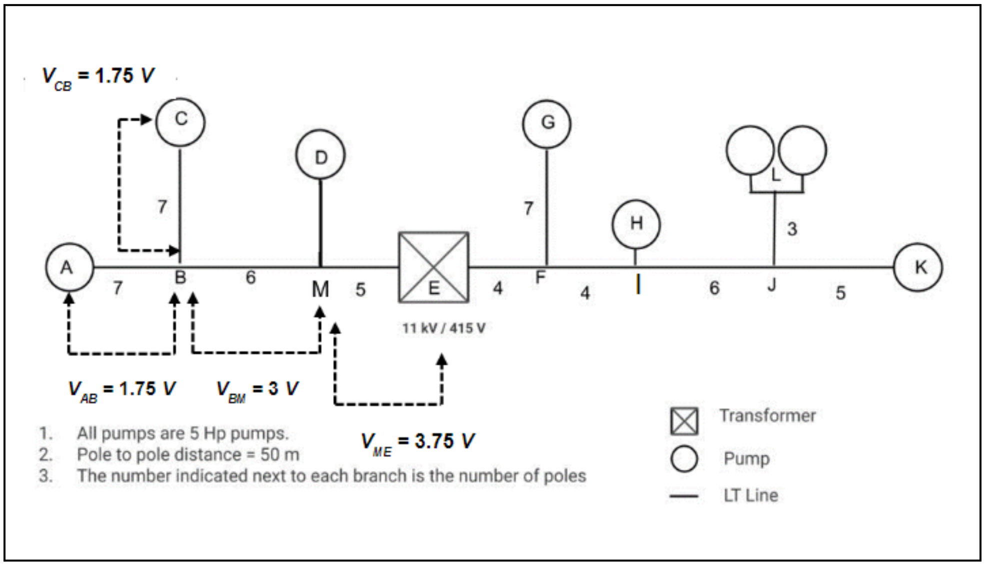

Figure 2. Voltage drop along each branch is calculated using the current flowing through the branch and the resistance of the branch. Then the voltage drops along a path are added up to find the total voltage drop. For example $V_{EC} = V_{ME} + V_{BM} + V_{CB}$. The voltages used in a single line diagram are phase voltages.

Follow steps a to d for all branches and buses, and find the voltages at all buses. Solutions have been provided in a separate document for this level of approximation.

<u>Finding losses in the conductors</u>

The second part of the analysis was to find the copper loss in the conductors or the distribution system.

$$\text{Copper loss} = I^2R \text{ (in W)}$$

$$\textit{Loss in branch AB} = I_{AB}^2R_{AB} = 10^2 * 0.175 = 17.5 \text{ W}$$

Find the loss in all branches and add up to find the total loss in the LT distribution network (except the DT). While it is important to find the loss in W, it is sometimes more instructive to calculate the loss as a % of the total power supplied.

$$\text{Loss (\%)} = \frac{Total\ Loss\ in\ the\ network\ (W)}{Power\ drawn\ by\ all\ pumps\ (W)} \times 100$$

4.7 Summary

This chapter covered an analysis of the Low Tension Network using simple models. Transmission line concepts such as simplified pi models were introduced. The approximate analysis for lagging loads was done. The data used is typical of field conditions, and you are now ready to conduct some basic analysis of the Low Tension Ag network.

Exercises

1. Complete the network analysis from section 3 using the resistance-only approximation as follows:
   a. Find the voltages at all buses.
   b. Find the copper loss of the I^2R loss in all branches.
   c. Find the loss as a % of the power drawn by the pumps. [Assume that the power drawn by a 5 HP pump = 5 kW. The reason for this assumption will be explained in the pumps chapter.]
2. Complete the network analysis from section 3 using the R, X approximation for lagging loads as follows:
   a. Find the voltages at all buses.
   b. Find the copper loss of the I^2R loss in all branches.
   c. Find the loss as a % of power drawn by the pumps. [Assume that the power drawn by a 5 HP pump = 5 kW. The reason for this assumption will be explained in the pumps chapter.]
   d. How different are the results between problem (1) and (2)?
3. What was the lowest voltage found in (2)? Find out how many additional 5 HP pumps can be connected (i) at bus F, and, (ii) at bus K so that the voltage does not drop below 204 V.
4. What is the voltage standard for Low Tension networks? Or in other words, what is the lower limit and upper limit of the voltage permitted (in V)? Where can this be found?

   MSEDCL standards document - can be found online. Go to <u>www.mahadiscom.com</u> *and find the standards document. Open it and check what the low tensions*

5. Why do we need to have a standard for the voltage level? What is a standard and why is it necessary?
6. As per pump standards, up to what voltage must they operate? What are the agricultural pump standards? Which body makes these standards?

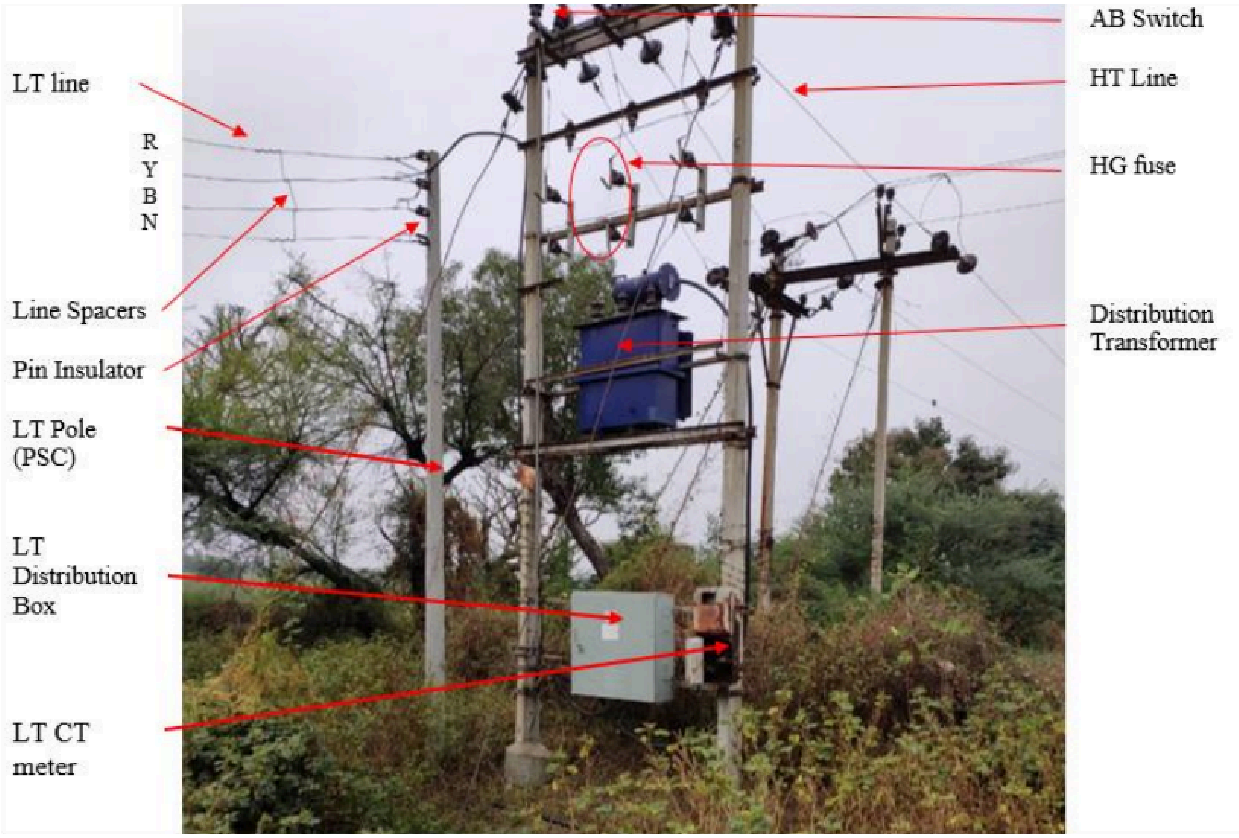

Figure 2. Schematic of a distribution transformer

b. Find the rated current on the primary and on the secondary side.

Since the system is three phase supply:

Power rating per phase, $P_{1\phi} = \frac{P_{3\phi}}{3} = \frac{5}{3}$ MVA $= \frac{5 \times 1000}{3}$ kVA = 1667 kVA = 16,67,000 VA

{ 1 MVA (Mega Volt Ampere = 1000 kVA (kilo Volt Ampere) }

In chapter 4 we saw that: $P_{1\phi} = V_P \times I_L = \frac{V_{LL}}{\sqrt{3}} \times I_L$ $\quad (\because V_P = \frac{V_{LL}}{\sqrt{3}})$

On the primary side: V_{LL} = 66 kV = 66000 V

Applying the formula for $P_{1\phi}$: 16,67,000 VA $= \frac{V_{LL}}{\sqrt{3}} \times I_{L,\,primary}$

=> $I_{L,\,primary}$ (A) $= \frac{16{,}67{,}000\ VA \times \sqrt{3}}{66000\ V}$ = 43.7 A

Exercises

1. The following table shows a list of farmers connected on a 25 kVA DT. The table shows the irrigation requirement for 6 Farmers for 10 days.
   a. What will be loading pattern if all farmers want to irrigate from day one
   b. If there will be uniform loading DT.

Farmer	Pump rating (HP)	Number of Irrigation days
Farmer 1	5 HP	3 Days
Farmer 2	5 HP	2 Days
Farmer 3	5 HP	4 Days
Farmer 4	5 HP	5 Days
Farmer 5	5 HP	4 Days
Farmer 6	5 HP	3 Days

References:

1. Electrical Distribution System Components, Ratings and on-field scenario- Prof. Priya Jadhav, Athira Panicker

7.3.4 Operational head (Static and frictional heads)

In our work, we need to consider three types of heads - ***static head***, ***frictional head***, and ***pressure head***. The head we considered above, the vertical height to which the water is being pumped, is called the ***static head***, which we refer to by h_s. Another type is the ***frictional head***. *The frictional head* is the resistance created by the walls of the pipe to the flow of the water which we refer to by h_f. The ***pressure head*** is relevant in drip and sprinkler systems. We understand the frictional head here in this chapter. The pressure head will be dealt with in subsequent chapters.

The frictional head is important when water is being transported over long distances. Farmers pump water from community sources such as rivers and dams which may be up to even 3 to 5 km away. Figure 6 has some images of water being pumped from Umbarda dam in Umbarda Bazar (village), Karanja Lad (taluka), Washim (district). The pumps are submersible pumps, and the pipes come out of dam water, and then are buried in the ground and carry water below the ground over a distance of up to 1 km to the fields.

Figure 6. Field images of water distribution from dam to fields[4]

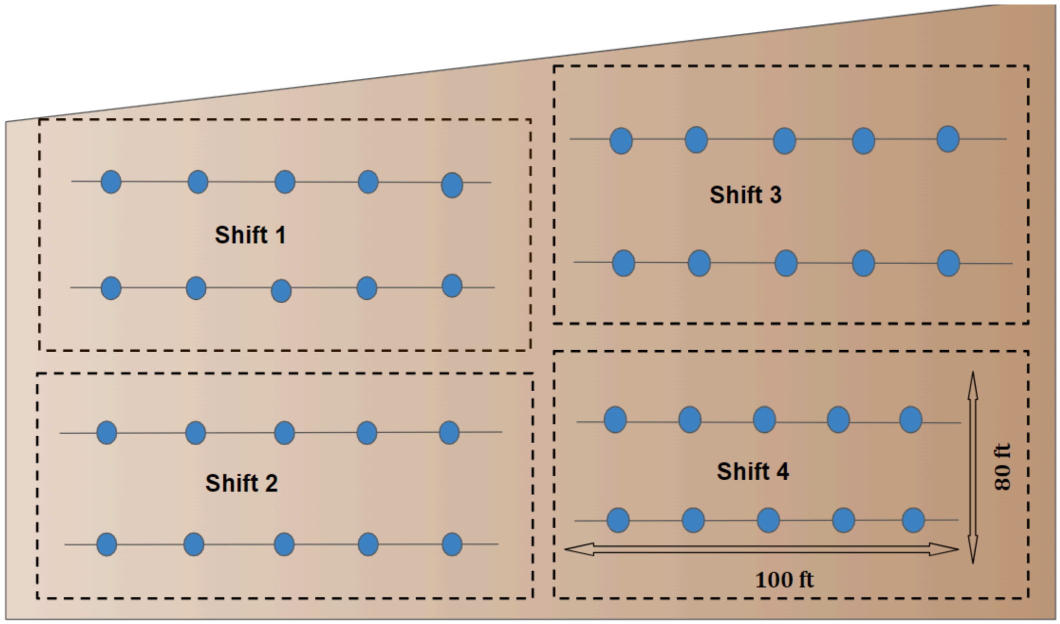

Figure 5. Schematic of the pattern of sprinkler irrigation on a field by a farmer in multiple shifts. Shift 1,2,3,4 represents the manner in which the farmer irrigates his field by moving the entire sprinkler system.

a. Find the area covered in each shift in m^2. (One shift is the period for which he leaves the sprinklers at one location to irrigate a patch of land)

Area of field cover by single nozzle = 12.2 x 6.1 = 74.4 m^2

Area of field cover by 12 nozzles =12 x 74.4 = 892 m^2

Area of the field = 0.25 ha = 0.25 * 10000 = 2500 m^2

b. Find how much time it takes to irrigate the 0.25 ha

$$Time\ required\ for\ overall\ irrigation\ = \frac{Area\ of\ Field \times Time\ required\ per\ shift}{Area\ of\ field\ per\ shift}$$

$$= \frac{2500\ \times 4}{892} = 11.2 =\sim 11\ \text{hours}$$

c. Find the average volume of water applied per unit area of land, in m^3/m^2 (or m).

The flow rate from each nozzle is 1 m^3/h

$$Volume\ of\ water\ applied\ per\ unit\ area\ of\ land$$

$$= \frac{Number\ of\ nozzles \times Time\ required\ for\ overall\ irrigation \times Flow\ rate\ of\ each\ nozzle}{Area\ of\ field}$$

2) Understanding the Generated Output File

After simulating the designed LT Network, the output file, shown in Figure 7, is generated. This section will explain how to read the simulation output. By understanding the key parameters, we can accurately analyze the results and ensure the simulation's reliability.

```
>> runpf('Niphad_LT_short1')

MATPOWER Version 7.1, 08-Oct-2020 -- AC Power Flow (Newton)

Newton's method power flow (power balance, polar) converged in 5 iterations.

Converged in 0.04 seconds
================================================================================
|     System Summary                                                           |
================================================================================

How many?                How much?              P (MW)            Q (MVAr)
---------------------    -------------------  -------------  -----------------
Buses              3     Total Gen Capacity   0.00024        0.04800 to 0.13500
Generators         1     On-line Capacity     0.00024            0.0 to 0.1
Committed Gens     1     Generation (actual)  0.35877           -1.04749
Loads              2     Load                 0.00333            0.00250
  Fixed            2       Fixed              0.00333            0.00250
  Dispatchable     0       Dispatchable      -0.00000 of -0.0   -0.00000
Shunts             1     Shunt (inj)         -0.00000            1.22989
Branches           2     Losses (I^2 * Z)     0.35544            0.17989
Transformers       0     Branch Charging (inj)     -             0.00000
Inter-ties         0     Total Inter-tie Flow 0.00000            0.00000
Areas              1

                          Minimum                      Maximum
                 -------------------------  --------------------------------
Voltage Magnitude   0.997 p.u. @ bus 2          1.109 p.u. @ bus 3
Voltage Angle     -18.73 deg   @ bus 3          0.03 deg   @ bus 2
P Losses (I^2*R)             -                 0.35543 MW    @ line 1-3
Q Losses (I^2*X)             -                 0.17989 MVAr  @ line 1-3

================================================================================
|     Bus Data                                                                 |
================================================================================
 Bus      Voltage          Generation             Load
  #   Mag(pu) Ang(deg)   P (MW)   Q (MVAr)   P (MW)   Q (MVAr)
----- ------- --------  --------  --------  --------  --------
    1  1.000    0.000*  0.35877  -1.04749       -         -
    2  0.997    0.027       -         -      0.00167   0.00125
    3  1.109  -18.726       -         -      0.00167   0.00125
                        --------  --------  --------  --------
               Total:   0.35877  -1.04749   0.00333   0.00250

================================================================================
|     Branch Data                                                              |
================================================================================
Brnch   From   To    From Bus Injection   To Bus Injection     Loss (I^2 * Z)
  #     Bus    Bus    P (MW)   Q (MVAr)   P (MW)   Q (MVAr)   P (MW)   Q (MVAr)
-----  -----  -----  --------  --------  --------  --------  --------  --------
   1      1      2   0.00167   0.00125  -0.00167  -0.00125   0.00001   0.00000
   2      1      3   0.35710  -1.04875  -0.00167   1.22864   0.35543   0.17989
                                                             --------  --------
                                                    Total:   0.35544   0.17989
```

Figure 7: Generated Output File

11.2 Preparation before Fieldwork

Before going to the field, students need to do preparatory work, which will help them to conduct fieldwork. It includes background research of the topic of study, understanding of local context, collection of secondary data and managing logistics & permissions. The following section explains it in detail.

11.2.1 Background Research

Gathering background information related to the study topic is essential before heading to the field. This creates a necessary foundation for students to reflect on and analyse the field-level reality. For example: If a student needs to do field work to study capacitors, then the student should have theoretical knowledge about the role of capacitors in the distribution network, its working mechanism & its usage. Students should also study the national and state policy-related aspects of the purpose of the study—for example, the MERC capacitor rule. So students should do a literature study related to the topic.

11.2.2 Understanding Local Context

Students should have an idea of the basic demographic profile of the field area. Example: Type of society - Rural/Periurban/Tribal hamlet, Type of occupation - Farming/Dairy/farm labours etc. Also, students should know what time is suitable to conduct fieldwork so that people will be available and ready to cooperate. For example - If fieldwork is planned on festival day, people might be busy and unavailable for interaction.

11.2.3 Collection of secondary data

Before going to the field, students should collect the following secondary-level data.

- Geographical Information: Collect maps and geographical data of the area (Rainfall, water sources etc)
- Existing Infrastructure: Review existing power infrastructure, including the location of substations, transformers, and distribution lines.
- Demographic data: Population, Number of farmers, literacy rate etc.

Annexure 1 gives a detailed list of sources of secondary data useful for fieldwork.

1. Analysis of the network of Distribution Transformer

The Distribution Transformer (DT), a critical component of the rural electrification infrastructure, is pivotal in delivering reliable electricity to agricultural feeders. A low tension (LT) network analysis of these distribution transformers is essential to ensure efficient and uninterrupted power supply to farmers. The LT network analysis evaluates load distribution, and energy losses within the LT network. By assessing parameters like voltage drop, and losses of LT network, one can identify inefficiencies and potential areas for improvement, thereby enhancing the overall reliability of electricity supply to farmers. The present case study aims to provide practical experience to students to estimate voltage drops and losses of the LT network associated with distribution transformers in agricultural feeders. The brief of this case study is as follows:

Purpose	To conduct an electrical analysis of a low-tension network
Chapters associated with this Case study	● *Electrical Analysis of Low-Tension Networks* ● *How to conduct fieldwork*
Number of Field Visits	Two 1. MSEDCL office 2. DT level
Time need to spend on a field visit	Two days
Nature of work during a field visit	● Interaction MSEDCL official ● Walk along the LT network of One DP ● Interaction with farmers on LT lines
Expected output	Case study report

1. Objectives of the Case Study

The purpose of this case study is to conduct a low-tension (LT) network analysis of one distribution Transformer. It has the following objectives :

A. To develop an understanding of the field-level situation of the LT network.
B. To understand the problems faced by farmers related to electricity.
C. To conduct LT network analysis for one Distribution Transformer (DT).