A New Heuristic Approach for Assessing Losses in Power Distribution System

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This Thesis is submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirement for the Degree of Master of Science in Electrical and Electronic Engineering, BRAC University, Dhaka

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Declaration

It is hereby declared that this thesis or any part of it has never been submitted to any place for obtaining any degree, diploma or any award.

Signature of the Candidate

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Approval

The thesis entitled “A new heuristic approach for Assessing Losses in Power Distribution System” submitted by B.D. Rahmatullah, ID: 11161002 of Academic Session 2011 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Science in Electrical and Electronic Engineering on March 6, 2018.

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Dedication

To my parents and faculties ………….

ABSTRACT

Among the three main components of the power system: generation, transmission and distribution, most pressing problem in the power sector has been with the distribution system. It is well conceived that almost all the revenue stream comes from distribution system. If this section is characterized with high system loss resulting poor revenue collection, then the toal power system tends to collapse. So, for financial viability of the sector, it is vital that the distribution sector should be taken care of. So, it is vital that serious efforts should be taken to bring the system loss to a standard level. It is acknowledged that in quantifying the standard loss of distribution system is not as easy as it has many complex calculations due to wide range of system variables.

Considering the urgency to find the loss quantity against the various contrast, a model tool has been devised following heuristic process in this thesis. It is anticipated that in finding distribution loss an expensive software with expertise are required. The software needs huge system data for identification and quantification of losses. This is also time consuming.

To get the required job done, a device is required to monitor the system in finding out the accurate quantity of loss. The thesis is aimed to develop how to find losses of both feeder and transformer by one item only that is current of low voltage side of the transformer. The fundamental concept which is considered is that maximum system load flow is 1/3 of the feeder length. Such consideration of load flow might deviate the actual expected result. This deviation needs a tool to be used to rationalize the calculated result. The tool which has been devised in this thesis is termed as “K” factor. “K” factor is the main part of this thesis.

The value of “K” depends on load ratio of feeder when each feeder is divided in two halves. It is known that loss varies in the feeder with same value of load if the load ratio varies between 1st half and 2nd half. As per load ratio, “K” is higher, if load in 2nd half is greater than load in 1st half. It is equal, if load in 2nd half is equal to load in 1st half and lower, if load in 2nd half is less than load in 1st half.

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Acronyms and Abbreviations

ADB	Asian Development Bank
ADP	Annual Development Program
APSCL	Ashugonj Power Station Company Limited
BAEC	Bangladesh Atomic Energy Commission
BAPEX	Bangladesh Petroleum Exploration & Production Company Ltd.
BCF	Billion Cubic Feet
BCSIR	Bangladesh Council of Scientific & Industrial Research
BERC	Bangladesh Energy Regulatory Commission
BGFCL	Bangladesh Gas Fields Company Limited
BGSL	Bakhrabad Gas Systems Limited
BOI	Board of Investment
BP	British Petroleum
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
BOGOMC	Bangladesh Oil, Gas & Mineral Corporation
CFT	Cubic Feet
CBO	Community Based Organization
CM	Cubic Meter
CNG	Compressed Natural Gas
CSO	Civil Society Organization
DESA	Dhaka Electric Supply Authority
DESCO	Dhaka Electric Supply Company Ltd.
E & P	Exploration and Production
EGCBL	Electricity Generation Company of Bangladesh Ltd.
EMRD	Energy and Mineral Resources Division
EQS	Equivalent Quality Standard
FOB	Freight on Board
GDP	Gross Domestic Product
GIIP	Gas Initially In Place
Gob	Government of People's Republic of Bangladesh
GS	Grameen Shakti
GSMP	Gas Sector Master Plan
GTCL	Gas Transmission Company Limited
GWh	Giga Watt Hour
HCU	Hydrocarbon Unit
HDI	Human Development Index
HSFO	High Sulphur Furnace Oil
HV	High Voltage
IDCOL	Infrastructure Development Company Ltd.
IOC	International Oil Company
IEA	International Energy Association
IPP	Independent Power Producer
JGTDSL	Jalalabad Gas Transmission and Distribution System Ltd
kV	kilo Volt
KGOE	Kilogram of Oil Equivalent
kWh	kilowatt-hour
LGED	Local Government Engineering Department

LIBOR	London Interbank Offered Rate
LCP	Least Cost Planning
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
TCF	Thousand Cubic Feet
MDG	Millennium Development Goal
MIC	Middle Income Country
MJ	Mega Joule
MMBBL	Million Barrel
MMBTU	Million British Thermal Unit
MMCFD	Million Cubic Feet Per Day
MOPEMR	Ministry of Power, Energy and Mineral Resources
MT	Million Tone
MTOE	Million Tons of Oil Equivalent
MW	Mega Watt
NEP	National Energy Policy
NGV	Natural Gas Vehicles
NGO	Non-Government Organization
NSAPA	National Strategy for Accelerated Poverty Alleviation of 2005
NPD	Norwegian Petroleum Directorate
OIIP	Oil Initially In Place
PBS	Palli Biddyut Samity
PDF	Price Deficit Fund
PGCB	Power Grid Company of Bangladesh
PGCL	Paschimanchal Gas Company Ltd.
PO	Partner Organizations
PREGA	Promotion of Renewable Energy, Energy Efficiency and Green House Gas Abatement
PRS	Poverty Reduction Strategy
PSC	Production Sharing Contract
PSMP	Power System Master Plan
PV	Photo Voltaic
R/P	Reserve-Production Ratio
RE	Renewable Energy
REB	Rural Electrification Board
R&D	Research & Development
REDA	Renewable Energy Development Agency
ROR	Rate of Return
RPGCL	Rupantarita Prakritik Gas Company Limited
SBCL	Shadaran Bima Company Ltd.
SAARC	South Asian Association for Regional Cooperation
SAPP	South African Power Pool
SARI/E	South Asia Regional Initiative in Energy
SD	Supplementary Duty
SGC	State gas companies
SGFL	Sylhet Gas Fields Limited
SHS	Solar Home System
SPE	Society of Petroleum Engineers
SPP	Small Power Plant
SPR	Strategic Petroleum Reserve

SRE	Sustainable Rural Energy
SZPDC	South Zone Power Distribution Company Ltd.
T & D	Transmission and Distribution
TCF	Trillion Cubic Feet
TFC	Total Fuel Consumption
TGTDCL	Titas Gas Transmission and Distribution Limited
Tk.	Taka, the Bangladesh Currency
USGS	United States Geological Survey
UNDP	United Nations Development Program
VAT	Value Added Tax
WAPP	West African Power Pool
WZPDC	West Zone Power Distribution Company Ltd.
WEO	World Energy Outlook
WM	Wood Mackenzie
WRI	World Resources Institute
WZPDC	West Zone Power Distribution Company
YTF	Yet-to-Find

CHAPTER-1

Introduction

1.1 Introduction

In Bangladesh it is unimaginably lagging in terms of energy development if compared with other SAARC, ASEAN, European and developed countries. There are many reasons, impediments and barriers behind these. This study of identification in determining the impediments in implementing loss reduction or efficient energy projects in Bangladesh may help to recognize the critical barriers and then to go ahead with proper recommendation to accelerating to implement the efficient energy projects.

Through this study, it is anticipated that if it is placed in proper level, then Bangladesh will be immensely benefited by removing the barriers in accelerating the loss reduction activities in developing the most desired and required targets.

Bangladesh lies in South Asia. It is bounded by India on West, North, and North-East, Myanmar on the South-East and Bay of Bengal on the south. The area of the country is 148, 39 sq.km. A network of rivers and their tributaries numbering about 230 with a total length of about 24,140 km covering the country flows down to the Bay of Bengal. There are a number of islands, offshore including the deep-sea areas. The total forest area covers about 14% of the land area.
Bangladesh enjoys generally a subtropical monsoon climate. While there are six seasons in a year, three namely, winter (Nov-Feb), summer (March-June) and Monsoon (July-October). The temperature varies from minimum of 04°C in winter to a maximum 42°C in summer.

Bangladesh has a population of some 160 million with an average density of around 1000 people per sq. km. a figure amongst the highest in the world. 75% of the population lives in-rural areas and agriculture, forestry and fishery account for 65% of the total employment.

The GDP (2017) is US $ 246.00 Billion at the per capita income is US$ 1602. The export and import of Bangladesh is US$ 12 billion and US$ 4415 million respectively [1]. The first discovery of gas in the country was in 1955 at Haripur, Sylhet Gas field and it came into commercial production in 1961 where the names of gas fields with estimated recoverable reserves are also given [2].

Bangladesh discovered the country's first oil-field at Haripur in Sylhet district in 1986. The oil was found at a depth of 2020 m with an expected reserve capacity of about 40 million barrels. But it has not yet gone into commercial exploitation. At present Bangladesh has to spend the major portion of its export earnings in importing about 3.43 million tons of oil with a value of US$ 3219 million [3].

However, the rural and remote sector of the Bangladesh economy, where about 75% of the population lives, is characterized by an abundance of open and disguised unemployment, poor man-land ratio and alarmingly large numbers of landless farmers, extremely inadequate economic and social facilities, low standard of living and a general environment of poverty and deprivation.

Larger energy supplies with greater efficiency of energy use, especially reduction of system loss is thus necessary to meet the basic needs of a growing population. It will, therefore, be necessary to tap all sources of energy and to distribute these efficiently in either natural or converted form to the people for their benefit.

Along with the soaring price hike of fossil fuel first in 1973, later on in 1990 and very recently in 2015 and the environmental degradation and pollution due to enormous use of fossil fuel-based power, which causes poor crop yielding globally is concurrently hampering the economic growth of Bangladesh. So, this study is aimed at fostering the sustainable development through integration of energy giving emphasis on efficient energy supply system aiming to economic development.

It has been stated in this section at the beginning that Bangladesh is facing serious crisis in the power and energy sector. The author believes that one of the vital reasons of these crises is being faced due to high system loss including both, technical and non-technical. As per Management Information System (MIS) the total transmission and distribution loss in Bangladesh was more than 18% in the year 2008 as per statistic (4) (5) whereas as per standard considering the Bangladesh circuit configuration the system loss should not be more than 6% [See Table 1.2]. It is also revealed through a joint study under a World Bank project comprising engineers from REB, PDB, DESA, Nepal Electric Supply Authority, Kenyan Power and Lighting Company and World Bank the loss should not be above 8 to 9% in the distribution system from 11KV and downwards [See Table:1.1.1]. The author was the Team Leader of that study group. As per present sold quantity per year of 28,000 MKWh in 2006, 1% of system loss stands around 280 MKWh per year. So, for 1% of system loss reduction we could save an amount of 1540 MTk per year. Now the sold amount of MKWh is almost doubled and tariff has been tripled. So, the cost of lost power of 1% would be around 6 times more than that amount which was incurred in 2006.

The accepted result including the Asian Pacific regional average system loss of power system including the result recommended through a study is attached below:

Table 1.1: Recommended Loss of the Utilities of Bangladesh [4(b)]

Organization	Technical Losses		
	Transmission (%)	Distribution (%)	Total (%)
DPDC System	2.00	7.50	9.50
DESCO System	2.00	7.50	9.50
REB/PBS System	0.50	8.50	9.00
PDB System	3.00ount	7.00	10.00

1.2 Problem Solution Statement

This paper proposes a methodology to derive a simplified model for distribution system loss analysis. According to the typical daily load patterns and the energy consumption of customers, the loading of distribution lines, equipment and transformers for specific period can be solved. A three-phase or single-phase load flow analysis can be done to calculate the feeder power and energy loss so that the hourly, daily or monthly feeder loading will be same as that obtained by the field test. The primary conductor loss, secondary conductor loss, transformer copper loss and core loss for a definite time period are then solved according to the analog mathematical calculation of system components. The accurate analysis of system loss with respect to the feeder loading, power factor, feeder length, transformer capacity is then performed to derive the simplified loss model of distribution feeders. A distribution feeder of ETAP system, a modelling software is then selected for computer simulation to demonstrate the effectiveness of the proposed method. By applying the simplified loss model derived, the loss pattern of distribution feeders is solved according to the actual feeder loading. It is concluded that the proposed simple and inexpensive methodology provides a useful tool for distribution engineers and personnel to estimate the operation efficiency of distribution systems in a very effective manner.

Although numerous methods of distribution system loss reduction are available, system reconfiguration for loss reduction is one of the more promising alternatives. The size and complexity of the distribution system make real-time reconfiguration an unrealistic objective if exhaustive search techniques are to be used. This paper proposes the basis for a new method of distribution system reconfiguration for loss reduction that has the potential to be suitable for real-time implementation. The method proposed by this paper is based upon a series of heuristic rules determined specifically for the purpose of loss reduction. Whereas in the past, heuristics rules have been used in the reconfiguration problem, the method introduced by this paper quantifies the status of the distribution system with a set of numerical indices. These indices are used to rapidly order the possible combinations, with respect to the potential loss reduction associated with them. The proposed method is suitable for use at the sub transmission and primary distribution levels where the network is radial in topology. The presence of transformers, capacitors, voltage regulators, and other distribution system line equipment can easily be accounted for in the proposed system.
Loss reduction show the advantages of the system of using power by the consumers otherwise those appliances connected to the national grid face a barrage of related problems such as due to high system loss**:**

1. Voltage fluctuation that damage household and industrial equipment;
2. Frequent interruptions ("load shedding"); Load shedding occurring frequently increases the production cost of any industrial output;
3. After load shedding potentially, destructive power surges when the current is restored;
4. For high system loss undesired cost of power of tariff will be increased;
5. A lack of reliable power severely impedes economic development of the country. Seventy-eight percent of Bangladeshi firms cite electricity service as a "major" or "severe" obstacle to expansion [7]. And many foreign investors shy away from Bangladesh because electricity quality is so poor [8].

Loss quantity in different locations of the system has been identified after thorough investigation, survey and interaction with relevant persons of different Pacific and Asian countries. This is summarized in Power System in Asia & Pacific with emphasis on Rural Electrification (206) published by United Nations given below.

Table 1.2: Standard Loss Quantity of Asia & Pacific Region [8(b)]

Loss Sources		**Type of power System**		
Equipment Rating	Location	(%) Strong	(%)Medium	(%)Weak
Step Up 11/132KV Transformer	At Power Station	0.25	0.375	0.50
Primary 230KV Line	Transmission Line	0.50	0.750	1.00
Primary 230/132KV Line	Gris Sub-Station	0.25	0.375	0.50
Secondary 132KV Line	Transmission Line	1.00	1.500	2.00
Secondary 132/33KV Line	Gris Sub-Station	0.25	0.375	0.50
Sub-Total (Transmission Loss)		**2.25**	**3.375**	**4.50**
Secondary 11/0.4KV Sub-Station	Distribution Sub-Station	0.25	0.375	0.50
Sub-Total (Distribution Loss)		**2.50**	**3.75**	**5.0**

1.3 Thesis Objective

This study has got 2(two) distinct objectives. First one, the study has given an effort to developing an equipment or tool to quickly identify the loss including loss areas of the system. Through this identification, steps can be taken immediately to take measure for loss reduction in a systematic manner. The second one is how to reduce or remove the high loss carrying segment from the system and suggesting an alternative way to develop a new system with low loss to supply and feed the same load.

Comparing a system loss of a particular area for supplying the same load with same demand a theoretical calculation has been exercised in a 3-θ system Vis-a Vis in 1-θ system. The elaboration of which is given in the pages which are showing detailed calculations with load and uses. A short result indicating the percentage of loss only are given in the table below which highlights the statement given above.

To find out the loss-benefit estimate for the thesis we have picked up 4 local overloaded feeders of the area. I have worked in old Dhaka area for the thesis. The detailed of the feeder drawing and single line diagram are given in the last section of the thesis. The demand loss and the energy loss calculations are given in detailed in the last part of the book. A summary of the calculations has been picked up here. The short brief of the feeders is given below.

Table1.3: 4 local overloaded feeders short brief

Sl. No	Feeder Name	Voltage Level	Connected Load(MVA)	Peak Load (MVA)	Remarks
1.	Zigatola Local -2	11KV	9.050	3.028	1.System Power Factor=0.80 2. System Load Factor=0.65 Supplied by Authority
2.	Meena Bazar	11KV	4.415	4.21	
3.	Kaptan Bazar	11KV	2.4	1.51	
4.	Dholai Khal	11KV	1.20	0.75	
	Total		17.065 MVA	9.50 MVA	
	Having PF 0.80 in MW		13.652 MW	7.6 MW	

Table 1.4: Energy Lost per Month of specific 4 feeders in the System

Existing Load		Energy Delivered Per month (KWh)	Existing System (Calculated)	
Connected Load	Peak Load	7.6MWx 0.65x720x1000= 3556800.00	Kwh Billed per Month should be (Kwh)	Kwh Loss Per month Calculated
17.065 MVA	9.50 MVA		3364732.80	195624.00
13.652 MW	7.6 MW			5.50%

In the specific area, picking up voluntarily 4(four) overloaded feeders having good consumer mix we can find the energy delivered in a month in that area = (3.028+4.21+1.51+0.75) x 0.80x1000x0.65x720= 3556800.00 Kwh where PF is 0.80 and LF is 0.65. Energy lost in a month due to technical reason for the existing system is calculated as 165623.72 Kwh which is 5.50%.

This has been thoroughly calculated at the last part of this book. A summary of the results is given below in the table 1.7.

Table 1.5: Calculated Technical Loss

SL. NO	Loss Area	Existing System	
		Peak Load Loss, Kw	**Kwh Loss Per month**
1	Primary Distribution	40.34	11794.48
2	X-former No-Load Loss	52.026	19708.052
3	X-former Load Loss	90.556	17563.51
4	Secondary Distribution 3-Ph	291.75	66365.43
	Secondary Distribution 1-Ph	0.151	21.21
5	Service Drop Loss	0.384	47889.74
6	Meter Loss	0.0088	21738.33
7	Jumper /Twisting & Wrapping Connection Loss	0.0041	10494.30
Total		**475.17**	**195625.22**

Note:

1. Service Drop for the proposed system has been suggested for 1kw to 2.5 kW by Duplex & from 2.5 kW to 10 kW by 3 duplex & from 10 kW to 15 kW by 3 Quadruplex which will reduce the loss by 50%.
2. Jumper & Twisting of any joints of conductor is not allowed in this system. Proper sleeve connection must be done. At least 80% loss will be reduced.
3. In finding out the no load loss and load loss of transformers care must be taken while making the average value of the transformers and use of LF and PF properly.
4. Loss calculated must be checked and verified with authentic software program.

1.4 Govt. Initiative to cope up with the Situation

However, NEP of 1995 has highlighted few vital issues watching some basic problems on energy expansion projects in Bangladesh. It emphasized that like other resources and economic inputs in developed countries; energy is an essential ingredient in the development of industrial activity and must be allocated in the best possible manner where it will continue to add to the economy. But, producing energy till today requires use of huge quantity of finite natural fossil resources which tends to generate pollution and creates health problems. As the question of sustainable energy has come up, it is therefore important that energy be generated and used efficiently. If external cost such as environmental degradation and health aspects are represented in the energy pricing calculations, the societal cost of using primary energy through fossil or nuclear sources should be higher than the cost of using primary energy directly through or solar systems. With passage of time and considering all these complexities, production and usage of energy is becoming more and more crucial.

Energy supplies must grow more rapidly than population in order to raise the quality and quantity of the human diet, increased income and employment and relieve human drudgery.

More food can be grown on existing cropping and increase the yield of each crop. Modernization of agriculture depends upon improved transportation and mechanization. New and non-farming jobs must be created to raise income and level of employment by establishing new industries. All such activities demand to establish efficient energy supply system.

In recognition to the importance and necessity of using all kinds of energy efficiently, Government of Bangladesh (GoB) has adopted a broad policy measures in the approved National Energy Policy (NEP) of 1996. Reduction of system loss and using of efficient appliances give multiple benefit of the power system. Before implementing such program, the following works must be implemented sequentially. To conceive the methodology abstracts from energy policy which are given below which reflects the image of seriousness of Bangladesh Government:

1. Rural sector plays a vital role in the national life in terms of economic activities, agricultural production and population. Therefore, energy needs of the rural areas are to be given priority in all activities.

2. Systematic assessments of energy resources of all types are to be made. In this process, scopes for alternate use of a part of such resources, like recycling a part of agro-residues into soil are to be identified.

3. Potentials of renewable sources of energy like solar, wind, mini/micro hydro, tidal, wave and geothermal are to be assessed along with the potentials for their harnessing as useful energy.

4. It would be prudent to conduct such assessment on an area basis, preferably considering Union or Thana as a unit for resource assessment.

3. End use-based demands are to be balanced with the supply of fuel for each planning unit, which are to be used for planning and for projections, thereby turning such areas into individual units for a decentralized planning structure.

4. Motivation and incentives shall be provided for implementing conservation measures including for using efficient appliances.

1.5 Loss of different utilities Up to year wise

Table 1.6: Loss of the Utilities of Bangladesh

Fiscal Year	BPDB	BREB	DPDC	DESCO	WZPDCL	Distribution Loss	T&D Loss
1999-2000	27.73%	16.24%	26.88%	32.47%		26.09%	31.60%
2000-2001	26.11%	18.08%	27.77%	29.86%		25.34%	28.43%
2001-2002	24.50%	16.61%	29.71%	26.66%		23.92%	27.97%
2002-2003	22.35%	17.33%	27.97%	21.06%		21.64%	25.69%
2003-2004	21.33%	15.60%	25.62%	19.24%		20.04%	24.49%
2004-2005	20.00%	13.78%	21.94%	16.64%		17.83%	22.79%
2005-2006	19.06%	12.98%	20.13%	16.20%		16.53%	21.25%
2006-2007	16.58%	12.38%	20.44%	13.44%	14.72%	16.26%	20.25%
2007-2008	14.39%	14.73%	18.41%	10.91%	13.04%	15.58%	16.60%
2008-2009	13.58%	13.97%	16.77%	9.79%	12.22%	14.33%	16.85%
2009-2010	13.11%	14.81%	12.43%	8.86%	11.73%	13.49%	15.73%
2010-2011	13.06%	14.13%	11.14%	8.79%	11.67%	12.75%	14.73%
2011-2012	12.15%	13.99%	9.87%	8.52%	11.66%	12.26%	14.61%
2012-2013	11.95%	13.89%	9.07%	8.44%	11.38%	12.03%	14.36%
2013-2014	11.89%	13.72%	8.99%	8.43%	10.97%	11.96%	14.13%

Source: Annual Report, PDB 2015

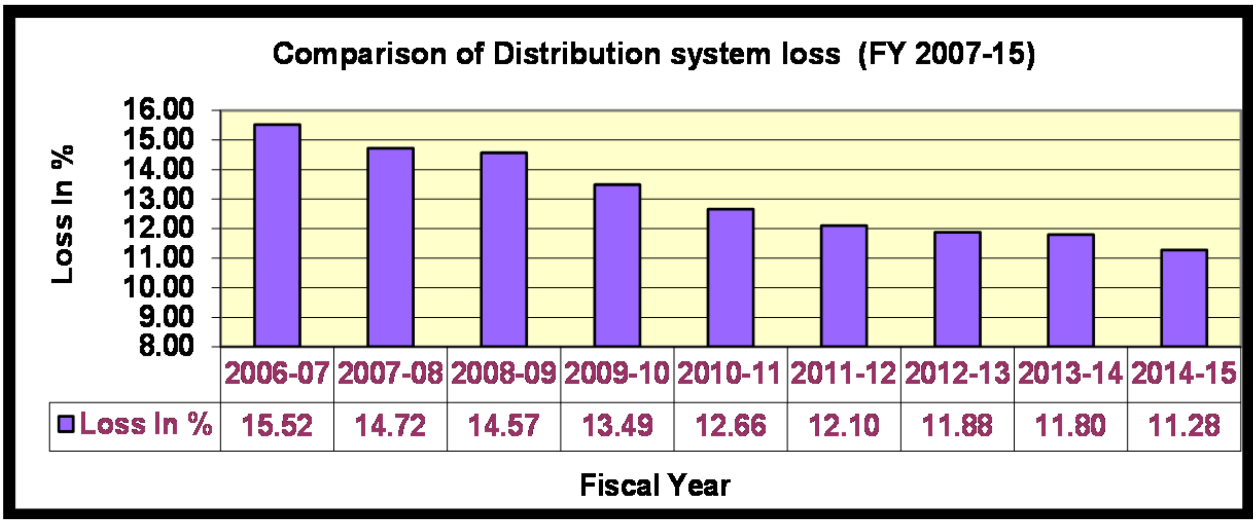


Fig 1.1: Bar Chart of Accumulative Loss of the power sector of Bangladesh

CHAPTER-2

Literature Review

2.1 Loss Quantification Impediments

Power loss reduction is one of the main targets in power industry and so in this paper, the problem of finding the optimal and simple calculation of distribution system for loss reduction is considered. This paper presents a new method for calculation of radial distribution systems. This type of methodology involves selection of the known set of factors to be used to find power and energy losses and voltage deviation, using distribution load flow (DLF) program such that the resulting RDS has the desired performance. The developed load flow program is integrated with known heuristic techniques in a new heuristic search methodology for determining the minimum loss configuration of a distribution system. The technique consists of two parts; one is to determine the loss in all loops with existing figure combination while the other is a power loss and voltage profile calculation of the changed configuration converting it into 1/3 of the feeder length. The solutions done in both ways should get converged very close result; therefore, conception and assumptions for calculating the things should be considered to be close to be accurate. In this paper an implementation of all the calculation and results presented are authenticated by software program and MATLAB simulation. The results show that the performance of the proposed method is praiseworthy.

2.2 Literature Review

While reviewed the paper “Development of simplified loss models for distribution system analysis “published in IEEE Journal in July 1994,Volume: 9 ,Issue:3,Page(s):1545 - 1551 Authored by Chen, C.S. Hwang, J.C. ; Cho, M.Y. ; Chen, Y.W., Dept. of Electr. Eng., Nat. Sun Yat-Sen Univ., Kaohsiung it is seen that this paper proposes a methodology to derive a simplified model for distribution system loss analysis. According to the typical daily load patterns and the energy consumption of customers, the hourly loading of distribution transformers can be solved. A three-phase load flow program is applied to calculate the feeder power flow so that the hourly feeder loading will be the same as that obtained by the field test. The hourly primary conductor loss, secondary conductor loss, transformer copper loss and core loss are then solved according to the mathematical modeling of system components. The sensitivity analysis of system loss with respect to the feeder loading, power factor, feeder length, transformer capacity is then performed to derive the simplified loss model of distribution feeders. A distribution feeder of Taipower system is then selected for computer simulation to demonstrate the effectiveness of the proposed method. By applying the simplified loss model derived, the daily loss pattern of distribution feeders is solved according to the actual hourly feeder loading. It is concluded that the proposed methodology provides a useful tool for distribution engineers to estimate the operation efficiency of distribution systems in a very effective manner.

In reviewing the paper “Finding the optimal implementation of feeder reconfiguration in unbalanced loading distribution systems “ appeared in in the paper in pages 10 to 14 during “Universities Power Engineering Conference (UPEC), 2010, 45th International, held in Aug. 31 2010-Sept. 3 2010 in the Conference Publications authored by Rugthaicharoencheep, N. and Sirisumrannukul, S, King Mongkut's Univ. of Technol. North Bangkok, Bangkok, Thailand it is seen that this paper presents an approach for finding the optimal implementation of feeder reconfiguration in unbalanced loading distribution systems with the objective of power loss reduction. The optimization problem is subjected to system constraints consisting of load-point voltage limits, radial configuration format, no load-point interruption and feeder capability limits. The system power losses and bus voltages are solved by a three-phase power flow algorithm. The solution technique, developed based on Tabu search, is employed to search switch statuses for feeder reconfiguration under different unbalanced loading conditions. The performance of the developed methodology is demonstrated by a radial distribution system with 69 buses, 7 laterals and 5 tie-lines (looping branches). The study results show that the optimal on/off patterns of the switches can be identified which give the minimum power loss while respecting all the constraints.

While reviewed the paper “ Loss Reduction in Distribution System with Photovoltaic System “,appeared in in the paper during “Power and Energy Engineering Conference (APPEEC), 2012 Asia-Pacific” in pages 1 to 4 during the Conference date 27-29 March 2012 in the Conference Publications authored by Kongtonpisan, S., Chaitusaney, S.,Dept. of Electr. Eng., Chulalongkorn Univ., Bangkok, Thailand it is found that this paper presents a loss reduction in distribution system with photovoltaic system by considering fixed and automatic switching capacitor banks using genetic algorithm (GA). The problem is to determine optimal capacity and location of grid connected photovoltaic system (GCPV) and capacitor banks. The proposed method has been tested with a Tahsai 34-bus system from the Provincial Electricity Authority (PEA) of Thailand.

In reviewing the paper “performing a distribution system loss reduction “appeared in in the paper in pages 164 - 167 vol.1 during “Electrical and Computer Engineering, 1995. Canadian Conference, held in 5-8 Sep 1995 in the Conference Publications authored by Sarfi, .J., Salama, M.M.A. ; Chikhani, Y.,Sarfi & Co. Ltd., Champlain, NY it is found that, facing constant pressure from municipalities and deregulation on the horizon, municipal utilities are forced to render their operation more efficient. Reduction of distribution losses not only contributes directly to the utilities bottom line, but also brings about many other benefits which can be more difficult to quantify. An overview of the practical concerns associated with performing a distribution system loss reduction is presented including capacitor installation, reconductoring, voltage modifications, distribution transformer load management, feeder reconfiguration, and SCADA capabilities.

2.3 Knowledge Gap of Policy Level People

The power sector though one of the vital sector is however not developed as expected. The major impediments are manifested in structuring well designed monitoring tools and proper supervision by the competent personnel. In Bangladesh power distribution sector, it is not clearly identified what should be standard loss quantity in different segment as per quality of the lines. The reluctance of the policy level people in pin pointing the issue made the situation worse. It is well estimated by the professional that due to high loss, power sector incurs a yearly loss to the tune of BDTk. 200 million considering consumption around 50, 000 MKWh/year and this estimation is done considering standard loss of distribution up to 7%.

2.4 Related Works by the Authority

The appropriate methodology and well-planned program is very important for loss reduction in both urban and rural power distribution system. 15 years back a program was taken by power ministry following a methodology for quantifying the loss amount and in time reduction of system loss. This might be considered is the only step taken by the authority for loss reduction. The program was initiated by Power Cell, the monitoring unit of Ministry under the name of Strategic Business Unit [SBU] as it was anticipated the distribution unit is not only a service center rather it is a business unit also. It sells electricity to the people. So with good service they should earn profit. On this concept a program was designed to quantify the actual loss of the unit and steps to reduce the high loss to bring it to the calculated value in time. Considering it as a business unit, with the reduction of loss a financial incentive package for the staff was introduced. It gave a very good result. But due to lack of correctness and monitoring the program taken under SBU failed at last. The thesis presented in this book is the outcome of those programs taken by power sector. The thesis is developed accurately in a refined methodology, more correctly.

CHAPTER-3

Details of Thesis Work

3.1 Outline of Thesis

Distribution and transmission loss of Bangladesh power system is abnormally high. It is moving around at a figure of 14% to 16% since many days [4] [5]. This topic will cover distribution loss only. Globally it is generally anticipated that 70% of the loss occurs at distribution area. We also find that in Bangladesh the distribution loss is high enough in comparison to transmission loss. The reason for this high loss is due to extensive use of secondary system in comparison to primary for supplying the same power. It is well conceived that the low-tension system carries enormous amount of high current for the same load which is being carried by the primary system. So it can be anticipated that we can have a low loss system if the low tension system be eradicated or reduced to a significant amount. Before doing that, we must know what is the amount of loss that occurs in 3-ϕ and for the same load that occurs in1-ϕ. But how it will be implemented to supplying various kind of load through 1-ϕ system? How it will justify the load calculations? What will be equivalence of 3-ϕ t with that of 1-ϕ system? What about investment cost and construction procedure? We need to develop a workable theory including construction design. That is also a part of the concept of the thesis to see the impact what happens if we convert the existing 3-ϕ to 1-ϕ system or instead we install a 1-ϕ system to feed the load at the beginning totally avoiding a 3-ϕ system.

3.2 Thesis Concept

The thesis is based on an easy conception to develop an easy methodology for quick quantification of distribution losses that yields in the system. It is for monitoring purpose. It is developed to find out total loss of the distribution system only by measuring the current at peak load principally at low voltage side of the transformer and transferring to high voltage side by the transformation ratio. The accurate loss could be found out through software which is available in the market at a much high cost. We must remember how often we need the result and what is the level of the people who are working in the field? As this is not possible to make these software uses friendly for the people who are working in the field, so this will be a useless effort at the cost of huge expenses. But a hand tool must be there to find out the loss result very quickly even within a day and this is possible by this sort of methodology. This will be considered as their hand tool to be used as when is required. It is to be mentioned that to find out the distribution loss calculation of a particular system few other things are required. And all these required things will always be available with the system authority as this is a mandatory order by the authority.

These things are:

(1) Single line diagram indicating line length and transformer location
(2) Transformer size with ratings and load demand
(3) Load quantity and load locations under the transformer
(4) Conductor size and specification
(5) Yearly/monthly billing data and
(6) System load factor, power factor, power cost etc.

Let us see a model single line diagram below reflecting a distribution system which is analogous to the thesis theory concept.

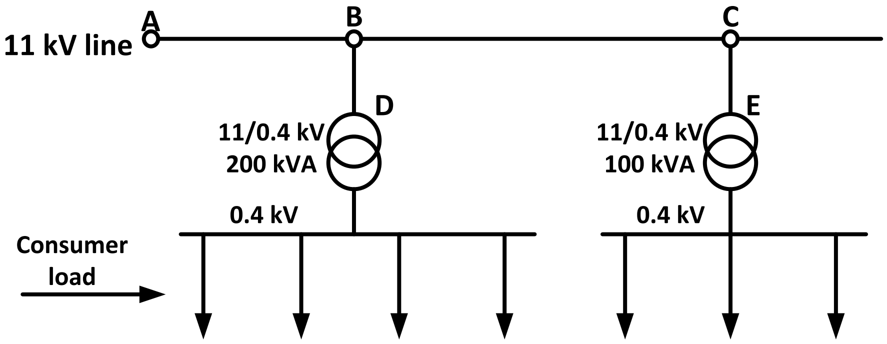


Fig 3.1: single line diagram-1

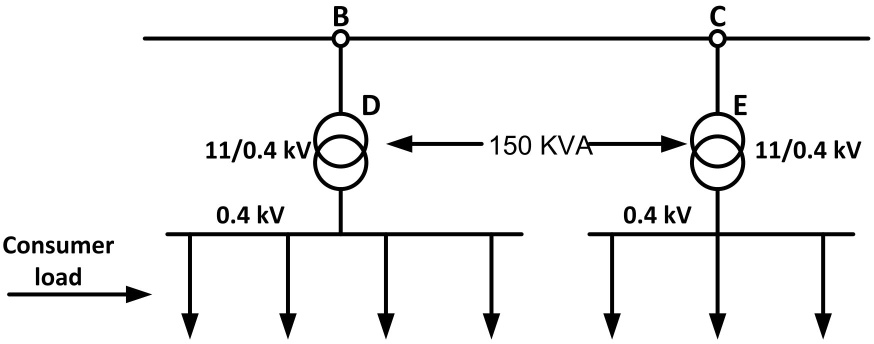


Fig 3.2: Single line diagram-2

Here in the Fig: 1 a system configuration is shown. Here line length of 11 KV A-B and B-C are known. One 11/0.4 KV, 200KVA and another 100KVA transformers are hooked up in the system. For simple calculation an average of the two transformers are considered which equals to 150 KVA each. “E” and “D” in the figure are primary side. Using a Clamp on Ammeter peak currents of all 3 phases in the secondary side, opposite side of the transformers high voltage side at points “E” and “D” are measured. By the transformation theory this current is reflected at the primary side that is at 11KV side of the transformers. In this way the currents of all the transformers hooked up in the feeder are measured. The summation of all the measured peak currents is the peak current flowing in that 11 KV line. The line loss is to be estimated on the basis of peak current thus measured using Load Factor, PF, Load Loss Factor, Demand Factor of the system and also using conductor resistance and conductor length, which all are known. We also know the consumer load quantity from the utility authority including the consumer load locations under the system that is under the transformers. Now a revised single line diagram as shown in Fig.-2 conceiving the theory concept discussed above. It is developed by averaging the transformer size. Now the measured amps-load is distributed in each transformer proportionately according to their size. Secondary load is easily found from the consumer’s connected load and the measured peak load by using diversity factor. So the amp’s flow in the secondary conductor is found and when these loads are transferred. Amps are flowing from source to down side. So the quantity of amps is higher at the source side. It will be more and more lower towards down side. It is also assumed that the load is balanced in 3 phase as it is a mandatory. Utilities are instructed to perform this. Transformers have 2 types of losses. One is (1) no load loss and another is (2) load loss. Again using formulae to quantify all types of losses is used here after converting into average size of all the transformers. So it is now easy to get the demand loss and also the energy loss for a specific system.

3.3 Identification of System Loss of the Existing System & Theory Development

A part of distribution system under DES of WARI has been picked up for case study. The area map & single line diagram of existing & proposed system is enclosed. In this distribution network centrally located distribution transformers mostly 200 KVA, 11/.400 KV & extensive secondary distribution systems serving for 100 to 200 consumers exist.

In the later part of the book with other recommendations a new system is proposed based upon small single phase or banking of single phase transformers at or near the load centers with short secondary as when compared it is manifested that in the proposed system a significant amount of loss would be reduced.

The decentralized systems were considered to serve the same load. This proposed system displaced centralized system. But, the study aimed at reducing & means to find the way of calculating well circulated term “system loss” has been given importance.

As per recommendation a 1-ϕ system has been suggested with small 1-ϕ transformers & banking located at load centers with either no secondary or with very short lengths of secondary lines with 11/6.35 KV primary lines displacing the 3-ϕ single bulky transformers & extensive secondary.

The alternatives may be summarized as follows:

i. The centralized system transport power to the consumer through low voltage (400/230v) secondary with excessive lines resulting high loss

ii. The decentralized system carries the power directly to the consumer at load centre at high voltage ($11/\sqrt{3}$=6.35Kv) and supply power by small or big 1-ϕ transformers with "zero" or almost "zero" secondary. Obviously, loss will be reduced by a greater extent.

But it is to be checked whether a decentralized system might need more investment due to the greater length of primary lines & the use of many small transformers and whether it is technically feasible. In this study we will compare the % of system loss, thus amount of lost unit for the year in both systems. The data mentioned above are collected for this study from PDB/DPDC area mentioned above, specially sold unit. However personal investigation and data collection was required to visit some of the industries & big houses of that area to make a reasonably correct calculation, especially in the case of sold unit. Load measurement at the secondary of the transformers were done to finding both the load of the transformers and the feeder load with the help of few consulting firm working in REB and PDB. A consumer survey under 20 X-formers was also performed & Kwh consumed & peak has been estimated by house to house investigation which have enclosed for reference.

For simplification, some of the technical points have been ignored which have been discussed in the relevant section or chapter of the write up. However, for this the main theme of the thesis will not be deviated. In this study, independent feeder was studied & the peak was considered to be coincidental, which through amps measuring had been proven to be correct.

Here in the study, for comparison of two alternatives, Distribution transformer losses, Feeder losses, Secondary losses, Service drop losses, Meter losses & Jumper & Twist connection losses has been considered.

3.4 1/3 Length Loss Calculation and Equating through "K" Factor

In finding out the losses of distribution system one is to make tedious and repeated calculation for every node and section points. We need to find out the losses for each of the distribution lines and equipment's through numerous calculations going point to point of actual load at actual location of each feeder with regard to line distance and line resistance. But here in this study, we need only (1) peak current at source (2) number of transformer including their size (3) line length (4) yearly energy bill and (5) equipment specification and data. Here except the peak current all other information and data are available with the system authority. These are given chapter wise.

A methodolgy to find out the loss, quickly and accurately for both demand loss and energy loss has been developed rare. Though different sofware program and simmulation to find losses are avialable but thinking of difficulties of using software in the field and level of people serving in the authority an effort has been taken through this thesis to develope a metholodology to find out the system loss quickly and accurately, which will be needed by the utility authority as a routine work to monitor the system and demand loss of the system. This will also guide the utility authority to compare and pick up the better option in installing distribution system whether it would be 3-ϕ or 1-ϕ.

In developing this thesis a distributuion .stem comprising of 11 KV and 0.4 KV has been picked up. In first step all the transformers in the line has been counted including their size(capacity). An average size of the transformer is calculated. Then the line length of a specific feeder has been identified to make 3 equal divisions to make three node points at B, C and D clearly showing line sections as A-B, B-C, and C-D equal to1/3 to its actual length (see the figure below). Conventionally the maximum load flows up to 1/3 of the distribution lines as the loads are concentrated up to that point [11] [12] [13]. It is a general practice in design to consider 1/3 concept and through all equipments including transformers. Since current is the main factor to quantify the loss, care has been taken to introduce some factors so that with the change of line length or distance of actual transformer location the results still manifest a correct result. The load flow (current flow) is the principal item to find the losses considering that the line lengths are measured and recorded accurately. The variation of calculated result of losses with what would be correct due to variation of transformer location is eliminated by a factor" K", which has been introduced here in the thesis. Actually this is the main theme of the thesis.

One model feeder is shown below. The actual line has been marked into sections at B, C and D considering length up to1/3 of the total. The total length of the feeder in this case is 0.858 KM. So 1/3 makes 0.2861 KM. All these calculation and methodology are shown chapter wise.

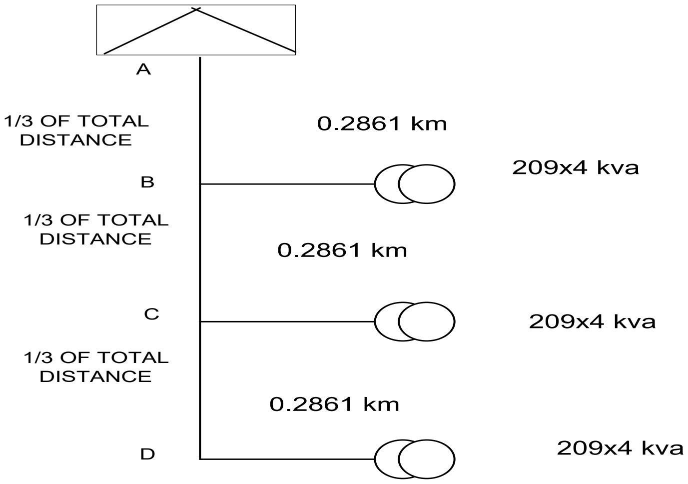


Fig 3.3: Conceptual Drawing of 1/3 System

We have seen that the actual loss of the feeder calculated in the conventional methodology or by ETAP becomes very close to that what we have found up to1/3 of the line by multiplying with the newly introduced factor "K". It can be done very quickly and accurately. This has been checked by soft were program called Electrical Technology of Analysis Process (ETAP). All these calculations and simulation results are given here in the book.

The basic question comes up why it is divided into 3 equal sections. It is conventionally practiced in the utilities that when any equipment such as Auto Power Factor Improvement (APFI) device or Auto Voltage Regulator (AVR) or Auto Circuit Reclose (ACR) needs to be installed, it is installed at 1/3 of the feeder length avoiding all complex calculations and tedious job. Normally when a survey is done for preparing the design to install a transformer say of the capacity of 200 or 100 KVA initially a load center is determined. In finding the load center to install the transformer at a load center or almost close to center between 2(two) feeders (normally) which would be emanating from the transformer, if the feeder length is around to the tune of 2(two) KMs, then approximately 1KM at one side and another 1 KM at the other side of the transformer. It is designed for optimum distribution quality, quantity and reliability. These are manifested in the survey that almost 75 to 80% of the loads are situated at the area which falls within 1/3 of the feeders at one side and almost same quantity of load is at the other side. It is due to social structure of an area or village or locality even in any country of the world [13]. In this process we used the concept of finding actual or close to actual losses of the total feeder considering the load point and line length taking into consideration the actual load at each location and resistance of the line. Then we studied each section where we have calculated the 1st half and 2nd half load of each section from the actual single line diagram to find the different values of "K" factor with an effort to remove the deviation from inaccurate results.

The result of loss calculations done using software and the method we are suggesting through this thesis becomes similar.

This "K" Factor is derived by practicing and solving few practical examples. Say for example here in 14(fourteen) model distribution lines, we have used, "K" factor. The loss has been calculated by using "K" factor which is described below. By this "K" factor we could find out demand loss (KW) and energy loss (KWh) safely, quickly and almost accurately.

Then now it is eminent to determine the value of" K". We are to remember that the value of "K" depends on the load ration between 1st half and 2nd half. We have practiced some simple model feeder shown in the relevant section. All the feeders we have used to find losses in two methods namely through simple calculation for the total feeder on actual load flow on length basis and by considering 1/3 of the length with total load flow in the section by both through ETAP and by Analog. We have seen that for uneven distribution load the loss for full length and 1/3 differs depending on load ratio between 1st half and 2nd half.

For eradicating this dissimilarity after calculating the loss on 1/3 system, we are to do some new calculations on the same model system but on the basis of load flow 1/2 (half) length of each section. We are to pick up each section and cut them into two equal pieces. We add the quantity of the load those are responsible for current flow through the 1st half of the section and similarly add up the rest loads which making current flow through the 2nd half. These are called as 1st half and 2nd half load of each section. It is quite obvious that the loads can never be connected in a balanced way in the practical field. In reality it is not possible even. Though as per ideal design it is always considered to be equal to make the distribution system to be balanced.

We know that loss varies in line for same load if load ratio varies between 1st half and 2nd half as per following criterion:

Total loss in the specific feeder is;

Higher, if load in 2nd half> 1st half
Equal, If load in 2nd half= 1st half
Lower, if load in 2nd half< 1st half

Someone needs to be confident about the calculated or estimated loss of the system by this newly introduced "K" factor. How this K Factor is determined? It is determined by iteration of various simple analogue calculations, ETAP and MATLAB simulation. We calculated the real loss by point to point on the basis of load distribution. Then we found loss on 1/3 length basis as we anticipated that significant amount of load flows up to 1/3 length. We find out the ratio of 2nd half load/1st half load. It is quite obvious that loss increases with the increment of the ratio of 2nd half load with that of 1st half load. So, the calculations and estimations on the basis of assumed factors considering load ratio between 2nd half and 1st half are very important. If an amount of load radiates from the source having load ratio between 2nd and 1st half is “1” or lower than “1”, then the full-length loss does not differ with that of 1/3 length. It is quite obvious. But with different load ratios between the 2nd half and 1st half the full-length loss result varies with that of 1/3 length. The variation of result depends on the load ratios between 2nd half with that of 1st half. To get a correct result we must find out a multiplying factor which has been introduced here named as “K” factor. It needs some detailed engineering mathematics to reach on a correct calculated result by the “K” factor developed through iterations and simulations. If this can give us a correct result, then it should be used in all feeders to find correct loss calculations. To justify the correct value of “K” we have done few practical calculations and on the same feeder and load

3.5 Load Ratio and its Impact

We have simulated through ETAP and Matlab to find at what load ratio between 2nd half and 1st half the value of “K” factor should be.
After these calculations we have seen that, if the ratio of,

2nd half load/1st half load is	0 to 0.5	then	K=	1.0
2nd half load/1st half load is	0 .5 to 1.0	then	K=	1.30
2nd half load/1st half load is	1.5 to 3.0	then	K=	1.50
2nd half load/1st half load is	3.0 to 4.5	then	K=	1.65
2nd half load/1st half load is	4.5 to 6.0	then	K=	1.783
2nd half load/1st half load is	6.0 to 7.5	then	K=	1.902
2nd half load/1st half load is	7.5 to 9.0	then	K=	2.028
2nd half load/1st half load is	9.0 to 10.5	then	K=	2.145
2nd half load/1st half load is	10.5 to 12.0	then	K=	2.259
2nd half load/1st half load is	12.0 to 13.5	then	K=	2.371
2nd half load/1st half load is	13.5 to 15.0	then	K=	2.482
2nd half load/1st half load is	15 to 16.5	then	K=	2.593
2nd half load/1st half load is	16.5 to 18.0	then	K=	2.702
2nd half load/1st half load is	18.0 to 19.5	then	K=	2.81

In finding out the load ratio between 2nd half and 1st half we should be accurate in allocating the current of two sides. If it is a junction where an amount of current flows towards then one must apply his knowledge what should be the amount of current to be divided in that part. If it heavy current, then 10% of the adjacent current can be added at the other side. For small amount of current an insignificant amount of current applying your knowledge can be added at the other end. A small deviation may distort the result if the division is not done properly. The best way is to compare the result of loss done in a simple calculation with that of result done by software. The comparison can be made closer and closer through iteration and in this way, one can find out the value of the probable parameters which need consideration.

3.6 K^{th} and K^{th-1} Value

These ratio values shown at the right side of the equations above are maximum values of the ratio. So, these values follow a range depending upon the values of the ratio of 2nd half load and1st half load. The K value is given more elaborately in the following table. These have been derived using the data from the model example shown in the later portion by using ETAP and MATLAB simulation.

Table 3.1: K^{th} Value Depending on Load

Load ratio of 2nd and 1st half Loads [can be verified of the example done 1 to 14]	Ratio Range [Ratio value is of a range. If it starts at say 0.5 ends up at 1.0 as shown in sl. number 2 and same with the other]	Ratio Between Maximum to Minimum Range Value of a Particular Range	Previous Value of K_{th}	Incremental Value of Kth [1st and 2nd Incremental Value @ 20% & Rest Value are @10%]	**Final Value of** K_{th} =[$K_{(Kth-1)}$ +Xth*@20% (1st 2 and rest @10%]
LR^{2nd}/ LR^{1st}	R_{min} to R_{max}	$L_{Rmax}/ L_{Rmin} = X_{th}$	K $_{(Kth-1)}$	**(20/100)*Xth)**	K_{th}
0< to 1.0	0< 1.0	0.5/0= ∞	1	0	1.0
1.0 to 1.5	1.0<1.5	1.5/1	1	.30	1.30
				(10/100)*Xth	
1.5 to 3.0	1.5< 3.0	3/1.5=2	1.30	.2	1.50
3.0 to 4.5	3.0<4.5	4.5/3=1.5	1.50	.15	1.65
4.5 to 6.0	4.5< 6.0	6/4.5=1.333	1.65	.133	1.783
6.0 to 7.5	6.0<7.5	7.5/6=1.25	1.783	.125	1.902
7.5 to 9.0	7.5 < 9.0	9/7.5=1.2	1.902	.12	2.028
9.0 to 10.5	9.0<10.5	1.17	2.028	.117	2.145
10.5 to 12.0	10.5< 12.0	12/10.5=1.14	2.145	.114	2.259
12.0 to 13.5	12.0<13.5	13.5/12=1.125	2.259	.112	2.371
13.5 to 15.0	13.5<15.0	15/13.5=1.11	2.371	.111	2.482
15 to 16.5	15<16.5	16.5/15=1.11	2.482	.111	2.593
16.5 to 18.0	16.5<18.0	18/16.5=1.09	2.593	.109	2.702
18.0 to 19.5	18.0<19.5	19.5/18=1.08	2.702	.108	2.81

Note:

a. X_{th} is the ratio between maximum values to minimum value of a particular range. In finding out the X_{th} of a section the load ratios of two sections of same feeder are related with this figure

b. K_{th} is the multiplying factor to eliminate the loss result variation between full length and 1/3 length

c. K_{th-1} is the previous value of K_{th}. It is known after devising all values of K_{th} which can be seen at the upper part of the table.

d. If 2nd half load/1st half load value is 1 or less the 1, that means 1st half current equal or higher than the 2nd half current than full length loss is equal or almost equal to 1/3 length loss as almost the maximum current flows within the 1/3 length of the feeder.

e. For these lower incremental values of X_{th} (L_{Rmax}/L_{Rmin}) that is up to 1, the factor is calculated by multiplying the factor by 20%. This factor is multiplied by 10% for higher than 1.

f. For more accuracy the range 0.0< 1.5 has been divided into 2 segments as 0 .0< 0.5 and 0 .5< 1.5.

h. If not divided then the X_{th} factor could be multiplied by 10% like all other factors having LR^{1st}/LR values more then 1

So, in developing the formula of K_{th} we are getting 2 factors, one is the K value of the previous one and another is for first 2(two) equations are at 20% respectively and rest all are @10%. It is to be noted that we are trying finding the K value on the basis of ascending value of ratio between ratio between 2nd half load and 1st half load. Why these percentages are considered? As because from the "K" equations we find that there is a range of "minimum" load to "maximum" load in each equation. Naturally the equation without the averaging would give the result for the higher value of the range of ratios only. So, it is obvious for more accuracy we need to rationalize the "K" value by putting an average value of the "minimum" load to "maximum" load in each of the equations and it is done by the equation. The pertinent question here why in the first 2(two) equations it is 20% and for the rest these are 10% only? Actually, for a result 10% for all was the best answer. It is again seen in the equations that the first 2(two) equations are for very smaller range. It is for better scanning divided by 2 parts splitting the standard range of 0< 1 .5 into 0< 0.5 and 0.5< 1.5. So, by splitting the bigger range into smaller one with enormous less value these need to be boosted up by multiplying with a higher factor to get increased value of load ratio. It is to be remembered that where the ratio is less than 1 which for this particular case study is done should be 20% for the equation. Accordingly, it was done by 20% and onward the equations are done by 10 %. As a model formula development, we have considered the ascending value of load ratio in symmetry like 0.5, 1.5, 3, 4.5,6, 7.5, 9.00 etc. All these K values are given with wide range up to the ratio value of 20 up to which the K values are covered. It is also to be remembered that load ratio more than 20 is impractical and impossible in distribution network. If it still, there it could be found following the formula given above. Since Xth is increasing more then it tends to increase the K value at a rate of maximum 20% for the first 2(two) and 10% for the rest of the ratio between two interrelated K equations. It is derived from the simulation that it increases with this maximum value. The K value of the new equation increases as more loads are increased in the second half what was there in the previous equation. It is very clear to anticipate which justifies the statement that more load is connected to the end, more loss will incur.

In applying all these recommendations and the developed tool in a very short and scientific way we can find out the results of system loss and thus can apply the results for monitoring purpose. We have tried to find the result in some model figures which are shown below.

Comparison results obtaining both demand loss and energy loss are given in the table below on the basis of detailed calculation by both method ETAP and hand calculation. There are differences of result for same figure done in the two methods as because in ETAP method includes many data and specification in the calculation which are in inbuilt software where as in the analog method loss is calculated following Ohm's Law. Here the vital issue is to check the loss difference ratio between full length loss and 1/3 length loss. All the figures and calculations of 1 to 14 are given in the pages below.

By applying these newly developed tools K we see from the table that demand loss and energy loss are very close to losses on the basis of actual calculations that incurred in the system. A deviation of results calculated in both the form is given in a table below. To find out the losses those occur in the system thus can be find out so quickly and easily which will be an important monitoring tool for the system authority. The calculation of the losses in 1/3 value has been performed averaging the minimum and maximum value of the current. So, in practice while this is applied using accurate value of K then the % of deviation shown here is expected either may not be there or would be insignificant.

3.7 Inaccurate Value of K^{th} and K^{th-1} Value with improper load ratio

If the load ratio is not correctly chosen, then the value of “K” factor that yields from the load ration does not give correct value of losses on 1/3 ratio as stated. The variation of result depends on the load ratios between 2nd half with that of 1st half we have seen earlier. To get a correct result we must find out a correct “K: factor which depends on load ration between 2nd half and 1st half.

Let us consider to find a new, though not accurate, “K” value with different load ration which is given below, considering the ratio of,

2nd half load/1st half load is 0 to 0.5 then K= 1.0
2nd half load/1st half load is 0 .5 to 1.5 then K= 1.6
2nd half load/1st half load is 1.5 to 3.0 then K= 1.85
2nd half load/1st half load is 3.0 to 4.5 then K= 1.99
2nd half load/1st half load is 4.5 to 6.0 then K= 2.133
2nd half load/1st half load is 6.0 to 7.5 then K= 2.263
2nd half load/1st half load is 7.5 to 9.0 then K= 2.394
2nd half load/1st half load is 9.0 to 10.5 then K= 2.511
2nd half load/1st half load is 10.5 to 12.0 then K= 2.626
2nd half load/1st half load is 12.0 to 13.5 then K= 2.735
2nd half load/1st half load is 13.5 to 15.0 then K= 2.847
2nd half load/1st half load is 15 to 16.5 then K= 2.967
2nd half load/1st half load is 16.5 to 18.0 then K= 2.978
2nd half load/1st half load is 18.0 to 19.5 then K= 3.090

These ratio values shown at the right side of the equations are maximum values of the ratio. So, these values follow a range depending upon the values of the ratio of 2nd half load and1st half load. The K value is given more elaborately in the following table. These have been derived using the data from the model example shown in the later portion and the MATLAB simulation.

Sl. No.	Load Ratio	Load Ratio (2nd half load/ 1st half load) = ($R_{th}L_2/R_{th}L_1$ = (R_2/R_1) =X_{th}	Ratio Between Maximum to Minimum Load	Formulae of $K_{th=}$ $K_{th-1)}$ +(10/100*Xth) = K_{th} **[1st 2 @30% & and rest are by @10%]**			**Ratio between Full Length Loss and 1/3 Length Loss by**		
				K_{th-1}	+(10/100 *Xth)	Kth	ETAP	Analog	Correct value of Kth
1.	5/41=.12	0< 0.5	0/.5=0	1	0	1.0	1.0000	1.00	1.0
2.	7/12=.58	0 .5< 1.5	1/.5=2	1	.6	1.6	1.6000	1.33	1.30
3.	18/12=1.5	1.5< 3.0	1.5/1=1.5	1.6	.15	1.75	1.7500	1.05	1.50
4.	38/12=3.16	3.0<4.5	3.5/2.5=1.4	1.76	.14	1.99	1.8833	1.91	1.65
5.	43/11=3.90	4.5< 6.0	5/3.5=1.43	1.9	.143	2.133	2.0083	1.58	1.783
6.	31/5=6.2	6.0<7.5	6.5/5=1.3	2.04	.13	2.263	2.1283	2.06	1.902
7.	88/12=7.33	7.5 < 9.0	8.5/6.5=1.31	2.17	.131	2.394	2.2450	1.719	2.028
8.	36/4=9.0	9.0<10.5	10/8.5=1.18	2.301	.118	2.511	.3593	2.25	2.145
9.	33/3=11.0	10.5< 12.0	11.5/10=1.15	2.42	.115	2.626	2.4718	2.21	2.259
10.	48/4=12.0	12.0<13.5	12.5/11.5=1.09	2.535	.109	2.735	2.5829	1.88	2.371
11.	52/4=13.0	13.5<15.0	14/12.5=1.12	2.64	.112	2.847	2.6929	2.125	2.482
12.	60/4=15.0	15<16.5	15/12.5=1.2	2.76	.12	2.967	2.8020	1.65	2.593
13.	48/3=16.0	16.5<18.0	16.5/15=1.1	2.88	.11	2.978	2.9103	1.288	2.702
14.	51/3=17.0	18.0<19.5	18.5/16.5=1.12	2.99	.112	3.090	3.0180	2.095	2.81

Note:

a. X_{th} is the load ratio between 2nd half load and 1st half load of the same section

b. In finding out the X_{th} of a section the load ratios of two sections of same feeder are related with this figure

c. K_{th} is the multiplying factor to eliminate the loss result variation between full length and 1/3 length

d. K_{th-1} is the previous value of K_{th}. It is known after devising all values of K_{th} which can be seen at the upper part of the table.

3.8 Different cases of calculation, analysis and simulation results

EXAMPLE-1

It is a simple example carrying maximum load within first half of the feeder. Here the load ration between first half and second half is less than one. The loss considering the 1/3 ratio will be same as the loss with that of calculating loss for full length of the feeder that exists.

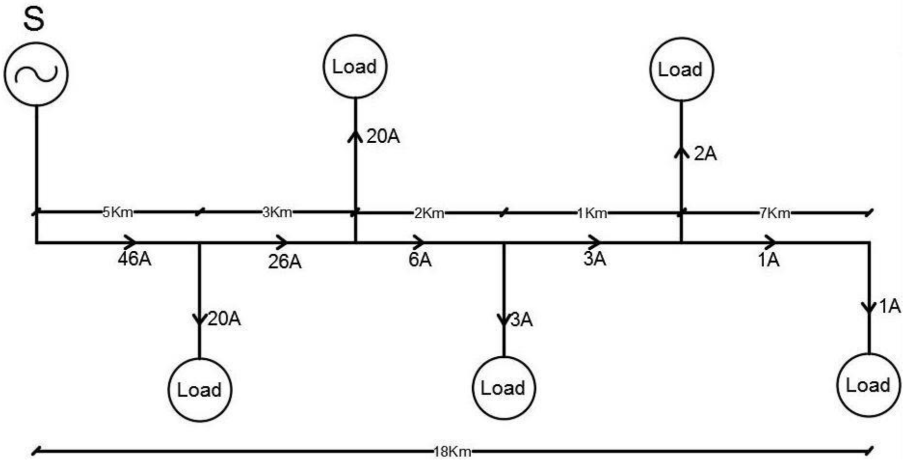


Fig 3.4: SLD of Example-1

Loss Factor (14) = [(Load Factor) ² × 0.85]+(Load Factor× 0.15)

$=(0.62^2 \times 0.85) + (0.62 \times 0.15)$

$=0.42$

Total Length $= 18Km$

Resistance $= 1\Omega/Km$

Load duration $=24Hours$

$\frac{1}{3}\ Length = 6Km$

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ

$$Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$$

$$= \{(46^2 \times 5) + (26^2 \times 3) + (6^2 \times 2) + (3^2 \times 1) + (1^2 \times 7)\} \times \frac{(3 \times 0.42 \times 24)}{1000}$$

$$= (10580 + 2028 + 72 + 9 + 7) \times 0.03024$$

$$= 12696 \times 0.03024\ Kwh$$

$$= 383.93 \simeq 384\ Kwh$$

In $\frac{1}{3}$ $Length$ System $Kwh/day = (I^2R/Km) \times \frac{(3 \times L_3F \times Load\ duration)}{1000}$

$$= (46^2 \times 6) \times 0.03024\ Kwh$$
$$= 12696 \times 0.03024$$
$$= 384Kwh$$

[Considering almost 46 amps is flowing up to 6 Km.]

Loss difference ratio $= \frac{(Real\ loss)}{(1/3\ System\ loss)}$

$$= \frac{384}{384}$$
$$= 1$$

We anticipated the loss for total length and up to 1/3 length for a balanced feeder is almost same.

Now we check the load ratio between 2nd half and 1st half.

We See from the feeder that Load ratio, C= $2nd\ half\ load/\ 1st\ half\ load$ = 6/40 = 0.15

So if load ratio as stated above is less than 1,

Then correction factor "K" = 1.00

By multiplying 1/3 by K, we get loss 384 KWh

ETAP Simulation Result:

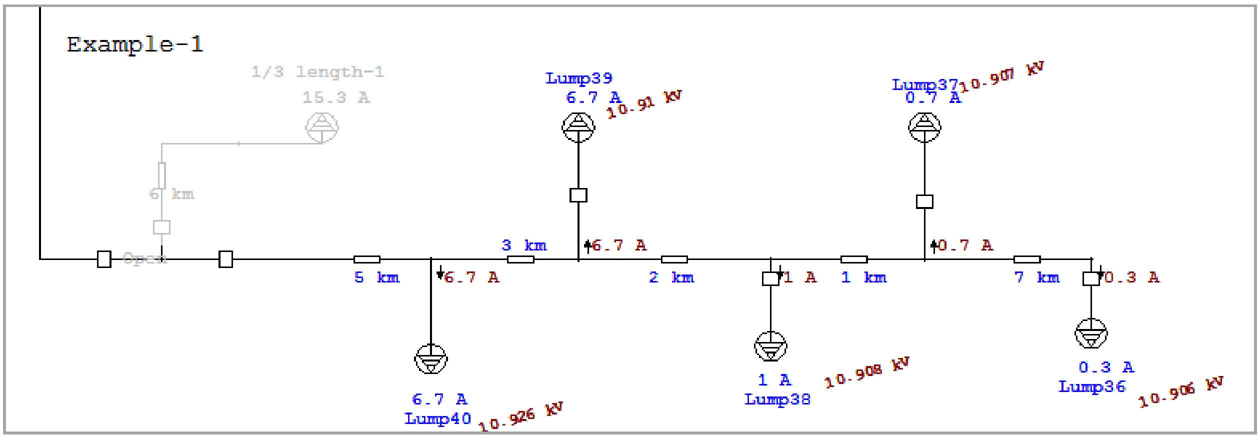
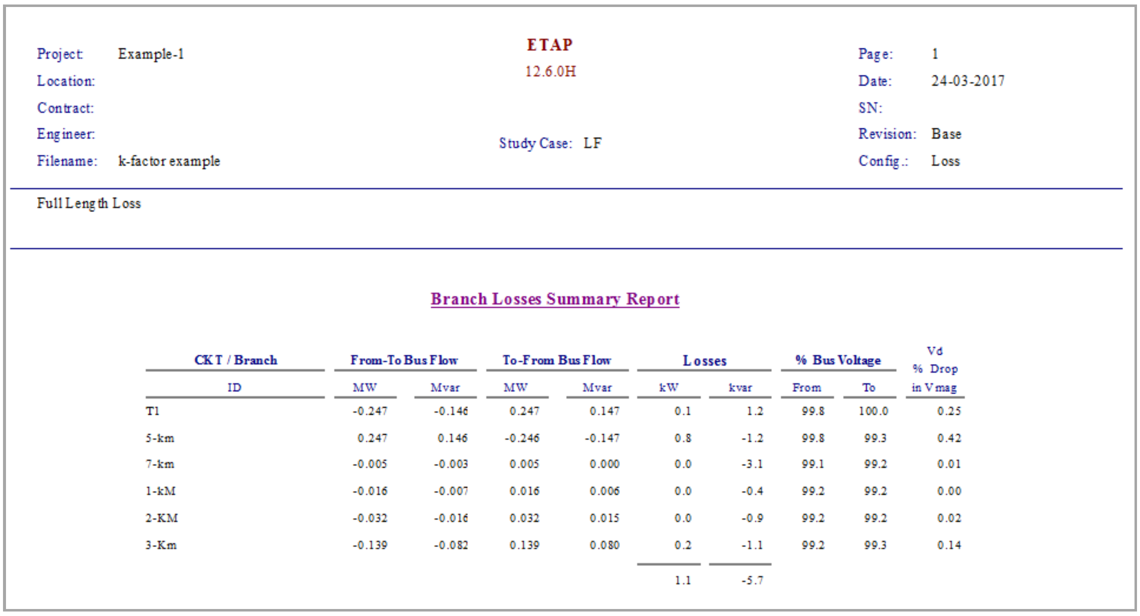


Fig 3.5: Full length Load Flow Analysis of Example-1



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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.247	-0.146	0.247	0.147	0.1	1.2	99.8	100.0	0.25
5-km	0.247	0.146	-0.246	-0.147	0.8	-1.2	99.8	99.3	0.42
7-km	-0.005	-0.003	0.005	0.000	0.0	-3.1	99.1	99.2	0.01
1-kM	-0.016	-0.007	0.016	0.006	0.0	-0.4	99.2	99.2	0.00
2-KM	-0.032	-0.016	0.032	0.015	0.0	-0.9	99.2	99.2	0.02
3-Km	-0.139	-0.082	0.139	0.080	0.2	-1.1	99.2	99.3	0.14
					1.1	-5.7			

Fig 3.6: Full length Loss Report of Example-1

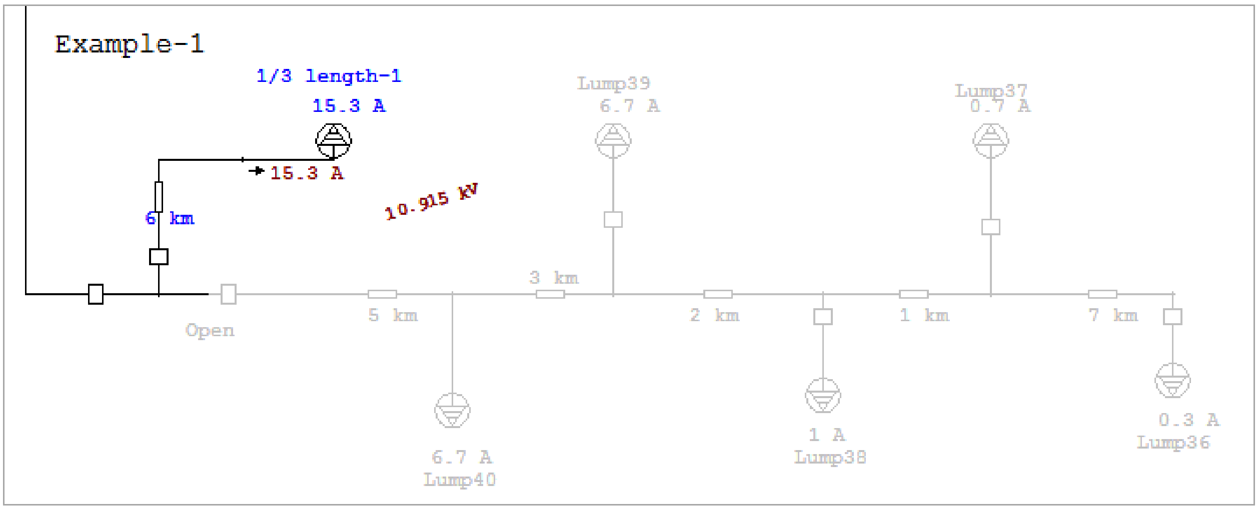
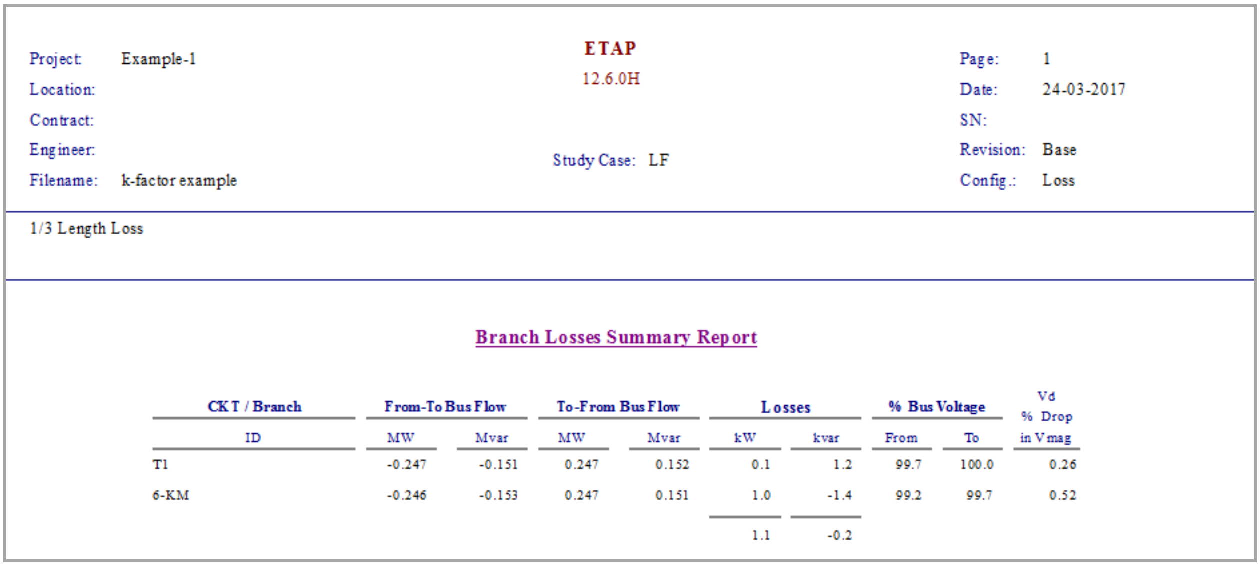


Fig 3.7: 1/3 length Load Flow Analysis of Example-1



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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.247	-0.151	0.247	0.152	0.1	1.2	99.7	100.0	0.26
6-KM	-0.246	-0.153	0.247	0.151	1.0	-1.4	99.2	99.7	0.52
					1.1	-0.2			

Fig 3.8: 1/3 length Loss Report of Example-1

$$\text{Loss Ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)}$$

$$= 1.1/1.1$$

$$= 1$$

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-2

It is a simple example carrying maximum load within first half of the feeder. Here the load ration between first half and second half is less than one. The loss considering the 1/3 ratio will be same as the loss with that of calculating loss for full length of the feeder that exists.

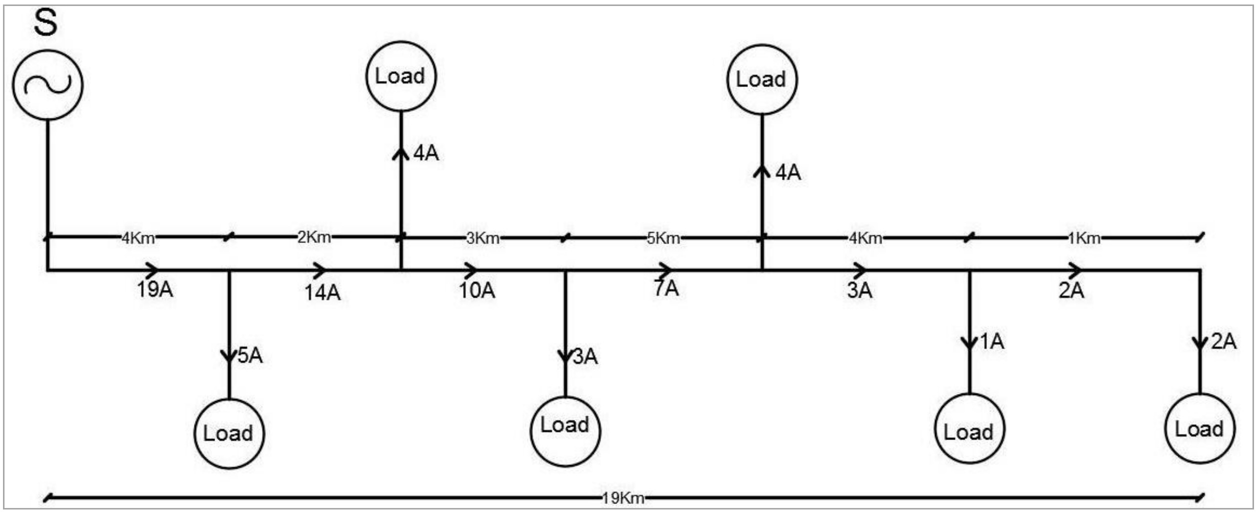


Fig 3.9: SLD of Example-2

Loss Factor $=0.42$
Total Length $= 19Km$
Resistance $= 1\Omega/\text{Km}$
Load duration $=24Hours$
$\frac{1}{3}\ Length = 6.33Km$

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ

$$Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$$

$$= \{(19^2 \times 4) + (14^2 \times 2) + (10^2 \times 3) + (7^2 \times 5) + (3^2 \times 4) + (2^2 \times 1)\} \times \frac{(3 \times 0.42 \times 24)}{1000}$$

$$= 2421 \times 0.03024$$

$$= 73.21\ Kwh$$

$$\simeq 73Kwh$$

In $\frac{1}{3}\ Length$ System$Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$

$$= (19^2 \times 6.33) \times 0.03024Kwh$$

$$= 2285.13 \times 0.03024\ Kwh$$

$$= 69Kwh$$

[Considering almost 19 amps is flowing up to 6.33 Km.]

Loss difference ratio $= \frac{(Real\ loss)}{(1/3\ System\ loss)}$

$$= \frac{73}{69}$$

$= 1.05$

Load ratio, C= $2nd\ half\ load/\ 1st\ half\ load$= 6/13 = 0.46
So if load ratio as stated above is 0.0 to 1.0,
Then correction factor “K” = 1.00
By multiplying 1/3 by K, we get loss 69 KWh

Etap Simulation Result:

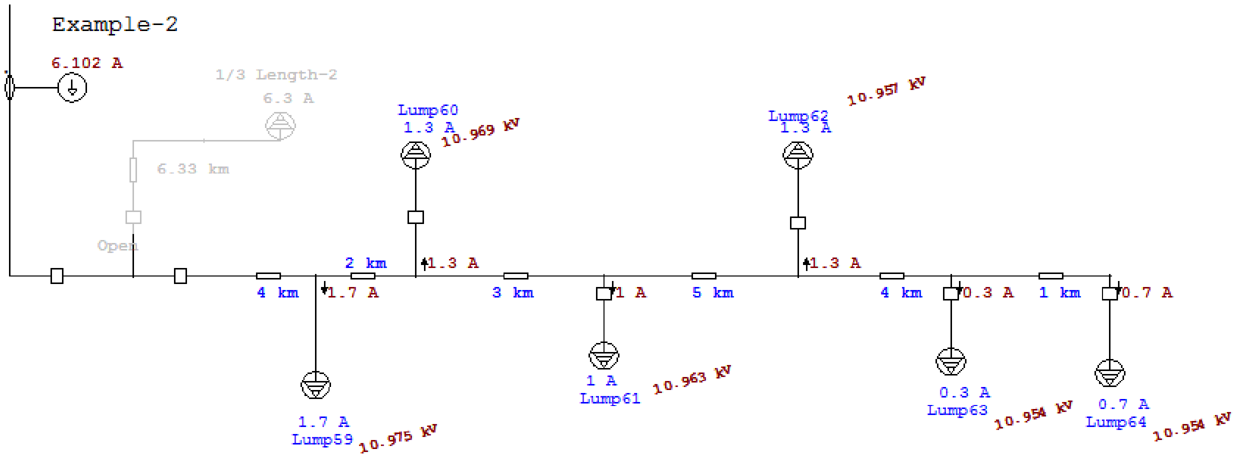
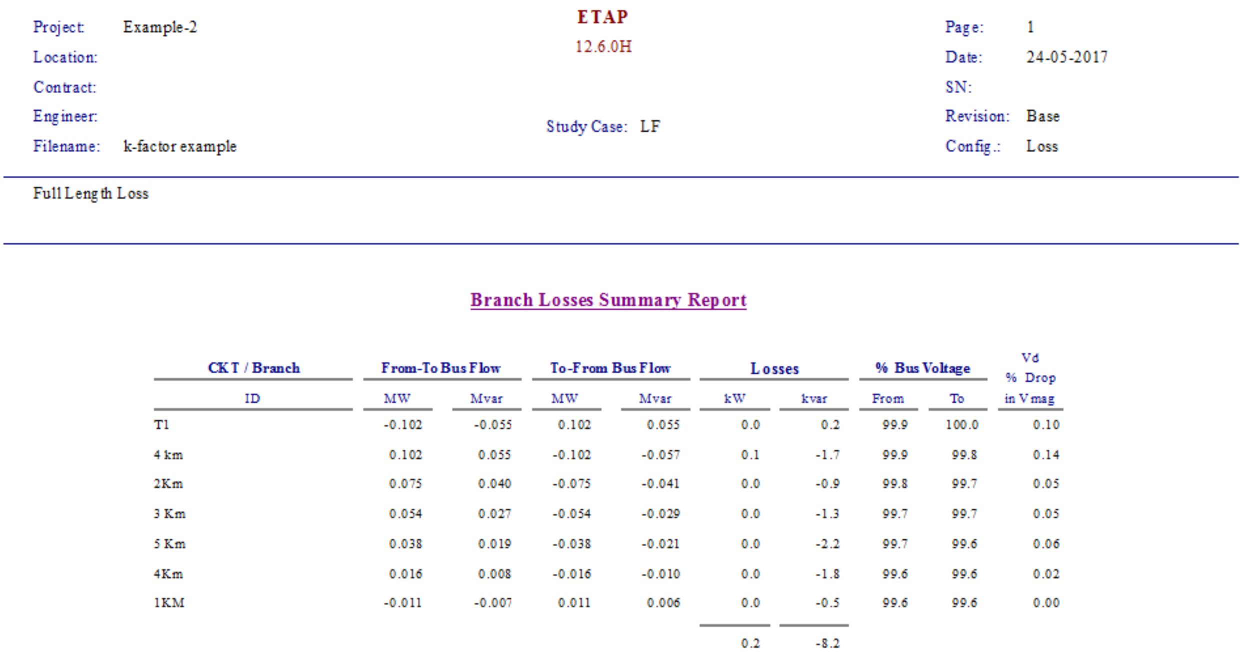


Fig 3.10: Full length Load Flow Analysis of Example-2



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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.102	-0.055	0.102	0.055	0.0	0.2	99.9	100.0	0.10
4 km	0.102	0.055	-0.102	-0.057	0.1	-1.7	99.9	99.8	0.14
2Km	0.075	0.040	-0.075	-0.041	0.0	-0.9	99.8	99.7	0.05
3 Km	0.054	0.027	-0.054	-0.029	0.0	-1.3	99.7	99.7	0.05
5 Km	0.038	0.019	-0.038	-0.021	0.0	-2.2	99.7	99.6	0.06
4Km	0.016	0.008	-0.016	-0.010	0.0	-1.8	99.6	99.6	0.02
1KM	-0.011	-0.007	0.011	0.006	0.0	-0.5	99.6	99.6	0.00
					0.2	-8.2			

Fig 3.11: Full length Loss Report of Example-2

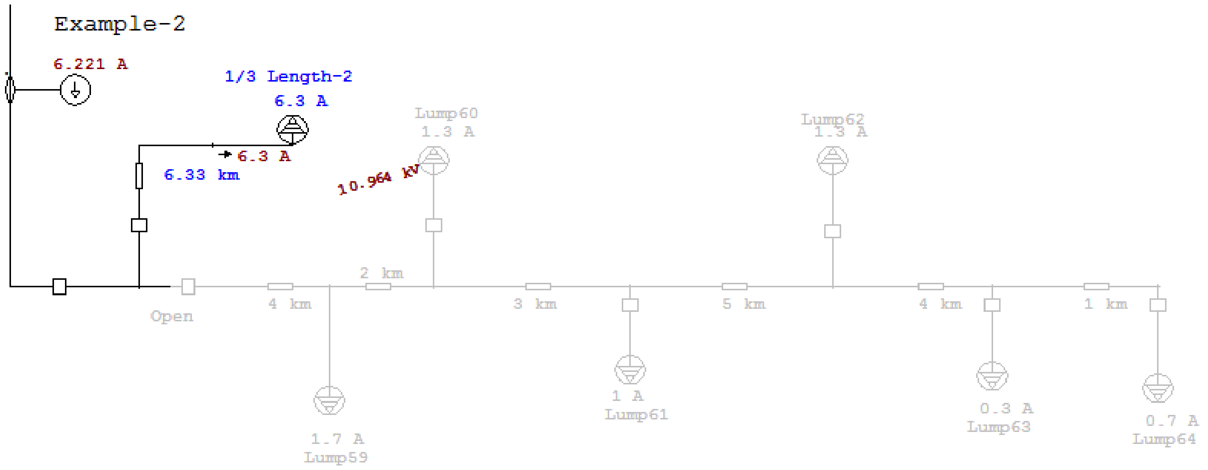
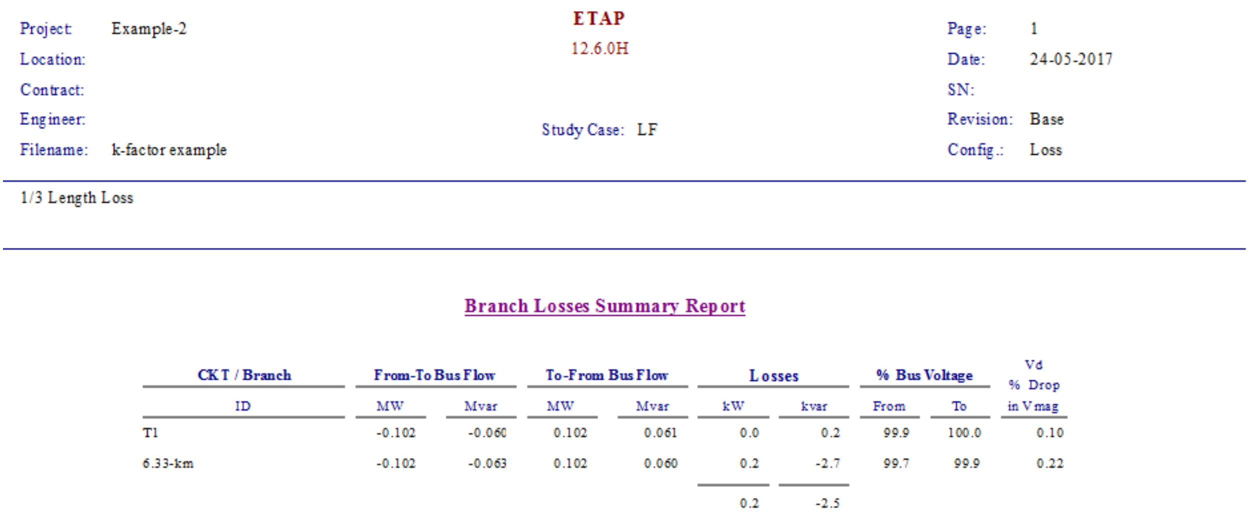


Fig 3.12: 1/3 length Load Flow Analysis of Example-2



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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.102	-0.060	0.102	0.061	0.0	0.2	99.9	100.0	0.10
6.33-km	-0.102	-0.063	0.102	0.060	0.2	-2.7	99.7	99.9	0.22
					0.2	-2.5			

Fig 3.13: 1/3 length Loss Report of Example-2

$$\text{Loss Ratio} = \frac{(\mathit{Real\ loss})}{(1/3\ \mathit{System\ loss})}$$

$$=0.2/0.2$$

$$=1$$

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-3

It is a simple example carrying maximum load within first half of the feeder. Here the load ration between first half and second half is less than one. The loss considering the 1/3 ratio will be same as the loss with that of calculating loss for full length of the feeder that exists.

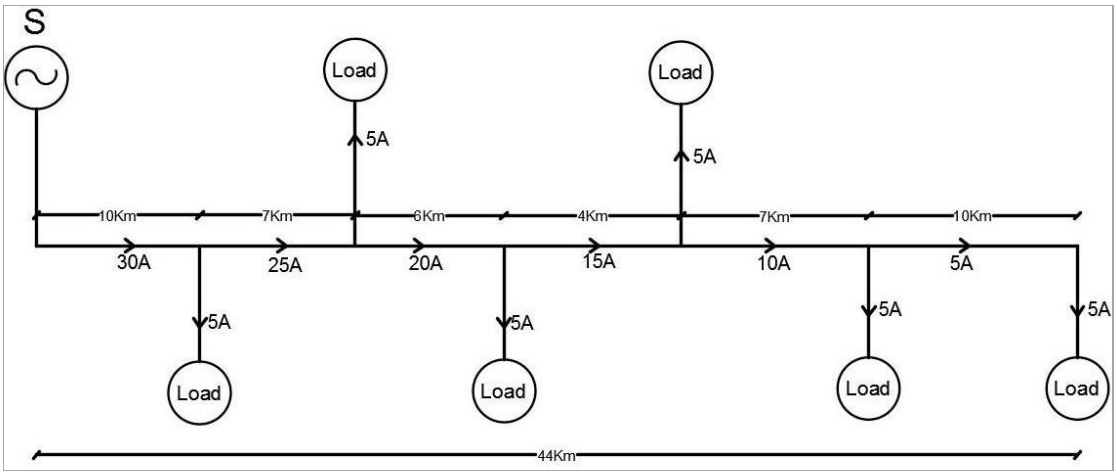


Fig 3.14: SLD of Example-3

Loss Factor $=0.42$
Total Length $= 44Km$
Resistance $= 1\Omega/\mathrm{Km}$
Load duration $=24 Hours$
$\frac{1}{3}\ Length = 14.67Km$

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ

$$Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$$

$$= \{(30^2 \times 10) + (25^2 \times 7) + (20^2 \times 6) + (15^2 \times 4) + (10^2 \times 7) + (5^2 \times 10)\} \times \frac{(3 \times 0.42 \times 24)}{1000}$$

$$= 17625 \times 0.03024\ Kwh$$

$$= 532.98$$

$$\simeq 533\ Kwh$$

In $\frac{1}{3}\ Length$ System $Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$

$$= (30^2 \times 14.67) \times 0.03024 Kwh$$

$$= 13203 \times 0.03024\ Kwh$$

$$= 399 Kwh$$

[Considering almost 30 amps is flowing up to 14.67 Km.]

$$\text{Loss difference ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)} = \frac{533}{399}$$

$= 1.33$

Load ratio, C= $2nd\ half\ load/\ 1st\ half\ load$= 18/12 = 1.5

So if load ratio as stated above is .5 to 1.0,

Then correction factor “K” = 1.30

By multiplying 1/3 by K, we get loss 518 KWh

Etap Simulation Result:

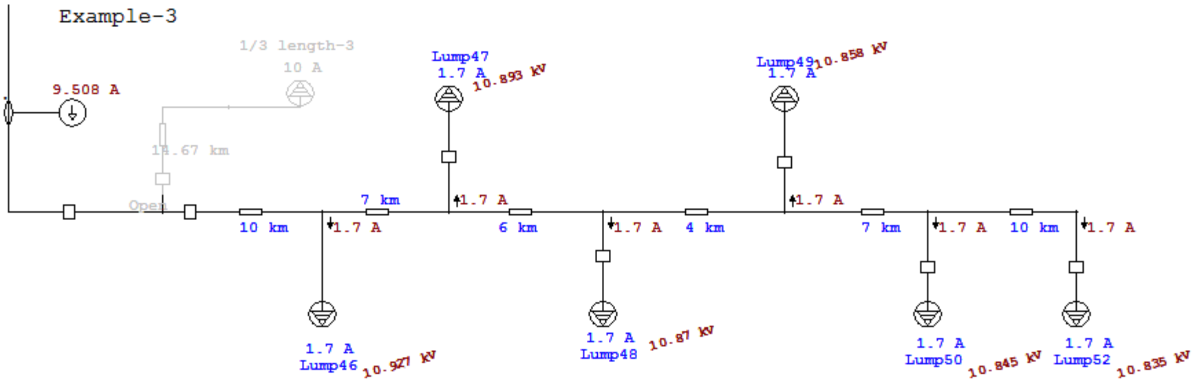
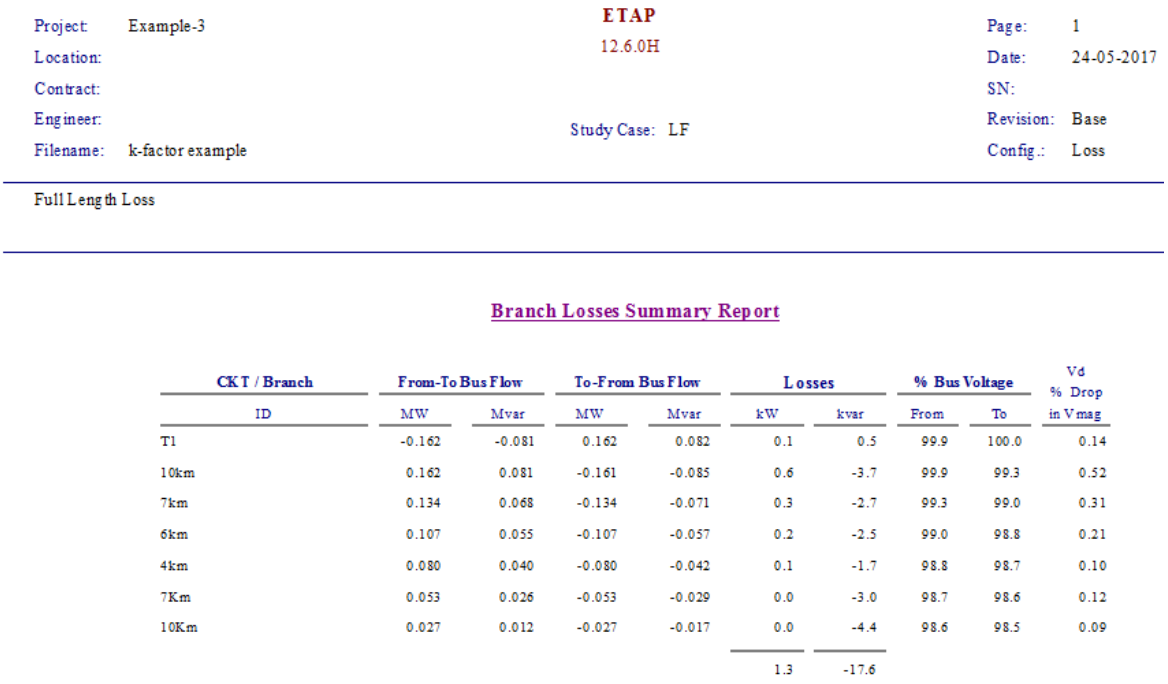


Fig 3.15: Full length Load Flow Analysis of Example-3



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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.162	-0.081	0.162	0.082	0.1	0.5	99.9	100.0	0.14
10km	0.162	0.081	-0.161	-0.085	0.6	-3.7	99.9	99.3	0.52
7km	0.134	0.068	-0.134	-0.071	0.3	-2.7	99.3	99.0	0.31
6km	0.107	0.055	-0.107	-0.057	0.2	-2.5	99.0	98.8	0.21
4km	0.080	0.040	-0.080	-0.042	0.1	-1.7	98.8	98.7	0.10
7Km	0.053	0.026	-0.053	-0.029	0.0	-3.0	98.7	98.6	0.12
10Km	0.027	0.012	-0.027	-0.017	0.0	-4.4	98.6	98.5	0.09
					1.3	-17.6			

Fig 3.16: Full length Loss Report of Example-3

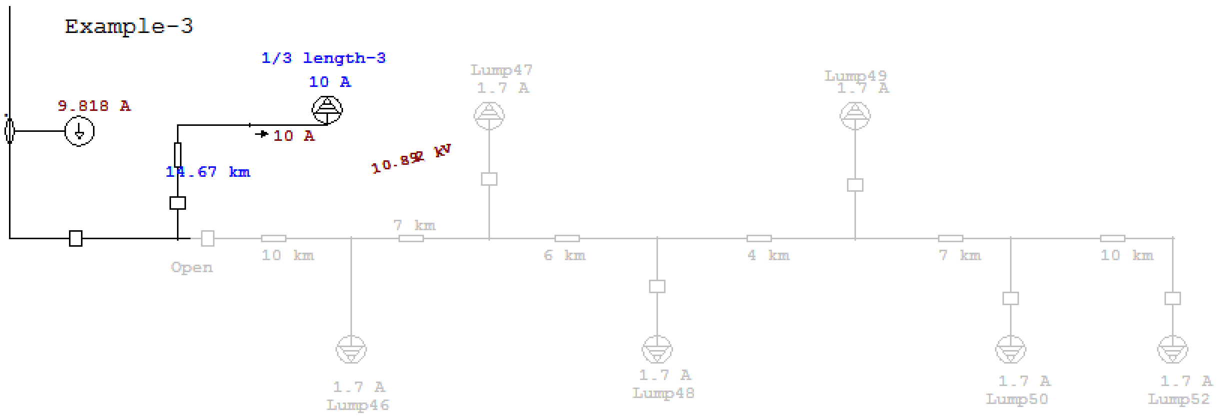
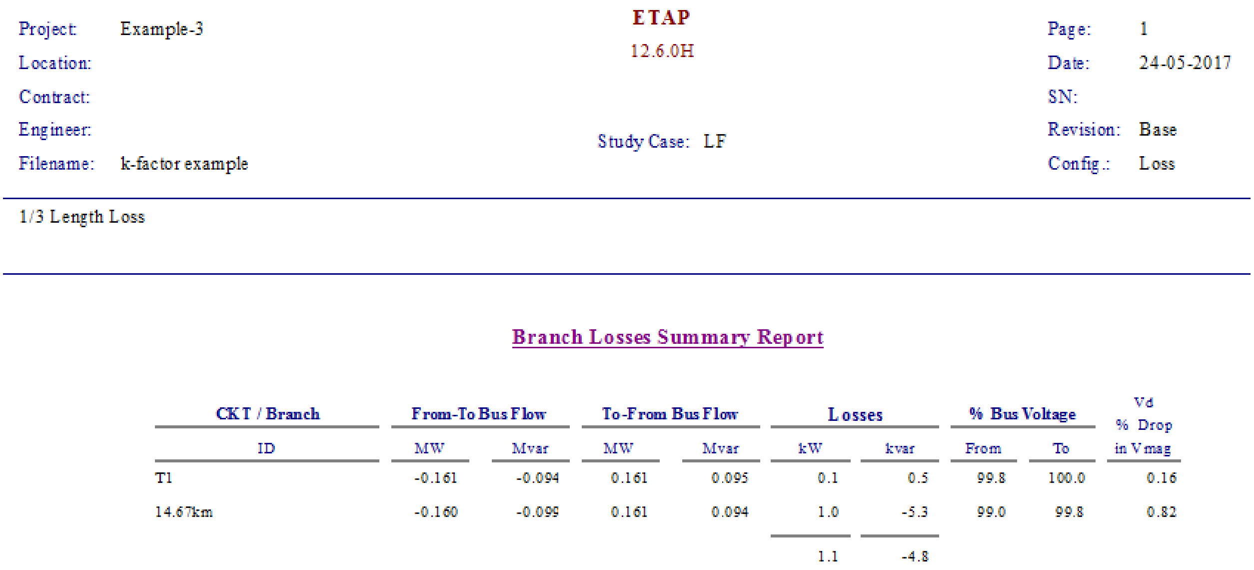


Fig 3.17: 1/3 length Load Flow Analysis of Example-3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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.161	-0.094	0.161	0.095	0.1	0.5	99.8	100.0	0.16
14.67km	-0.160	-0.099	0.161	0.094	1.0	-5.3	99.0	99.8	0.82
					1.1	-4.8			

Fig 3.18: 1/3length Loss Report of Example-3

$$\text{Loss Ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)}$$

=1.3/1.1

=1.18

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-4

It is a complex example carrying maximum load within second half of the feeder. Here the load ration between first half and second half is more than one. The loss considering the 1/3 ratio needs to be multiplied by K factor to get the loss for full length of feeder that exists.

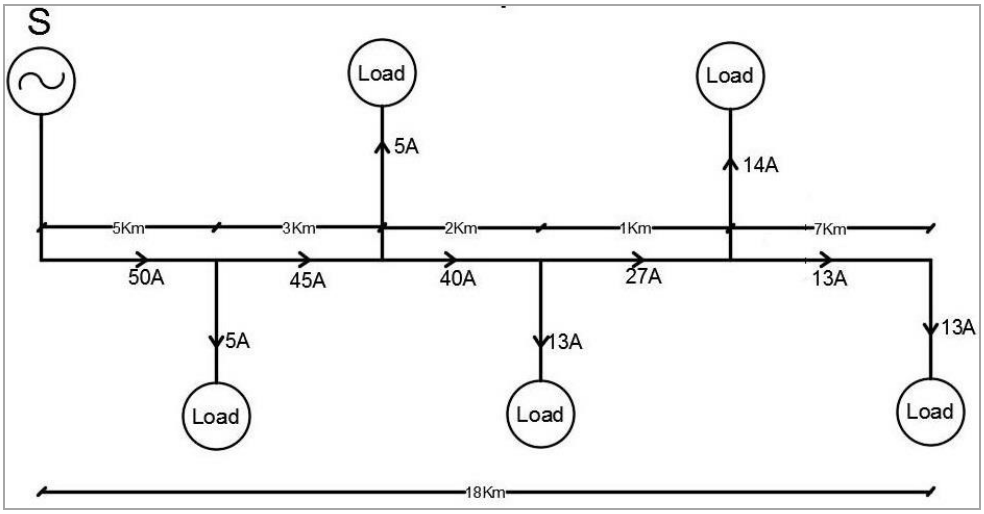


Fig 3.19: SLD of Example-4

Loss Factor $=0.42$

Total Length $= 18Km$

Resistance $= 1\Omega/Km$

Load duration $=24 Hours$

$\frac{1}{3}\ Length = 6Km$

[;

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ

$$Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$$
$$= 23687 \times 0.03024$$
$$= 716.29Kwh$$

In $\frac{1}{3}\ Length$ System $Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$

$$= (50^2 \times 6) \times 0.03024Kwh$$
$$= 15000 \times 0.03024\ Kwh$$
$$= 453.6Kwh$$

[Considering almost 50 amps is flowing up to 6 Km.]

Loss difference ratio = $\frac{(Real\ loss)}{(1/3\ System\ loss)}$

$= \frac{716.29}{453.6}$

$= 1.58$

Load ratio, C= $2nd\ half\ load/\ 1st\ half\ load$ = 40/10 = 4

So if load ratio as stated above is 3.0 to 4.5,
Then correction factor “K” = 1.54
By multiplying 1/3 by K, we get loss 697 KWh

<u>Etap Simulation Result:</u>

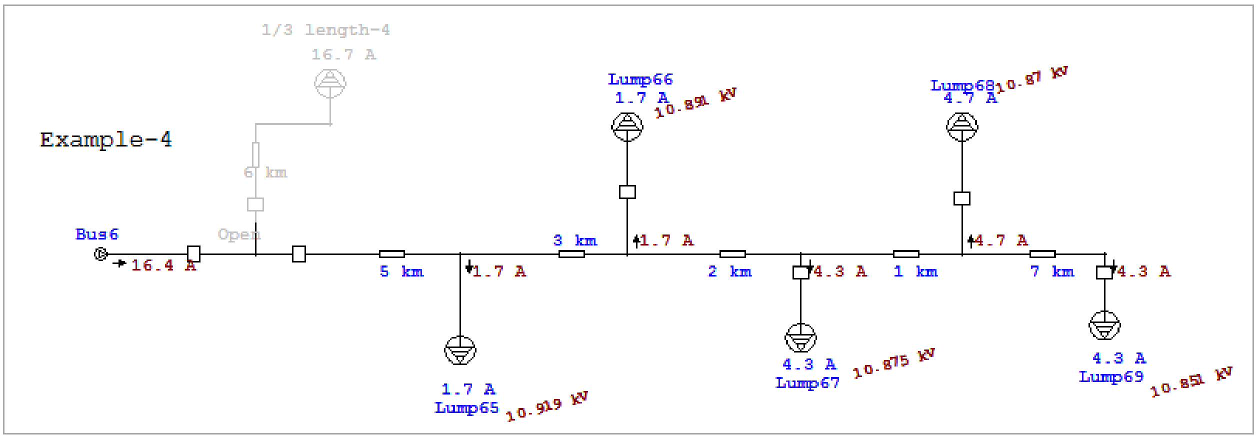
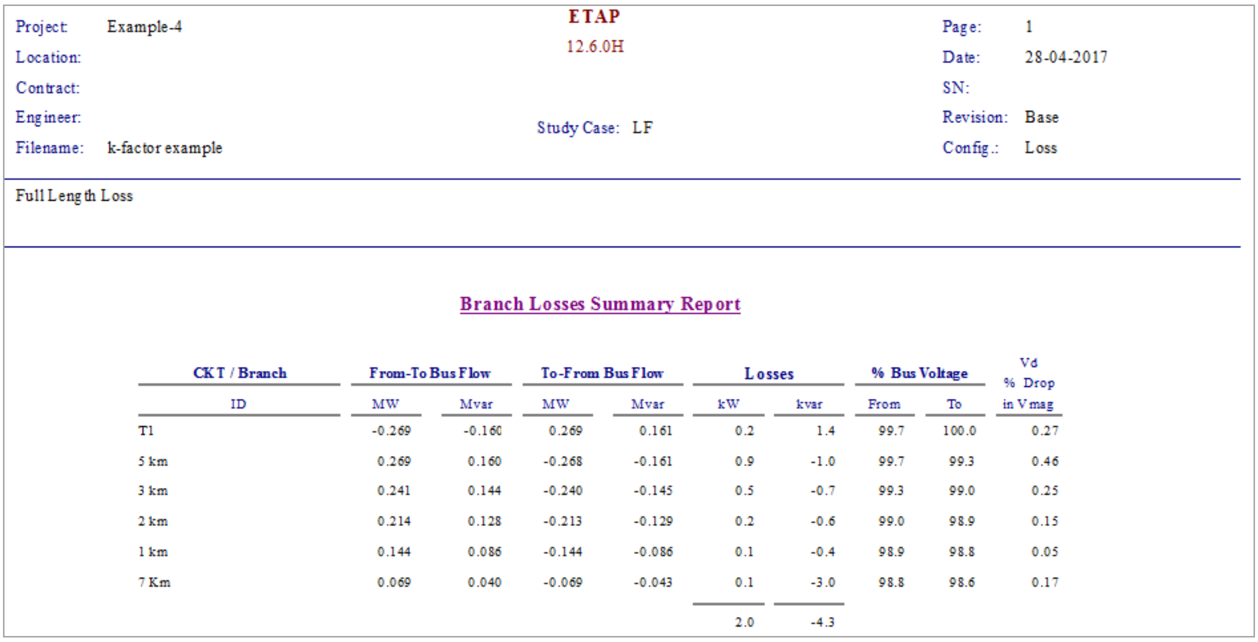


Fig 3.20: Full length Load Flow Analysis of Example-4



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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop in Vmag
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	
T1	-0.269	-0.160	0.269	0.161	0.2	1.4	99.7	100.0	0.27
5 km	0.269	0.160	-0.268	-0.161	0.9	-1.0	99.7	99.3	0.46
3 km	0.241	0.144	-0.240	-0.145	0.5	-0.7	99.3	99.0	0.25
2 km	0.214	0.128	-0.213	-0.129	0.2	-0.6	99.0	98.9	0.15
1 km	0.144	0.086	-0.144	-0.086	0.1	-0.4	98.9	98.8	0.05
7 Km	0.069	0.040	-0.069	-0.043	0.1	-3.0	98.8	98.6	0.17
					2.0	-4.3			

Fig 3.21: Ful length Loss Report of Example-4

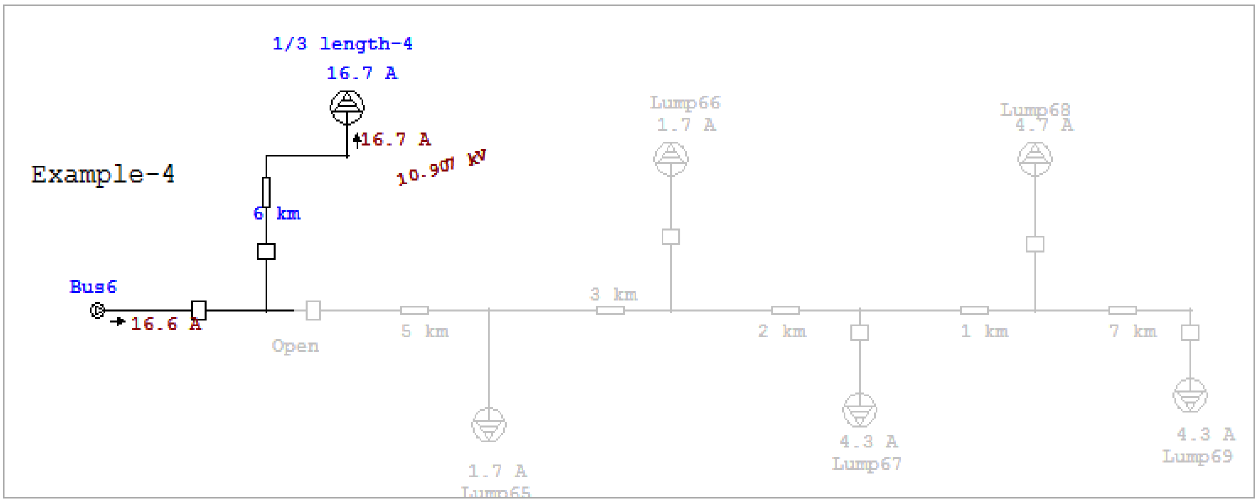
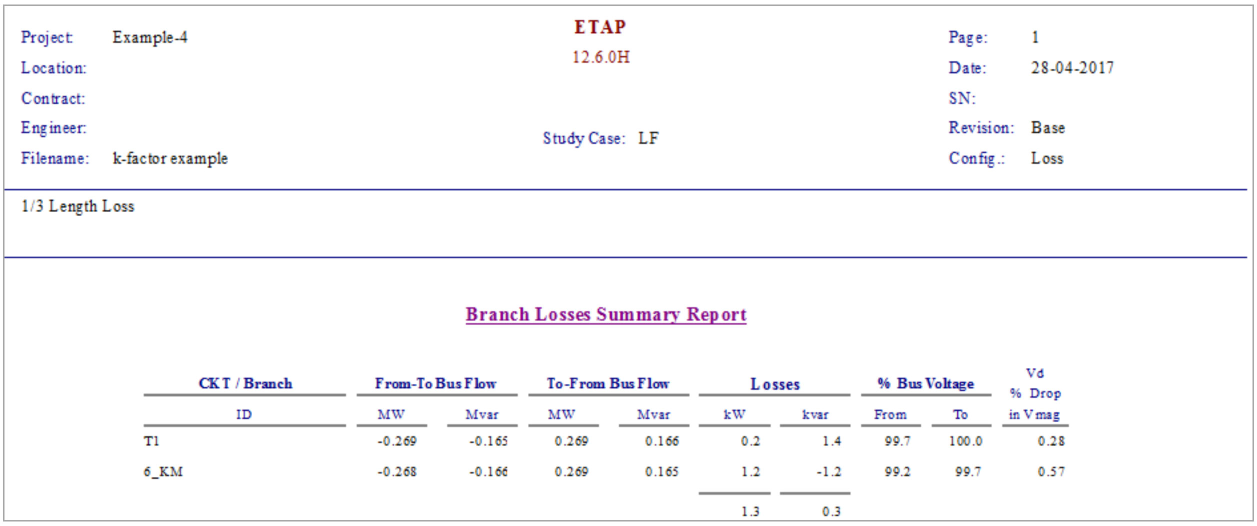


Fig 3.22: 1/3 length Load Flow Analysis of Example-4



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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.269	-0.165	0.269	0.166	0.2	1.4	99.7	100.0	0.28
6_KM	-0.268	-0.166	0.269	0.165	1.2	-1.2	99.2	99.7	0.57
					1.3	0.3			

Fig 3.23: 1/3length Loss Report of Example-4

$$\text{Loss Ratio} = \frac{(\mathit{Real\ loss})}{(1/3\ \mathit{System\ loss})}$$

$$= 2.0/1.3 \quad = 1.4$$

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-5

It is a complex example carrying maximum load within second half of the feeder. Here the load ration between first half and second half is more than one. The loss considering the 1/3 ratio needs to be multiplied by K factor to get the loss for full length of feeder that exists.

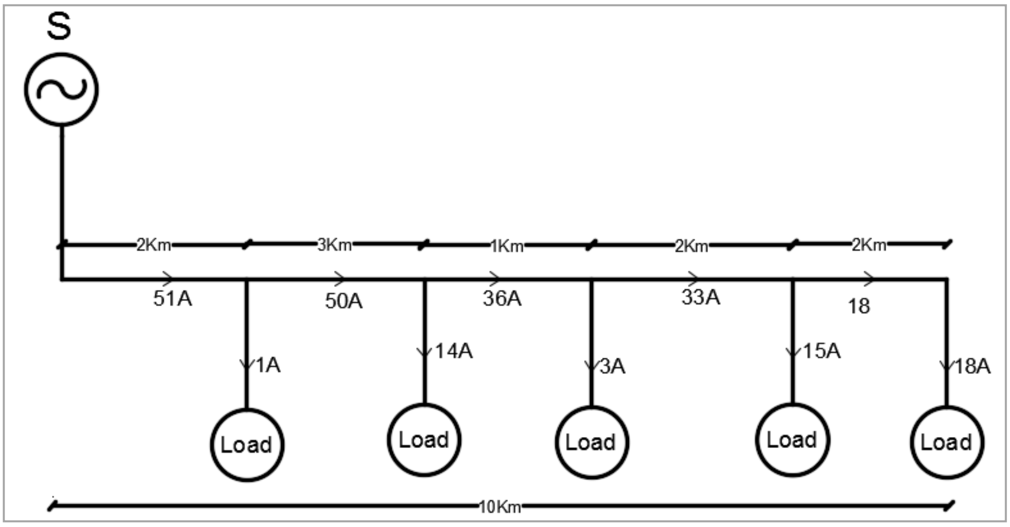


Fig 3.24: SLD of Example-5

Loss Factor = 0.24
Total Length = 10 Km.
Resistance = 1 ohms/Km.
Load duration = 24hours
1/3 length = 3.33 Km

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ,

KWh/day = $(I^2R/Km.\ x3xLsFxLx24h)\ /1000$

$= (51^2x2 + 55^2x3 + 41^2x1 + 37^2x2 + 22^2x2\ X\ (0.42x24x3)/1000$

= 595 KWh

In 1/3 length System = $51^2x5.33x3x.42x24/1000$ KWh/day

=418 KWh

Loss difference ratio = $\frac{(Real\ loss)}{(1/3\ System\ loss)}$

= 595/418

=1.43

Load ratio between 2nd half and 1st half. We
2nd half load/ 1st half load = 42/9 = 4.67
So if load ratio is 4.5 to 6.0
Then correction factor "K" = 1.683
By multiplying 1/3 by K, we get 703 KWh

Etap Simulation Result:

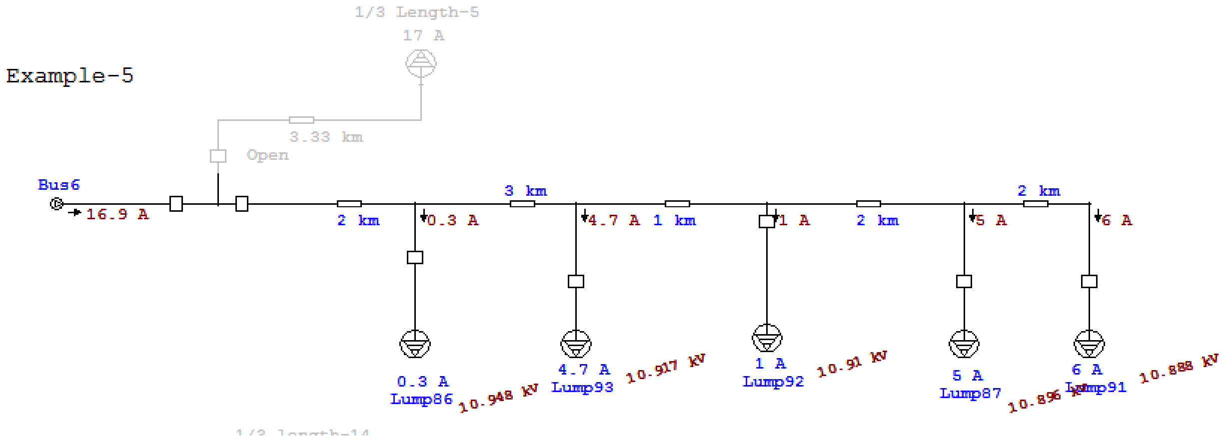
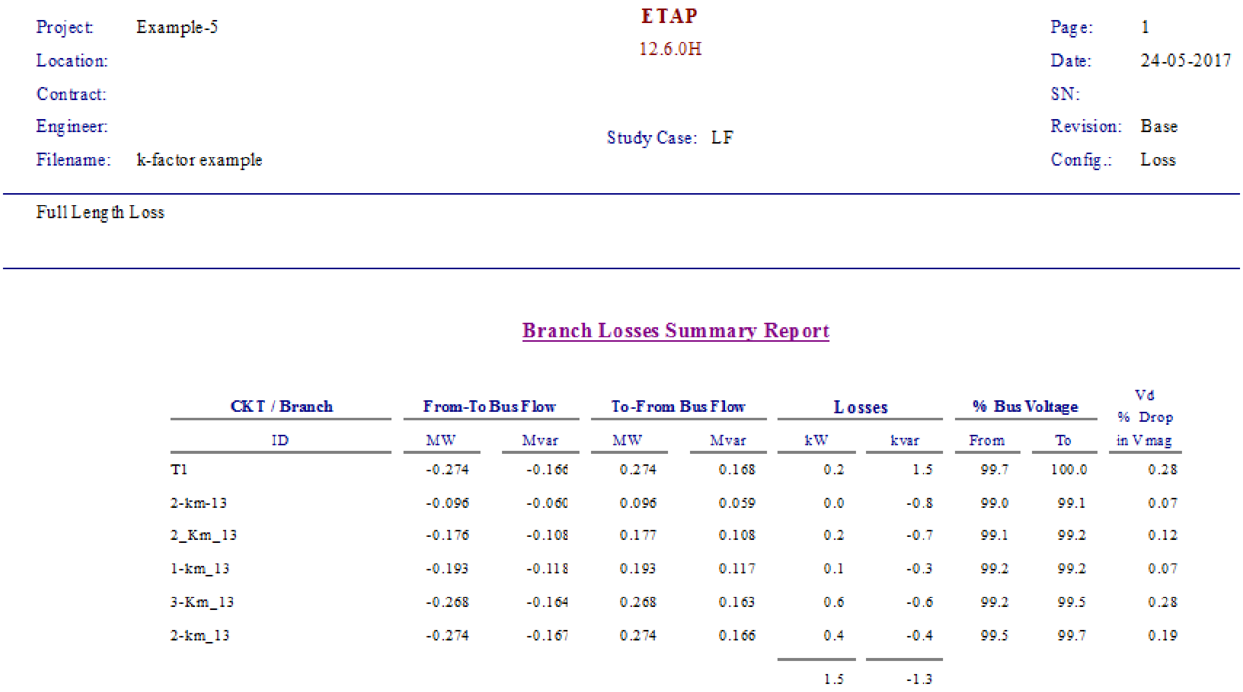


Fig 3.25: Full length Load Flow Analysis of Example-5



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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.274	-0.166	0.274	0.168	0.2	1.5	99.7	100.0	0.28
2-km-13	-0.096	-0.060	0.096	0.059	0.0	-0.8	99.0	99.1	0.07
2_Km_13	-0.176	-0.108	0.177	0.108	0.2	-0.7	99.1	99.2	0.12
1-km_13	-0.193	-0.118	0.193	0.117	0.1	-0.3	99.2	99.2	0.07
3-Km_13	-0.268	-0.164	0.268	0.163	0.6	-0.6	99.2	99.5	0.28
2-km_13	-0.274	-0.167	0.274	0.166	0.4	-0.4	99.5	99.7	0.19
					1.5	-1.3			

Fig 3.26: 1/3length Loss Report of Example-5

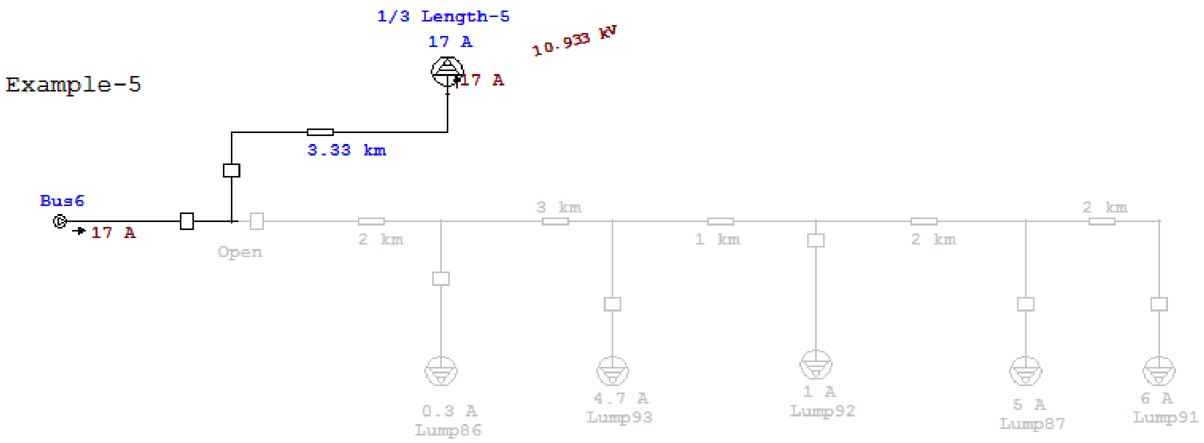
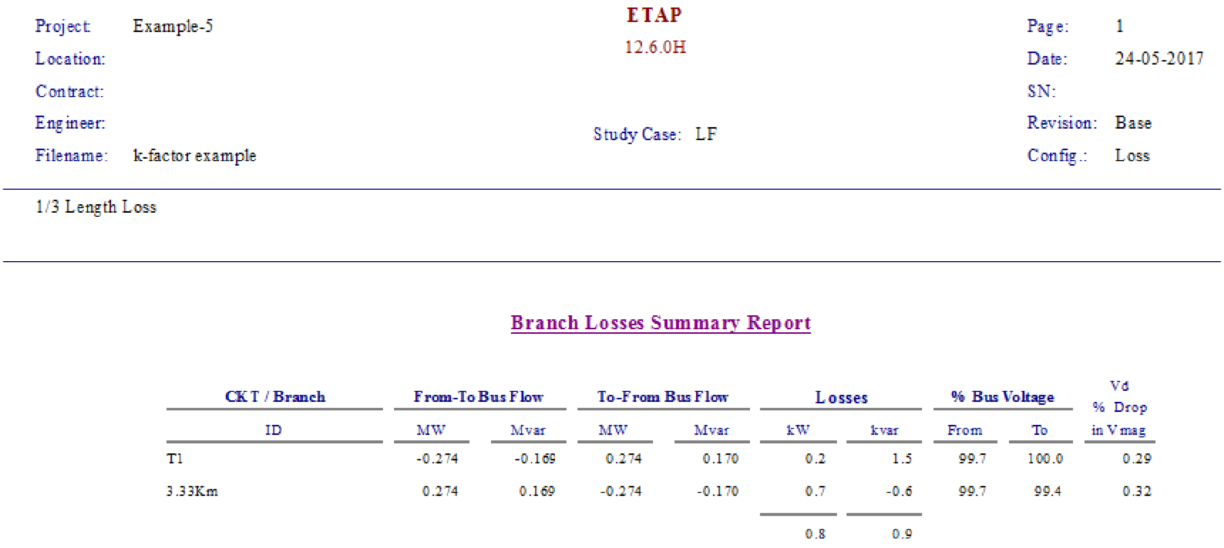


Fig 3.27: Full length Load Flow Analysis of Example-5



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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.274	-0.169	0.274	0.170	0.2	1.5	99.7	100.0	0.29
3.33Km	0.274	0.169	-0.274	-0.170	0.7	-0.6	99.7	99.4	0.32
					0.8	0.9			

Fig 3.28: 1/3length Loss Report of Example-4

$$\text{Loss Ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)}$$

=1.5/0.8

=1.87

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-6

It is a complex example carrying maximum load within second half of the feeder. Here the load ration between first half and second half is more than one. The loss considering the 1/3 ratio needs to be multiplied by K factor to get the loss for full length of feeder that exists.

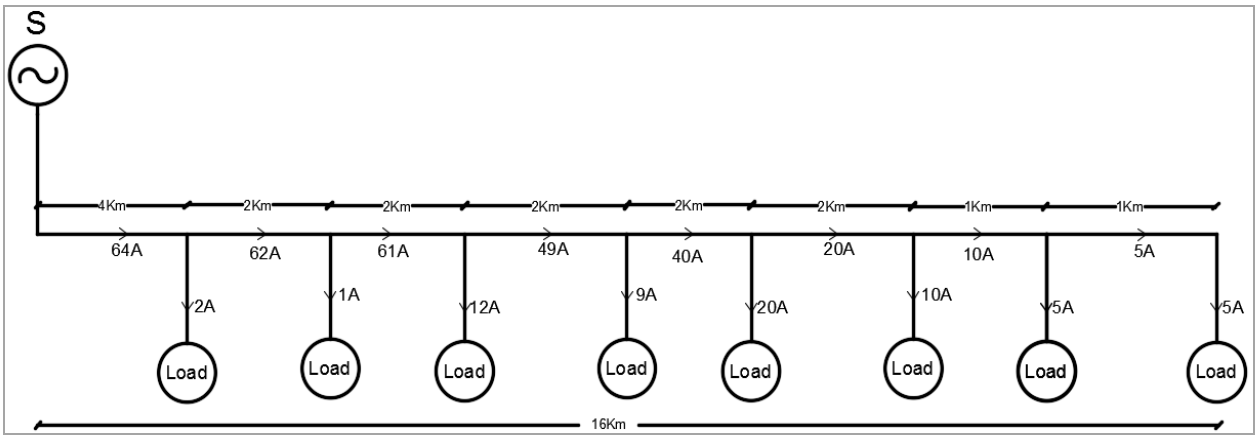


Fig 3.29: SLD of Example-6

Loss Factor = 0.24
Total Length = 16 Km.
Resistance = 1 ohms/Km.
Load duration = 24hours
1/3 length = 5.33 Km

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ,
KWh/day = (I^2R/Km. x3xLsFxLx24h) /1000
= (64^2x4 + 62^2x2 + 61^2x2 + 41^2x2 + 21^2x2 + 11^2x2 + 5^2x1+5^2x1 X (0.24x24x3)/1000
= 623 KWh

In 1/3 length System = 64^2X5.33x3x.24x24/1000 KWh/day
=377 KWh

Loss difference ratio = $\frac{(Real\ loss)}{(1/3\ System\ loss)}$
= 623/377
=1.65

Load ratio between 2nd half and 1st half. We
2nd half load/ 1st half load = 54/10 = 5.4
So if load ratio is 4.5 to 6.0
Then correction factor “K” = 1.683
By multiplying 1/3 by K, we get 634 KWh

Etap Simulation Result:

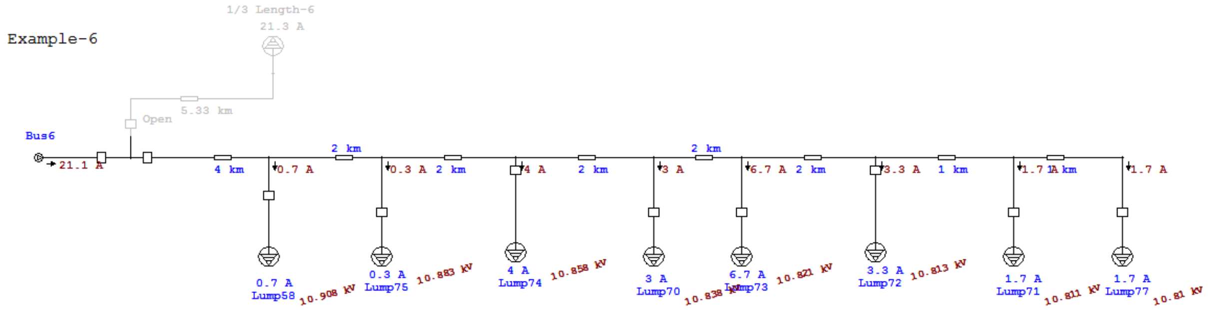
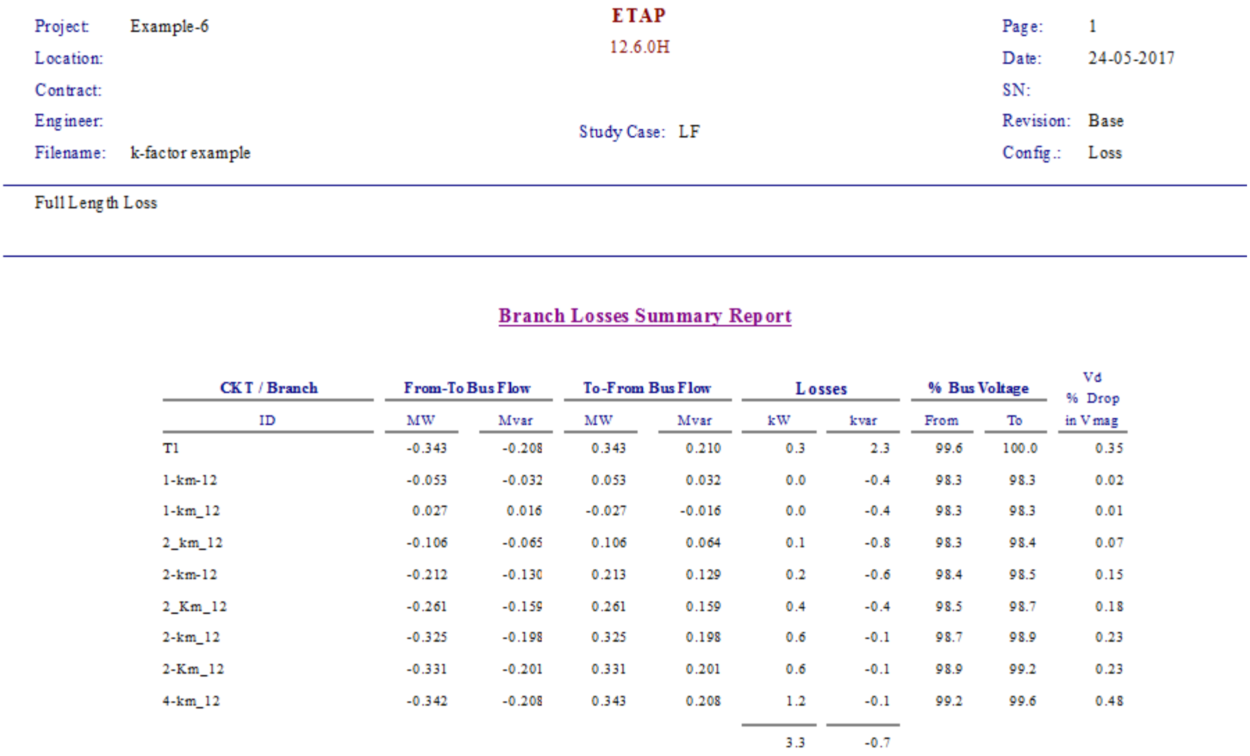


Fig 3.30: Full length Load Flow Analysis of Example-6



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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.343	-0.208	0.343	0.210	0.3	2.3	99.6	100.0	0.35
1-km-12	-0.053	-0.032	0.053	0.032	0.0	-0.4	98.3	98.3	0.02
1-km_12	0.027	0.016	-0.027	-0.016	0.0	-0.4	98.3	98.3	0.01
2_km_12	-0.106	-0.065	0.106	0.064	0.1	-0.8	98.3	98.4	0.07
2-km-12	-0.212	-0.130	0.213	0.129	0.2	-0.6	98.4	98.5	0.15
2_Km_12	-0.261	-0.159	0.261	0.159	0.4	-0.4	98.5	98.7	0.18
2-km_12	-0.325	-0.198	0.325	0.198	0.6	-0.1	98.7	98.9	0.23
2-Km_12	-0.331	-0.201	0.331	0.201	0.6	-0.1	98.9	99.2	0.23
4-km_12	-0.342	-0.208	0.343	0.208	1.2	-0.1	99.2	99.6	0.48
					3.3	-0.7			

Fig 3.31: Full Length Loss Report of Example-6

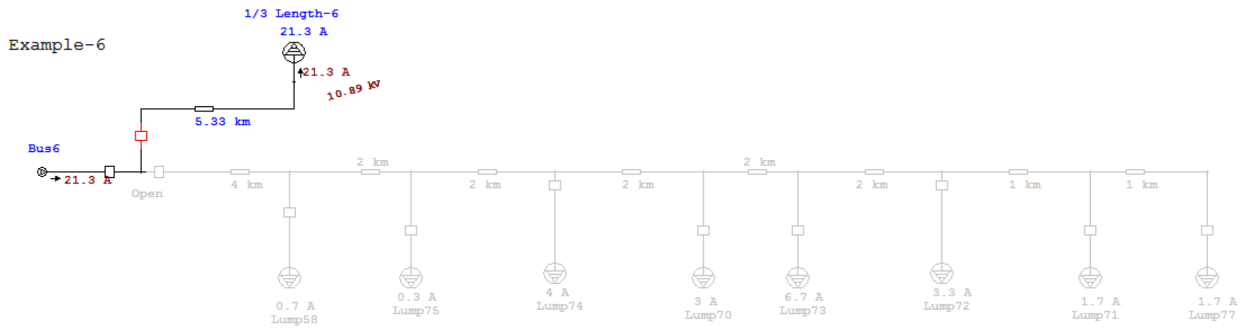
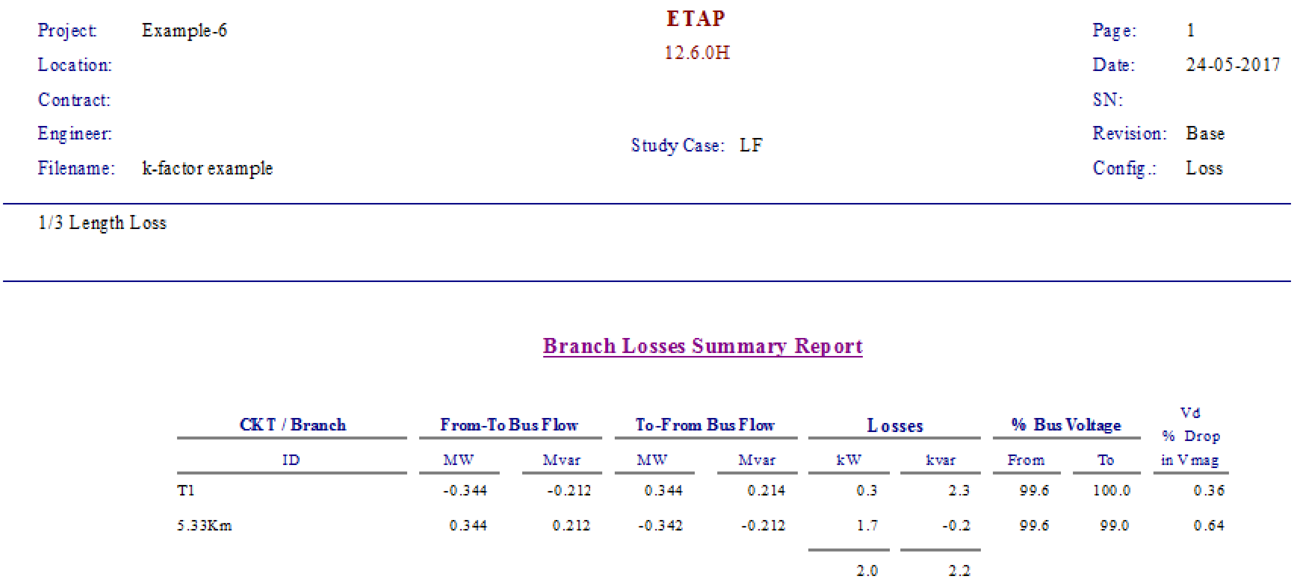


Fig 3.32: 1/3 length Load Flow Analysis of Example-6



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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.344	-0.212	0.344	0.214	0.3	2.3	99.6	100.0	0.36
5.33Km	0.344	0.212	-0.342	-0.212	1.7	-0.2	99.6	99.0	0.64
					2.0	2.2			

Fig 3.33: 1/3length Loss Report of Example-6

$$\text{Loss Ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)}$$
$$=3.3/2$$
$$=1.65$$

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-7

It is a complex example carrying maximum load within second half of the feeder. Here the load ration between first half and second half is more than one. The loss considering the 1/3 ratio needs to be multiplied by K factor to get the loss for full length of feeder that exists.

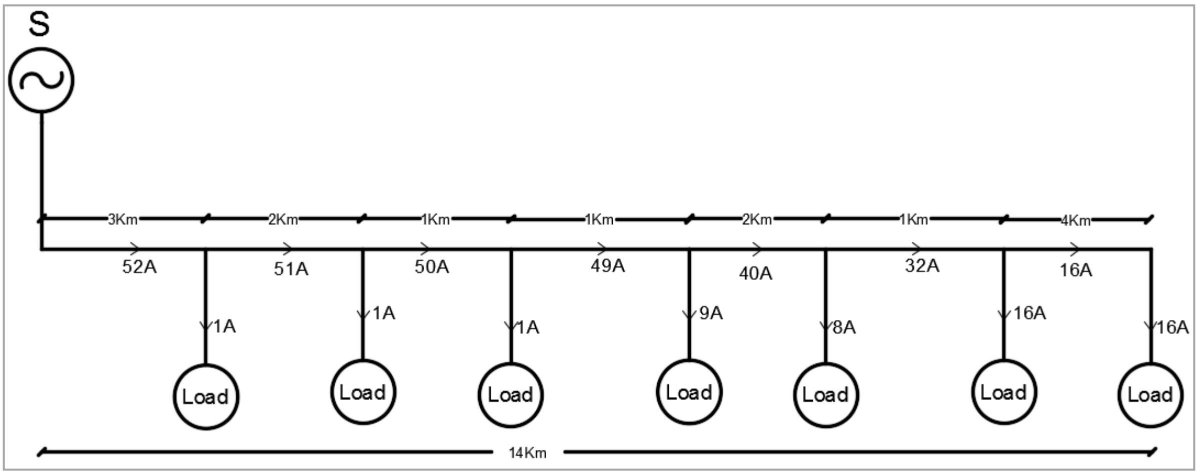


Fig 3.34: SLD of Example-7

Loss Factor = 0.24
Total Length = 14 Km.
Resistance = 1 ohms/Km.
Load duration = 24hours
1/3 length = 4.67 Km

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ,

$$\text{KWh/day} = (I^2R/\text{Km. } x3xLsFxLx24h)/1000$$
$$= (52^2x3 + 51^2x2 + 50^2x1 + 49^2x1 + 48^2x2 + 32^2x1 + 16^2x4X\ (0.24x24x3)/1000$$
$$= 721\ \text{KWh}$$

$$\text{In 1/3 length System} = 52^2x4.67x3x.24x24/1000\ \text{KWh/day}$$
$$= 381.86\ \text{KWh}$$

$$\text{Loss difference ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)}$$
$$= 721/381.86$$
$$= 1.88$$

Load ratio between 2nd half and 1st half. We
2nd half load/ 1st half load = 45/7 = 6.42
So if load ratio as stated above is 6.0 to 7.5
then correction factor "K" = 1.813
By multiplying 1/3 by K, we get 716 KW

Etap Simulation Result:

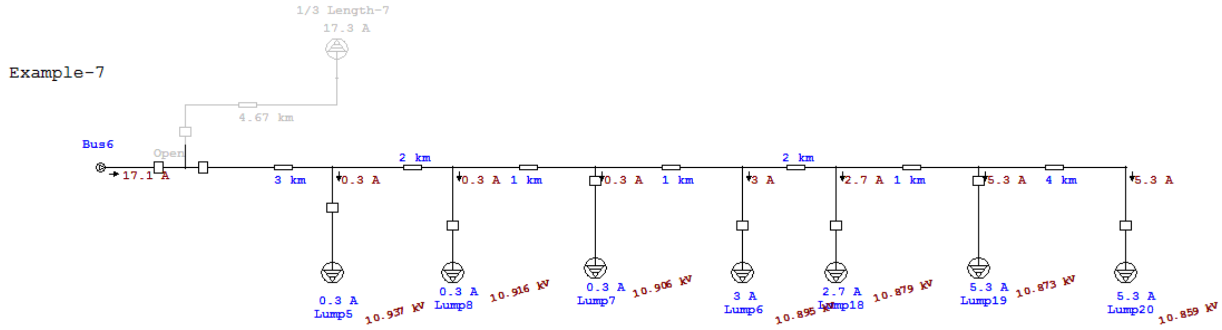
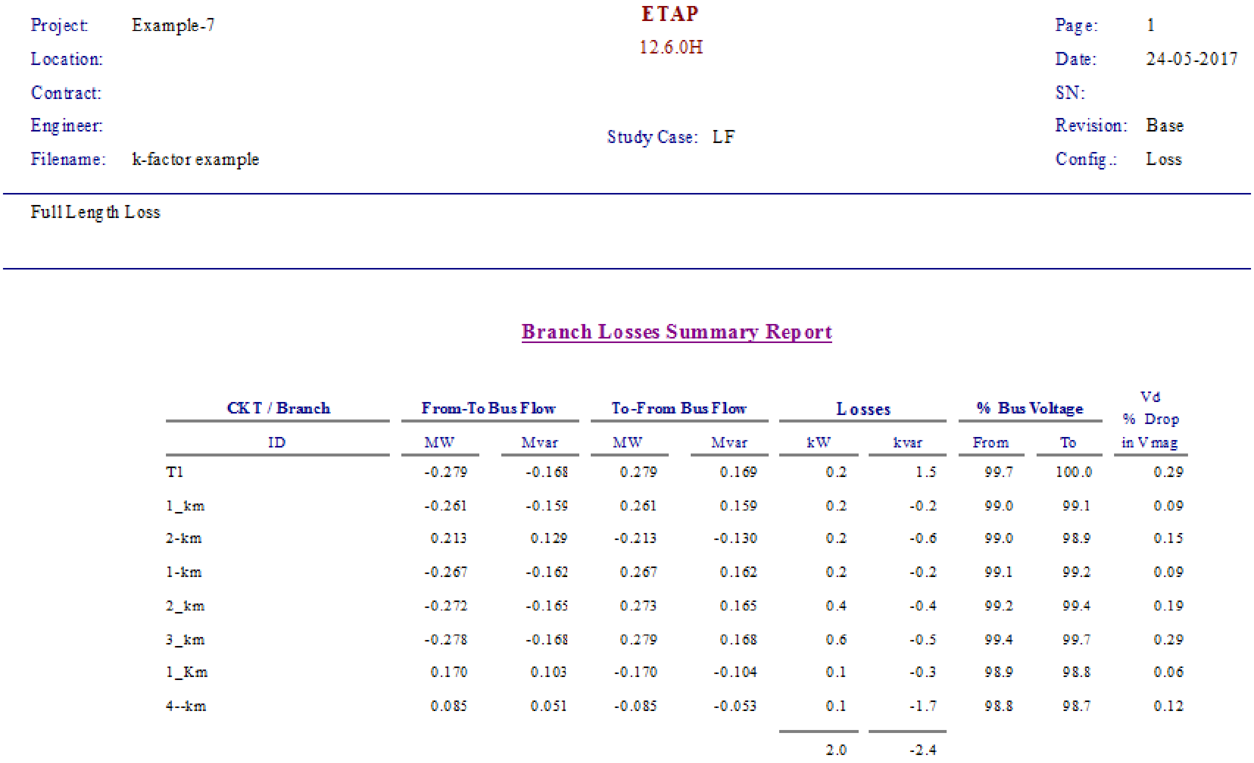


Fig 3.35: Full length Load Flow Analysis of Example-7



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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.279	-0.168	0.279	0.169	0.2	1.5	99.7	100.0	0.29
1_km	-0.261	-0.159	0.261	0.159	0.2	-0.2	99.0	99.1	0.09
2-km	0.213	0.129	-0.213	-0.130	0.2	-0.6	99.0	98.9	0.15
1-km	-0.267	-0.162	0.267	0.162	0.2	-0.2	99.1	99.2	0.09
2_km	-0.272	-0.165	0.273	0.165	0.4	-0.4	99.2	99.4	0.19
3_km	-0.278	-0.168	0.279	0.168	0.6	-0.5	99.4	99.7	0.29
1_Km	0.170	0.103	-0.170	-0.104	0.1	-0.3	98.9	98.8	0.06
4--km	0.085	0.051	-0.085	-0.053	0.1	-1.7	98.8	98.7	0.12
					2.0	-2.4			

Fig 3.36: Full length Loss Report of Example-7

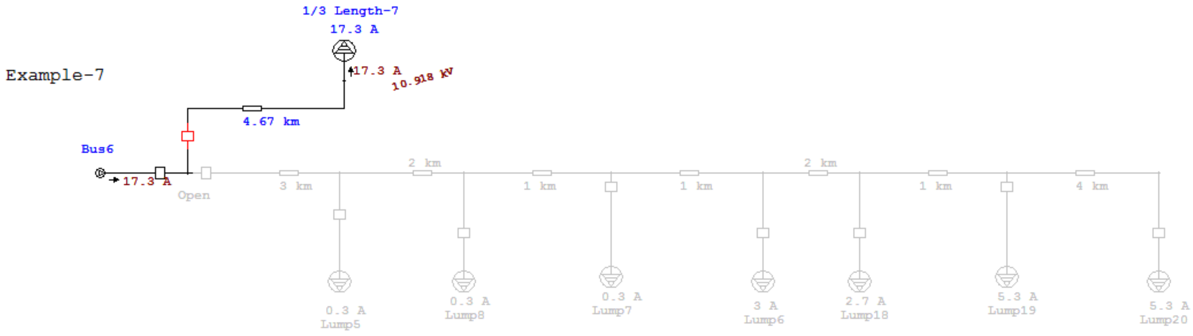
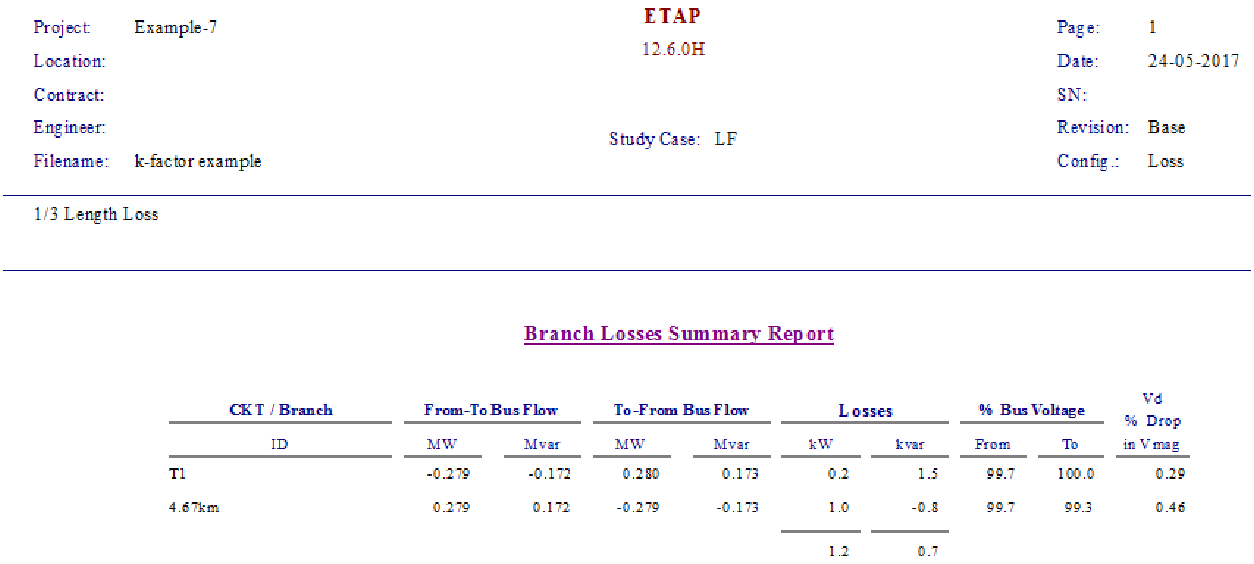


Fig 3.37: 1/3 length Load Flow Analysis of Example-7



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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.279	-0.172	0.280	0.173	0.2	1.5	99.7	100.0	0.29
4.67km	0.279	0.172	-0.279	-0.173	1.0	-0.8	99.7	99.3	0.46
					1.2	0.7			

Fig 3.38: 1/3length Loss Report of Example-7

$$\text{Loss Ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)}$$

$$=2/1.2$$

$$=1.67$$

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-8

It is a complex example carrying maximum load within second half of the feeder. Here the load ration between first half and second half is more than one. The loss considering the 1/3 ratio needs to be multiplied by K factor to get the loss for full length of feeder that exists.

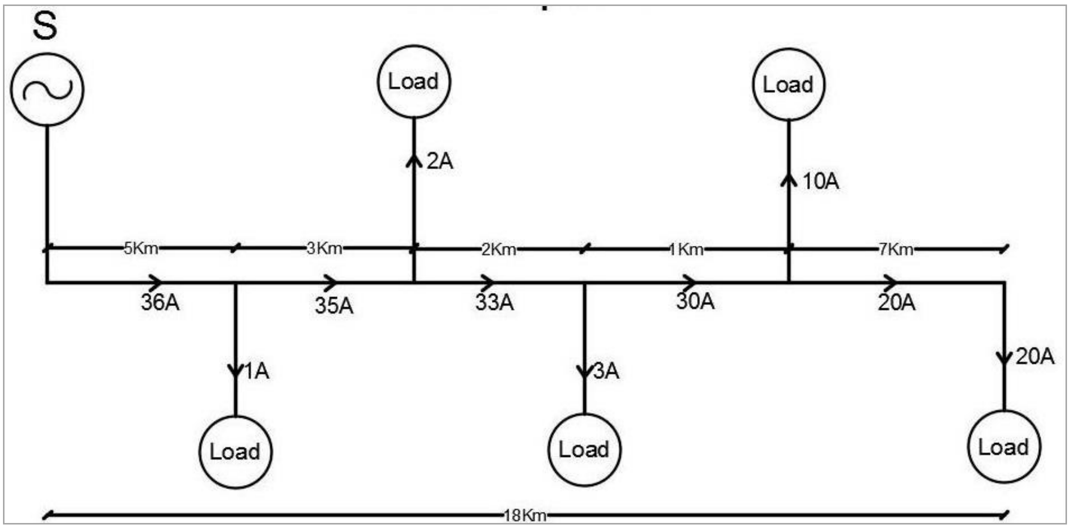


Fig 3.39: SLD of Example-8

Loss Factor$=0.42$
Total Length $=18Km$
Resistance $=1\Omega/\text{Km}$
Load duration $=24Hours$
$\frac{1}{3}\ Length$ $=6Km$

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ

$$Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$$

$$= \{(36^2 \times 5) + (35^2 \times 3) + (33^2 \times 2) + (30^2 \times 1) + (20^2 \times 7)\} \times \frac{(3 \times 0.42 \times 24)}{1000}$$

$$= 16033 \times 0.03024$$

$$= 484.84\ Kwh$$

In $\frac{1}{3}\ Length$ System$Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$

$$= (36^2 \times 6) \times 0.03024 Kwh$$

$$= 7776 \times 0.03024\ Kwh$$

$$= 235.15 Kwh$$

[Considering almost 36 amps is flowing up to 6 Km.]

Loss difference ratio $= \frac{(Real\ loss)}{(1/3\ System\ loss)}$

$$= \frac{484.84}{235.15}$$

$$= 2.06$$

Load ratio, C= $2nd\ half\ load/\ 1st\ half\ load$ = 32/4 = 8

So if load ratio as stated above is 7.5 to 9.0,
Then correction factor "K" = 1.944
By multiplying 1/3 by K, we get loss 456 KWh

Etap Simulation Result:

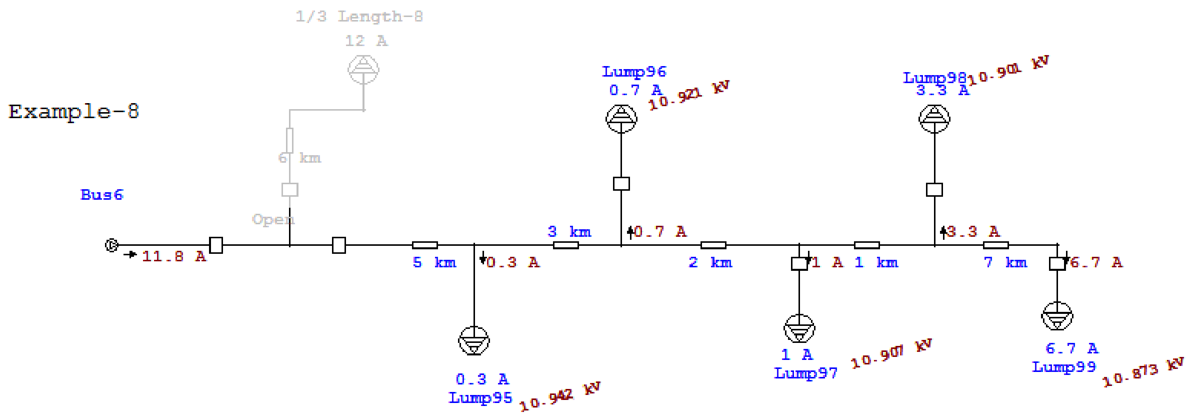
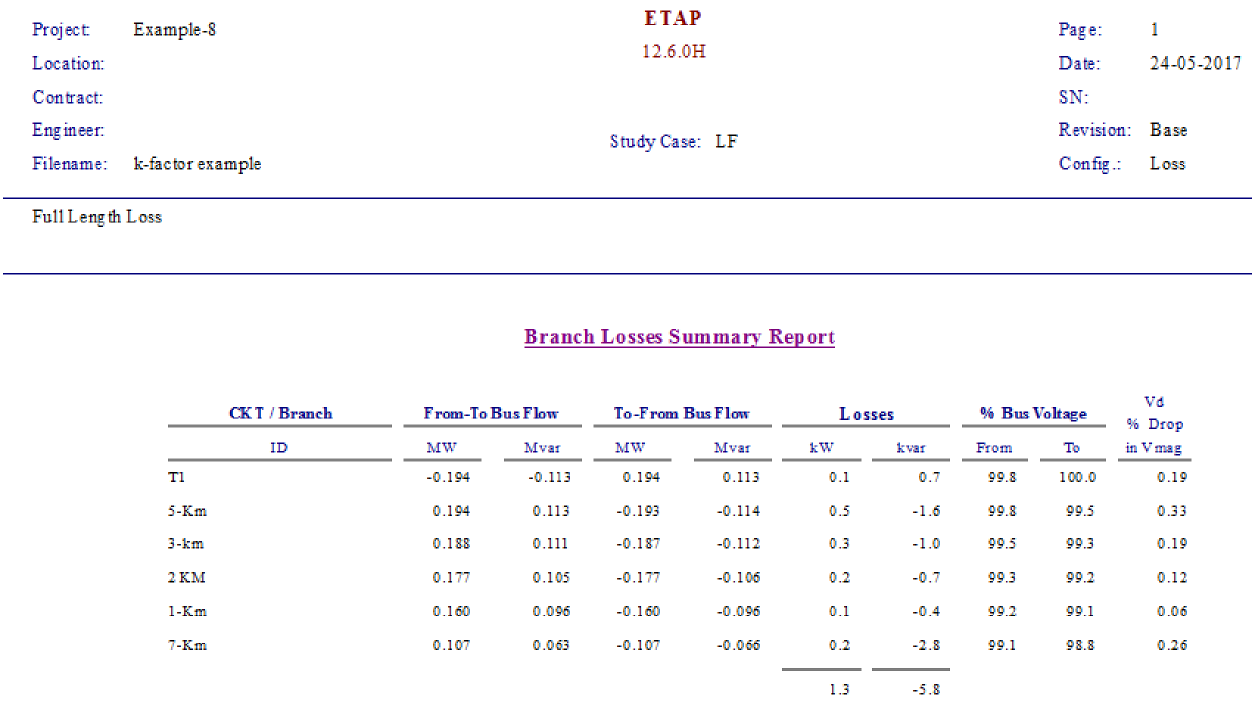


Fig 3.40: Full length Load Flow Analysis of Example-8



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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.194	-0.113	0.194	0.113	0.1	0.7	99.8	100.0	0.19
5-Km	0.194	0.113	-0.193	-0.114	0.5	-1.6	99.8	99.5	0.33
3-km	0.188	0.111	-0.187	-0.112	0.3	-1.0	99.5	99.3	0.19
2 KM	0.177	0.105	-0.177	-0.106	0.2	-0.7	99.3	99.2	0.12
1-Km	0.160	0.096	-0.160	-0.096	0.1	-0.4	99.2	99.1	0.06
7-Km	0.107	0.063	-0.107	-0.066	0.2	-2.8	99.1	98.8	0.26
					1.3	-5.8			

Fig 3.41: Full length Loss Report of Example-8

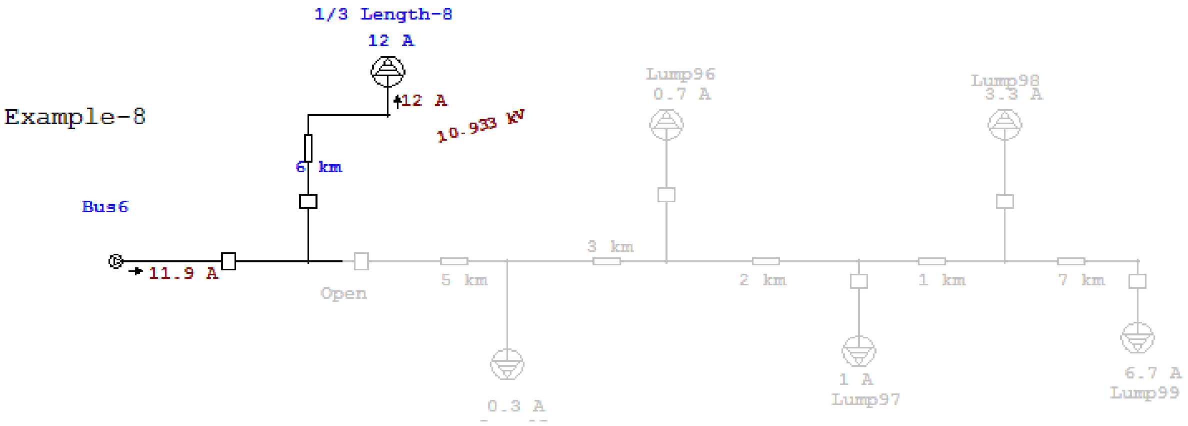
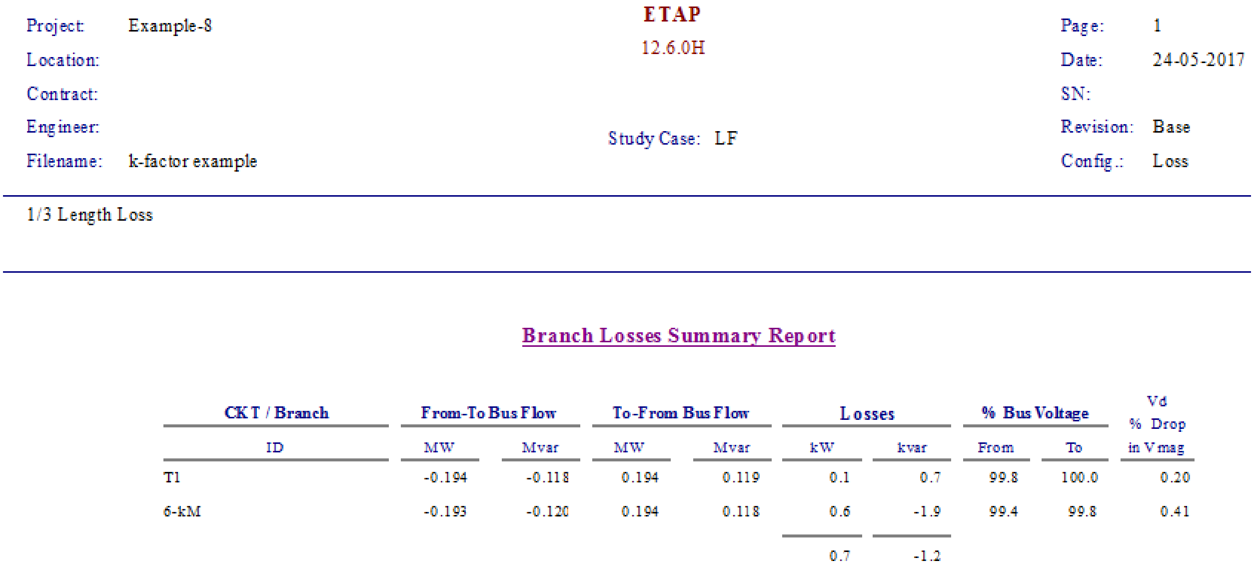


Fig 3.42: 1/3 length Load Flow Analysis of Example-8



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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.194	-0.118	0.194	0.119	0.1	0.7	99.8	100.0	0.20
6-kM	-0.193	-0.120	0.194	0.118	0.6	-1.9	99.4	99.8	0.41
					0.7	-1.2			

Fig 3.43: 1/3length Loss Report of Example-8

$$\text{Loss Ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)}$$

=1.3/0.7

=1.85

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-9

It is a complex example carrying maximum load within second half of the feeder. Here the load ration between first half and second half is more than one. The loss considering the 1/3 ratio needs to be multiplied by K factor to get the loss for full length of feeder that exists.

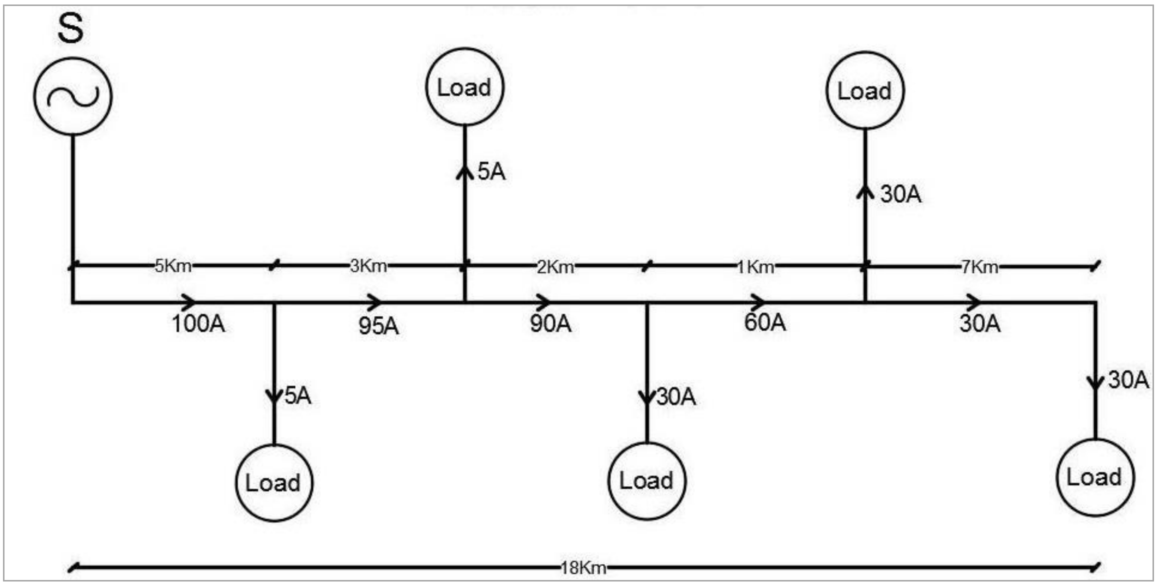


Fig 3.44: SLD of Example-9

Loss Factor$=0.42$
Total Length $= 18Km$
Resistance $= 1\Omega/Km$
Load duration $=24Hours$
$\frac{1}{3}$ $Length = 6Km$

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ

$$Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$$

$$= \{(100^2 \times 5) + (95^2 \times 3) + (90^2 \times 2) + (60^2 \times 1) + (30^2 \times 7)\} \times \frac{(3 \times 0.42 \times 24)}{1000}$$

$$= 103175 \times 0.03024$$

$$= 3120.012Kwh$$(100

In $\frac{1}{3}$ $Length$ System $Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$

$$= (100^2 \times 6) \times 0.03024\ Kwh$$

$$= 60000 \times 0.03024\ Kwh$$

$$= 1814.4\ Kwh$$

[Considering almost 100 amps is flowing up to 6 Km.]

Loss difference ratio $= \frac{(Real\ loss)}{(1/3\ System\ loss)}$

$$= \frac{3120.012}{1814.4} = 1.719$$

Load ratio, C= *2nd half load/ 1st half load* = 89/11 = 8.09
So if load ratio as stated above is 7.5 to 9.0,
Then correction factor “K” = 1.944
By multiplying 1/3 by K, we get loss 3526 KWh

<u>Etap Simulation Result:</u>

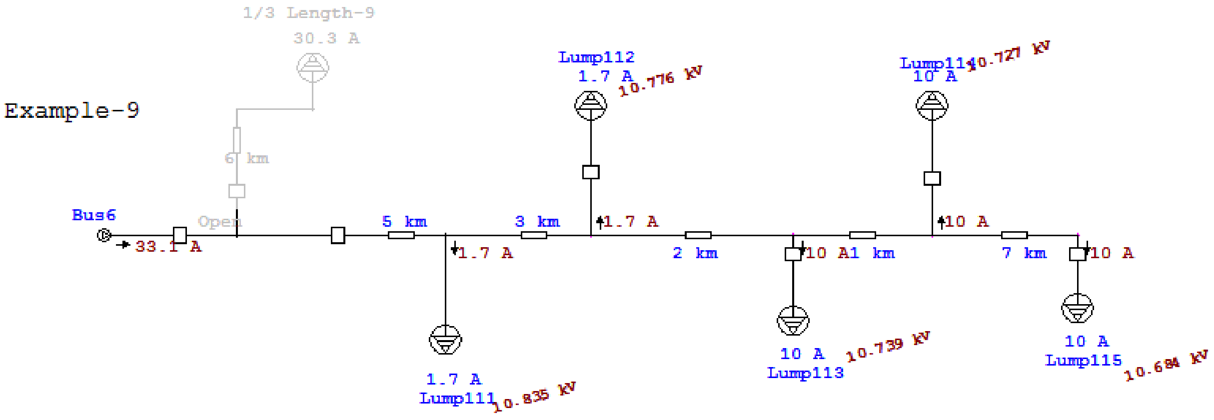
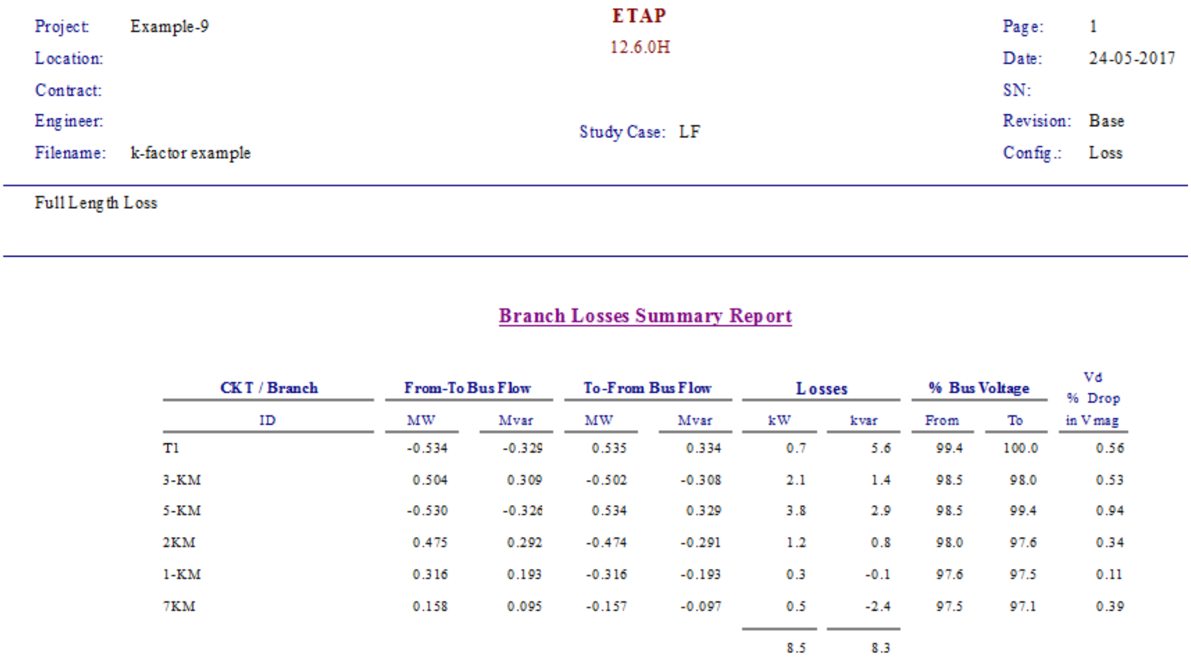


Fig 3.45: Full length Load Flow Analysis of Example-9



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Full Length Loss

<u>Branch Losses Summary Report</u>

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop in Vmag
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	
T1	-0.534	-0.329	0.535	0.334	0.7	5.6	99.4	100.0	0.56
3-KM	0.504	0.309	-0.502	-0.308	2.1	1.4	98.5	98.0	0.53
5-KM	-0.530	-0.326	0.534	0.329	3.8	2.9	98.5	99.4	0.94
2KM	0.475	0.292	-0.474	-0.291	1.2	0.8	98.0	97.6	0.34
1-KM	0.316	0.193	-0.316	-0.193	0.3	-0.1	97.6	97.5	0.11
7KM	0.158	0.095	-0.157	-0.097	0.5	-2.4	97.5	97.1	0.39
					8.5	8.3			

Fig 3.46: Full length Loss Report of Example-9

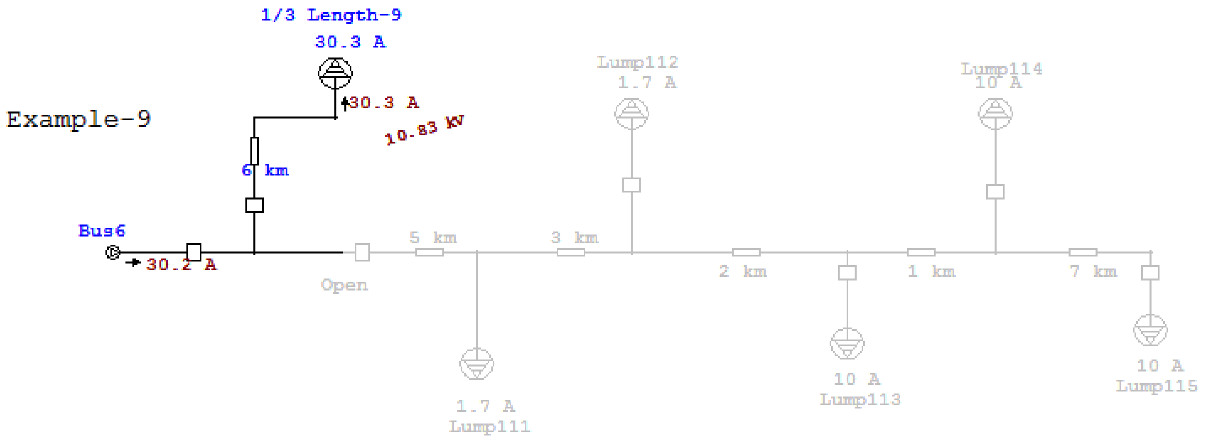
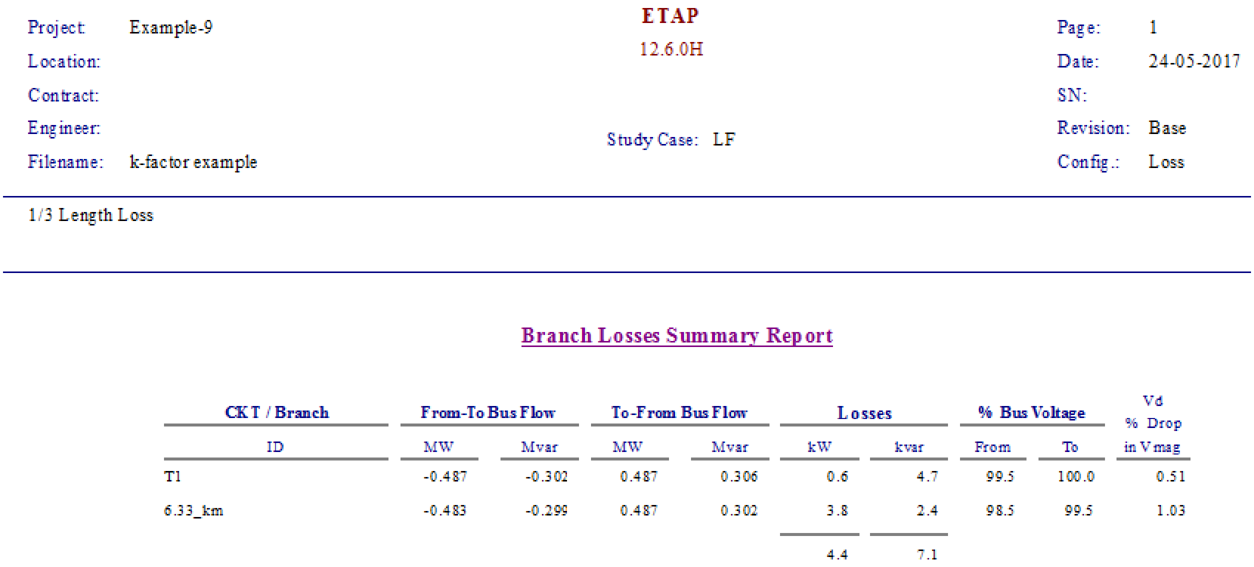


Fig 3.47: 1/3 length Load Flow Analysis of Example-9



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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.487	-0.302	0.487	0.306	0.6	4.7	99.5	100.0	0.51
6.33_km	-0.483	-0.299	0.487	0.302	3.8	2.4	98.5	99.5	1.03
					4.4	7.1			

Fig: Fig 3.48: 1/3length Loss Report of Example-9

$$\text{Loss Ratio} = \frac{(\text{Real loss})}{(1/3 \text{ System loss})}$$

$=8.5/4.4$

$=1.93$

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-10

It is a complex example carrying maximum load within second half of the feeder. Here the load ration between first half and second half is more than one. The loss considering the 1/3 ratio needs to be multiplied by K factor to get the loss for full length of feeder that exists.

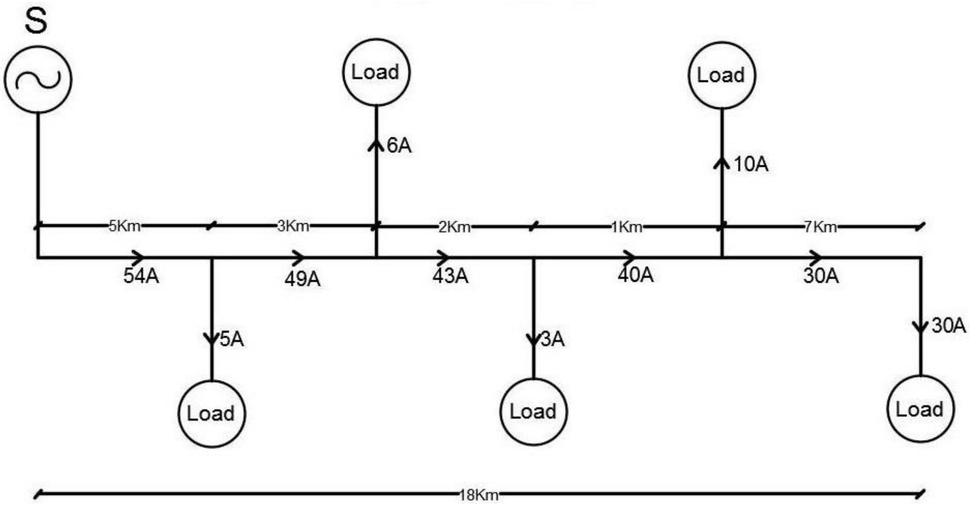


Fig 3.49: SLD of Example-10

Loss Factor $=0.42$
Total Length $= 18Km$
Resistance $= 1\Omega/Km$
Load duration $=24Hours$
$\frac{1}{3}\ Length = 6Km$

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ

$$Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$$

$$= \{(54^2 \times 5) + (49^2 \times 3) + (43^2 \times 2) + (40^2 \times 1) + (30^2 \times 7)\} \times \frac{(3 \times 0.42 \times 24)}{1000}$$

$$= 33381 \times 0.03024$$
$$= 1009.44Kwh$$
$$\simeq 1009$$

In $\frac{1}{3}\ Length$ System$Kwh/day = (I^2R/Km) \times \frac{(3 \times L_sF \times Load\ duration)}{1000}$

$$= (54^2 \times 6) \times 0.03024Kwh$$
$$= 17496 \times 0.03024\ Kwh$$
$$= 529Kwh$$

[Considering almost 54 amps is flowing up to 6 Km.]

Loss difference ratio $= \frac{(Real\ loss)}{(1/3\ System\ loss)}$

$$= \frac{1009}{529}$$
$$= 1.91$$

Load ratio, C= *2nd half load/ 1st half load* = 45/5 = 9
So if load ratio as stated above is 7.5 to 9.0,
Then correction factor “K” = 1.944
By multiplying 1/3 by K, we get loss 1028 KWh

Etap Simulation Result:

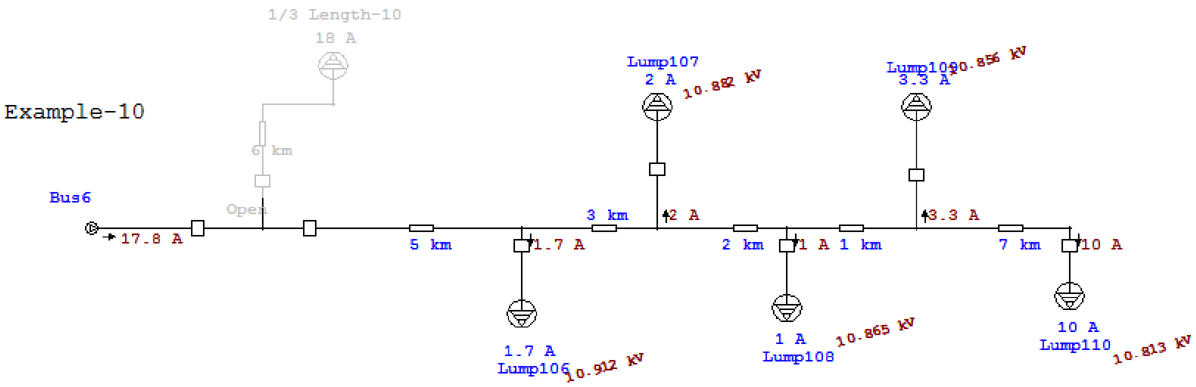
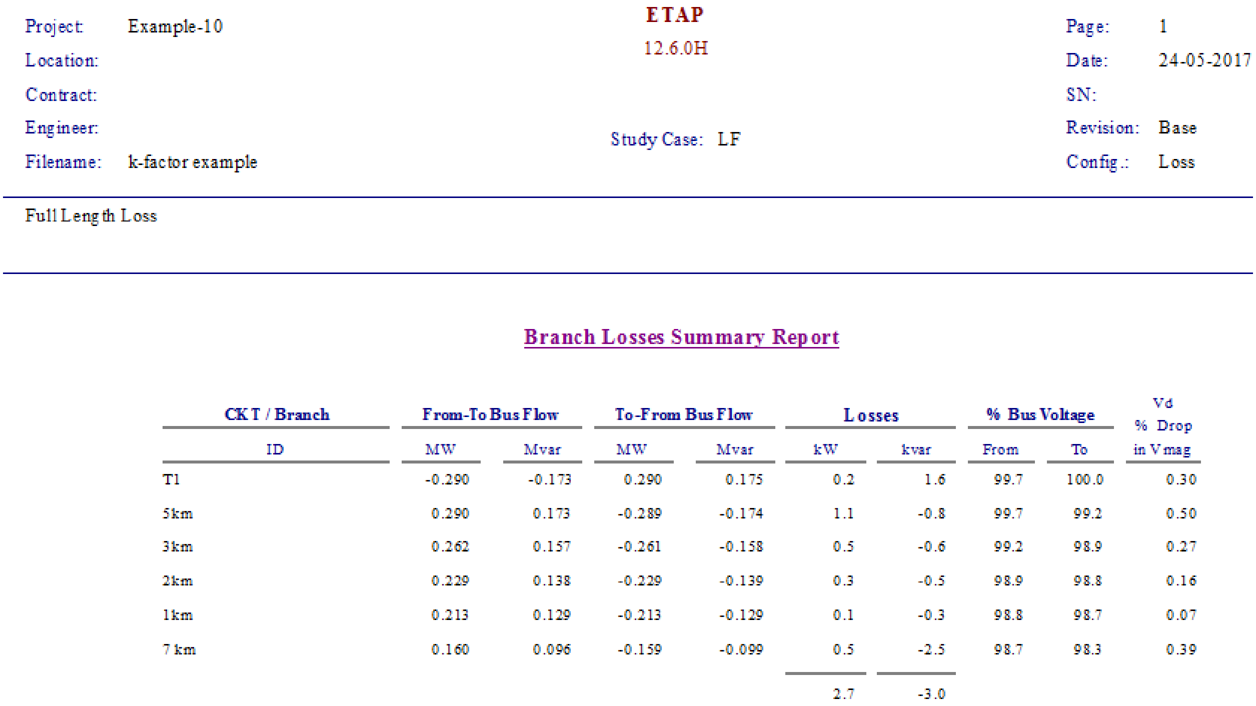


Fig 3.50: Full length Load Flow Analysis of Example-10



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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.290	-0.173	0.290	0.175	0.2	1.6	99.7	100.0	0.30
5km	0.290	0.173	-0.289	-0.174	1.1	-0.8	99.7	99.2	0.50
3km	0.262	0.157	-0.261	-0.158	0.5	-0.6	99.2	98.9	0.27
2km	0.229	0.138	-0.229	-0.139	0.3	-0.5	98.9	98.8	0.16
1km	0.213	0.129	-0.213	-0.129	0.1	-0.3	98.8	98.7	0.07
7km	0.160	0.096	-0.159	-0.099	0.5	-2.5	98.7	98.3	0.39
					2.7	-3.0			

Fig 3.51: Full length Loss Report of Example-10

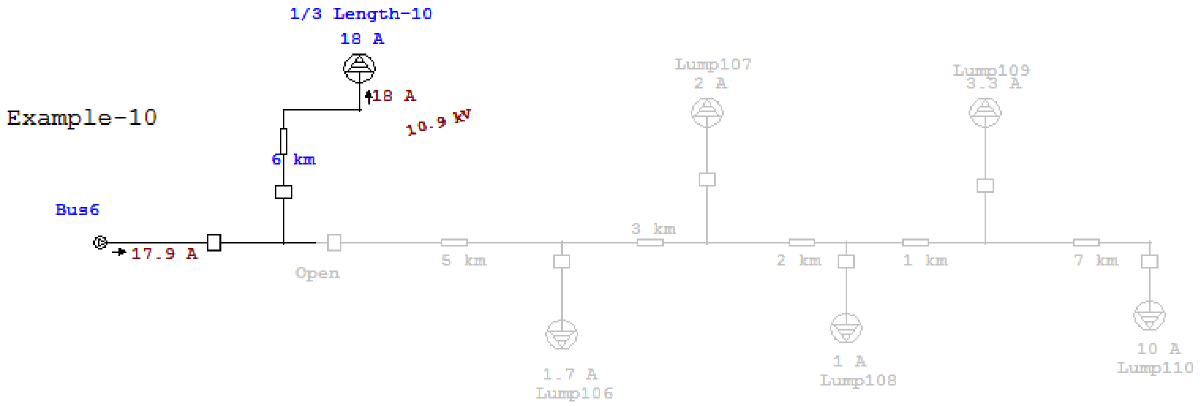
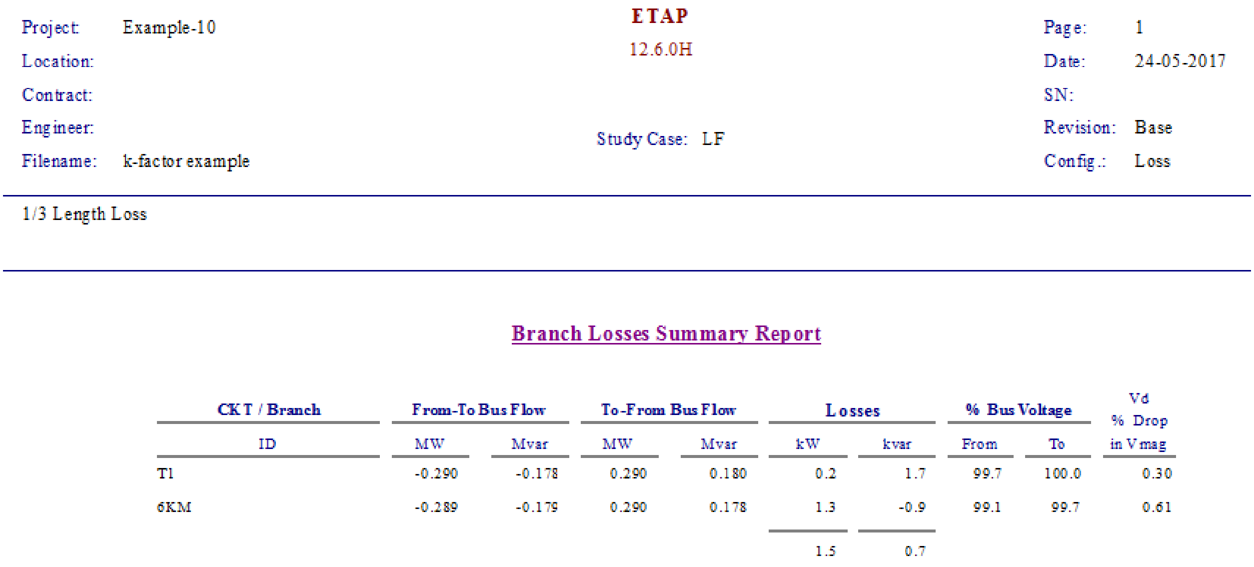


Fig 3.52: 1/3 length Load Flow Analysis of Example-10



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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.290	-0.178	0.290	0.180	0.2	1.7	99.7	100.0	0.30
6KM	-0.289	-0.179	0.290	0.178	1.3	-0.9	99.1	99.7	0.61
					1.5	0.7			

Fig 3.53: 1/3length Loss Report of Example-10

$$\text{Loss Ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)}$$

=2.7/1.5

=1.8

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-11

It is a complex example carrying maximum load within second half of the feeder. Here the load ration between first half and second half is more than one. The loss considering the 1/3 ratio needs to be multiplied by K factor to get the loss for full length of feeder that exists.

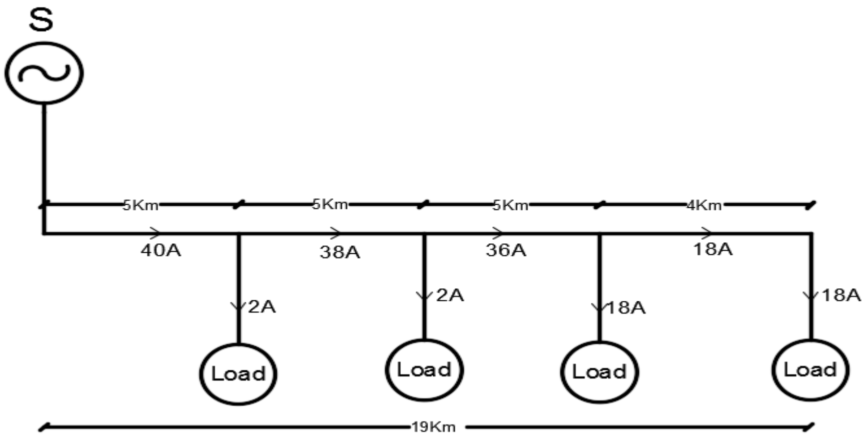


Fig 3.54: SLD of Example-11

Loss Factor = 0.24
Total Length = 18 Km.
Resistance = 1 ohms/Km.
Load duration = 24hours
1/3 length = 6 Km

So Real loss in the total feeder on the basis of actual load at each point and distance of the Line up to that point from the source, for 3-ϕ,
KWh/day = (I^2R/Km. x3xLsFxLx24h) /1000
= (40^2x5 + 38^2x4 + 36^2x5 + 18^2x4 X .01728
= 372 KWh
In 1/3 length System = 40^2x6x3x.24x24/1000 KWh/day
=165 KWh

Loss difference ratio = $\frac{(Real\ loss)}{(1/3\ System\ loss)}$
= 372/165
=2.25

Load ratio between 2nd half and 1st half. We
2nd half load/ 1st half load = 36.5/3.5 = 10.42
So if load ratio as stated above is 9.0 to 10.50
Correction factor “K” = 2.04
By multiplying 1/3 by K, we get loss 391 KWh

Etap Simulation Result:

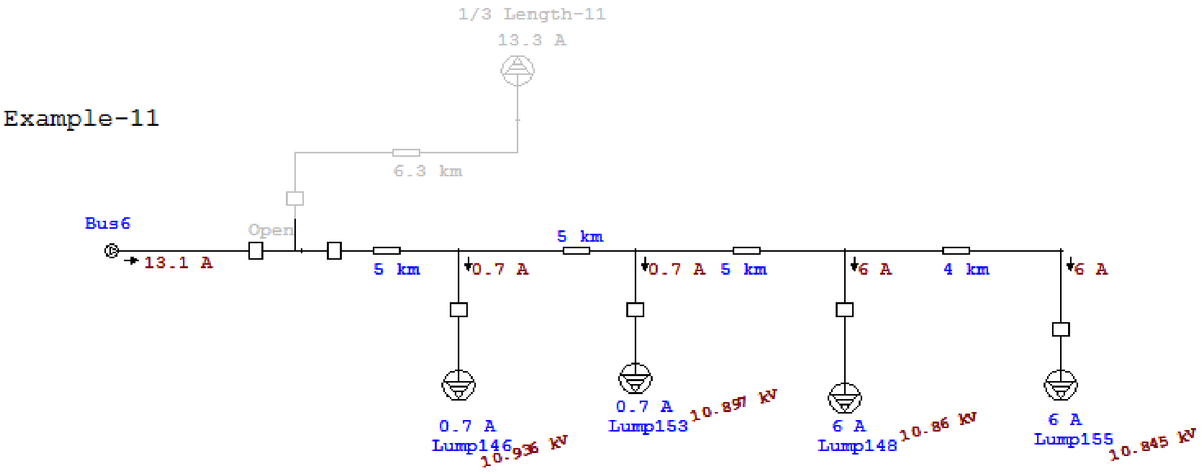
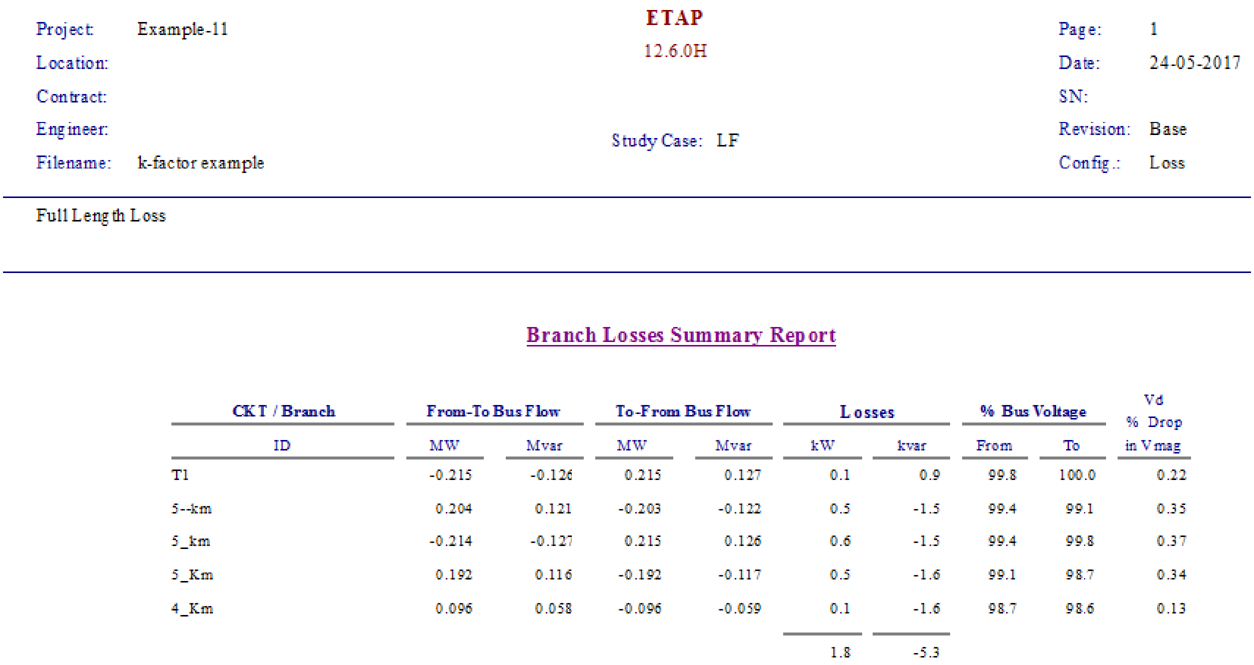


Fig 3.55: Full length Load Flow Analysis of Example-11



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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.215	-0.126	0.215	0.127	0.1	0.9	99.8	100.0	0.22
5--km	0.204	0.121	-0.203	-0.122	0.5	-1.5	99.4	99.1	0.35
5_km	-0.214	-0.127	0.215	0.126	0.6	-1.5	99.4	99.8	0.37
5_Km	0.192	0.116	-0.192	-0.117	0.5	-1.6	99.1	98.7	0.34
4_Km	0.096	0.058	-0.096	-0.059	0.1	-1.6	98.7	98.6	0.13
					1.8	-5.3			

Fig 3.56: Full length Loss Report of Example-11

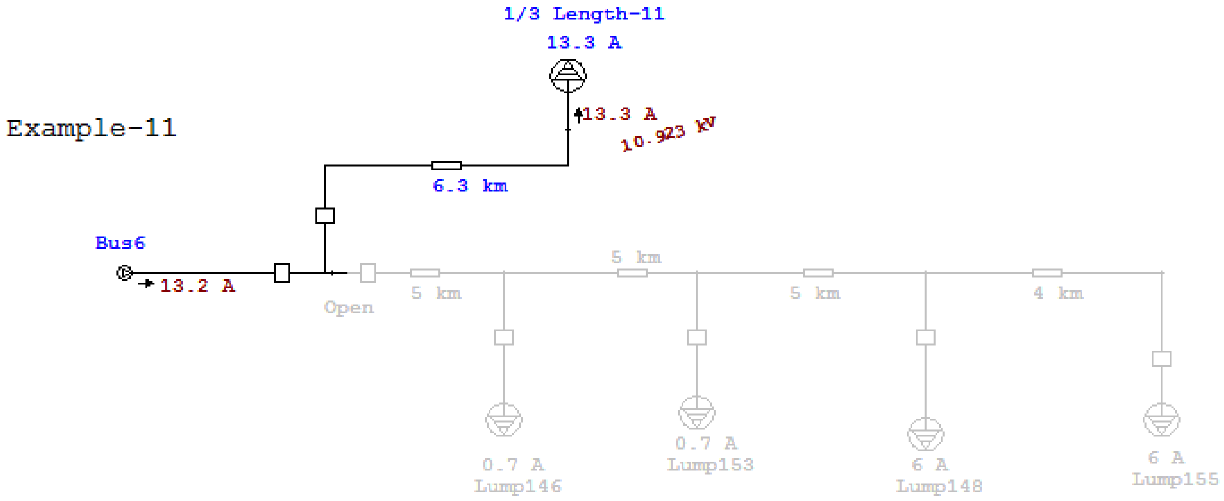
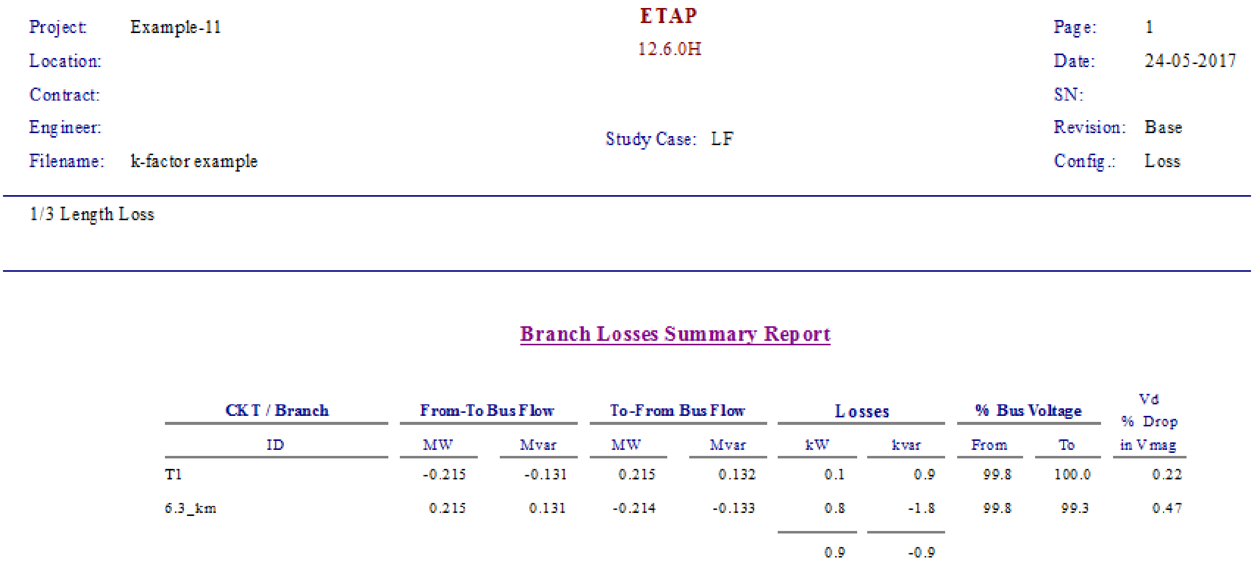


Fig 3.57: 1/3 length Load Flow Analysis of Example-11



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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.215	-0.131	0.215	0.132	0.1	0.9	99.8	100.0	0.22
6.3_km	0.215	0.131	-0.214	-0.133	0.8	-1.8	99.8	99.3	0.47
					0.9	-0.9			

Fig 3.58: 1/3length Loss Report of Example-11

$$\text{Loss Ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)}$$

=1.8/0.9

=2.0

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-12

It is a complex example carrying maximum load within second half of the feeder. Here the load ration between first half and second half is more than one. The loss considering the 1/3 ratio needs to be multiplied by K factor to get the loss for full length of feeder that exists.

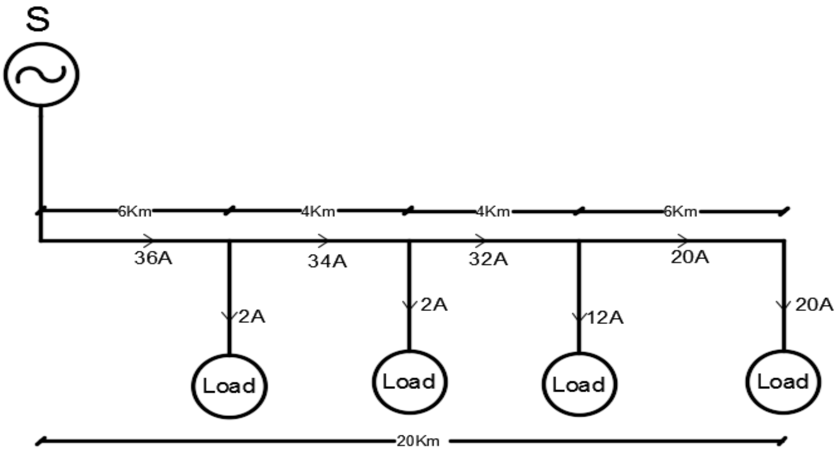


Fig 3.59: SLD of Example-12

Loss Factor = 0.24
Total Length = 20 Km.
Resistance = 1 ohms/Km.
Load duration = 24hours
1/3 length = 6.67 Km

So Real loss in the total feeder on the basis of actual load at each point and distance of the Line up to that point from the source, for 3-ϕ,
KWh/day = $(I^2R/Km.\ x3xLsFxLx24h)\ /1000$
= $(36^2x6 + 34^2x4 + 33^2x4 + 20^2x6\ X\ (0.24x24x3)/1000$
= 579 KWh
In 1/3 length System = $36^2x6.67x3x.24x24/1000$ KWh/day
=261 KWh

Loss difference ratio = $\frac{(Real\ loss)}{(1/3\ System\ loss)}$
= 579/261
=2.21

Load ratio between 2nd half and 1st half. We
2nd half load/ 1st half load = 33/3 =11.0
So if load ratio is 10.5 to 12.0, than
Correction factor “K” = 2.175

By multiplying 1/3 by K, we get 567 KWh

Etap Simulation Result:

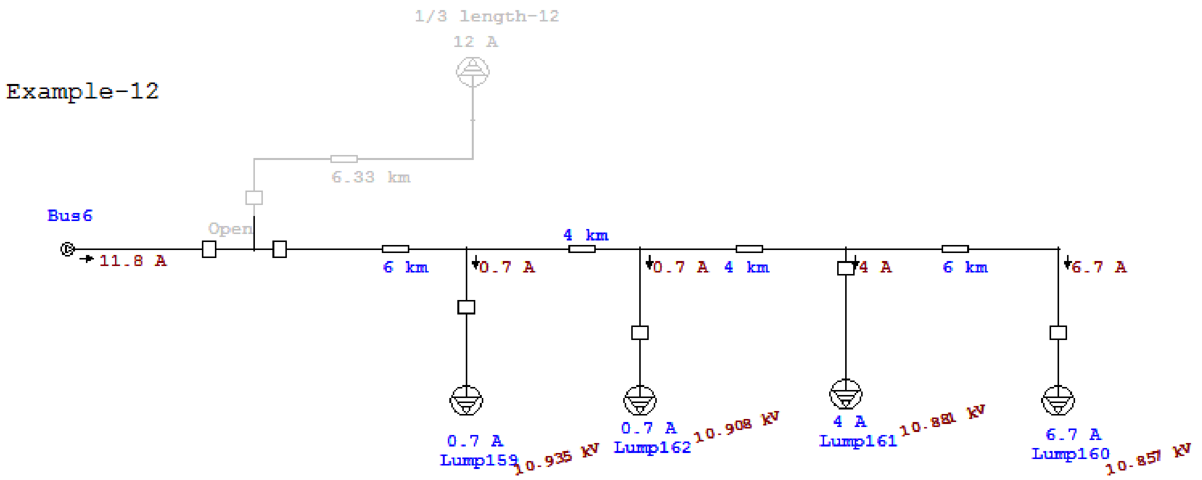
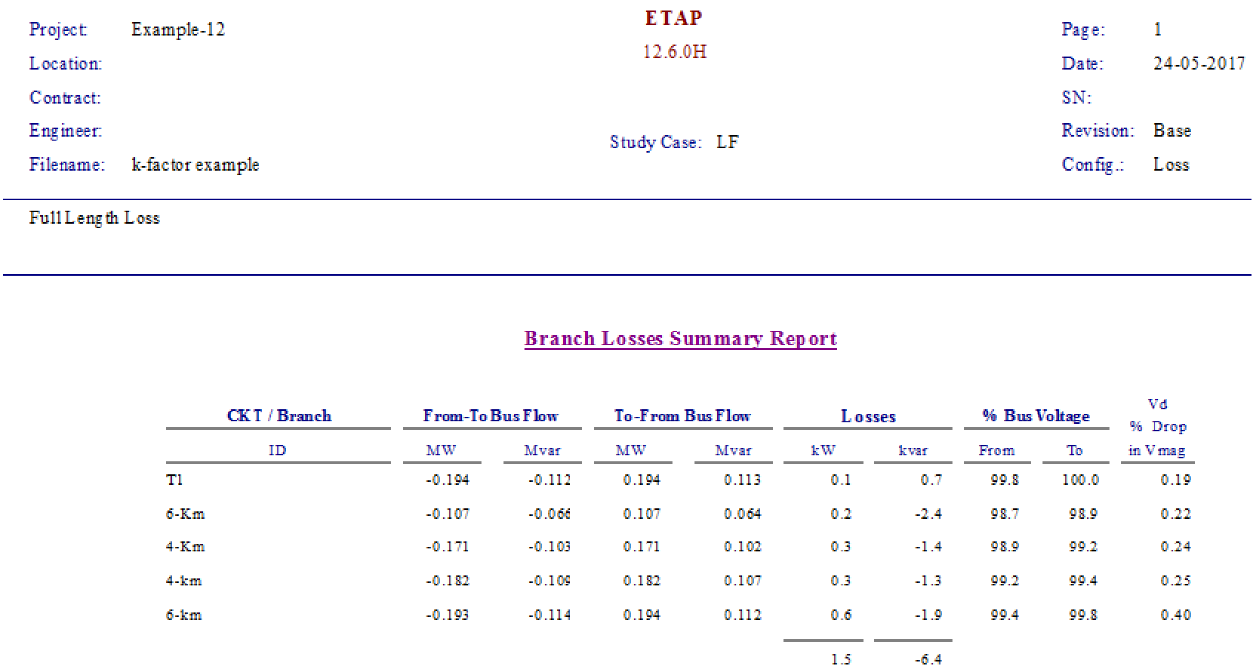


Fig 3.60: Full length Load Flow Analysis of Example-12



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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	% Drop in Vmag
T1	-0.194	-0.112	0.194	0.113	0.1	0.7	99.8	100.0	0.19
6-Km	-0.107	-0.066	0.107	0.064	0.2	-2.4	98.7	98.9	0.22
4-Km	-0.171	-0.103	0.171	0.102	0.3	-1.4	98.9	99.2	0.24
4-km	-0.182	-0.109	0.182	0.107	0.3	-1.3	99.2	99.4	0.25
6-km	-0.193	-0.114	0.194	0.112	0.6	-1.9	99.4	99.8	0.40
					1.5	-6.4			

Fig 3.61:Full length Loss Report of Example-12

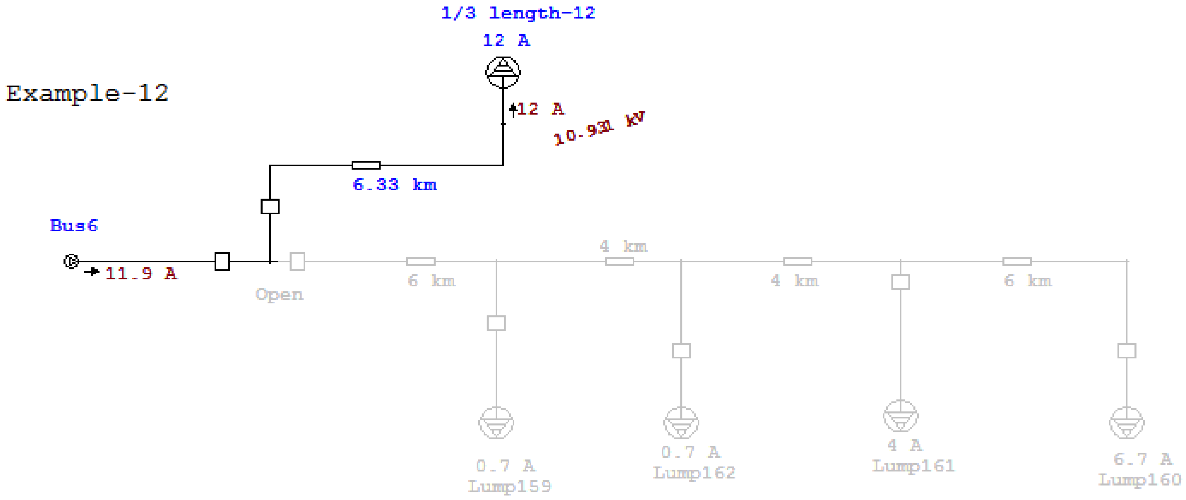
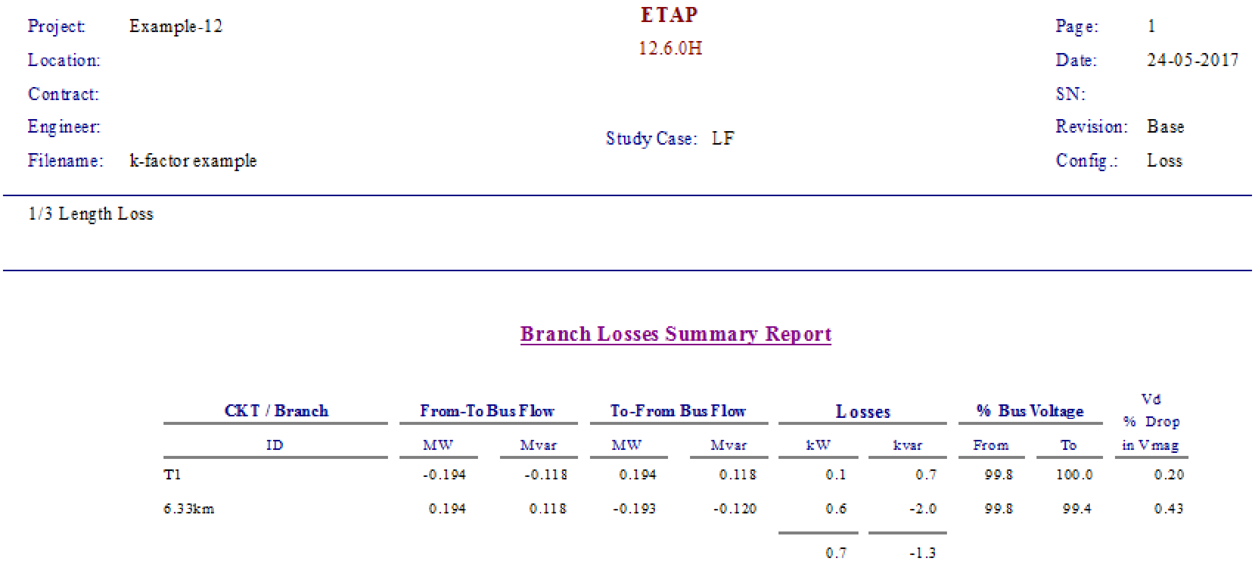


Fig 3.62: 1/3 length Load Flow Analysis of Example-12



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1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	% Drop in Vmag
T1	-0.194	-0.118	0.194	0.118	0.1	0.7	99.8	100.0	0.20
6.33km	0.194	0.118	-0.193	-0.120	0.6	-2.0	99.8	99.4	0.43
					0.7	-1.3			

Fig 3.63: 1/3length Loss Report of Example-12

Loss Ratio $= \dfrac{(Real\ loss)}{(1/3\ System\ loss)}$

$=1.5/0.7$

$=2.14$

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-13

It is a complex example carrying maximum load within second half of the feeder. Here the load ration between first half and second half is more than one. The loss considering the 1/3 ratio needs to be multiplied by K factor to get the loss for full length of feeder that exists.

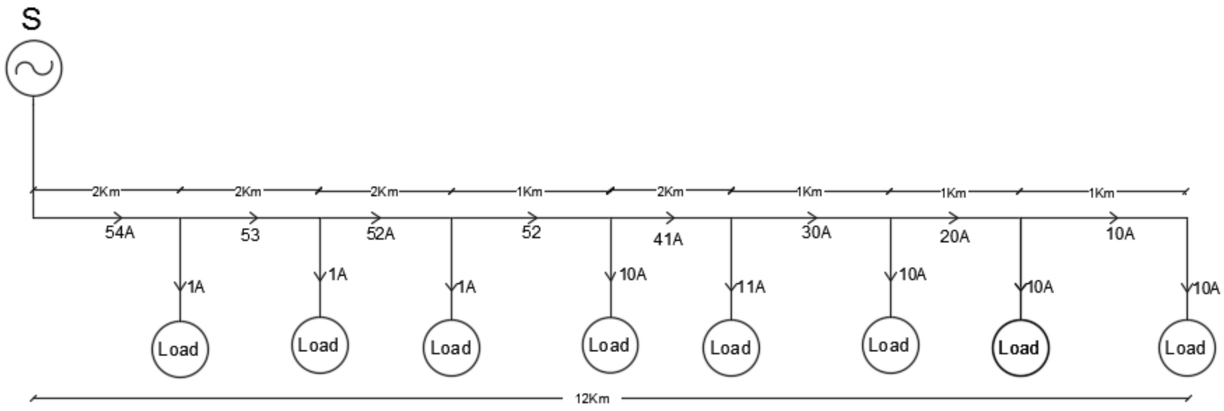

Fig 3.64: SLD of Example-13

Loss Factor = 0.24
Total Length = 12 Km.
Resistance = 1 ohms/Km.
Load duration = 24hours
1/3 length = 4 Km

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ,

KWh/day = (I^2R/Km. x3xLsFxLx24h) /1000
= (54^2x2 + 53^2x2 + 53^2x2 + 52^2x1+ 45^2x2+ 35^2x1+ 25^2x1+ 15^2x1 X (0.24x24x3)/1000
= 444 KWh

In 1/3 length System = 54^2x4x3x.24x24/1000 KWh/day
=200 KWh

Loss difference ratio = $\frac{(Real\ loss)}{(1/3\ System\ loss)}$
= 444/200
=2.22

Load ratio between 2nd half and 1st half. We
2nd half load/ 1st half load = 50.5/3.5 = 14.42
So if load ratio is 13.5 to 15
then correction factor “K” = 2.397
By multiplying 1/3 by K, we get 479 KWh

Etap Simulation Result:

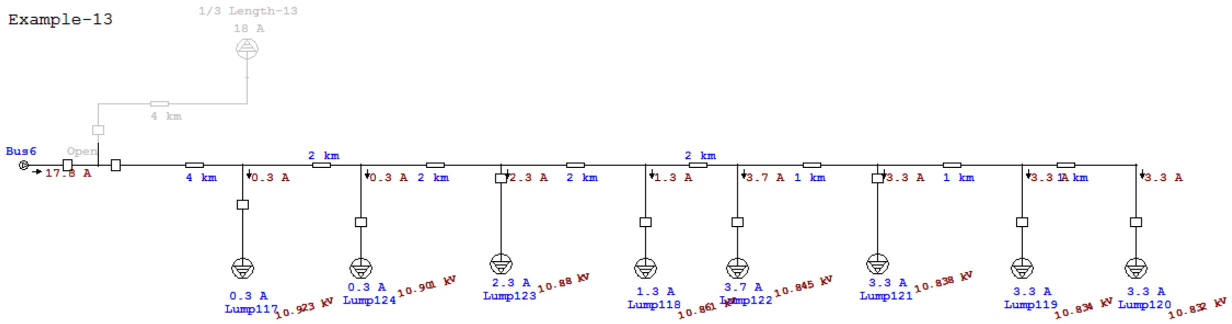

Fig 3.65: Full length Load Flow Analysis of Example-13

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Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.289	-0.174	0.290	0.176	0.2	1.6	99.7	100.0	0.30
1-km_14	-0.053	-0.033	0.053	0.032	0.0	-0.4	98.5	98.5	0.02
1km-14	-0.106	-0.065	0.106	0.065	0.0	-0.4	98.5	98.5	0.04
1-km-14	-0.159	-0.098	0.159	0.098	0.1	-0.4	98.5	98.6	0.06
2-km-14	-0.218	-0.134	0.218	0.133	0.3	-0.5	98.6	98.7	0.15
1-Km-14	-0.240	-0.146	0.240	0.146	0.3	-0.5	98.7	98.9	0.17
2km-14	-0.277	-0.169	0.278	0.169	0.4	-0.3	98.9	99.1	0.19
2-Km-14	-0.283	-0.172	0.283	0.172	0.4	-0.3	99.1	99.3	0.20
2-km_14	-0.289	-0.175	0.289	0.174	0.9	-0.6	99.3	99.7	0.40
					2.6	-1.9			

Fig 3.66: Full length Loss Report of Example-13

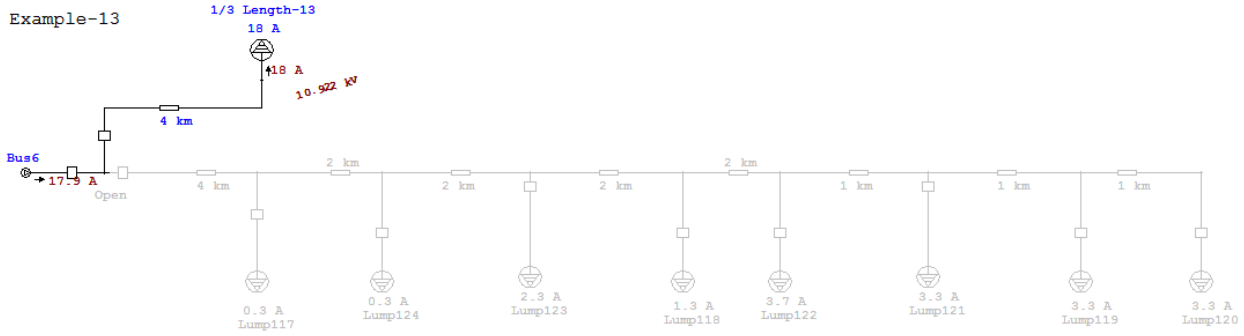
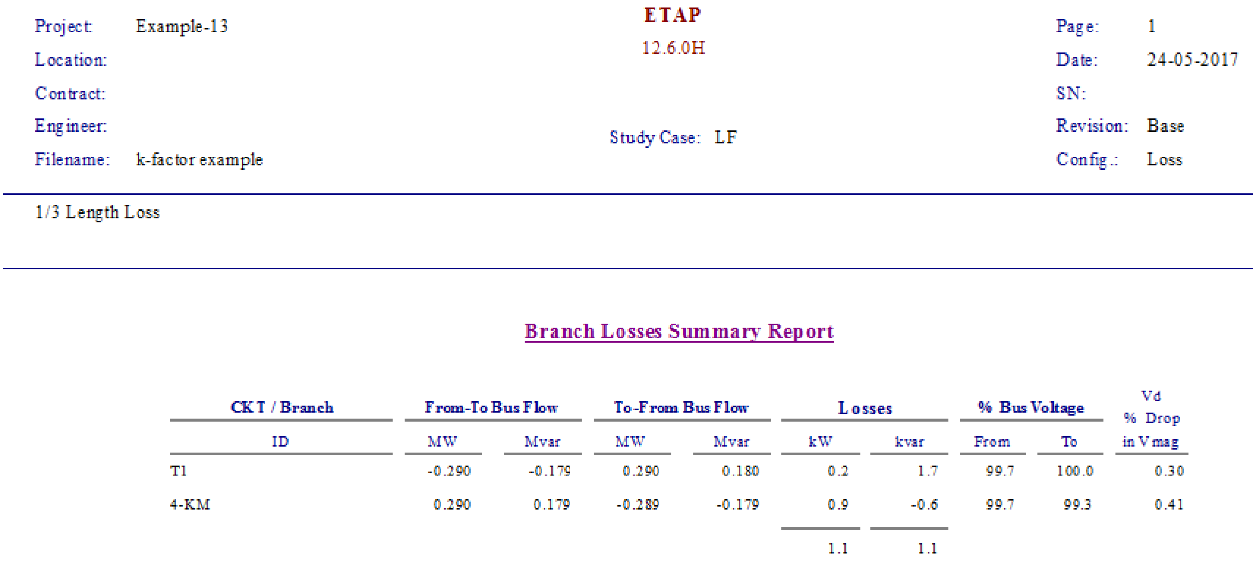


Fig 3.67: 1/3 length Load Flow Analysis of Example-13



Project:	Example-13	**ETAP** 12.6.0H	Page:	1
Location:			Date:	24-05-2017
Contract:			SN:	
Engineer:		Study Case: LF	Revision:	Base
Filename:	k-factor example		Config.:	Loss

1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.290	-0.179	0.290	0.180	0.2	1.7	99.7	100.0	0.30
4-KM	0.290	0.179	-0.289	-0.179	0.9	-0.6	99.7	99.3	0.41
					1.1	1.1			

Fig 3.68: 1/3length Loss Report of Example-13

$$\text{Loss Ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)}$$

$$=2.6/1.1$$

$$=2.36$$

Inference between calculated results and simulation results are given in the graph.

EXAMPLE-14

It is a simple example carrying maximum load within first half of the feeder. Here the load ration between first half and second half is less than one. The loss considering the 1/3 ratio will be same as the loss with that of calculating loss for full length of the feeder that exists

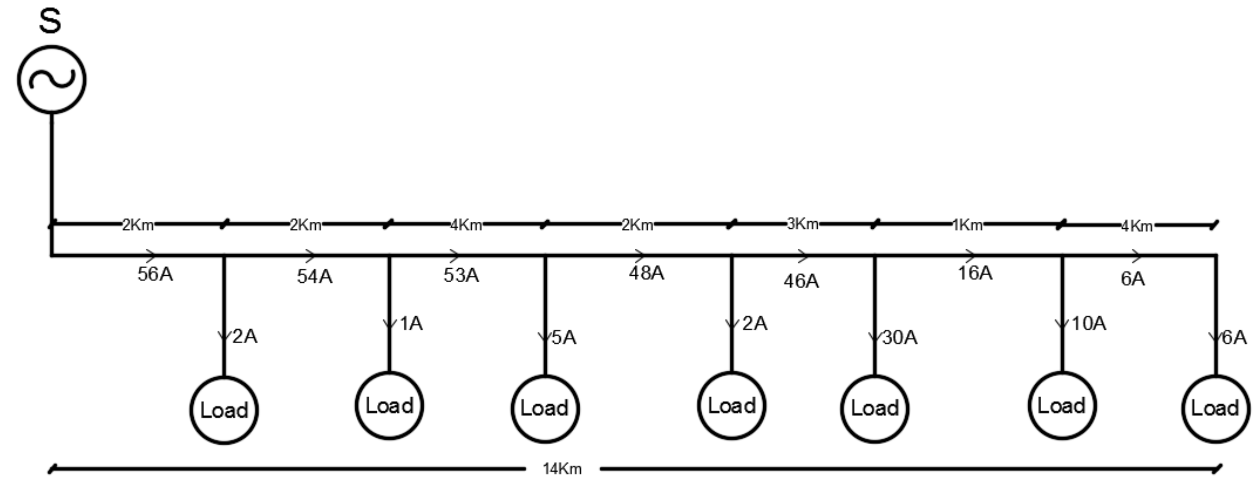


Fig 3.69: SLD of Example-14

Loss Factor = 0.24
Total Length = 16 Km.
Resistance = 1 ohms/Km.
Load duration = 24hours
1/3 length = 5.33 Km

So Real loss in the total feeder on the basis of actual load at each point and distance of the line up to that point from the source, for 3-ϕ,

KWh/day = (I^2R/Km. x3xLsFxLx24h) /1000
= (56^2x2 + 54^2x2 + 53^2x4 + 52^2x2 + 46^2x3 + 16^2x2 + 6^2x1X.0178
= 612 KWh

In 1/3 length System = 56^2x5.33x3x.24x24/1000 KWh/day
=288 KWh

Loss difference ratio = $\frac{(Real\ loss)}{(1/3\ System\ loss)}$ 888
= 612/288
=2.125

Load ratio between 2nd half and 1st half. We
2nd half load/ 1st half load = 52.5/3.5 = 15
So if load ratio is 13.5 to 15 than
Correction factor “K” = 2.357
By multiplying 1/3 by K, we get 678 KWh

Etap Simulation Result:

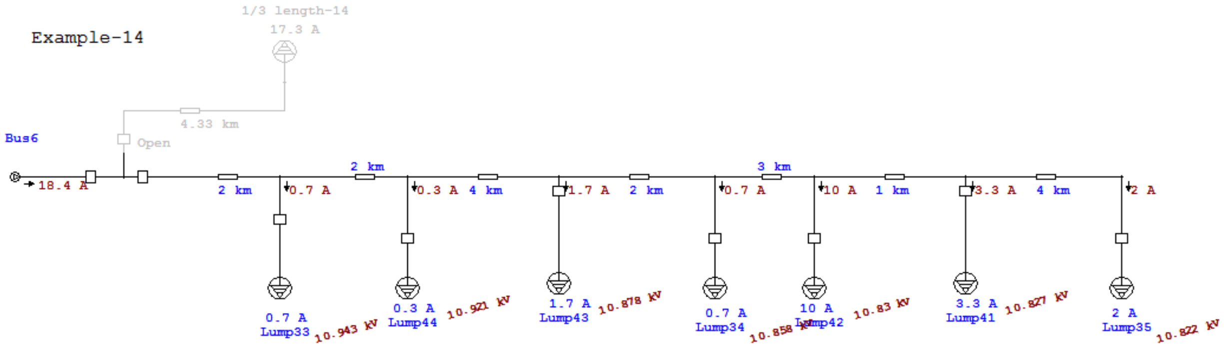
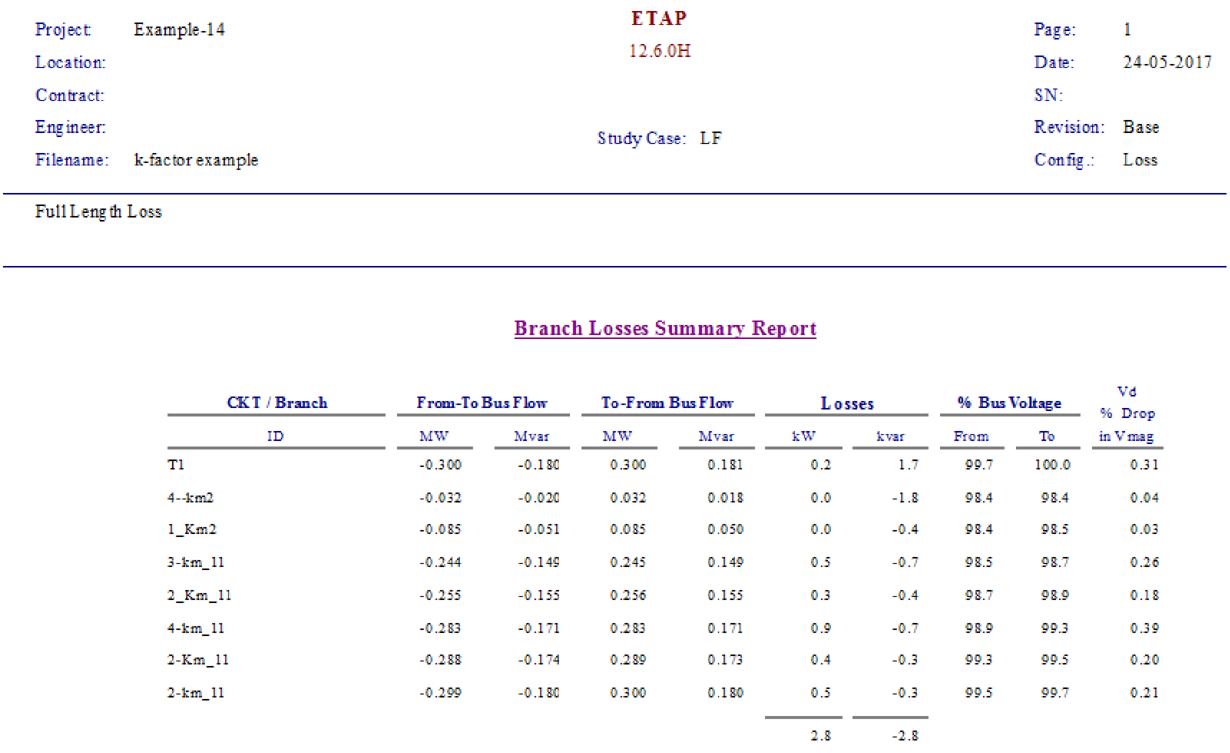


Fig 3.70: Full length Load Flow Analysis of Example-14



Project: Example-14
Location:
Contract:
Engineer:
Filename: k-factor example

ETAP
12.6.0H

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Config.: Loss

Full Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.300	-0.180	0.300	0.181	0.2	1.7	99.7	100.0	0.31
4--km2	-0.032	-0.020	0.032	0.018	0.0	-1.8	98.4	98.4	0.04
1_Km2	-0.085	-0.051	0.085	0.050	0.0	-0.4	98.4	98.5	0.03
3-km_11	-0.244	-0.149	0.245	0.149	0.5	-0.7	98.5	98.7	0.26
2_Km_11	-0.255	-0.155	0.256	0.155	0.3	-0.4	98.7	98.9	0.18
4-km_11	-0.283	-0.171	0.283	0.171	0.9	-0.7	98.9	99.3	0.39
2-Km_11	-0.288	-0.174	0.289	0.173	0.4	-0.3	99.3	99.5	0.20
2-km_11	-0.299	-0.180	0.300	0.180	0.5	-0.3	99.5	99.7	0.21
					2.8	-2.8			

Fig 3.71: Full length Loss Report of Example-14

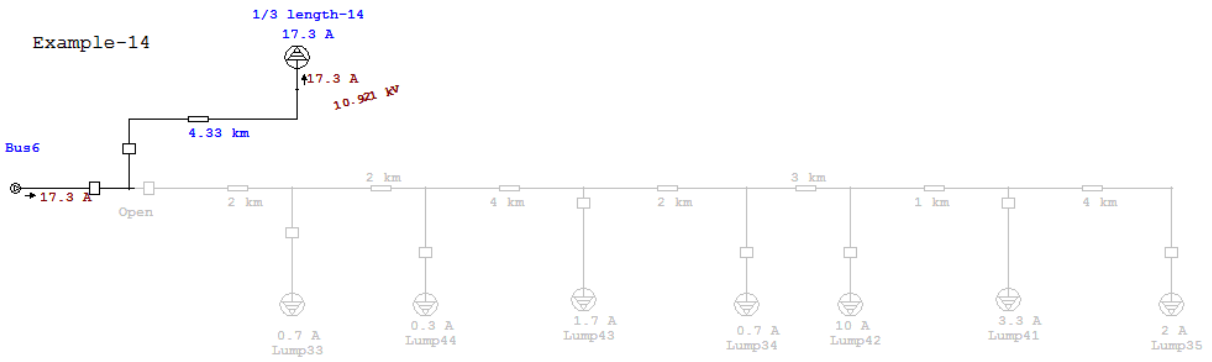
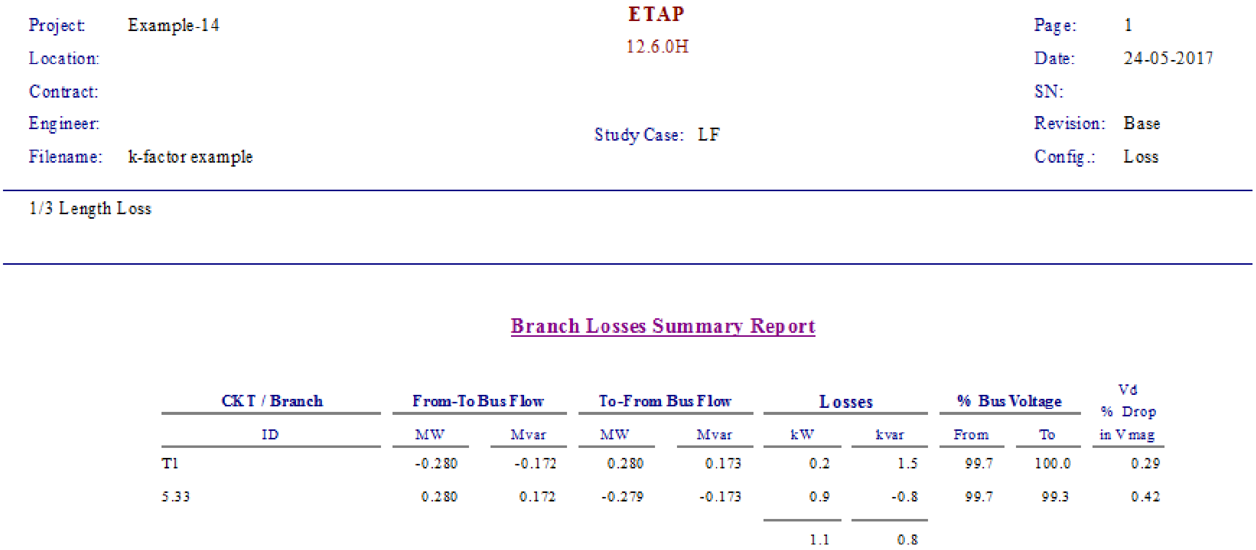


Fig 3.72: 1/3 length Load Flow Analysis of Example-14



Project:	Example-14	Page:	1
Location:		Date:	24-05-2017
Contract:		SN:	
Engineer:		Revision:	Base
Filename:	k-factor example	Config.:	Loss

ETAP
12.6.0H

Study Case: LF

1/3 Length Loss

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	-0.280	-0.172	0.280	0.173	0.2	1.5	99.7	100.0	0.29
5.33	0.280	0.172	-0.279	-0.173	0.9	-0.8	99.7	99.3	0.42
					1.1	0.8			

Fig 3.73: 1/3 length Loss Report of Example-14

$$\text{Loss Ratio} = \frac{(Real\ loss)}{(1/3\ System\ loss)}$$

$$= 2.8/1.1$$

$$= 2.54$$

Inference between calculated results and simulation results are given in the graph.

3.9 Result of Losses and Comparisons

We have computed the result of both Analog method and ETAP method with that of K_{th} and % of variation of loss ratio result which is given below.

Table 3.2: Loss Ratio of Analog and ETAP with that of K_{th} and % of variation of loss ratio (i)

1	2	3	4	5	6	7	8	9	10
Sl. No	Standard Values of Load ratio of 2nd and 1st half	K_{th}	**Sl. No. Ex 1-14**	2ndhalf/1st half load & Load Ratio of the example model	K_{th} for load ratio	Ratio by Analog	% variation of Analog system from Kth	Ratio by ETAP	% variation of ETAP system from Kth
1.	0 to 1.0	1.0	**1.**	6/40=.15	1.0	1.0	0	1.0	0%
2.	1.0 to 1.5	1.30	**2.**	6/13=.46	1.00	1.05	4.7%	1.0	0%
3.	1.5 to 3.0	1.45	**3.**	18/12=1.5	1.30	1.33	2.2%	1.18	9.2%
4.	3.0 to 4.5	1.54	**4.**	40/10=4.0	1.54	1.58	2.5%	1.4	11%
5.	4.5 to 6.0	1.683	**5.**	42/9=4.67	1.683	1.40	8.1%	1.87	10%
6.	6.0 to 7.5	1.813	**6.**	54/10=5.4	1.683	1.65	1.9%	1.65	1.9%
7.	7.5 to 9.0	1.944	**7.**	45/7=6.42	1.813	1.88	3.5%	1.67	7.8%
8.	9.0 to 10.5	2.04	**8.**	32/4=8.0	1.944	2.06	5.3%	1.85	4.8%
9.	10.5 to 12.0	2.175	**9.**	89/11=8.09	1.944	1.719	6.3%	1.85	4.8%
10.	12.0 to 13.5	2.285	**10.**	49/5=9.0	1.944	1.91	2%	1.8	7%
11.	13.5 to 15.0	2.397	**11.**	36.5/3.5=10.42	2.04	2.25	9.3%	2.0	1.9%
12.	15 to 16.5	2.517	**12.**	33/3=11.0	2.175	2.21	1.5%	2.14	1.6%
13.	16.5 to 18.0	2.528	**13.**	50.5/3.5=14.42	2.397	2.22	7.3%	2.36	1.5%
14.	18.0 to 19.5	2.64	**14.**	52.5/3.5=15.	2.357	2.125	9.8%	2.54	7.2%

Table 3.3: Loss Ratio of Analog and ETAP with that of K_{th} and % of variation of loss ratio (ii)

1	2	3	4	5	6	7
Sl. No. Ex 1-14	2ndhalf/1st half load & Load Ratio of the example model	K_{th} for load ratio	Ratio by Analog	% variation of Analog system from Kth	Ratio by ETAP	% variation of ETAP system from Kth
1	6/40=.15	1.0	1.0	0	1.0	0%
2	6/13=.46	1.00	1.05	4.7%	1.0	0%
3	18/12=1.5	1.30	1.33	2.2%	1.18	9.2%
4	40/10=4.0	1.54	1.58	2.5%	1.4	11%
5	42/9=4.67	1.683	1.40	8.1%	1.87	10%
6	54/10=5.4	1.683	1.65	1.9%	1.65	1.9%
7	45/7=6.42	1.813	1.88	3.5%	1.67	7.8%
8	32/4=8.0	1.944	2.06	5.3%	1.85	4.8%
9	89/11=8.09	1.944	1.719	6.3%	1.85	4.8%
10	49/5=9.0	1.944	1.91	2%	1.8	7%
11	36.5/3.5=10.42	2.04	2.25	9.3%	2.0	1.9%
12	33/3=11.0	2.175	2.21	1.5%	2.14	1.6%
13.	50.5/3.5=14.42	2.397	2.22	7.3%	2.36	1.5%
14.	52.5/3.5=15.	2.357	2.125	9.8%	2.54	7.2%

Table 3.4: Loss Ratio of and ETAP with that of K_{th}

Sl.No.	2ndhalf/1st half load & Load Ratio of the example model	K_factor for load ratio	Ratio by Analog	Ratio by ETAP
1	6/40=.15	1.0	1.0	1.0
2	6/13=.46	1.00	1.05	1.0
3	18/12=1.5	1.30	1.33	1.18
4	40/10=4.0	1.54	1.58	1.4
5	42/9=4.67	1.683	1.40	1.87
6	54/10=5.4	1.683	1.65	1.65
7	45/7=6.42	1.813	1.88	1.67
8	32/4=8.0	1.944	2.06	1.85
9	89/11=8.09	1.944	1.719	1.85
10	49/5=9.0	1.944	1.91	1.8
11	36.5/3.5=10.42	2.04	2.25	2.0
12	33/3=11.0	2.175	2.21	2.14
13	50.5/3.5=14.42	2.397	2.22	2.36
14	52.5/3.5=15.	2.357	2.125	2.54

Computed result of both Analog method and ETAP method with that of K_{th} and % of variation of loss ratio are seen here in the graph.

3.10 MATLAB Simulation

3.10.1 Full length/ (1/3) length loss ratio (ETAP) Vs “K” factor

Table 3.5: ETAP Loss ratio VS “K” factor data

Sl. No.	ETAP Ratio	“K” Value	Load Ratio
1.	1.0	1.00	.15
2.	1.0	1.00	.46
3.	1.18	1.30	1.5
4.	1.4	1.54	4.0
5.	1.65	1.683	5.4
6.	1.67	1.525	6.42
7.	1.85	1.944	8.0
8.	1.85	1.944	8.0
9.	2.00	2.04	10.42
10.	2.14	2.175	11.0
11.	2.36	2.397	14.42
12.	2.54	2.357	15.0

Computed result of both Load Ratio and ETAP method with that of K_{th} and % of variation of loss ratio are seen here in the graph.

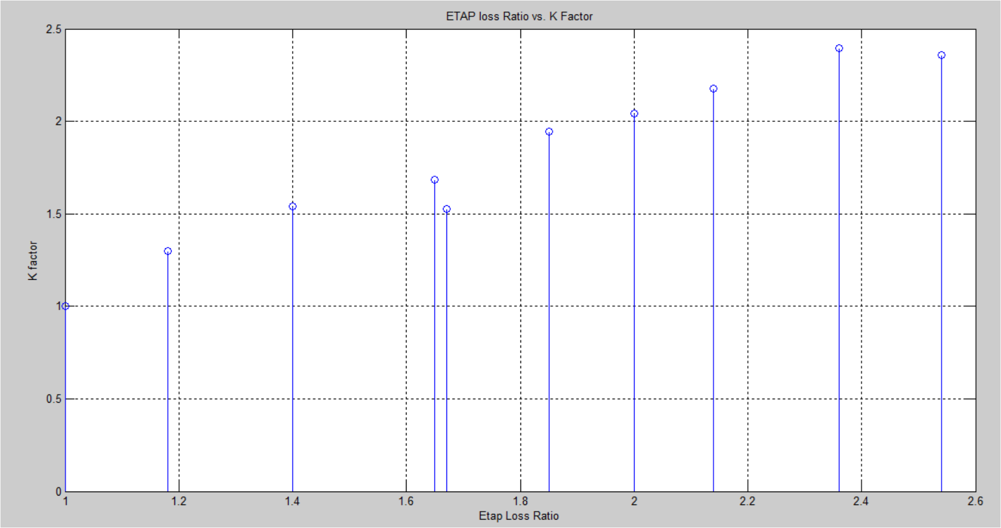


Fig 3.74: ETAP Loss Ratio Vs K-factor Simulation-1

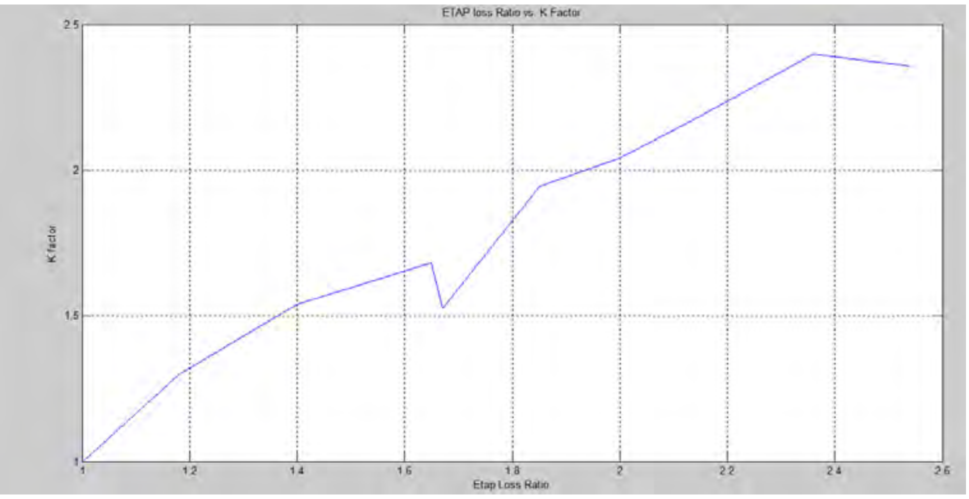


Fig- 3.75: ETAP Loss Ratio Vs K-factor Simulation-2

3.10.2 Analog $\frac{Full\ load\ loss}{\frac{1}{3} length\ loss}$ Loss ratio Vs “K” factor value.

Table 3.6: Analog Loss Ratio Vs “K” Factor data

Sl.No.	2ndhalf/1st half load & Load Ratio of the example model	K-Factor for load ratio	Ratio by Analog
1	6/40=.15	1.0	1.0
2	6/13=.46	1.00	1.05
3	18/12=1.5	1.30	1.33
4	42/9=4.67	1.683	1.40
5	54/10=5.4	1.683	1.65
6	45/7=6.42	1.813	1.88
7	32/4=8.0	1.944	2.06
8	33/3=11.0	2.175	2.21
9	50.5/3.5=14.42	2.397	2.22

Computed result of loss in both by Analog method and by load ratio method with that of K_{th}..

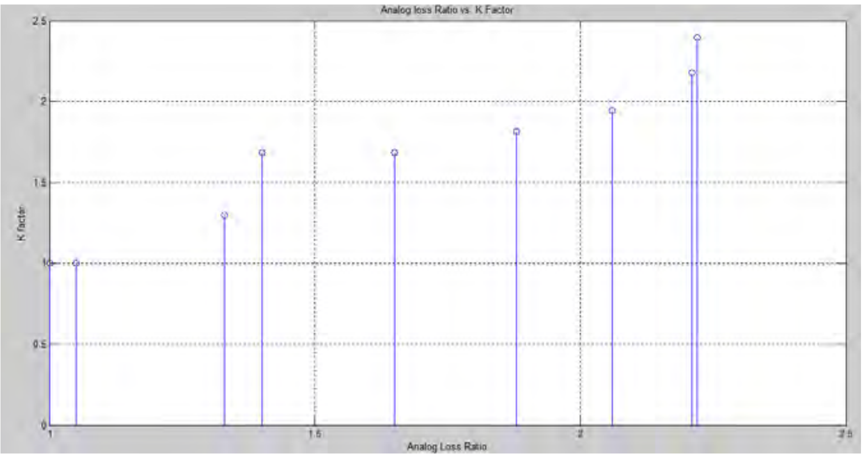


Fig- 3.76 : Analog Loss Ratio Vs K -factor Simulation-1

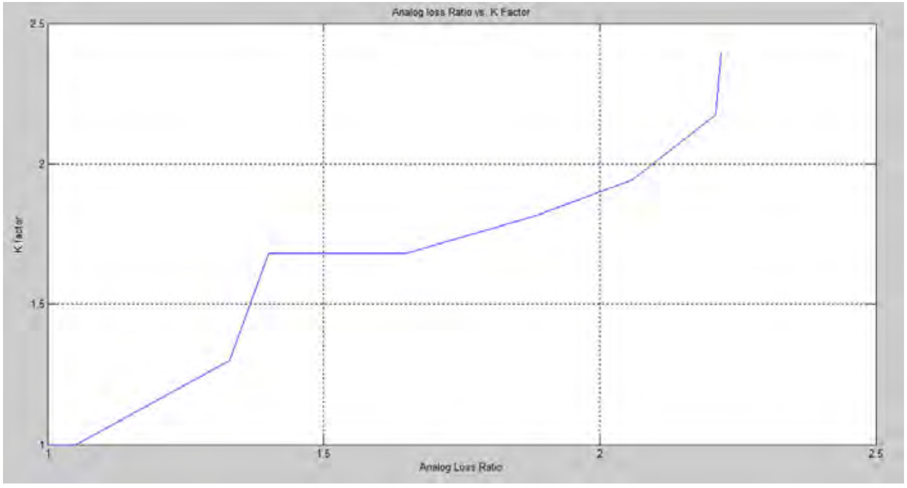


Fig- 3.77 : Analog Loss Ratio Vs K -factor Simulation-2

3.10.3 ETAP Loss Ratio Vs Analog Loss Ratio

Table 3.7: ETAP Loss Ratio Vs Analog loss Ratio

Sl. No.	2ndhalf/1st half load & Load Ratio of the example model	K_{th} for load ratio	Ratio by Analog	Ratio by ETAP
1.	6/40=.15	1.0	1.0	1.0
2.	6/13=.46	1.00	1.05	1.0
3.	18/12=1.5	1.30	1.33	1.18
4.	40/10=4.0	1.54	1.58	1.4
5.	54/10=5.4	1.683	1.65	1.65
6.	45/7=6.42	1.813	1.88	1.67
7.	32/4=8.0	1.944	2.06	1.85
8.	33/3=11.0	2.175	2.21	2.14
9.	50.5/3.5=14.42	2.397	2.22	2.36

Computed result of loss in both Analog method and ETAP method with that of K_{th} and % of variation of loss ratio are seen here in the graph.

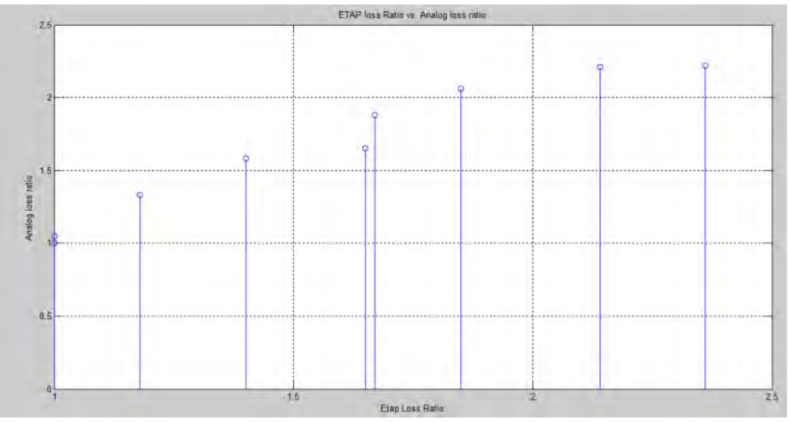


Fig 3.78: ETAP Vs Analog Loss Ratio Simulation-1

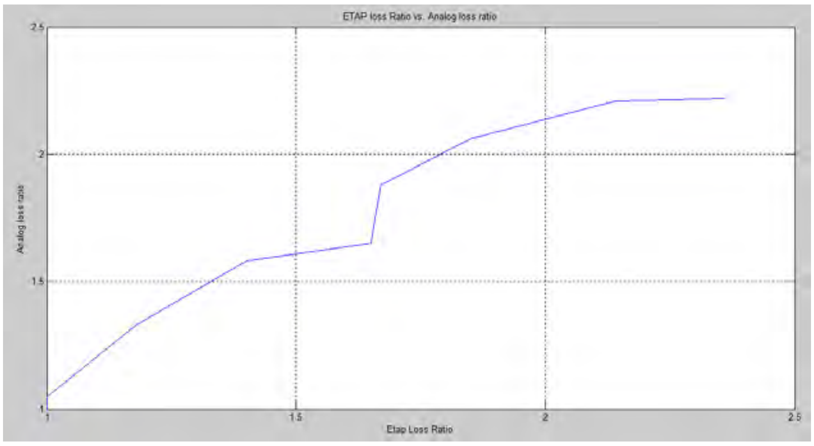


Fig 3.79: ETAP Vs Analog loss Ratio Simulation-2

3.10.4 (2nd half /1st half) Load Ratio Vs "K" factor

Table 3.8: 2nd half Load/1st half Load Ratio Vs "K" Factor

Sl. No.	2nd half Load/1st half Load Ratio	"K" Value
1.	1.0	1.0
2.	1.5	1.30
3.	3.0	1.45
4.	4.5	1.54
5.	6.0	1.683
6.	7.5	1.813
7.	9.0	1.944
8.	10.5	2.04
9.	12.0	2.175
10.	13.5	2.285
11.	15.0	2.397
12.	16.5	2.517
13.	18.0	2.528
14.	19.5	2.64

Estimated equation of load ration with that of "K" factor considered in thesis.

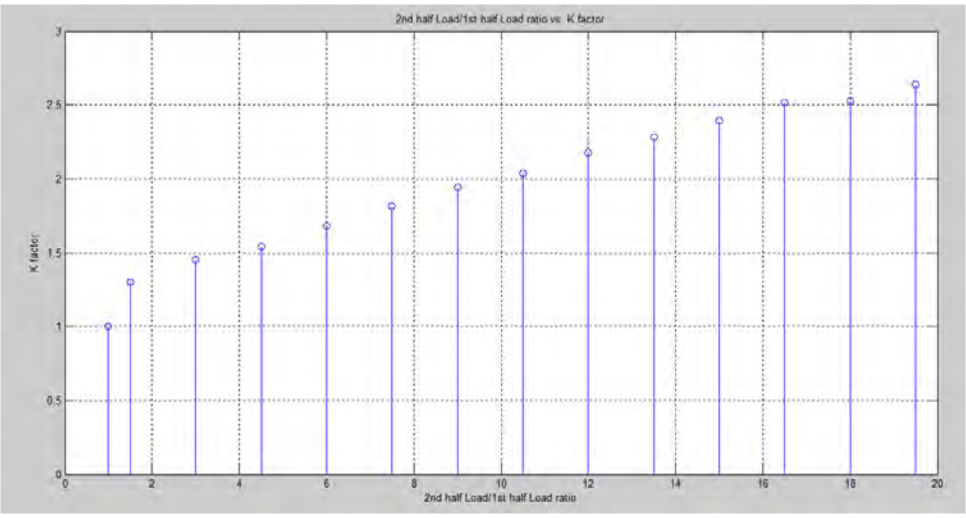


Figure 3.80: Load Ratio Vs K-factor Simulation-1

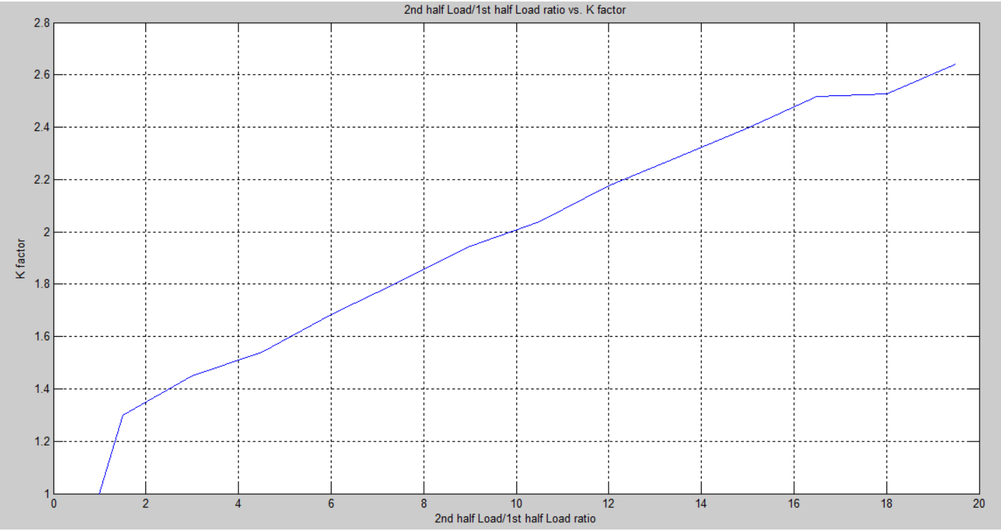


Figure 3.81: Load Ratio Vs K-factor Simulation-2

CHAPTER-4

Loss Calculation

4.1 Scope and Limitation

1) Power factor has been considered 95%. if not, required rating of capacitor is to be installed to improve the system. It is instructions of all the power utilities to all industrial consumers through survey. So, deviation for less power factor in neglible industries may be avoided.

2) All the phases have been considered balanced. Imbalanced load increases the System loss & detoriate the condition of equipment. Balancing is always a Pre- condition for system improvement. These are practiced by the utilities. Through survey which has been found to be OK.

3) All conductors in the same voltage level have been considered same for simplification of calculations. Survey has revealed that a small percentage of different conductor size in the same voltage level exists. So, probability of error can be avoided.

4) All underground cable has been considered as overhead cable for simplification of calculation.

5) In all calculations voltage drop has not been considered, though it is not correct. Hence for simplification, the error due to this could be accepted.

6) The methodology applied here, considering the peak load is proportionately conceived by each transformer under the feeder. So a variation if measured by clamp on ammeter may develop with the results calculated in this paper. But we are confident that in Dhaka Electricity Supply the transformers are loaded proportionately to their sizes with a little exception. So little error for the methodology may be checked by measurement. If this is accepted, then the primary feeder losses & secondary losses may be accepted on the same conception.

7) In case of finding losses on 1/3 feeder length basis, each feeder has been picked up for total calculations. More divisions are better options for correct result. But it increases huge calculation which is tedious. Then each section is divided in 2(two) parts. Such as 1st half and 2nd half. All the loads of each section are marked in single line diagram as 1st half load and 2nd half load which are shown in the diagram manifesting the existing condition as well the proposed system. The probable error is removed or significantly reduced by introducing the factor, termed as “K” factor which is explained in point 7 under section 4.1 of Scope and Limitation above. Then considering each section an independent feeder is made showing the demand loss and energy loss as estimated/calculated.

8) In the case of finding losses in the distribution network a 1/2 feeder length by “K” factor has been developed by iterative process.” K” factor is given details page above including the simulation. The accuracy by introducing “K” factor has been shown by few examples in the relevant pages. It is for simplification; a lot of calculation has been avoided through introducing them.

4.2 Applying the Methodology to Find Out the Losses in the Practical Field

4.2.1 The Feeder Losses

The loss in the feeder is due only to the load current flowing through the resistance of the wires in the lines. It is necessary to devise a means of calculating the loss through each section of the line.

It is assumed that the single line diagram has been prepared, that all loads have been determined & entered on the diagram, the accumulated load for each line section has been placed on the map & that the line sections have been listed on a form similar to the accompanying Appendix D & E.

The process is as follows:

(1) Assume all transformers installed into the system show their actual peak KVA load (Peak Kw/P. F).

(2) Enter on the single line diagram the accumulated peak KVA load which it carries on each line section.

(3) At 11kv side of three phase’s x-former, amps per phase is 0.05249 amperes hence this current flow in each phase conductor.

(4) Then for each line section the watt loss stands at ;

(KVA “load” connected/diversity factor× 0.05249) ^{2} ×resistance per Km × L per Km × 3= watts.

(5) At 6.35kv side of a single-phase x-former, amps per phase is 0.157 amperes hence this current flow in each phase conductor & return neutral.

(6) For each line section the watt loss is:

(KVA “load” connected/diversity factor× 0.157) ^{2} ×resistance per Km × L per Km × 2=watts.

(7) Sum of the losses for all line sections, the result is the watts’ demand loss for the section/feeder, naturally these watts’ demand divided by 1000 is the Kw loss demand.

(8) Unequal loads unevenly disbursed require analysis by nodes and sections. But this is tedious. So taking the peak load of the feeder and averaging it in the feeder in proper blocks; loads factors; line parameters and loss duration may be defined.

(9) Since uneven load does not proportionately flow through the total length; for loss calculation; 1/3rd length of the total feeder may be considered. Without proper treatment this will deviate the result for load variations and for length variation. So, a recommendation for introducing a correction factor ''K'' has been developed and made to get a close result which is clarified in the calculation sheet in the next section.

(10) The Kwh energy loss per month for the feeder is:

Kw x Feeder Lsf x 24 Hours x Month = Kwh/Month

(11) Percent Feeder Loss Kw demand is:

$$\frac{\text{Kw (loss)}}{\text{Demand in the section}} \times 100 = \ldots\ldots\ \%$$

(12) Percent Kwh energy loss is:

$$\frac{\text{Kwh (loss)}}{\text{Section Kwh (load)}} = \ldots\ldots\%$$

4.2.2 The Distribution Transformer Losses

The losses are due to the exciting current which energizes the cores of the transformers and is also due to the load currents flowing through the resistance of the transformers windings.

The steps to be taken to determine the distribution transformer losses for each feeder are:

1. Determine total number of single phase and total number of three phase distribution transformers.

2. Determine total KVA of single phase and total KVA of three phase distribution transformers.

3. Determine average capacity of single phase and average capacity of three phase distribution transformers.

4. For single phase transformers the following formula has been used to determine the watt's core loss for the average size single phase distribution transformer

$$\text{Watts} = 1.694127 \times (\text{KVA}) + 13.3174$$

Note: This is a derived formula based on Geometric Regression of the core loss of the HICO distribution transformers and has been tested to be accurate within 1% given by HICO.

5. Multiply this by the number of single phase transformers and divide the answer by 1000 to determine the total single-phase transformer Kw core loss.

6. For three phase transformers the following formula has been used to determine the watt's core loss for the average size three phase distribution transformer.

$$\text{Watts} = 10.58519 \times (\text{KVA})^{0.7466645}$$

Note: This is a derived formula based on Geometric Regression of the core loss for the GEM Bangladesh distribution transformers and has been tested to be accurate within 1% and tested in GEM

7. Multiply this by the number of three phase transformers and divide the answer by 1000 to determine the total three phase transformer Kw core loss.

Kw No Loads Loss X Number of transformers = Total Kw No Load Demand

8. Add the total single phase and total three phase transformer core loss to get the total distribution transformer Kw core loss.

9. The total distribution transformer core loss is the demand required to supply the core loss.

10. The total Kwh required to supply the core loss is:

Kw x24 hours x month = Kwh loss / month

11. For each transformer installation determine:

   a. Number of transformer.
   b. Installed KVA capacity.
   c. KW demand.
   d. Power Factor.
   e. Load Factor.

12. Determine Demand Factor by using formula:

$$\frac{\text{KVA (load)}}{\text{KVA (capacity)}} = \text{DF}$$

13. Calculate load loss for each single-phase transformer by using formula:

$$\text{Watts} = 24.04647 \times (\text{KVA})^{0.8649422}$$

Note: This formula is derived by Geometric Regression of the load loss of the HICO distribution transformers and has been tested and found to be accurate within 1 to 2 percent. used by HICO. Determine actual load loss Kw demand by using formula:

(DF) x Full Load Loss /1000 =Kw

14. Determine load loss for each three-phase transformer by using the formula:

$$\text{Watts} = 56.81502 \times (\text{KVA})^{0.7722969}$$

Note: This formula is derived by Geometric Regression of the load loss of the GEM Bangladesh three phase transformers and has been tested and found to be accurate within 1 to 2 percent.

15. Determine actual load loss Kw demand by using formula:

(DF) x Full Load Loss, KW/1000 = Kw

16. For each transformer determine the Kwh Load Loss by:

Kwh = Kw x Lsf x 24 hours’ x Month

17. Determine total Distribution Transformer Loss Kw demand using:

Transformer no load loss Kw demand + transformer load loss Kw demand = total distribution transformer loss Kw demand.

18. Determine percent Kw demand loss of substation area demand using:

$$\frac{\text{Distribution x-former Loss Kw}}{\text{Sub-Station Demand Kw}} \times 100 = \%$$

19. Total kwh loss is:

$$\frac{\text{KWH Loss}}{\text{Substation Kwh}} \times 100 = \%$$

Note: in order to prepare this procedure for application with a hand calculator it is necessary to accept some assumptions, the effect of which are considered to be small. We assumed that this not true because there is voltage drop all along the feeder. This drop will have a small affect on the transformer core loss (No Load Loss), However it is believed that the overall effect will be small. The results can be seen in appendix F & G.

4.2.3 The Low-Tension System Losses

The low-tension losses are caused by the load currents flowing through the resistance of the wires and it should be realized that for each kVA of load at low tension the currents are 26.50 times greater than they are at high tension voltage. The result is that for each kVA at low tension the loss is 702 times greater than a kVA at high tension for the same conductor. Therefore, it should be noted that a large amount of the loss might be attributed to the low-tension system. Because of the possible large loss, the low-tension system must be carefully considered.

The low-tension losses are determined in a manner very similar to that used in determining the feeder losses, except that the transformer loads are not used, instead the customer loads are considered to be reflected in the secondary feeders of the transformer covered by that. This method is as follows:

1. Prepare a single line diagrams for each low-tension system.
2. For each line section use the diversified load and calculate the loss for each section under the transformer.
3. Total the loss for the low-tension system and calculate the Kw, kWh and percentages as for the feeders, as done by 1/3rd method and introducing “k” factor like primary distribution feeder.
4. Similarly, the single phase low tension secondary losses are found, which is given in the calculation sheet in appendix H & I.

4.2.4 Service Drop Losses

For the service drop loss, take the average length & size of service conductor for different categories of consumer. Find the no. of consumer category wise. Find the undiversified load for each type of load & calculate the peak loss & Kwh loss for each service & then multiply by the no. of consumer. The result is given in appendix J & K.

4.2.5 Meter Losses

Loss of Energy Meter has been picked up from the manufacturer`s name plate data & total loss for the total meters of a month has been calculated. please see appendix M.

4.2.6 Twisting & Jumper Connection Losses

Improper jumper connection & twisting develops some heat resulting watt loss which ultimately increase Kwh loss. Calculation to find out the real losses for these is troublesome. But the reality is that these jumpers & twisting incur losses. However, a poor or high resistance connection invariably causes significant loss, especially during peak. No specific study result is available to find out losses for wrapping or twist connection. A lump sum % of loss has been assumed & included in this study which is 50% of meter loss, which may be higher or lower than the meter losses. Please see appendix M.

4.2.7 Street Light Load Losses

There are 210 points of street light having 30% of which is 2 X 40-watt fluorescent bulb & the rest are halogen bulb in the area. These street lights are supplied by 10 nos. of transformer by extensive single-phase supply by ant conductor. The supply for the street light runs at both ends of same transformer. The losses for this street lights have been calculated in the same way as feeder & line losses previously done, considering 12 hours of operation. The calculation has been given in appendix J.

CHAPTER-5

Proposed System

5.1 Proposed System

Same procedure has been adopted to find the losses by replacing the existing system by the proposed system, the single line diagram of which is enclosed feeding the same load.

5.2 Comparisons

1. The comparison of peak loss & Kwh loss has been given in the appendix O.

2. In the comparison sheet of losses we see that the peak Kw loss as well as the kWh loss for the decentralized system has been reduced drastically. Although a service drop loss may remain constant in both the cases if not altered, but suggestions are there to replace the service drops by higher size of conductor which will reduce the loss by 50%. Calculation has been done by changing the service drop by replacing the existing one by higher size.

5.3 Construction Proposition

1. Single line diagram considering the loads has been enclosed. A greater quantity of primary line is required which increases the capital cost, but almost all the secondary conductor except the neutral to be dismantled. Banking of single phase transformer in almost all the poles of proper size has been suggested. Service drop from the secondary of the transformer bushing will feed the consumer directly. Construction drawing for the proposed system has been enclosed for ready reference (see Appendix R).

2. Street light of 175-watt mercury bulb can be hanged directly from the transformer in every alternate pole. Since the illumination of 175-watt mercury bulb gives more light then 2 X 40-watt fluorescent tube, it covers an area of 50 meters' diameter. It shall be installed with one photo cell. So, line loss for the street light conductors will be negligibly small & the bill for the no. of lights can be realized on fixed charge basis considering the hours of operation & watts.
3. The drawing of street light installation is enclosing for ready reference (see appendix R)

5.4. Comparison between Technicality of the Existing and the Proposed System

Now a summery sheet is prepared on the basis of these calculations which show 168923.72 units of kwh are lost in that area in a month, which after converting into tk. Stands at tk. 844618.6 /-at the rate of tk.5.0 kwh. But due to inheriting quantity of equipment's & conductors we are to loss some energy. But how much we will loss? That shall be optimized. We see from the proposed system & loss comparison sheet we can save 77066.43 Kwh of energy in a month if the system is constructed as proposed. So, in a year the saved money will be tk. 47, 00,000/-. We can compare the money saved from the system changed & cost involvement from the cost comparison sheet (appendix N).

CHAPTER-6

Cost and Financial Analysis

6.1 Cost Comparison

The cost comparison for transforming the work from existing to the proposed one has been enclosed to evaluate the study result .

6.2 Energy Loss Comparison

In the specific area, we can find that energy delivered in a month = (3.028+4.21+1.51+0.75) MW X 0.65 X 720X1000 = 3383,640 Kwh.

Energy lost in a month due to technical reason for the existing system = 168923.72 Kwh which is 5.11%.

Energy lost in a month due to technical reason for the proposed system is =2.78%.
So by renovating the system we can save energy in a month 77066.43 Kwh which is 2.33% & amounts tk. 385332.15 in a month i.e., tk. 4623985.8 in year.

HERE, From Table A.1

1. Diversity Factor= Diversity factor is the ratio of the sum of the individual maximum demands of the various subdivisions of a system (or part of a system) to the maximum demand of the whole system (or part of the system) under consideration. Diversity Factor = Installed load / Running load. Diversity is usually more than one. So in this calculation Diversity Factor is determined by, Total avg. KVA/Total Demand KVA: 9050/3048= 2.97
2. At 11kv side of three phases x-former, amps per phase is 0.05249 amperes hence this current flow in each phase conductor.
3. At 6.35kv side of a single-phase x-former, amps per phase is 0.157 amperes hence this current flow in each phase conductor & return neutral.
4. Amp^2= (Total avg. KVA/ Diversity Factor x 0.05249) ^{2} for 3 ϕ
5. Load Factor (L.F) = Actual Load / Full Load. The ratio of the Actual Load of equipment to Full load of equipment. It is the ratio of actual kilowatt-Hours used in a given period, divided by the total possible kilowatt -hours that could have been used in the same period at the peak KW level. So, it stands as, Load Factor = (energy (kWh per month)/ (peak demand (kW) x hours/month). In other terms Load factor is defined as the ratio of Average load to maximum demand during a given period. Load Factor= Average Load / Maximum Demand during given Time Period. The Load factor is always <=1. Feeder wise L.F is calculated and put in the table.
6. Loss Factor= (L.F) ^{2} X 0.85 +L. F X 0.15
7. Peak loss Kw on 1/3rd basis, Kw
8. = (Amp^2 X Line Length X K X Resistance/km)/1000
9. Kw Loss/month = Peak loss in Kw X Ls F X720
10. K= (Section 2nd half Load, /section 1st half Load, KVA)

Up to 0.5 K=1
For 0.51 to 1, K=1.10
For 1.1 to 5, K=1.60
For 5.1 to 10, K=1.70
For 10.1 to 15, K=1.90
For 15.1 to 20, K=2.18

SYESTEM: EXISTING (Appendix D)
LOSS AREA: PRIMARY DISTRIBUTION

Table A.1: Calculated Loss of Primary Distribution OF Project Area

Sl No	Feeder Name	Line Section	Average Section Line Length Km	Average Load KVA	Diversity Factor	Line Resistance Ohm/Km	Amp^2	Section 1st half Load KVA	Section 2nd half Load KVA	"K" Val-ue	Peak Loss in Section Kw	Section Load Factor	Section Loss Factor	Loss in Section for a month Kwh
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1A	Zigatola Local	A-B	0.2861	2500	2.97	0.375	1952.18	2500	2080	1	0.209	0.75	0.59	88.783
1B	Zigatola Local2	B-C	0.2861	1666.67	2.97	0.375	867.64	1672	1250	1.5	0.139	0.75	0.59	59.047
1C	Zigatola Local1	C-D	0.2861	833.33	2.97	0.375	216.91	836	418	1	0.023	0.75	0.59	9.77
											0.371			157.60
2A	Zigato-la local2	A-B	0.5209	6550	2.97	0.375	13400.56	6550	5500	1.5	3.926	0.75	0.59	1667.76
2B	Zigato-la local2	B-C	0.5209	4366.66	2.97	0.375	5955.78	4375	3280	1.5	1.75	0.75	0.59	743.4
2C	Zigato-la local2	C-D	0.5209	2183.33	2.97	0.375	1488.95	2100	1000	1	0.291	0.75	0.59	123.62
											5.967			2534.78
3A	Meena bazar	A-B	1.7602	4415	2.97	0.375	6385.85	4400	3700	1.50	6.32	0.75	0.59	2796.6
3B	Meena bazar	B-C	1.7602	2943.33	2.97	0.375	2838.15	3000	2200	1.50	2.81	0.75	0.59	1193.69
3C	Meena bazar	C-D	1.7602	1471.67	2.97	0.375	709.51	1500	750	1.25	0.585	0.75	0.59	248.68
											9.715			4238.97
4A	Kaptan Bazar	A-B	2.60	2616	1.56	0.375	7747.82	2600	2100	1.50	11.16	0.45	0.24	1927.91
4B	Kaptan Bazar	B-C	2..60	1744	1.56	0.375	3443.47	1750	1300	1.50	4.96	0.45	0.24	856.85
4C	Kaptan Bazar	C-D	2.60	872	1.56	0.375	860	850	450	1.25	1.03	0.45	0.24	178.51
											17.15			2926.27
5A	Dholaikhal	A-B	1.08	1200	1.54	0.375	1672.92	1200	1000	1.50	1.02	0.45	0.24	175.62
5B	Dholaikhal	B-C	1.08	800	1.54	0.375	743.52	800	600	1.50	0.45	0.45	0.24	78.05
5C	Dholaikhal	C-D	1.08	400	1.54	0.375	185.88	400	200	1.50	0.11	0.45	0.24	19.51
											1.01			273.18
											34.78			1067.7

SYSTEM: EXISTING (app K)
LOSS AREA: SERVICE DROP

Table A.2: Calculated Loss of Service Drop of Project Area with Existing System

Sl No.	**Consumer Type**	**Phase**	**Load in Kw**	**Conductor size Sq.mm**	**Resistance Ohm/ Kw**	**Average length Km**	**Diversity Factor**	**Amp^2**	**Total no. of Consumers**	**Loss in Kw**	**Load Factor in %**	**Loss Factor**	**Loss Kwh /Each/Month**	**Total Kwh /Loss /Month**
1	**DOMESTIC**	**1-Ph**	2	1.5	12.37	0.03	1.5	34.1	8250	.0255	20	0.06	1.08	8992.50
2	**COMMERCIAL**	**1-Ph**	2.5	2.5	7.55	0.03	1.5	53.26	4030	.024	25	0.09	1.56	6267.46
3	**INDUSTRIAL**	**1-Ph**	5	2.5	7.55	0.03	2	119.84	1840	.054	45	0.24	9.38	17259.20
4	**DOMESTIC**	**3-Ph**	8	2.55	7.55	0.03	1.5	60.89	1984	.041	20	0.06	1.77	3511.68
5	**COMMERCIA**	**3-Ph**	20	16	1.18	0.03	2	214.08	990	.023	45	0.24	3.97	3930.3
6	**INDUSTRIA**	**3-Ph**	20	16	1.18	0.03	2	214.08	138	.023	45	0.24	3.97	547.86
7	**INDUSTRIA**	**3-Ph**	26	16	1.18	0.03	2	361.8	118	.0384	45	0.24	6.57	775.26
	Total								17350	.228				41284.26

Here,

1. Power Factor =0.95
2. Amp^2,
   For 1-phase = $\{(KVA/D.F) \times 4.16\}^2$
   For 3-phase = $\{(KVA/D.F) \times 1.39\}^2$
3. Loss Factor = $(L.F)^2 \times 0.85 + L.F \times 0.15$
4. Kw loss,
   For 1-phase = $Amp^2 \times R \times L \times 2/1000$
   For 3-phase = $Amp^2 \times R \times L \times 3/1000$
5. Kwh Loss/month/each = Kw Loss X Loss factor x720
6. Total Kw Loss/month = Kw Loss/month/each x no. of consumer

System: Proposed (app L)
Loss area: Service Drop

Table A.3: Calculated Loss of Service Drop of Project Area with Proposed System

Sl No	Consumer Type	Phase	Load in Kw	Conductor size Sq.mm	Resistance Ohm/Kw	Average length Km	Diversity Factor	Amp^2	Total no. of Consumers	Loss in Kw	Load Factor in %	Loss Factor	Loss Kwh/ Each/ Month	Total Kwh/ Loss/ Month
1.	DOMESTIC	1-Ph	2	1.5	1.524	0.03	1.5	34.1	8250	0.0031	20	0.06	0.133	1104.84
2.	COMMERCIAL	1-Ph	2.5	2.5	1.524	0.03	1.5	53.26	4030	0.0044	25	0.09	0.3175	1279.61
3.	INDUSTRIAL	1-Ph	5	2.5	1.48	0.03	2	119.84	1840	0.0106	45	0.24	1.83	3370.29
4.	DOMESTIC	3-Ph	8	2.55	1.48	0.03	1.5	60.89	1984	0.0081	20	0.06	0.34992	694.24
5.	COMMERCIA	3-Ph	20	16	1.18	0.03	2	214.08	990	0.01177	45	0.24	3.92	3880.8
6.	INDUSTRIA	3-Ph	20	16	1.18	0.03	2	214.08	138	0.01177	45	0.24	3.92	540.96
7.	INDUSTRIA	3-Ph	26	16	1.18	0.03	2	361.8	118	0.03842	45	0.24	6.64	783.52
	Total								17350	0.0811				11654.26

Here,

1. Power Factor =0.95
2. Amp^2,
   For 1-phase = $\{(KVA/D.F) \times 4.16\}^2$
   For 3-phase = = $\{(KVA/D.F) \times 1.39\}^2$
3. Loss Factor = $(L.F)^2 \times 0.85 + L.F \times 0.15$
4. Kw loss,
   For 1-phase = Amp^2 x R X L x2/1000
   For 3-phase = Amp^2 x R X L x3/1000
5. Kwh Loss/month/each = KW Loss X Loss factor x720
6. Total Kw Loss/month = Kw Loss/month/each x no. of consumer

A.2.1 Meter Loss (app M)

As per manufacturer's name plate data, Meter Loss is
= (8VA * 0.95)/1000 Kw = 7.6 * 10^{-3} Kw/Each

With a Loss factor of 0.24,
Monthly loss due to a meter stands at,
=7.6 * 10^{-3} * 0.24 * 720h
=1.3133 Kwh
So far total 14270 meters in the area,
Kwh losses stand at,
= 18740.79 Kwh/month.

A.2.2 Twist & Jumper Connection Loss

Considering 50% of meter loss Kwh loss for the area stands at,
= 9370.40 Kwh/month.

A.2.3 Loss Comparison (app N)

Table A.4: Calculated Loss of Two System of Project Area

SL. NO	**Loss Area**	**Existing System**		**Proposed System**	
		Peak Load Loss, Kw	**Kwh Loss Per month**	**Peak Load Loss, Kw**	**Kwh Loss Per month**
1	Primary Distribution	34.78	10167.67	33.17	6122.302
2	X-former No Load Loss	44.85	16989.76	45.91	28239.63
3	X-former Load Loss	78.066	15140.972	78.066	26100.303
4	Secondary Distribution 3-Ph	251.51	57211.58		
	Secondary Distribution 1-Ph	0.13	18.29		
5	Service Drop Loss	0.288	41284.26	0.0811	11654.26
6	Meter Loss	0.0076	18740.79	0.0076	18740.79
7	Jumper /Twisting & Wrapping Connection Loss	0.0038	9370.40		1000
Total		**409.64**	**168923.72**	**157.23**	**91857.29**

Note:

5. Service Drop for the proposed system has been suggested for 1kw to 2.5 kW by Duplex & from 2.5 kW to 10 kW by 3 duplex & from 10 kW to 15 kW by 3 Quadruplex which will reduce the loss by 50%.
6. Jumper & Twisting shall be avoided. Proper sleeve connection must be done. At least 80% of loss will be reduce

Cost Comparisons (app P)
Table: Cost Comparisons

Table A.5: Calculated Loss-Benefit ratio of Two System of Project Area

Si. no	Area of Work	To be Dismantle-d	Salvage Quantity	Unit Price of Salvage Material Tk.	Total Salvage Value Tk.	To be Installed	Quant-ity	Unit Price Tk.	Total Value Tk.	Salvage Work Cost	Installation cost Tk.
1	Primary Distribution					3-Ph, 11kv DOG	3.724X 3 km	20,000/00/km	223440	10% of material cost	15% of material cost
2	Pole	9 meters	1016 nos.	15,000/00	15240000	-------		15,000/00	13248000		
		12 meters	----------	18,000/00		12 meters	736 nos.	18,000/00			
3	X-former	800kva 11/0.4 kva 650 Kva 11/0.4 Kva 500 Kva 11/0.4 400 Kva 11/0.4 kva 315 Kva 11/0.4 Kva 250 Kva 11/0.4 Kva 200 Kva 11/0.4 Kva	1 Nos. 1 Nos. 1 Nos. 5 Nos. 1 Nos. 5 Nos. 56 Nos.	4,50,000/00 4,00,000/00 3,50,000/00 3,00,000/00 2,75,000/00 2,50,000/00 2,25,000/00	450000 400000 350000 150000 275000 1250000 12600000	167 Kva 6.35/ 0.24 Kva 100kva 6.35/ 0.24 Kva 75kva 6.35/ 0.24 kva 50 kva 6.35/ 0.24 kva 37.5kva 6.35/ 0.24 kva 25kva 6.35/ 0.24 kva	15 Nos. 24 Nos. 60 Nos. 33 Nos. 18 Nos. 84 Nos. 15 Nos. 417 Nos. 57 Nos.	1,20,000/00 1,00,000 80,000/00 70,000/00 40,000/00	1800000 2400000 4800000 2310000 720000 2520000		

						15 Kva 6.35/ 0.24 kva 10 kva 6.35/ 0.24 kva 5 kva 6.35/ 0.24 kva		30,000/00 20,000/00 15,000/00 8,000.00	300000 6255000 456000		
4	Dropout type cut out fuse	11 Kv	70	20,000/set(3 Phase)	--------	723	723	7000	5061000		
5	Secondary Distribution 0.400/0.23 kv line	Wasp. Ant.	40.4117 X 3 km 0.12x 3 km	5000/km 4000/km	606175.5 1440						
6	Street light conductor	0.23 Kv Ant.	20x 3 km	4000/km	240000						
7	X-former Bracket	70		1,000/set	70000	For banking 175 watts. Mercury bulb	723	1000/-	723000		
8	Street lights	a) local tube with bracket. b)Sodium light	2X40 w 60 Nos. 150 Nos.	500/set 1000/set	30000 150000	175 watts. Mercury bulb	2x150 nos.	1000	300000		
9	Service Drop	All	250 km	3 duplex	250000000	3 duplex 3 Quadruplex	250km 250km	1,000/km 1,500/km	250000 375000		
10	LT Insulators	Pertly	4064	50/pc	203200	---------	-------	--------	---------	---------	---------
	Total				20742935.5				41741440	4174144	6261216

A.2.4 Remarks

All poles to be reused from X-former H-pole

Note:

1. Real salvage value considered 70% of total salvage value
2. Total cost involved for the work=Total installation value + salvage cost + Installation Cost - Real salvage value =22957792
3. Salvage cost has been considered 10% of Material cost.
4. Installation Cost has been considered 15% of Material cost

A.2.5 Energy lost per month

Table 7.6: Total Benefit under the Proposed System

SI. No.	Energy Delivered in a month	Energy lost in Existing system per month, kwh	Percentage system loss(%)	Energy lost in the proposed system	Percentage system loss(%)	Energy saved per month	System loss saved in %	Tk saved per month
	7.061x0.65x 720x1000= 3304548 kwh	168923.72	5.11	91857.29	2.78	77066.43	2.33	385332.15

For a year Tk. Saved=4623985.8

CHAPTER-7

Conclusions

Now-a-days many countries using decentralize system for power distribution. Like Australia, most of the countries of North America, Japan etc. Even in our country rural area (which is under control of REB) using this system. (Data has given at Appendix S of a site visit at saver area).

We can see from the loss & cost comparison sheet that within only five years of time the investment comes back. Then, in every year it should give back a profit of tk. 47, 00,000/year more for technical loss saved more than what is giving now. What an impetuous result.

(1) The result, if accepted & refined, sounds within our knowledge & pragmatic capability, can perform a loss reduction project, which in turn gives huge amount of turnover from the utility supply.

(2) This work also stresses that both KWh & KW losses are important & this should be valued at long run policies for a sustained financial viability of the system as well as the nation.

(3) This study also identifies methodology to isolate losses, technical, non-technical & optimize loss level on an economic basis.

(4) The relevance of loss analysis in establishing engineering design & operating criterion should be co-ordinate.

(5) Now, just for academic interest let us accept the result is correct & we are also confident about it. If it happens so, the loss comes down to that level what is calculated here, the DPDCL is earning tk.100 corers per month (as per billed amount). With a demand of 1000 mw can earn. tk. 150 core per year & if non-technical loss is also checked, then DPDCL could earn tk.197 core in a year.

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[9(b)] Comparison of REB and PDB Distribution system

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Appendix-A

A.1 Single Line Diagram of Existing & Proposed System

These are some example in finding out the losses of the feeders under the distribution transformers in old Dhaka area which are densely populated and system loss is high.

NOCS,ZIGATOLA,DPDC
SINGLE LINE DIAGRAM OF ZIGATOLA LOCAL 11KV O/H FEEDER

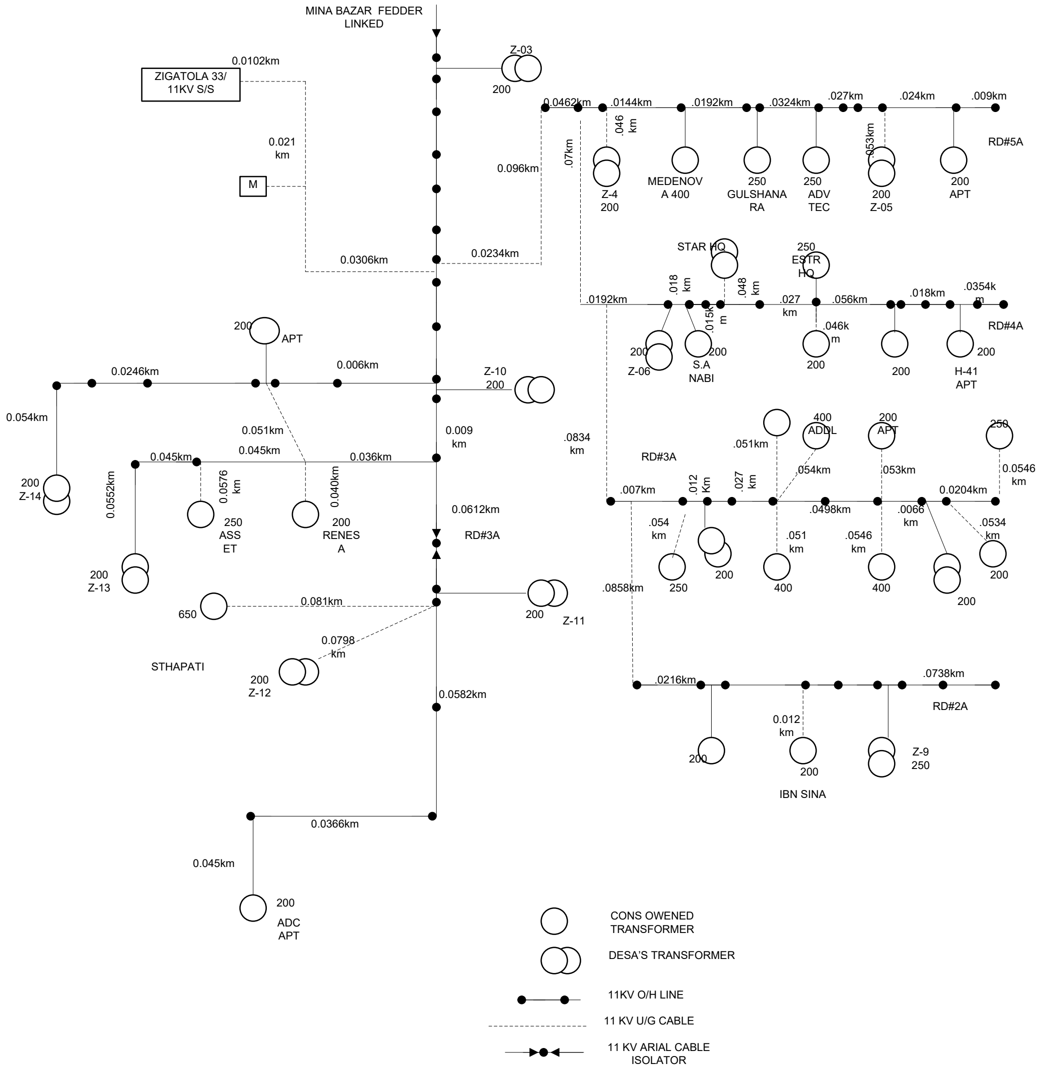
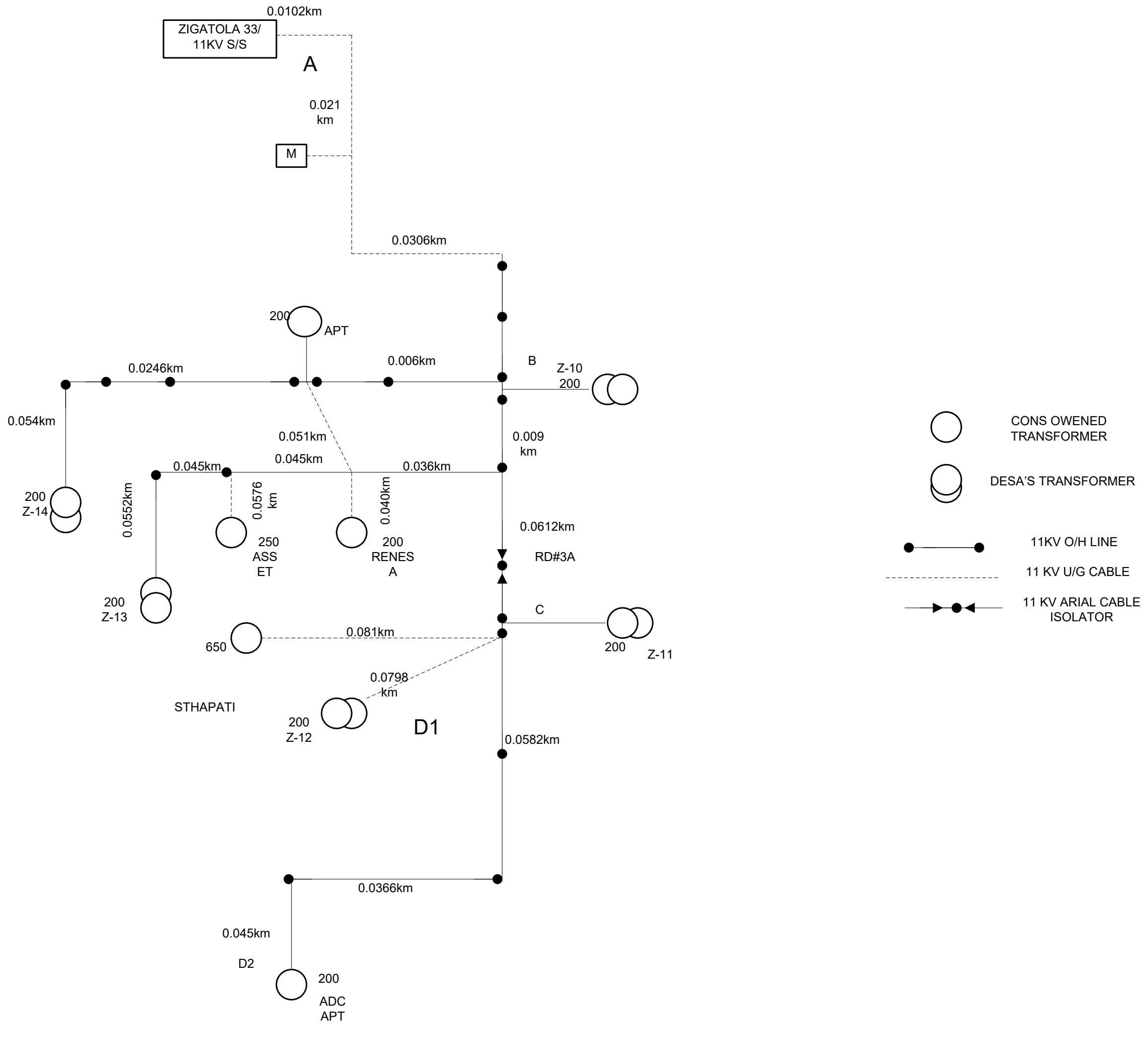


Fig A.1: Single line diagram of Zigatola local feeder (Existing)

LOSS AREA: PRIMARY DISTRIBUTION

NOCS,ZIGATOLA,DPDC
SINGLE LINE DIAGRAM OF ZIGATOLA
LOCAL 11KV O/H FEEDER(1)



N.B.: feeder divided for simplification of calculation

Fig A.2: Single line diagram of Zigatola local feeder-1 (existing)

FEEDER NAME:ZIGATOLA LOCAL Feeder(1)

SOURCE:ZIGATOLA 33/11 KV LOCAL
Load in peak hours : 3028.41 KVA
Total MVA Connected :9050 KVA
Single Line Diagram In Bunched load
System : Existing

LOSS CALCULATED ON 1/3 OF EACH
SECTION

DIVERSITY FACTOR = 9050/3028.41
= 2.97

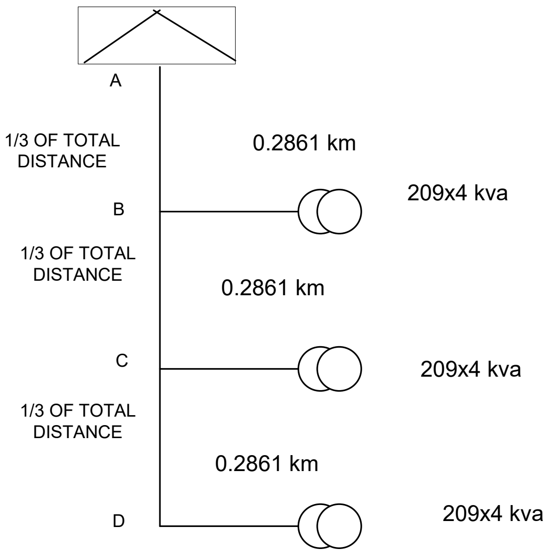


Fig A.3: Simplified bunched loaded single line diagram of Zigatola local feeder-1 (existing)

FEEDER NAME:ZIGATOLA LOCAL Feeder(2)

SOURCE:ZIGATOLA 33/11 KV LOCAL
Load in peak hours : 3028.41 KVA
Total MVA Connected :9050 KVA
Single Line Diagram In Bunched load
System : Existing

LOSS CALCULATED ON 1/3 OF EACH SECTION

DIVERSITY FACTOR = 9050/3028.41
= 2.97

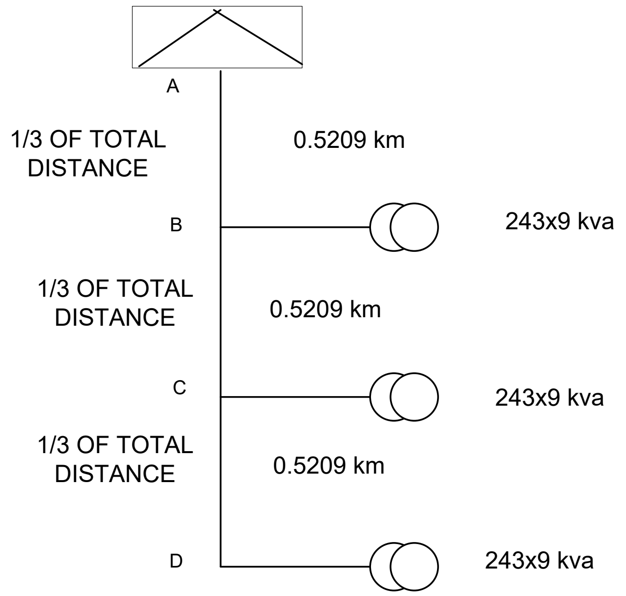


Fig A.4: Simplified bunched loaded single line diagram of Zigatola local feeder2 (existing)

SINGLE LINE DIAGRAM OF PROPOSED SYSTEM

FEEDER NAME :ZIGATOLA LOCAL
SORCE:ZIGATOLA SUBSTATION 33/11KV S/S
LOAD IN PEAK HOUR :3048.41KVA
CONNECTED KVA :10119KVA
TOTAL PRIMARY LENGTH :3.2714KM
TOTAL TRANSFORMER : 183

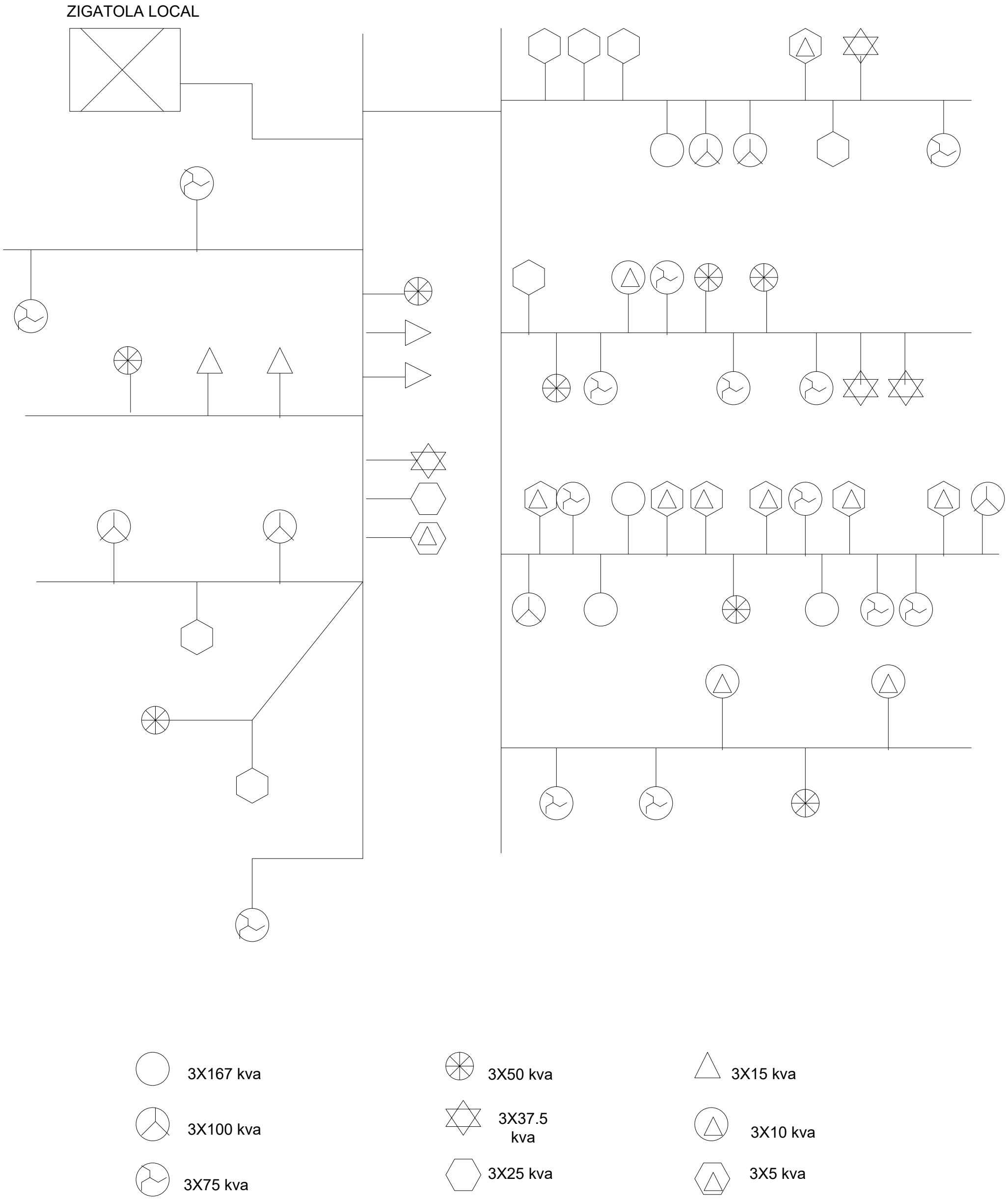


Fig A.5: Single line diagram of Zigatola local feeder. (Proposed)

FEEDER NAME:ZIGATOLA LOCAL Feeder(1)

SOURCE:ZIGATOLA 33/11 KV LOCAL
Load in peak hours :3028.41 KVA
Total MVA Connected :10.119 MVA
Single Line Diagram In Bunched load
System : Proposed

LOSS CALCULATED ON 1/3 OF EACH SECTION

DIVERSITY FACTOR = 10119/3028.41
= 3.32

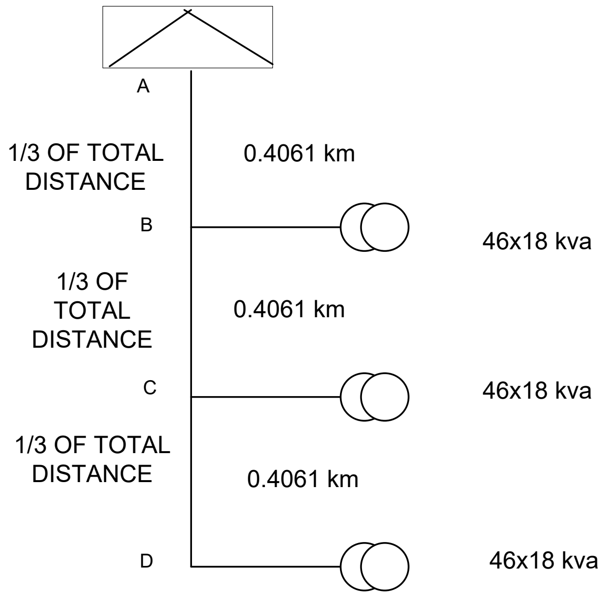


Fig A.6: Simplified bunched loaded single line diagram of Zigatola local feeder 1. (Proposed)

FEEDER NAME:ZIGATOLA LOCAL Feeder(2)

SOURCE:ZIGATOLA 33/11 KV LOCAL
Load in peak hours : 3.028 MVA
Total MVA Connected :10.119 MVA
Single Line Diagram In Bunched load
System : proposed

LOSS CALCULATED ON 1/3 OF EACH SECTION

DIVERSITY FACTOR = 10119/3028.41
= 3.32

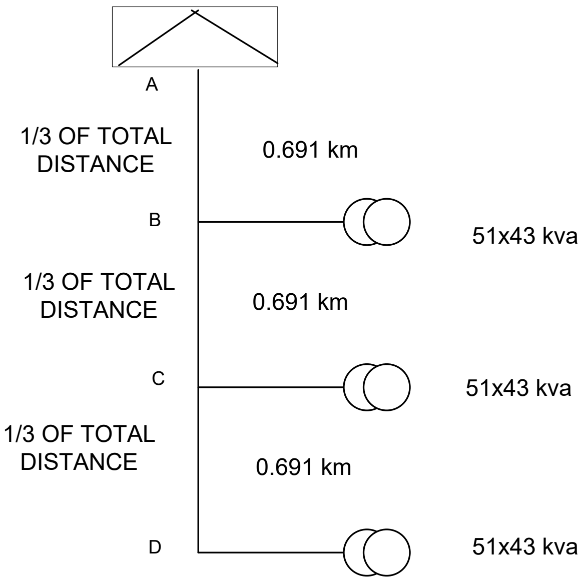


Fig A.7: Simplified bunched loaded single line diagram of Meena bazaar feeder (existing)

NOCS ZIGATOLA,DPDC
SINGLE LINE DIAGRAM OF
MENNA BAZAR 11KV O/H FEEDER

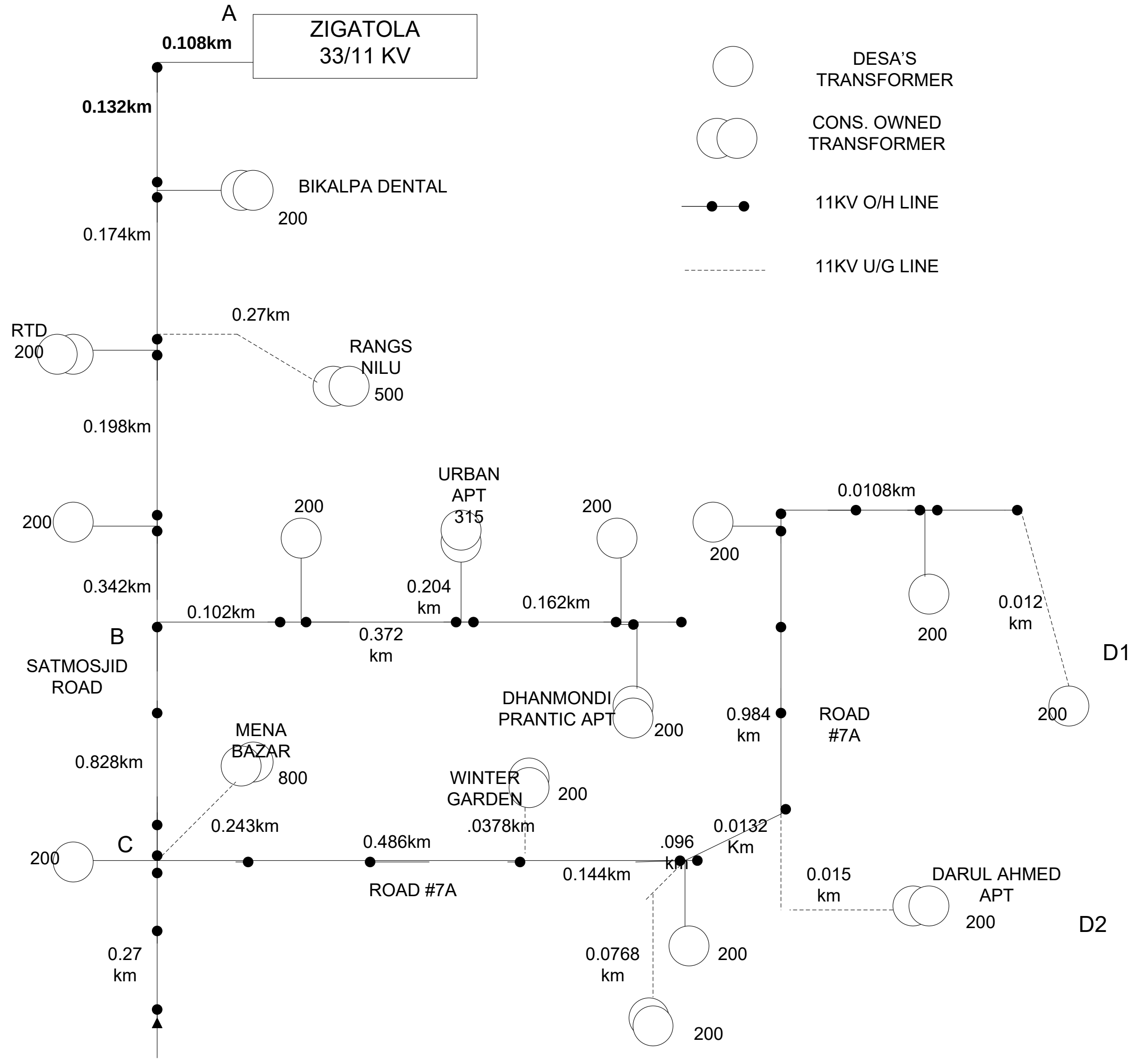


Fig A.8: Single line diagram of Meena Bazar Feeder (existing)

SOURCE:ZIGATOLA 33/11 KV LOCAL

Load in peak hours :1524KVA
Total MVA Connected :4.215MVA
Single Line Diagram System Existing
MEENA BAZAR Feeder

TOTAL LENGTH OF THE FEEDER :5.4846KM
LOSS CALCULATION ON 1/3 EACH SECTION
DIVERSITY FACTOR =259.7/89.66
=2.9

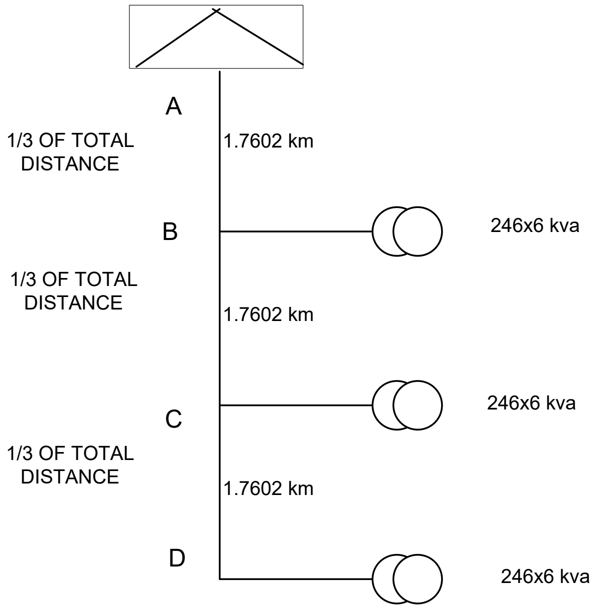


Fig A.9: Simplified bunched loaded single line diagram of Meena bazaar feeder (existing)

SINGLE LINE DIAGRAM OF PROPOSED SYSTEM

FEEDER NAME :MEENA BAZAR
SORCE:ZIGATOLA SUBSTATION 33/11KV S/S
LOAD IN PEAK HOUR :1524.2KVA
CONNECTED MVA :4.415 MVA
TOTAL PRIMARY LENGTH :5.4846KM
TOTAL TRANSFORMER :17

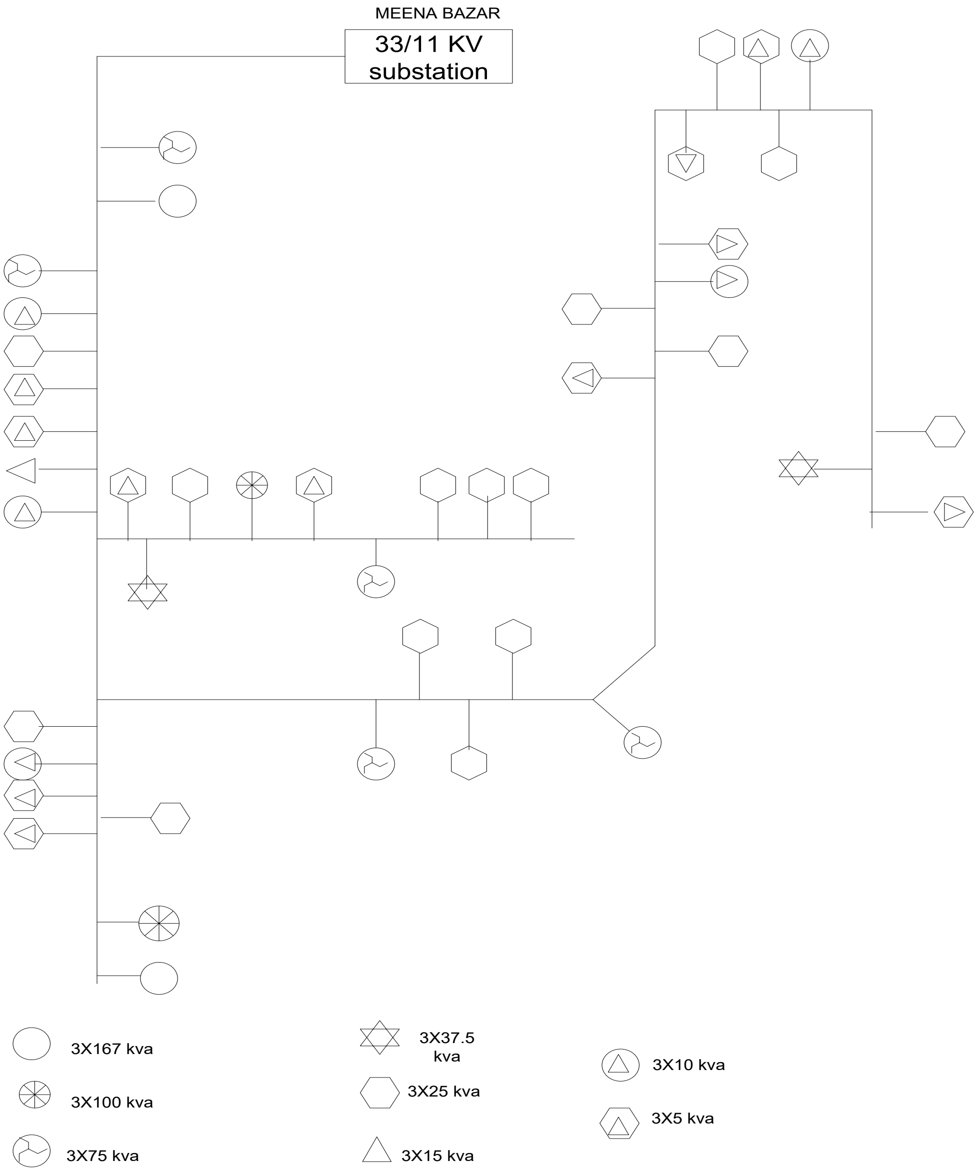


Fig A.10: Single line diagram of Meena Bazar feeder (proposed)

FEEDER NAME:MEENA BAZAR Feeder

SOURCE:ZIGATOLA 33/11 KV LOCAL
Load in peak hours : 4.437 MVA
Total MVA Connected :1.52 MVA
Single Line Diagram In Bunched load
System : Proposed

LOSS CALCULATED ON 1/3 OF EACH SECTION

DIVERSITY FACTOR = 4437/1524.2
= 2.94

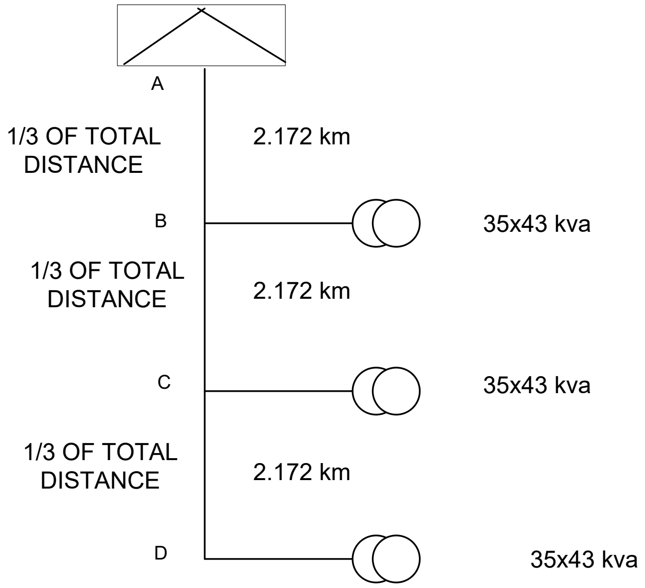


Fig A.11: Simplified bunched loaded single line diagram of Meena Bazaar Feeder (proposed)

SINGLE LINE DIAGRAM OF KAPTAN BAZAR FEEDER

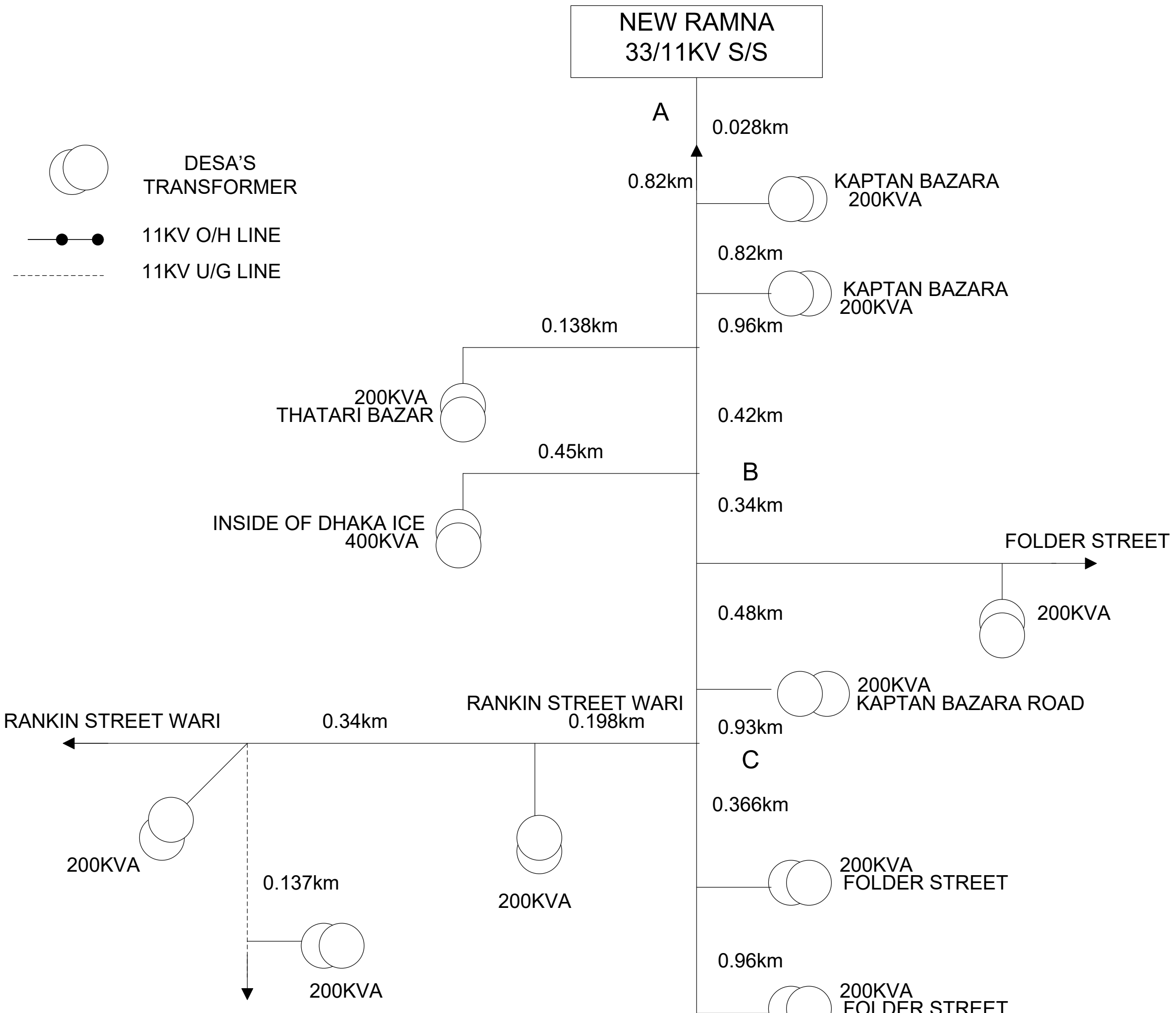


Fig A.12: Single line diagram of Kaptan Bazaar Feeder (existing)

These are some example in finding out the losses of the feeders under the distribution transformers in old Dhaka area which are densely populated and system loss is high.

SOURCE:NEW RAMNA 33/11 KV S/S

KAPTAN BAZAR Feeder
Load in peak hours :1.524MVA
Total MVA Connected :2400KVA
Single Line Diagram System : Existing

TOTAL LENGTH OF THE FEEDER : 7.796KM
LOSS CALCULATION ON 1/3 EACH SECTION
DIVERSITY FACTOR =219/140
=1.56

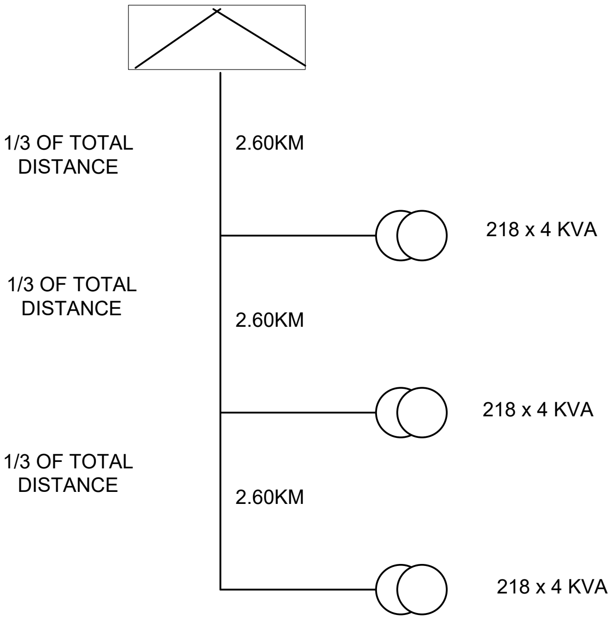
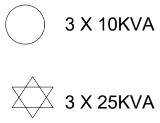


Fig A.13: Simplified bunched loaded single line diagram of Kaptan Bazar Feeder (existing)

SINGLE LINE DIAGRAM OF PROPOSED SYSTEM

FEEDER NAME :KAPTAN BAZAR
SOURCE:NEW RAMNA 33/11KV S/S
LOAD IN PEAK HOUR :1.524MVA
CONNECTED MVA :3.465 MVA
TOTAL PRIMARY LENGTH :8.80KM
TOTAL TRANSFORMER :324



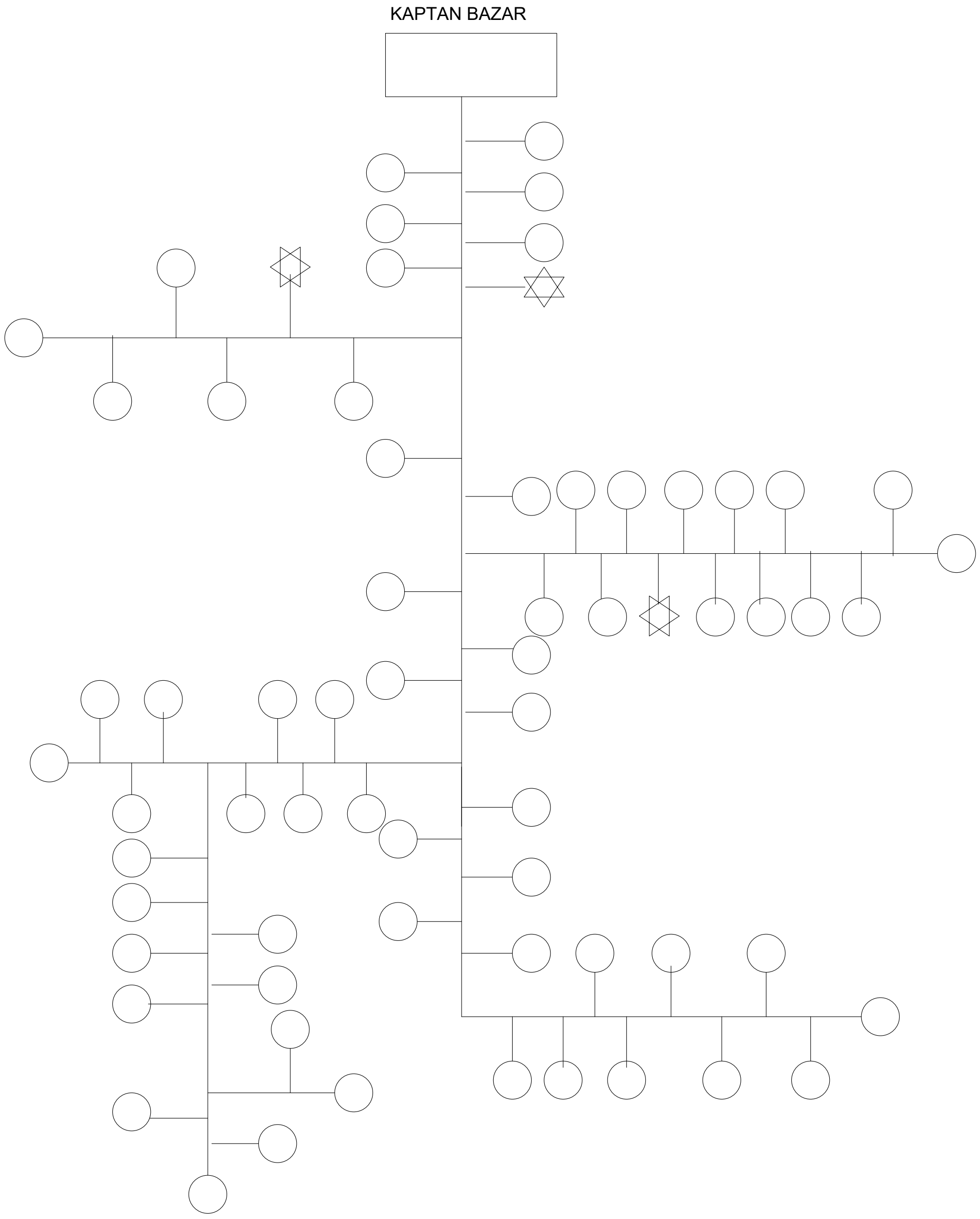


Fig A.14: Single line diagram of Kaptan Bazaar Feeder (Proposed)

FEEDER NAME:KAPTAN BAZAR Feeder

SOURCE:NEW RAMNA 33/11 KV S/S
Load in peak hours : 1.524 MVA
Total MVA Connected : 3.465 MVA
Single Line Diagram In Bunched loaded
System : Proposed

LOSS CALCULATED ON 1/3 OF EACH SECTION =2.93

DIVERSITY FACTOR =11 / 4.84
=2.27

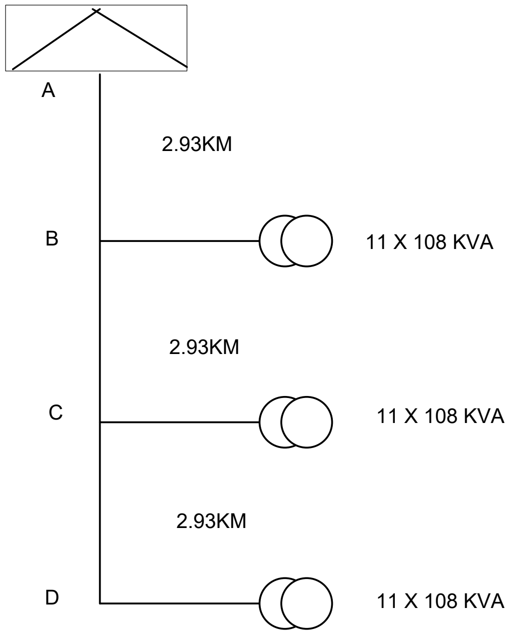


Fig A.15: Simplified bunched loaded single line diagram of Kaplan Bazaar Feeder (proposed)

SINGLE LINE DIAGRAM OF DHOLAIKHAL FEEDER

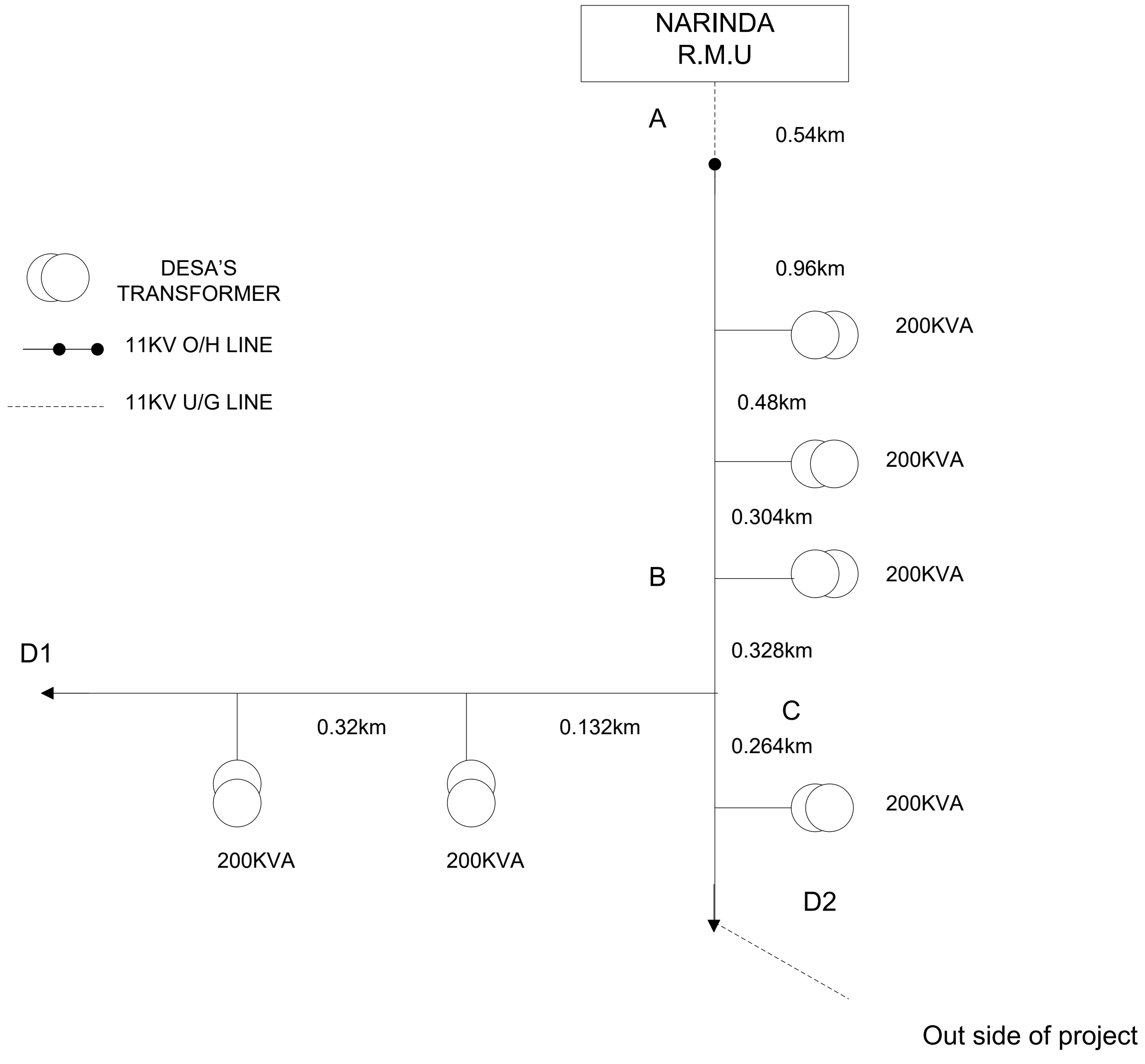


Fig A.16: Single line diagram of Dholaikhal Feeder (existing)

SOURCE:NEW RAMNA 33/11 KV S/S

DHOLAIKHAL Feeder
Load in peak hours :0.78MVA
Total MVA Connected :1.20MVA
Single Line Diagram System : Existing

TOTAL LENGTH OF THE FEEDER : 3.328KM
LOSS CALCULATION ON 1/3 EACH SECTION
DIVERSITY FACTOR =200/130
=1.54

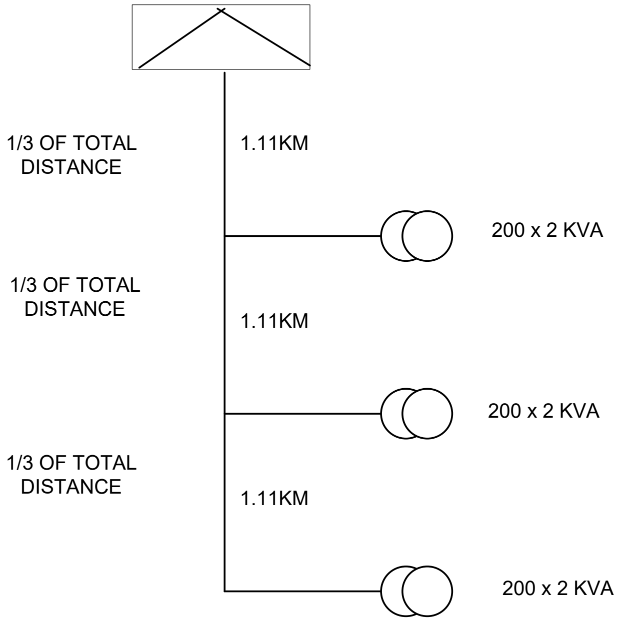


Fig A.17: Simplified bunched loaded single line diagram of Dholaikhal Feeder (existing)

SINGLE LINE DIAGRAM OF PROPOSED SYSTEM

FEEDER NAME :DHOLAIKHAL
SOURCE:NARINDA R.M.U
LOAD IN PEAK HOUR :0.78 MVA
CONNECTED MVA :1.350 MVA
TOTAL PRIMARY LENGTH :3.95KM
TOTAL TRANSFORMER :93

○ 3 X 10KVA

✡ 3 X 50KVA

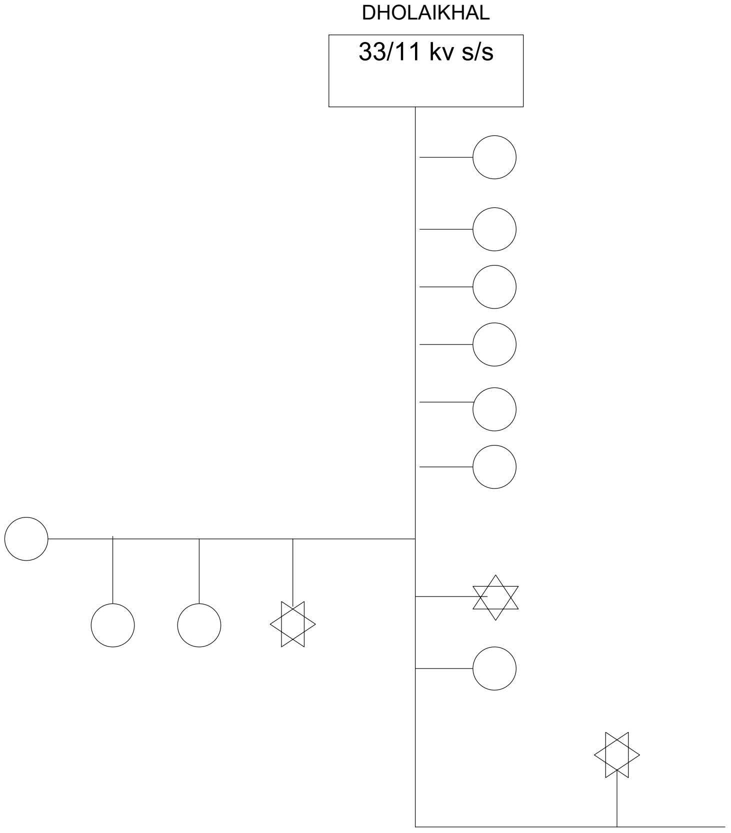


Fig A.18: Single line diagram of Dholaikhal Feeder (proposed)

FEEDER NAME:DHOLAIKHAL Feeder

SOURCE:NARINDA R.M.U
Load in peak hours : 0.78 MVA
Total MVA Connected : 1.35 MVA
Single Line Diagram In Bunched
loaded
System : Proposed

LOSS CALCULATED ON 1/3 OF EACH
SECTION =1.32 KM

DIVERSITY FACTOR =14.52/8.39
=1.72

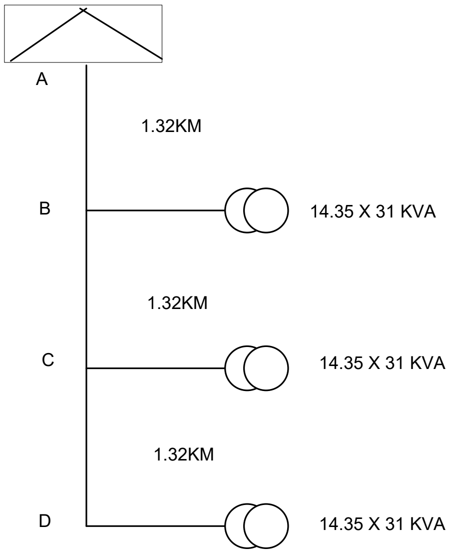


Fig A.19: Simplified bunched loaded single line diagram of Dholaikhal Feeder (proposed)

Appendix-B

The Gross Domestic Product (GDP) in Bangladesh was worth 129.86 billion US dollars in 2013. The GDP value of Bangladesh represents 0.21 percent of the world economy. GDP in Bangladesh averaged 33.77 USD Billion from 1960 until 2013, reaching an all time high of 129.86 USD Billion in 2013 and a record low of 4.30 USD Billion in 1960. GDP in Bangladesh is reported by the World Bank.

Actual	Previous	Highest	Lowest	Dates	Unit	Frequency
129.86	116.03	129.86	4.30	1960 - 2013	USD Billion	Yearly

The gross domestic product (GDP) measures of national income and output for a given country's economy. The gross domestic product (GDP) is equal to the total expenditures for all final goods and services produced within the country in a stipulated period of time. This page provides - Bangladesh GDP - actual values, historical data, forecast, chart, statistics, economic calendar and news. Content for - Bangladesh GDP - was last refreshed on Monday, March 2, 2015.

Bangladesh GDP	Last	Previous	Highest	Lowest	Unit
GDP	129.86	116.03	129.86	4.30	USD Billion
GDP Growth Rate	6.01	6.32	6.71	4.08	percent
GDP Annual Growth Rate	6.12	6.01	6.71	4.08	percent
GDP Constant Prices	4337.20	4090.53	4337.20	2372.59	BDT Billion
Gross National Product	4773.82	4488.39	4773.82	2483.46	BDT Billion
GDP per capita	625.34	597.02	625.34	219.28	USD
Gross Fixed Capital Formation	2786.13	2436.91	2786.13	594.12	BDT Billion
GDP per capita PPP	2475.97	2363.83	2475.97	1067.55	USD

Appendix-C

Import payments by mode of Financing(Quarterly data)

TABLE- I

(Amount in Millions)

Import by mode of financing	April-June, 2014			January-March, 2014			Changes	
	Amount		Percentage of total	Amount		Percentage of total	Taka (1)-(4)	USD (2)-(5)
	Taka	USD		Taka	USD			
	1	2	3	4	5	6	7	8
Cash	609244	7846.5	75.2	598393	7697.7	74.2	10851 (+1.8)	148.8 (+1.9)
Buyers Credit	115586	1488.7	14.3	110976	1427.7	13.8	4610	61
Loans/Grants	1542	19.9	0.2	74	0.9	0.0	1468	19
Short term loans (IDB)	20862	268.6	2.6	20919	269.0	2.6	-57	-0.4
Other unclassified imports	1557	20.0	0.2	2086	26.9	0.4	-529	-6.9
A. Sub-total	748791	9643.7	92.5	732448	9422.2	90.9	16343	221.5
B. Imports of EPZ	61147	787.5	7.5	73540	946.1	9.1	-12393	-158.6
Total Import: (A+B) (c&f)	809938	10431.2	100.0	805988	10368.3	100.0	3950 (+0.5)	62.9 (+0.6)

Export receipts by mode of Financing (Quarterly data)

Export Receipts of Bangladesh (including exports of EPZ) during the quarter April-June,2014 stood at Tk.557894 million or US$ 7186 million. On the other hand Export Receipts for the quarters January-March,2014 and April-June,2013 were Tk.543043 million or US$ 6986 million and Tk.508662 million or US$ 6532 million respectively.

Export Receipts for the quarter under review increased by Tk. 14851 million (or 2.7%) or increased by US$ 200 million (or 2.9%) and increased by Tk. 49232 million (or 9.7%) or increased by US$ 654 million (or 10.0%) over the quarters January-March,2014 and April - June,2013 respectively.

A comparative position of export receipts by mode of financing for the quarters April-June,2014,January-March,2014 and April-June,2013 is shown below in Table-I & Table-

I(A).

TABLE- I(A)

(Taka in Millions)

Mode of financing	April-June, 2014	January-March, 2014	April-June, 2013	Changes (1)-(2)	Changes (1)-(3)
	Amount	Amount	Amount		
	1	2	3	4	5
Cash	461021	456308	424798	4713.00	36223.00
Exports of EPZ	96873	86735	83864	10138.00	13009.00
Total	557894	543043	508662	14851.00	49232.00
(Changes in %)				(2.7)	(9.7)

TABLE- I(B)

(US dollar in Millions)

Mode of financing	April-June, 2014	January-March, 2014	April-June, 2013	Changes (1)-(2)	Changes (1)-(3)
	Amount	Amount	Amount		
	1	2	3	4	5
Cash	5938	5870	5455	68.00	483.00
Exports of EPZ	1248	1116	1077	132.00	171.00
Total	7186	6986	6532	200.00	654.00
(Changes in %)				(2.9)	(10)

Source: Statistics Department, Bangladesh Bank.

Appendix-D

Energy Balance 1990

In Peat Joule (10^{15} Joule)

	Crude Oil	*Petroleum Product*	*Coal*	*Natural Gas*	*Electricity*	*Total Comm.*	*Non-Wood Biomass*	*Wood Fuel*	*Total Biomass*	*TOTAL ENERGY*
I. SUPPLY							Biomass Fuels			
Indigenous Production	0.00	2.70	0.00	163.40	3.30	169.40	410.80	88.20	499.00	668.40
Import	53.40	48.00	12.30	0.00	0.00	113.70	0.00	0.00	0.00	113.70
Export	0.00	-6.30	0.00	0.00	0.00	-6.30	0.00	0.00	0.00	-6.30
Stock Exchange	-5.90	-6.80	0.10	0.00	0.00	-12.60	0.00	0.00	0.00	-12.60
Total Primary	**47.50**	**37.60**	**12.40**	**163.40**	**3.30**	**264.20**	**410.80**	**88.20**	**499.00**	**763.20**
Primary (Percent)	**6.20**	**4.90**	**1.60**	**21.40**	**0.40**	**34.50**	**53.80**	**11.60**	**65.40**	**99.90**
II. TRANSFORMATION										
Refinery	-47.50	44.10	0.00	-1.00	0.00	-4.40	0.00	0.00	0.00	-4.40
Thermal Power	0.00	-8.80	0.00	-69.30	24.40	-53.70	0.00	0.00	0.00	-53.70
Loses & Own Use	0.00	-4.00	0.00	-9.90	-8.30	-22.20	0.00	0.00	0.00	-22.20
Total Final Supply	**0.00**	**68.90**	**12.40**	**83.20**	**19.40**	**183.90**	**410.80**	**88.20**	**499.00**	**682.90**
III. CONSUMPTION										
Domestic	0.00	23.60	0.00	9.30	4.90	37.80	337.20	67.30	404.50	442.30
Industrial	0.00	7.00	9.50	14.00	10.00	40.50	73.60	19.10	92.70	133.20
Commercial	0.00	0.00	0.40	3.10	3.60	7.10	0.00	1.80	1.80	8.90
Transport	0.00	25.00	2.50	0.00	0.00	27.50	0.00	0.00	0.00	27.50
Agricultural	0.00	11.00	0.00	0.00	0.90	11.90	0.00	0.00	0.00	11.90
Others	0.00	0.30	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.30
Non-Energy Use (Urea)	0.00	2.00	0.00	56.80	0.00	58.80	0.00	0.00	0.00	58.80
Total Final Consumption	**0.00**	**68.90**	**12.40**	**83.20**	**19.40**	**183.90**	**410.80**	**88.20**	**499.00**	**682.90**
Consumption Final Energy %	**0.00**	**10.10**	**1.80**	**12.20**	**2.80**	**26.90**	**60.20**	**12.90**	**73.10**	**100.00**

Source: National Energy Policy: January 15, 1996

Energy Balance 2000

(In Peta Joule (10^{15} Joule)

	Crude Oil	**Petroleum Product**	**Coal/ Coke**	**Natural Gas**	**Electricity**	**LPG**	**Total Comm. Energy**	**Non-Wood Biomass**	**Wood Fuel**	**Total Biomass Energy**	**Other Traction**	**Total Energy**
I. SUPPLY												
Indigenous Production	0.39	0.00	18.62	355.98	0.00	0.00	374.99	323.12	331.09	654.21	14.47	1043.67
Imports	64.33	52.09	0.00	0.00	0.00	0.21	116.63	0.00	0.00	0.00	0.00	116.63
Exports	0.00	-12.53	0.00	0.00	0.00	0.00	-12.53	0.00	0.00	0.00	0.00	-12.53
Total Primary	64.72	39.56	18.62	355.98	0.00	0.21	479.09	323.12	331.09	654.21	14.47	1147.77
Total Primary (Percent)	5.64	3.45	1.62	31.01	0.00	0.02	41.74	28.15	28.85	57.00	1.26	100.00
II. TRANSFORMATION												
Oil Refining	-64.72	62.49	0.00	0.00	0.00	0.73	-1.51	0.00	0.00	0.00	0.00	-1.51
Electricity Gen.	0.00	-4.39	-0.30	-218.69	67.84	0.00	-155.54	0.00	0.00	0.00	0.00	-155.54
T & D Losses	0.00	-0.88	-0.15	-7.48	-18.30	-0.01	-26.82	0.00	-3.26	-3.26	0.00	-30.08
Coke Production	0.00	0.00	-3.72	0.00	0.00	0.00	-3.72	0.00	0.00	0.00	0.00	-3.72
Total Final Supply	0.00	96.78	14.45	129.81	49.54	0.93	291.51	323.12	327.83	650.95	14.47	956.92
III. CONSUMPTION	0.00											
Domestic	0.00	16.15	0.00	31.39	17.46	0.90	65.9	258.92	252.74	511.66	0.00	60.36
Industrial	0.00	13.02	14.45	32.34	17.95	0.00	77.76	63.49	65.12	128.61	0.00	21.57
Commercial	0.00	0.00	0.00	4.43	4.30	0.03	8.76	0.71	2.20	2.91	0.00	1.22
Transport	0.00	50.93	0.00	0.00	0.00	0.00	50.93	0.00	0.00	0.00	0.28	5.35
Agriculture	0.00	12.43	0.00	0.00	1.630	0.00	14.06	0.00	0.00	0.00	13.9	2.92
Others	0.00		0.00	0.00	0.00	0.00	4.24	0.00	7.76	7.76	0.29	1.28
Urea (Non-Energy)	0.00	0.00	0.00	61.65	8.19	0.00	69.84	0.00	0.00	0.00	0.00	7.30
Total Final Consumption	0.00	96.77	14.45	129.81	49.53	0.93	291.49	323.12	327.82	650.94	14.47	956.9
Final Consumption (Percent)	0.00	10.11	1.51	186	5.18	0.10	30.46	33.71	34.26	68.03	1.51	100.00

Source: Pl. Comm. (2002), adapted.

Energy Balance Table 1990

Description	Commercial Energy						Biomass Fuels					
	Natural Gas	Crude Oil	Petroleum Product	Coal	Electricity	Total comm.	Agric. Residues	Tree Residues	Fuel Wood	Dung	Total Biomass	Total Energy
1. SUPPLY												
Primary Production	163.4	-	27	-	3.3	169.4	316.6	22.5	88.2	71.7	499.0	668.4
Import	-	53.4	48.0	12.3	-	113.7	-	-	-	-	-	113.7
Export	-	-	-6.3	-	-	-6.3	-	-	-	-	-	-6.3
Stock Exchange	-	-5.9	-6.8	0.1	-	-12.6	-	-	-	-	-	-12.6
Total Primary	163.4	47.5	37.6	12.4	3.3	264.2	316.6	22.5	88.2	71.7	499.0	763.2
Primary Percent	21.4	6.2	4.9	1.6	0.4	34.5	41.5	2.9	11.6	9.4	65.4	99.9
11. TRANSFORMATION												
Refinery	-1.0	-47.5	44.1	-	-	-4.4	-	-	-	-	-	-4.4
Thermal Power	-69.3	-	-8.8	-	24.4	-53.7	-	-	-	-	-	-53.7
Losses & Own Use	-9.9	-	-4.0	-	-8.3	-22.2	-	-	-	-	-	-22.2
Total Final Supply	83.2	-	68.9	12.4	19.4	183.9	316.6	22.5	88.2	71.7	499.0	682.9
111. CONSUMPTION												
Domestic	9.3	-	23.6	-	4.9	37.8	243.0	22.5	67.3	71.7	404.5	442.3
Industrial	14.0	-	7.0	9.5	10.0	40.5	73.6	-	19.1	-	92.7	133.2
Commercial	3.1	-	-	0.4	3.6	7.1	-	-	1.8	-	1.8	8.9
Transport	-	-	25.0	2.5	-	27.5	-	-	-	-	-	27.5
Agricultural	-	-	11.0	-	0.9	11.9	-	-	-	-	-	11.9
Others	-	-	0.3	-	-	0.3	-	-	-	-	-	0.3
Non-Energy	56.8	-	2.0	-	-	58.8	-	-	-	-	-	58.8
Total Final Consumption	83.2	-	68.9	12.4	19.4	183.9	316.6	22.5	88.2	71.7	499.0	682.9
Final Energy %	12.2	-	10.1	1.8	2.8	26.9	46.4	3.3	3.3	10.5	73.1	100.0

Conversion Factors

Natural Gas	1	MMCF	= 0.00099PJ	Electricity	1	GWh	= 0.0036 PJ
Crude Oil	1000	Tonne	= 0.0427 PJ	Petroleum Product (Av.)	1000	Tonne	= 0.0427 PJ
Coal	1000	Tonne	= 0.027 PJ	Fuel wood	1000	Tonne	= 0.0151 PJ
Agri. & Tree Res.	1000	Tonne	= 0.0125 PJ	Dung	1000	Tonne	= 0.0116 PJ

Source: GOB 1990 *National Energy Policy*

Appendix-E

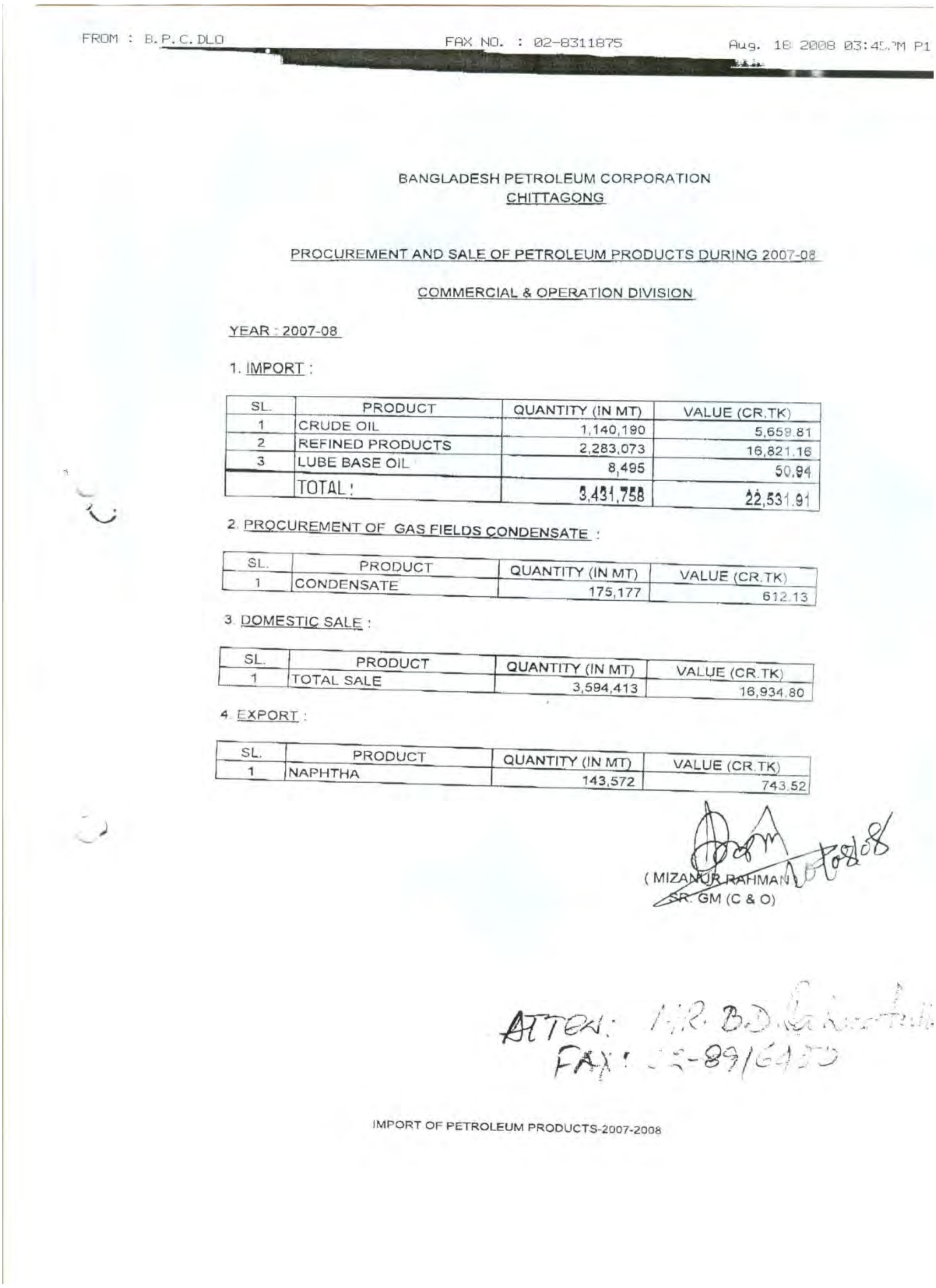
Natural Gas Reserves of Bangladesh

Field	Discovery	Reserve		++ Cumulative Production TCF	Net REC Reserve TCF	REC Condensate MMBBL	++ CUM Production MMBBL	Net REC Condensate MMBBL
		Proven + Probable TCF	Recoverable TCF					
Bakhrabad	1969	1.432	0.867	0.328	0.539	2.13	0.53	1.60
Feni	1981	0.132	0.08	0.0113	0.0687	0.24	0.03	0.21
Hobiganj	1963	3.66	1.90	0.375	1.520	0.10	0.02	0.08
Kailashtila	1962	3.65	2.53	0.0626	2.466	27.56	0.68	26.88
Rashidpur	1960	2.24	1.31	-	1.310	4.00	-	4.00
* Sylhet	1955	0.44	0.27	0.1521	0.114	0.89	0.52	0.37
Titas	1962	4.13	2.10	1.00	1.099	3.02	1.44	1.68
* Chatak	1959	1.90	1.14	0.026	1.114	0.08	0	0.08
* Kamta	1981	0.32	0.20	0.021	0.174	0.04	-	0.04
Beanibazaar	1981	0.243	0.114	-	0.114	1.82	-	1.82
Begumganj	1977	0.025	0.015	-	0.015	0.01	-	0.01
Belabo	1990	0.194	0.126	-	0.126	0.31	-	0.31
Fenchuganj	1988	0.35	0.21	-	0.210	0.52	-	0.52
Jalalabad	1989	1.50	0.90	-	0.900	15.75	-	15.75
Kutubdia	1977	0.78	0.468	-	0.468	-	-	-
Meghna	1990	0.159	0.104	-	0.104	0.21	-	0.21
Semutang	1969	0.164	0.098	-	0.098	0.02	-	0.02
	Total	**21.354**	**12.416**	**1.977**	**10.439**	**56.70**	**3.22**	**53.48**

* Production Suspended, ++ Cumulative Production up to June 1993, Source : Petrobangla

Appendix-F

Procurement and Sale of Petroleum Products during 2007-2008



FROM : B.P.C.DLO FAX NO. : 02-8311875 Aug. 18 2008 03:45PM P1

BANGLADESH PETROLEUM CORPORATION
CHITTAGONG

PROCUREMENT AND SALE OF PETROLEUM PRODUCTS DURING 2007-08

COMMERCIAL & OPERATION DIVISION

YEAR : 2007-08

1. IMPORT :

SL.	PRODUCT	QUANTITY (IN MT)	VALUE (CR.TK)
1	CRUDE OIL	1,140,190	5,659.81
2	REFINED PRODUCTS	2,283,073	16,821.16
3	LUBE BASE OIL	8,495	50.94
	TOTAL :	3,431,758	22,531.91

2. PROCUREMENT OF GAS FIELDS CONDENSATE :

SL.	PRODUCT	QUANTITY (IN MT)	VALUE (CR.TK)
1	CONDENSATE	175,177	612.13

3. DOMESTIC SALE :

SL.	PRODUCT	QUANTITY (IN MT)	VALUE (CR.TK)
1	TOTAL SALE	3,594,413	16,934.80

4. EXPORT :

SL.	PRODUCT	QUANTITY (IN MT)	VALUE (CR.TK)
1	NAPHTHA	143,572	743.52

10/08/08
(MIZANUR RAHMAN)
SR. GM (C & O)

ATTEN: MR. B.D. [illegible]
FAX: 02-8916450

IMPORT OF PETROLEUM PRODUCTS-2007-2008

Appendix-G

Loss load factors for distribution

Introduction

C.1 in July 1996, the Transformer Capitalization Working Party produced a guide for the Electricity Engineers' Association entitled *Purchase and Operating Costs of Transformers*. The written guide and associated spreadsheet covered both distribution and zone substation transformers.

C.2 of *Purchase and Operating Costs of Transformers* states that the **LLF** of transformers is not easy to obtain as the value depend on the loading pattern. There are two ways by which **LLFs** are commonly derived.
This report examines the issues associated with computation of distribution loss factors in Tasmania. The aim of this report is to consider methodology associated with the computation and application of distribution loss factors (DLFs) in the electricity network in Tasmania.

Definitions

Aurora Energy Pty Ltd -Tasmania's electricity distribution and Retail Company. Transcend Networks Pty Ltd - owns and operates the electricity transmission system in Tasmania Point of Purchase Physical point at which Aurora purchases its electricity from Transcend High Voltage System voltages 66kV and above and below 330 kV Medium Voltage System voltages above 1kV and below 66kV Low Voltage System voltages less than 1kV Load Factor Ratio of average demand over maximum demand Load Loss Factor Ratio of average power loss over power loss at maximum demand DLF Distribution Loss Factor AL-n Annual losses in Customer Category n SL-n Sales in Customer Category.

System Losses

1.1 Power and Energy Losses

Power system losses are the difference in the amount of energy or power that is required to be delivered to a system to supply the customer's energy or power needs.

1) Power losses, defined in kW or MW create a need for the provision of additional capacity to be installed on the system over and above that required to meet the system demand
2) Energy Losses, defined in kWh or MWh, is the integral of the power losses with respect to time and represents the amount of additional energy that needs to be purchased at the point of purchase by Aurora to supply the customer demand for the corresponding period. Energy losses associated with a distribution system can be classified as follows:

1) Technical Losses - losses associated with the electrical system
a) Series losses which are proportional to the square of the current and to the resistance of the circuit elements and
b) Shunt losses due the excitation losses in transformers and rotating machines, as well as leakage currents in cables
2) Non-technical losses - losses associated with unidentified and uncollected revenue. This covers matters such as illegal connections, meter tampering, metering errors, errors in estimating unmetered supplies, errors in invoicing and revenue collection. Total power in a system is the vector sum of real and reactive power. Losses on the system are generally

considered in terms of the real power and energy components and are measured in kW and kWh respectively. With respect to reactive power losses on a system (kVAr and kVArh), although the area of reactive power is a significant issue for distribution network service providers it is not a parameter that is easily measured and does not form part of the normal revenue basis. Accordingly, it is not considered further in this report.

Load factor and loss load factor

1.2.1 Series power losses

Losses in series elements are related to the square of the current flow. It is possible to establish a relationship between peak demand on a system and the average technical losses through consideration of load factors and loss load factors.

Load Factor (LF) is defined as the ratio of the average demand over a period of time to the maximum demand within that period for the particular network.

Loss Load Factor (LLF) is defined as average power losses over a period of time to the losses at the time of peak demand.

Where demand recordings exist, such as 15 minute readings (or half hour readings), the LF and LLF can be expressed as follows:

LF= Sum of 15 min demands / (maximum demand * number of 15min periods)

LLF= Sum of squares of 15min demands / (square of maximum demand * Number of 15min periods) or expressed in mathematical terms for a one year period.

$$LF = \sum_{15\ min}^{1\ Year} \frac{15\ Min\ Energy\ for\ Year}{Maximum\ Demand\ X\ Number\ of\ 15\ Min\ Periods\ for\ Year}$$

$$LLF = \sum_{15\ min}^{1\ Year} \frac{(15\ Min\ Energy\ For\ Year)^2}{Maximum\ Demand\ X\ Number\ of\ 15\ Min\ Periods\ for\ Year}$$

Where 15-minute demand recordings are not available, empirical formulae are available that can be used to estimate the LLF from an LF. Such as,

$LLF = k * LF + (1 - k) * (LF)^2$

Where k = a constant, typically 0.1, 0.2 or 0.3

Typically

= 0.3 for sub transmission systems

= 0.2 for medium voltage feeders and distribution substations

= Sample sections of the network can be analyzed to produce an Estimate of the k factor applicable for the rest of the system.

$LF = P_{ave} / P_{max}$

Where Pave   average system demand for say 1(one) year

= average demand over a period (say 1 year)

Pmax = maximum demand over a period (say 1 year).

1.2.2 Shunt power losses

Shunt power losses, mainly iron losses in transformers, may be regarded as substantially fixed losses, provided system voltages are kept reasonably constant.

1.2.3 Total power losses

Total losses are the sum of Series power losses as described in 3.2.1 and Shunt power losses as described in 3.2.2

Application of Distribution Loss Factors

In accordance with Clause 3.6.3 (b) (3) of the NEC Distribution Loss Factors (DLFs) are to be used in the settlement process as a notional adjustment to the electrical energy, expressed in MWh, flowing at a distribution network connection point in a trading interval to determine the adjusted gross energy amount for that connection point in that trading interval in accordance with clause 3.15.4."That is, customers metered consumption data is adjusted to allow for electrical losses in the distributor's network. In accordance with the requirements of the NEC, they are only applied to the consumption of second tier customers in the National Electricity Market. The local retailer is responsible for paying for distribution losses that are not allocated to second tier customers.

In accordance with clause 3.6.3. (b) (2) of the NEC DLFs are either:

"(i) a site specific DLF ...for each distribution network connection point of the following types:

A. connection point for an embedded generator with actual generation of more than 10MW......

B. a connection point for an end-use with actual or forecast load of more than 40GWh or an electrical demand of more than 10MW....

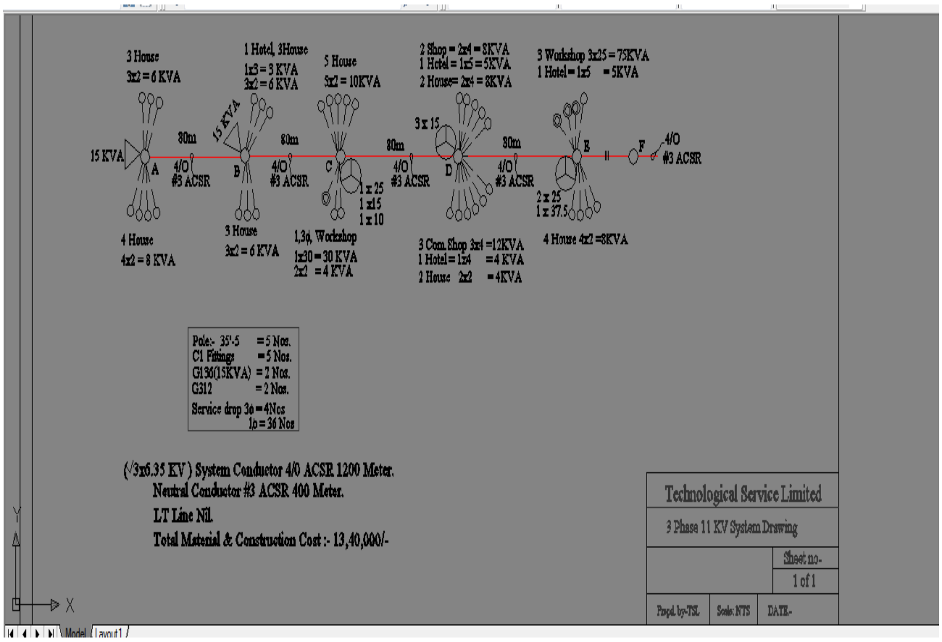
C. a connection point for a market network service provider; and

D. a connection point between two or more distribution networks; OR

(ii) derived ...using a volume weighted average of the average electrical energy loss between the transmission network connection point or virtual transmission node to which it is assigned and each distribution network connection point in the relevant voltage class assigned to that transmission network connection point or virtual transmission nodes.

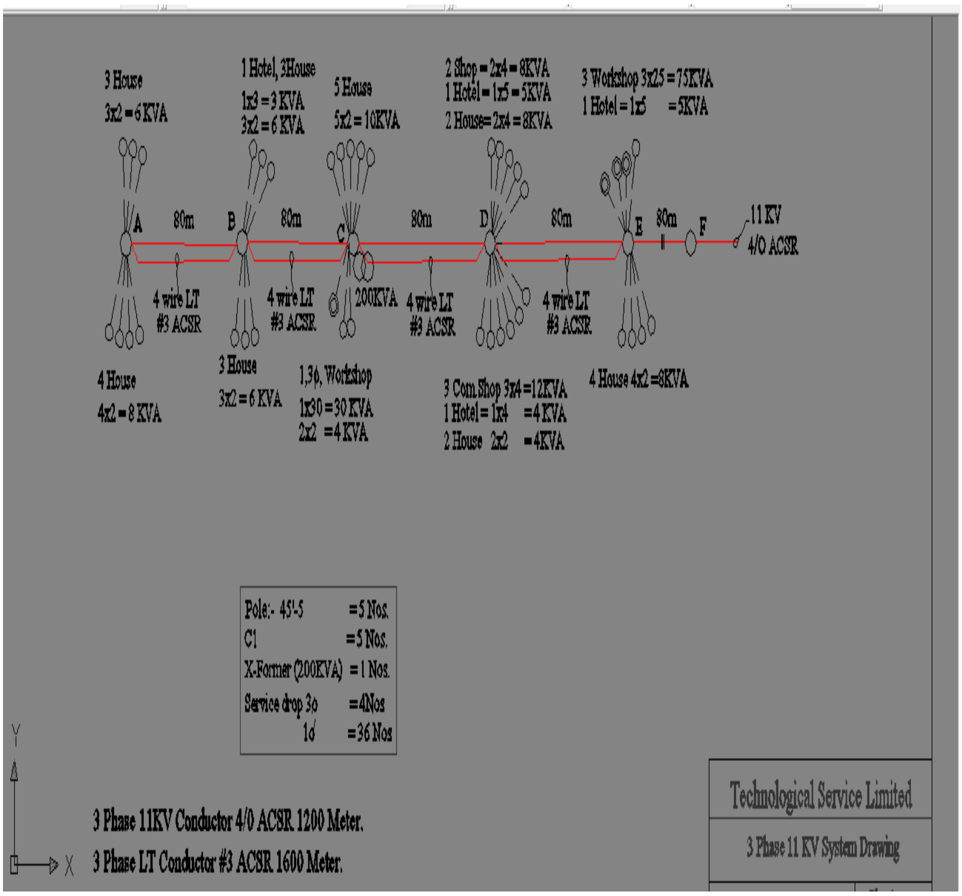
Appendix-H

A lack of reliable power severely impedes economic development of the country. Seventy-eight percent of Bangladeshi firms cite electricity service as a “major” or “severe” obstacle to expansion. And many foreign investors shy away from Bangladesh because electricity quality is so poor. [Bangladesh Enterprise Institute, 2003].



Pole:- 35'-5 = 5 Nos.
C1 Fittings = 5 Nos.
G136(15KVA) = 2 Nos.
G312 = 2 Nos.
Service drop 3ϕ = 4Nos
1ϕ = 36 Nos

(√3x6.35 KV) System Conductor 4/0 ACSR 1200 Meter.
Neutral Conductor #3 ACSR 400 Meter.
LT Line Nil.
Total Material & Construction Cost :- 13,40,000/-



Pole:- 45'-5 = 5 Nos.
C1 = 5 Nos.
X-Former (200KVA) = 1 Nos.
Service drop 3ϕ = 4Nos
1ϕ = 36 Nos

3 Phase 11KV Conductor 4/0 ACSR 1200 Meter.
3 Phase LT Conductor #3 ACSR 1600 Meter.

Appendix-I

Power Sector at a Glance

	Upto June, 2005	Upto June, 2006
❐ Present Installed Capacity	5025 MW	5275 MW
● Public Sector	3735 MW	3985 MW
● Private Sector	1290 MW	1290 MW
❐ Generation Capability (Including IPP)	4030 MW	4582 MW
❐ Peak Demand	3751 MW	3812 MW
❐ Total Transmission Lines (Circuit KM)	6758 KM	6806 KM
● 230 kV	1466 KM	1466 KM
● 132 kV	5292 KM	5340 KM
❐ Grid sub-station Capacity		
● 230/ 132 kV	4375 MVA	5050 MVA
● 132/33 kV	7676 MVA	8084 MVA
❐ Net Energy Generated	21408 mkWh	22978 mkWh
❐ Energy Sold	16685 mkWh	18093 mkWh
❐ System Loss (Transmission & Dist.)	22.79%	21.25%
● Transmission Loss	6.16%	5.62%
➢ PGCB	3.63%	3.52%
➢ DESA	10.44%	9.01%
● Distribution Loss		
▤ PDB	20.00%	19.06%
▤ DESA	21.94%	20.13%
▤ REB	13.78%	12.98%
▤ DESCO	16.64%	16.20%
▤ WZPDCo	19.66%	16.21%
▤ National	17.83%	16.53%
❐ Collection/Import Ratio		
● PDB	84.16%	88.79%
● DESA	71.09%	75.80%
● REB	84.44%	84.00%
● DESCO	80.92%	80.98%

- WZPDCL : 89.05% : 96.64%

☐ Distribution Line (Total) : 244104 Km : 264891
Km

☐ Consumer Number : 8.80 million : 9.73
million

☐ Access to Electricity of Population : 38% : 42%

☐ Per Capita Generation : 158 kWh : 165
kWh

☐ Generation Mix

- Gas : 91% : 90%
- Hydro : 2% : 2.30%
- Liquid Fuel : 7% : 6%
- Coal : - : 1.70%

Power Sector Key Statistics

(FY 1996 to FY 2001)

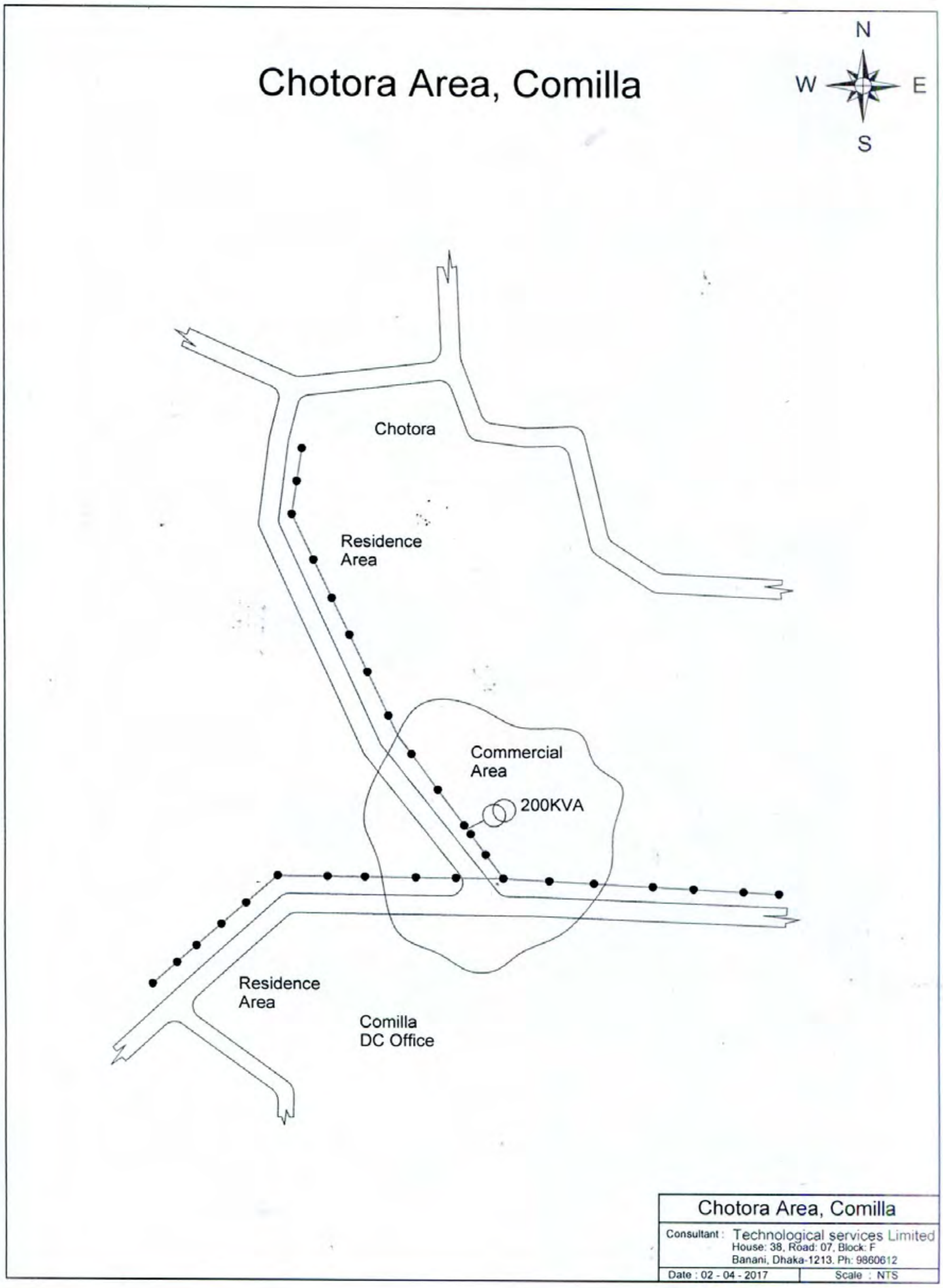
Item	**FY 1995-96**	**FY 1996-97**	**FY 1997-98**	**FY 1998-99**	**FY 1999-2000**	**FY 2000-2001**	**Achievement**	
							quantity	**%**
Installed Capacity (MW)	2908	2908	3091	3603	3711	4005	1097	38%
Generation Capacity (derated) (MW)						3115		
Maximum Demand Served (MW)	2087	2114	2136	2449	2665	3033	946	45%
Net Energy Generation (MkWh)								
(a) BPDB	11474	11858	12882	13872	14319	14062	2588	
(b) IPP & mixed				578	1244	2193	2193	
Total	**11474**	**11858**	**12882**	**14450**	**15563**	**16255**	**4781**	**42%**
Transmission Line (KM)	3122	3159	3159	3287	3438	3738	616	20%
Distribution Line (KM)	112222	125325	135051	147102	156777	176179	63957	57%
Total Number of Consumer (lacs)	30.97	34.51	39.24	43.33	48.83	55.30	24.33	79%

Agriculture Consumer (lacs)	0.75	0.79	0.84	0.90	0.94	1.1	0.35	48%
Number of Village Electrified	20841	22488	25986	29332	31388	35797	14956	72%
Access to Electricity (%)	15	17	19	20	23	25	10	64%
Per Capita Generation (kWh)	97	99	102	113	120	129	32	33%
System Loss (Tr & Dist) (%)	31.20	30.40	31.30	31.80	31.60	28.43	-2.77	-9%

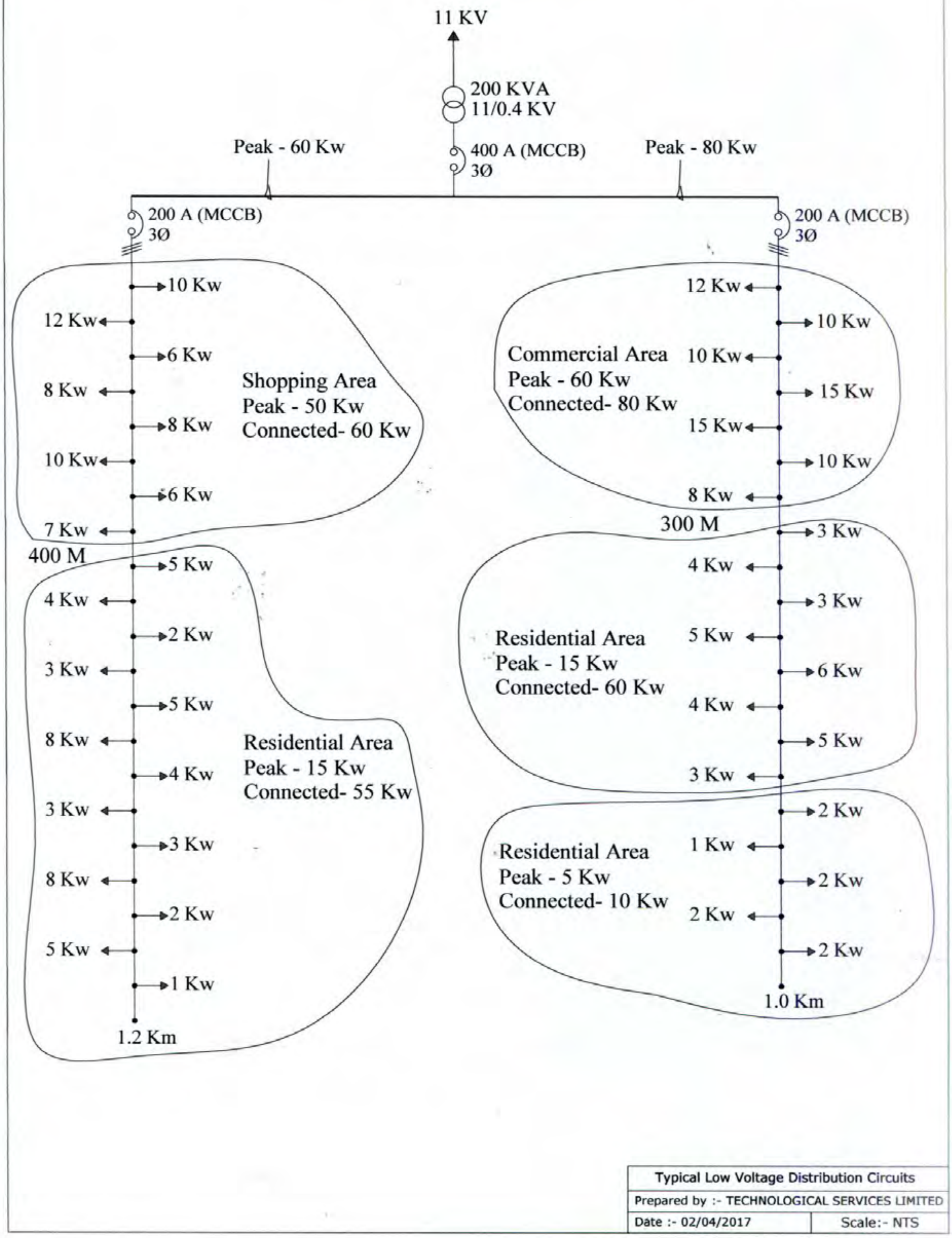
Power Sector Key Statistics
(FY 2001 to FY 2006)

Item	**FY 2000-01**	**FY 2001-02**	**FY 2002-03**	**FY 2003-04**	**FY 2004-05**	**FY 2005-06**	**Achievement**	
Installed Capacity (MW)	4005	4260	4710	4710	5025	5275	1270	32%
Generation Capacity (derated), (MW)	3115	3332	3780	3780	4030	4582	1467	47%
Maximum Generation (MW)	3033	3248	3458	3622	3751	3812	779	26%
Net Energy Generation (MkWh) (a) BPDB (b) IPP & mixed (c) REB	14062 2193 -	13674 3771 -	12159 6299 -	12584 7478 240	13223 7939 246	14456 8286 236		
Total	**16255**	**17445**	**18458**	**20302**	**21408**	**22978**	**6723**	**41%**
Transmission Line (230kV&132kV) (Route KM)	3738	3750	3859	3919	4038	4119	381	10%
Distribution Line (KM)	176179	192140	209932	226232	244104	264891	88712	50%
Total Consumer Number (lacs)	55.30	63.33	70.64	79.6	88.47	97.33	42.03	76%
Agriculture Consumer (lacs)	1.1	1.21	1.35	1.53	1.78	2.16	1.50	136%
No. of Village Electrified	35797	39028	41814	44546	47612	49435	13638	38%
Access to Electricity (%)	25	30	32	35	38	42	17	68%
Per Capita Generation (%)	129	136	144	155	158	165	36	28%
System Loss (Tr. & Dist) (%)	28.43	27.97	25.69	24.49	22.79	21.25	(7.18)	(25%)

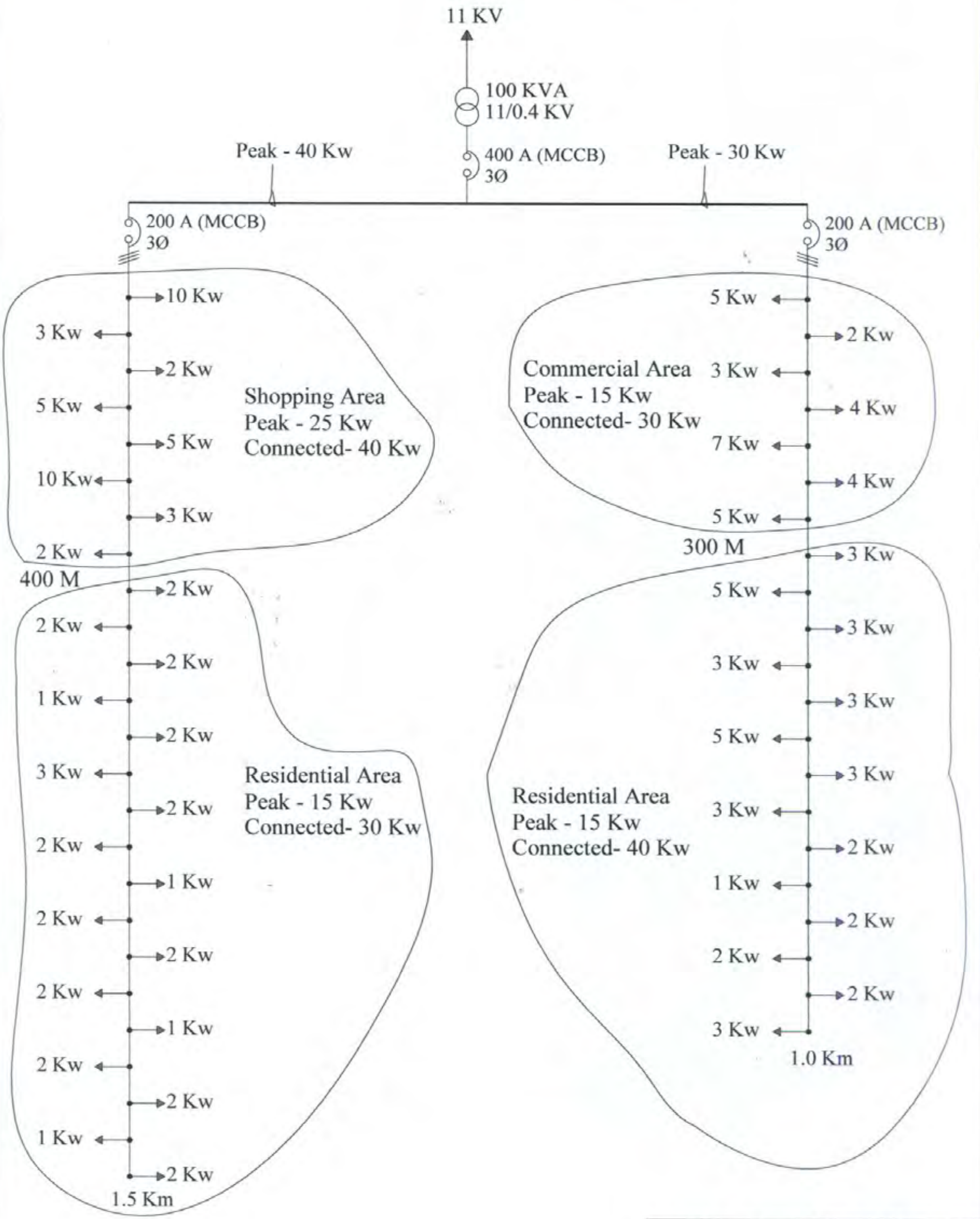
Appendix-J


Chotora Area, Comilla
N
W
E
S
Chotora
Residence Area
Commercial Area
200KVA
Residence Area
Comilla DC Office
Chotora Area, Comilla
Consultant : Technological services Limited
House: 38, Road: 07, Block: F
Banani, Dhaka-1213. Ph: 9860612
Date : 02 - 04 - 2017
Scale : NTS

Typical Low Voltage Distribution Circuits



Typical Low Voltage Distribution Circuits



Typical Low Voltage Distribution Circuits	
Prepared by :- TECHNOLOGICAL SERVICES LIMITED	
Date :- 02/04/2017	Scale:- NTS

Appendix-K

Code:

```
clc;
clear all;
close all;
el= [1.0 1.0 1.18 1.4 1.65 1.67 1.85 1.85 2.00 2.14 2.36 2.54];
%ETAP full length/ (1/3) length loss ratio
k= [1.00 1.00 1.30 1.54 1.683 1.525 1.944 1.944 2.04 2.175 2.397 2.357];
%K factor
etap_loss_ratio=el'
k_factor=k'
figure (1);
stem (el, k)
xlabel ('Etap Loss Ratio');
ylabel ('K factor');
title ('ETAP loss Ratio vs. K Factor');
gridon;
figure (2);
plot (el, k)
xlabel ('Etap Loss Ratio');
ylabel ('K factor');
title ('ETAP loss Ratio vs. K Factor');
gridon;
```

OUTPUT:

Table 13.1.: ETAP Loss Ratio Vs K-factor output

etap_loss_ratio =	k_factor =
1.0000	1.0000
1.0000	1.0000
1.1800	1.3000
1.4000	1.5400
13.6500	1.6830
1.6700	1.5250
1.8500	1.9440
1.8500	1.9440
2.0000	2.0400
2.1400	2.1750
2.3600	2.3970
2.5400	2.3570

Code:

```
clc;
clearall;
closeall;
al= [1.0 1.05 1.33 1.40 1.65 1.88 2.06 2.21 2.22]; %analog loss ratio
k= [1.0 1.00 1.30 1.683 1.683 1.813 1.944 2.175 2.397]; %k factor
analog_loss_ratio=al'
k_factor=k'
figure (1);
stem (al, k)
xlabel ('Analog Loss Ratio');
ylabel ('K factor');
title ('Analog loss Ratio vs. K Factor');
gridon;
figure (2);
plot (al, k)
xlabel ('Analog Loss Ratio');
ylabel ('K factor');
title ('Analog loss Ratio vs. K Factor');
gridon;
```

OUTPUT:

Table 13.2: Analog Loss Ratio Vs k-factor Output

```
analog_loss_ratio =            k_factor =
    1.0000                         1.0000
    1.0500                         1.0000
    1.3300                         1.3000
    1.4000                         1.6830
    1.6500                         1.6830
    1.8800                         1.8130
    2.0600                         1.9440
    2.2100                         2.1750
    2.2200                         2.3970
```

Code:

```
clc;
clearall;
closeall;
el= [1.0 1.0 1.18 1.4 1.65 1.67 1.85 2.14 2.36]; %ETAP loss ratio
al= [1.0 1.05 1.33 1.58 1.65 1.88 2.06 2.21 2.22]; %Analog loss ratio
etap_loss_ratio=el'
analog_loss_ratio=al'
figure (1);
stem (el, al)
xlabel ('Etap Loss Ratio');
ylabel ('Analog loss ratio');
title ('ETAP loss Ratio vs. Analog loss ratio');
gridon;
figure (2);
plot (el, al)
xlabel ('Etap Loss Ratio');
ylabel ('Analog loss ratio');
title ('ETAP loss Ratio vs. Analog loss ratio');
gridon;
```

OUTPUT:

Table 13.3: ETAP Vs Analog Loss Ratio output

etap_loss_ratio =	analog_loss_ratio =
1.0000	1.0000
1.0000	1.0500
1.1800	1.3300
1.4000	1.5800
1.6500	1.6500
1.6700	1.8800
1.8500	2.0600
2.1400	2.2100
2.3600	2.2200

Code:

```
clc;
clearall;
closeall;
lr= [1.0 1.5 3.0 4.5 6.0 7.5 9.0 10.5 12.0 13.5 15.0 16.5 18.01 19.5]; %load ratio
kf= [1.0 1.30 1.45 1.54 1.683 1.813 1.944 2.04 2.175 2.285 2.397 2.517 2.528 2.64]; %k-factor
load_ratio=lr'
k_factor=kf'
figure (1);
stem (lr, kf)
xlabel ('2nd half Load/1st half Load ratio');
ylabel ('K factor');
title ('2nd half Load/1st half Load ratio vs. K factor');
gridon;
figure (2);
plot (lr, kf)
xlabel ('2nd half Load/1st half Load ratio');
ylabel ('K factor');
title ('2nd half Load/1st half Load ratio vs. K factor');
gridon;
```

OUTPUT:

Table 13.4: 2nd half Load/1st half Load Ratio Vs K- factor output

load_ratio =	k_factor =
1.0000	1.0000
1.5000	1.3000
3.0000	1.4500
4.5000	1.5400
6.0000	1.6830
7.5000	1.8130
9.0000	1.9440
10.5000	2.0400
12.0000	2.1750
13.5000	2.2850
15.0000	2.3970
16.5000	2.5170
18.0100	2.5280
19.5000	2.6400