ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

An ISO 3297: 2007 Certified Organization *Vol.4, Special Issue 3, April 2016*

3rd National Conference on Emerging Trends In Electronics and Communication Engineering (NCETECE'16)

Organized by

Dept. of ECE, New Prince Shri Bhavani College of Engineering & Technology, Chennai-600073, India

Analysis of LT Distribution Losses by SCADA Load Flow Techniques

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ABSTRACT: In this paper an attempt to save the energy losses in low tension distribution networks by SCADA (Supervisory Control and Data Acquisition) load flow techniques are utilized. The electricity distribution control system faces a major problem of distribution losses due to usage of analogy meters, inadequate size conductors, cables, lengthily distribution lines, failure of sub-station equipments, improper earthling, transformer failure etc., Therefore, the main objective of this paper is to calculate the energy losses in power transformers, distribution transformers and 11KV Level Cross feeder circuits in Chennai Electricity Distribution Control Centre-SCADA networks. The results are compared with theoretical and practical values of energy losses in power circuits using Mean Absolute Percentage Error (MAPE) method. The proposed method is increases the good quality of power factor and reduce voltage drop at tail end of distribution feeder circuits. In this study of sample survey was conducted based on constitution Indian Electricity Act-2003 and follow up Tamil Nadu Electricity Board Rules and Regulations [1].

KEYWORDS: Distribution Transformers losses, 11 KV Feeder losses, load factor, load loss factor, load curve and load duration curve, MAPE, Power Transformers losses.

I. INTRODUCTION

The Chennai electricity distribution control centre consists of a group of ring main feeder with the voltage levels of 400KV, 230KV, 110KV, 33KV, 11KV and LT lines which can be mutually inter-linked with several back feeding arrangements. The energy consumed in distribution system at various techniques is involved. In this SCADA load flow technique is describe the future expansion of existing electricity distribution networks and monitoring the load flow or power flow in electrical generators, transmission lines and distribution feeder networks. The proposed method is find out energy losses in a pair of power transformers, distribution transformers and 11 KV Level Cross feeder circuits are discussed. In this paper, a method that includes the availability of load and corresponding to the SCADA Multi Function Transducer (MFT) values are considered from 33 KV Saidapet sub-station, Chennai Electricity Distribution Circle (CEDC) for the period of one month. The SCADA MFT Telemeters values may used to calculate actual energy losses in the power transformers, distribution transformers and 11 KV Level Cross feeder circuits are discussed as follows.

II. SCADA LOAD FLOW TECNIQUES

The load flow studies are probably the most common of all power system analysis measurements; they are used in planning studies to determine if and when specific elements will become overloaded or under loaded. The major investment decisions begin with reinforcement strategies based on the load flow or power flow analysis. In operating studies, load flow analysis is used to ensure that each generator run at the optimum operating point; that the demand will be met without overloading facilities; and maintenance plans can proceed without undermining the security of the system level.

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II (a) Function SCADA control centre

The main function of SCADA control centre in load flow techniques are:

i. Supervisory control of operation, Data acquisition from RTU and storage of data in online,
ii. Providing user interface from operators, Voltage magnitude and phase angle at each bus
iii. Real and reactive power flow in each bus, Reactive power loading on each generator
iv. Power system planning and control, Historical and real time events
v. Sequential mode of operation, Protective and information tagging of electrical equipments which are under out off service

II (b) Data obtained to identify the following:

i. Normal/Emergency mode of operation, Break/backup operation mode, Contingency analysis& Outage security assessment
ii. Optimum load dispatch, Stability analysis, Load flow analysis, Power flow analysis, & Optimum power flow analysis
iii. State estimation, Economics dispatching, Security analysis, Rescheduling & Load management

II (c) Benefit of SCADA load flow technique

i. To increase reliability and availability of power system
ii. To eliminates the manual mode of operation
iii. Effective load management of Distribution Network
iv. Close monitoring of supply status for essential services & VIP functions
v. Prompt restoration of supply in case of outages.
vi. Quick change over of supply while normalizing the feeding condition.
vii. Malfunctioning of breakers and protection system can be identified and action can be taken for rectifying the same early.
viii. Breakers which are tripping frequently can be identified and maintenance work can be taken up in time.
ix. Existing manned substations could be completely controlled from the Distribution Control Centre (DCC), after executing the necessary improvements i.e., they can be operated as unmanned substations.
x. As real time load details will be available for fault analysis can be made effectively.
xi. Reduce maintenance cost

III. TRANSFORMER AND FEEDER CIRCUITS

The electrical energy is received from generating station to substation and end use of customer at various voltage level of EHT to LT networks. In this paper, energy losses in real time SCADA electricity distribution networks are discussed as follows.

i. Energy losses power transformer
ii. Energy losses in feeder circuits
iii. Energy losses in distribution transformers
iv. Comparison statement of theoretical Vs practical values
v. Mean Absolute Percentage Error (MAPE) values

In this 33 KV Saidapet sub-station primary supply received from 110 KV Velachery sub-station and 110 KV Nandanam Sub-station via 33 KV MHU Compound sub-station, The primary distribution supply feeds a pair of 33/11KV-16 MVA power transformer I & II, In addition to that eight numbers 11 KV feeder circuits are parallel connected to 16 MVA power transformers-LV1 and LV2. The analysis of 16 MVA power transformers I & II, 11 losses KV Level Cross feeder circuits with 14 No's distribution transformers are considered as calculation of energy in whole power circuits. The systematic singleline diagram of 33 KV Saidapet sub-station as shown in Fig.1.

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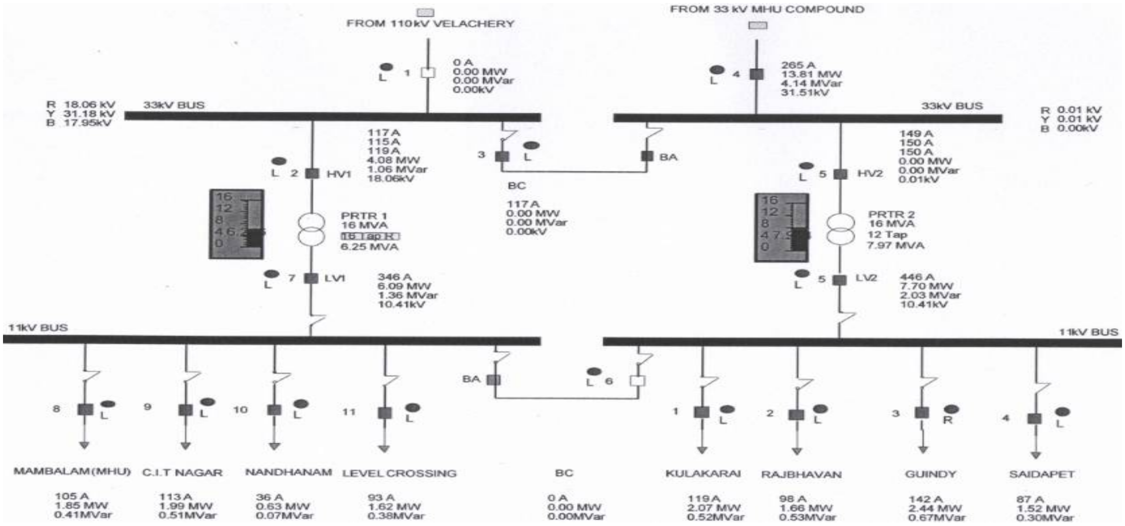

Fig.1 KV Saidapet sub-station power transformers and feeder circuits

VI. Load and Load Duration Curve for 11 KV Level Cross feeder circuits and Power Transformers I&II

The actual load and load duration curve for typical 16 MVA power transformers I & II, 11 KV Level Cross feeder circuits in Saidapet sub-station as shown in Figure.2 and Figure.3 and also theoretical and practical values of energy loss calculation as shown in Table.3 and Table.4 and Table.5 load data's obtained from Table.2, The real time values are implemented in ETAP software program to get energy losses in MW, MVAr and Voltage drop at each and every point of nodes as shown in Figure.4.and Table.6

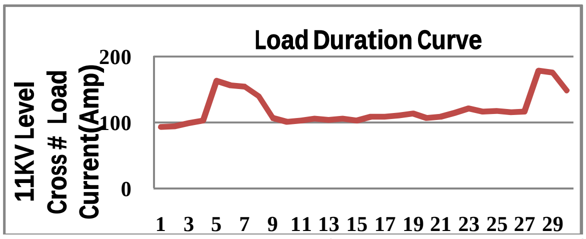

Fig.2 Load and Load duration curve for 11 KV Level Cross feeders

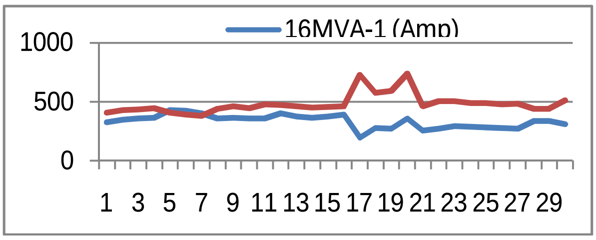

Fig.3 MVA Power Transformers I & II Load Duration Curve

Energy consumption losses in Feeder Circuits in MU 11KV Feeder $= 3 * I^2 * R * L * LLF * 24 * 30 * 10^{-6}$ (8)

Where

$$LLF = LF^2 + 0.273 * (LF - K)^2$$

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Energy consumption losses in Power Transformer in **MU**

$$\text{Power Transformer} = \frac{Noload + [(\%Loading)^2 * Conductor.constant * LLF] * 8760}{10^6} \quad (9)$$

The Mean Absolute Percentage Error (MAPE) is difference between the theoretical and practical values of energy losses divided by theoretical energy losses in power circuits. This method is used to find out accuracy of distribution losses in real time theoretical and practical values of Chennai Electricity Distribution Control Centre, SCADA networks.

$$MAPE = \frac{1}{N}\sum_T \frac{|T_v - P_v|}{T_v}$$

Where
N-Total period of calculation
Tv-Theoretical energy losses in power circuits
Pv-Practical energy losses in power circuits

Sl.No	Feeder & Power Transformer Load in Amp			
1	Day(Hrs)	Level Cross	16MVA-1	16MVA-2
3	1	93	327.6	405.00
4	2	94.2	353.7	429.30
5	3	98.7	361.8	433.80
6	4	102.3	367.2	444.60
7	5	163.2	432.9	405.90
8	6	156.6	425.7	391.50
9	7	154.2	405	379.80
10	8	139.8	362.7	437.40
11	9	106.2	366.3	461.70
12	10	100.8	363.6	448.20
13	11	102.6	360.9	476.10
14	12	105.6	406.8	471.60
15	13	104.1	379.8	462.60
16	14	105.3	368.1	450.00
17	15	102.9	376.2	459.00
18	16	108.3	394.2	464.40
19	17	108.9	198.9	728.10
20	18	110.1	279	576.90
21	19	113.4	275.4	591.30
22	20	106.2	360.9	741.60
23	21	108.3	260.1	461.70
24	22	114.9	273.6	505.80
25	23	120.9	294.3	507.60
26	24	116.4	290.7	486.90
27	25	117	283.5	486.90
28	26	115.2	282.6	477.00
29	27	116.4	276.3	484.20
30	28	178.8	338.4	438.20
31	29	176	340.2	438.30
32	30	148.2	313.2	513.90

Table.1 Average Load details in 11 KV Feeder and Power Transformers

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Energy losses in Feeder Circuit		
LF=(Average Load)/(Maximum Load)		
$LLF=K*LF=(1-K)*LF^2$ (OR) $0.2*LF+0.8*LF^2$		
Technical loss=$3*I^2*R*Length*LLF*24*30*10^{-9}$		
Feeder name	11KV Level cross	
Lengh of Cable	9.72	KM
Peak Load	178.8	Amp
Average Load	150	
Load Factor	0.84	
Load loss Factor(0.20)	0.73	
Technical losses in Feeder	0.696	MU

Table.2 Theoretical values of energy losses in 11 KV Level Cross feeder circuits in MW

Energy losses in Power Transformers		
LF=(Average Load)/(Maximum Load)		
$LLF=K*LF=(1-K)*LF^2$ (OR) $0.2*LF+0.8*LF^2$		
Technical loss for Power transformer={No Load loss+[(% of Loading)^2 *Rated Cu		
Power transformer Capacity	16	MVA
Full Load Capacity	840	Amp
Power Transformer 11KV Peak Load	741.6	Amp
% of Peak Load	0.88	
Load Factor	0.81	
Load loss Factor(0.20)	0.69	
Standard losses of Power Transformer		
No Load losses	16.8	KW
Full(Cu) Load losses	68	KW
Technical losses in Power Transformer in MU	0.47	MU

Table.3 Theoretical values of energy losses in Power transformer I & II

Energy losses in Distribution Transformers				
LF=(Average Load)/(Maximum Load)				
$LLF=K*LF=(1-K)*LF^2$ (OR) $0.2*LF+0.8*LF^2$				
After Load Bifurcation: Technical losses in Transformer				
Technical loss for Power transformer={No Load loss+[(% of Loading)^2 *Rated Cu loss]}*LLF*24*365*10^{-6}				
Description of Calculation				
Transformer Capacity	100	250.00	500	KVA
Full Load Capacity	84	210.00	420	Amp
Transformer 11KV Peak	79.8	157.50	273	Amp
% of Peak Load	0.95	0.75	0.65	%
Load Factor	0.475	0.38	0.325	
Load loss Factor(0.20)	0.2755	0.19	0.1495	
Standard losses of Transfor				
No Load losses	0.3	0.50	0.9	KW
Full(Cu) Load losses	1.2	2.00	3.5	KW
Technical losses in Power Transformer in MU	0.00	0.00	0.003	MU

Table.4 Theoretical values of energy losses in Distribution transformers I & II

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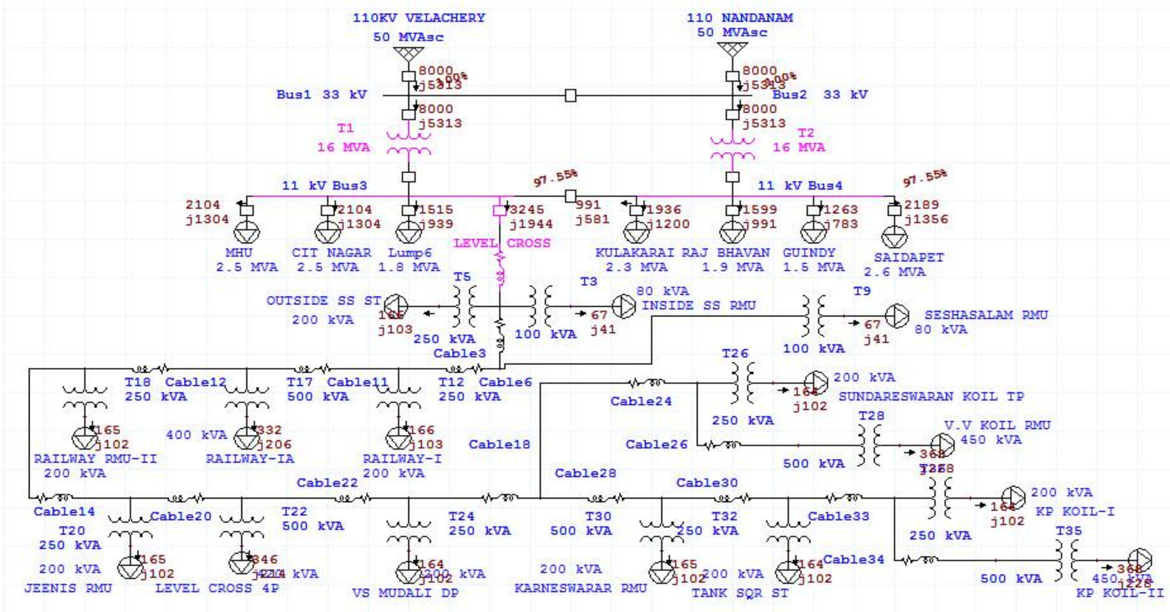

Fig.4. ETAP diagram of 33 KV Saidapet sub-station power transformers I&II and 11 KV Level cross feeder circuits

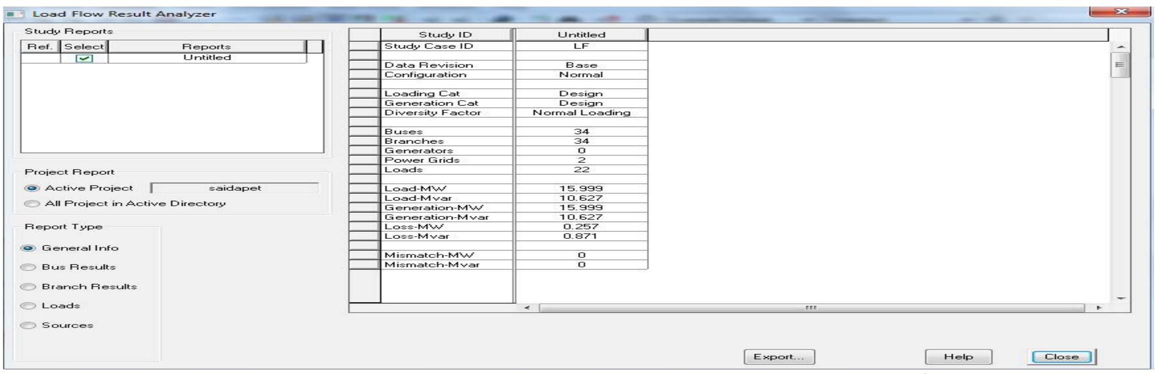

Table.5 Actual energy consumption losses in whole power circuits by ETAP software program

V. RESULT

The case study was successfully conducted and calculated average energy losses in power circuits is 1.131 Million Units per annum was dissipated in 16 MVA power transformers I & II, 11 KV Level Cross feeder circuits and 14Nos distribution transformers by Electrical Transient and Analysis soft program and also comparative statement of theoretical and practical values are as shown in Table.6

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Sl.No	Energy losses in power circuits	Thecretical Values in MU	ETAP Programming in MU
1	Power Transformers	0.47	0.537
2	11KV feeders	0.696	0.591
3	14Nos Distribution Transformers	0.05	0.003
4	Total Energy losses per Annum	1.216	1.131

Table.6 Nett energy consumption in theoretical and practical values

The theoretical and practical values are almost equal and achieving of Mean Absolute Percentage Error is **0.70** only.

VI. CONCLUSION

This paper discussed to analysis of energy losses in a SCADA Electricity Distribution Network. These measures include load switching, feeder reconfiguration, load reduction and voltage control. The use of this application improves the reliability and effiency of the transmission and distribution network.

By proper selection of transformers, feeders, proper re-organization of distribution network, reducing the length of LT lines, bifurcating of HT lines, placing the compensating equipments in appropriate places, that may reduce the distribution losses and also training of the operating personal would result in improve the efficiency of system.

VII. FUTURE WORK

The existing Transmission and distribution feeder circuits are appropriate rating and distribution transformers are installed at nearer to load centre, which becomes good quality of power factor raised in consumer's terminal or tail end of distribution transformer. For accurate calculation of energy losses, energy meters should be connected to all distribution transformers. Installing shunt capacitors of optimum rating at vantage point of substation, line losses in LT networks may considerably reduced.

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PIC16F877 is 40 pin IC. There are six ports in this microcontroller namely PORT A, PORT B, PORT C, PORT D and PORT E. Each pins in the ports can be used as either input or output pins.