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Effect of Tapped Load on Distribution Line Power Flow

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***Abstract* - In the distribution power system, electric power is distributed among various consumers, thus a number of tapings are taken from a distribution line. In the developing countries and even in the small areas there is a lots of problems related to the power theft. Which results in a large amount of power wastage and the overall efficiency of power system is reduced to a great extent. The objective of this paper is to analyze the effect on the power flow in the distribution lines when an extra tapping or an unauthorized load is connected in a distribution line i.e. called POWER THEFT in general language. And in future we will detect this unauthorized tapping and give signals for taking appropriate action against the tapping. So that the efficiency of power system gets increased.**

***Keywords* - Tapped Load, Power Theft, Power Flow.**

I. INTRODUCTION

India's network losses exceeded 32% in 2010 including Non-technical losses, compared to world average of less than 15%.Both technical and non-technical factors contribute to these losses, but quantifying their proportions in difficult. but the government pegs the national T & D losses at around 24% for the year 2011 .Some experts estimate that technical losses are about 15% to 20%.A high proportion of non-technical losses are caused by illegal tapping of lines. but faulty electric meters also contribute to reduced payment collection. A case study in Kerala estimate that replacing faulty meters could reduce distribution losses from 34% to 29%.

Electric power is defined as the rate at which electrical energy is transferred by an electric circuit. A line or conductor to which various consumers are connected through service mains is known as distributor. It is to distribute electric power among various consumers, thus a number of tappings are taken from the distribution lines. There is a large network of conductors between the generating stations and the consumers. The network is called the transmission and distribution system.The Theft of Electricity is a crime which adversely affects all utility customers. Residential customers are responsible for about 80 percent of all thefts, while commercial and industrial users account for the remaining 20 percent. However, commercial and industrial users account for an estimate of 80 percent of an rupee losses, Power theft also leads to lost government revenues.

According to Smith [1], electricity theft can be in the form of fraud (meter tampering), stealing (illegal connections), billing irregularities, and unpaid bills. The evidence of the extent of electricity theft in a sample of 102 countries between 1980 and 2000 shows that theft is increasing in most regions of the world. The

Financial impacts of theft are reduced income from the sale of electricity and the necessity to charge more to consumers.

According to Solomon Nunoo and Joseph C, Attachie[2],Electricity theft, a common form of commercial losses, involves tampering with meters to distort the billing information or direct connections to the power system. Commercial losses are nearly impossible to measure using traditional power system analysis tools. This is due to the lack of information on both commercial and the legitimate loads in the system, which translates to insufficient inputs for any meaningful loss calculations.[3] The extent of theft varies with the electoral cycle of the state. Theft is increasing with the intensity of tube wells, suggesting that it is linked to unmetered electricity use by farmers. Incumbent legislative members of the state assembly are more likely to be reelected as power theft in their locality increases.[4]A major problem that electricity utilities companies in emergent countries face is the loss of revenue caused by non-technical losses, which are originated mainly by fraud or theft of electricity. This work describes the development of a non-invasive and low-cost process that allows for the improvement of the energy theft inspection routine, increasing the field inspection team productivity and reducing the customer's embarrassment in cases where no irregularity is found. This new process is based on the development of an electronic Ah meter device that can be installed on the customer's pole input connections to the power lines.

II. METHODOLOGY

The required parameters for the analysis of distribution lines are voltage, current, impedance. For this two types of analysis are required, software analysis and hardware analysis.
In the hardware analysis we analyze the losses in one or two meter wire having the cross sectional area of 2.5 mm2, and having impedance 7.41 ohm/km.
In the software analysis we used software tools such as MATLAB, simulation for analyzing the losses in long distances (kilometers) distribution lines.

(A)HARDWARE ANALYSIS:

In the hardware analysis we analyze the losses in one or two meter wire having the cross sectional area of 2.5 mm2, and having impedance7.41 ohm/km.The hardware analysis is performed with a purely resistive load and with R-L load.
1. With Purely Resistive Load:

The circuit diagram (Figure 1) shows a 150 cm wire, having tapping on each 30 cm.The voltage supply is 230 volts and an ammeter is connected in series with the voltage source. A purely resistive load of 100 ohms is connected with the 150 cm wire. A tapped load i.e. lamp load 0f 100 watt is connected in parallel with the existing load. And readings are taken by changing the position of tapped load with each 30 cm.

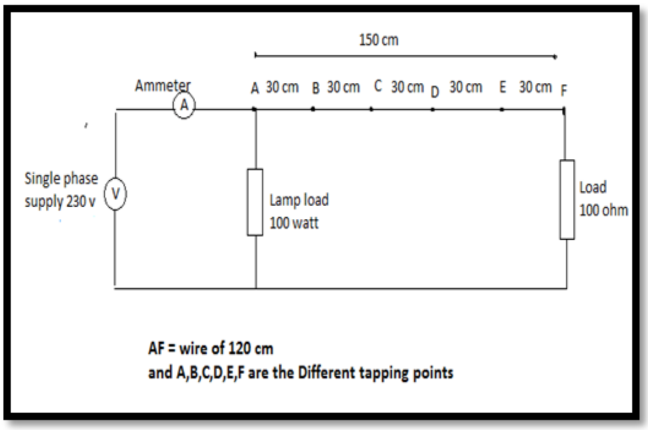

Figure 1. Tapping with purely Resistive Load

The following readings are obtained by the experiment:

Distance (cm)	Current (I)(amp)	Voltage (volt)	Impedance (V/I)ohms
30 cm	3.3 A	21 mv	.0063
60 cm	3.2 A	37 mv	.0115
90 cm	3.19 A	43.4 mv	.0136
120 cm	3.17 A	47 mv	.074

Table 1. Readings with Purely Resistive load

2.Same experiment is performed with the R-L Load.

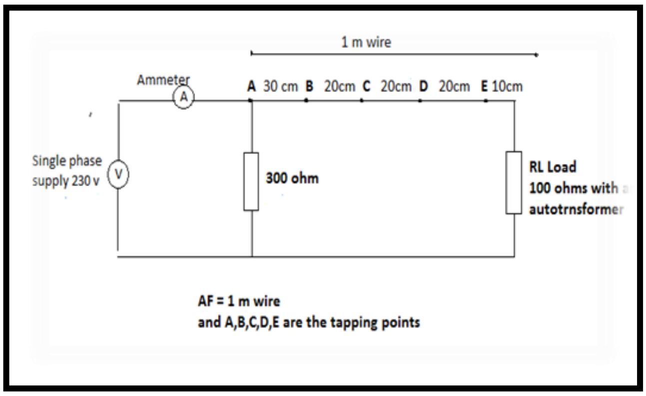

Figure 2: Tapping with R-L load

The following Readings are obtained with R-L Load:

Loads	Distance (cm)	Current (I)Amp	Current (I_1)Amp	Current (I_2) Amp
150 ohms	0	1.54	0.56	1.18
	50	1.73	0.58	1.18
	70	1.71	0.56	1.18
300 ohms	0	1.25	0.57	0.58
	50	1.19	0.56	0.58
	70	1.18	0.57	0.58
500 ohms	0	1	0.59	0.4
	50	1.02	0.58	0.4
	70	1.02	0.59	0.4
1000 ohm	0	0.85	0.74	.21
	50	0.9	0.69	.21
	70	0.91	0.68	.21

Table 2 : Readings with R-L Load

(B) SOFTWARE ANALYSIS:

In the software analysis we used software tools such as MATLAB, simulation for analyzing the losses in long distances (kilometers) distribution lines. The simulation diagram for the analysis of active power is shown. Here one π section line is taken as km distribution line.

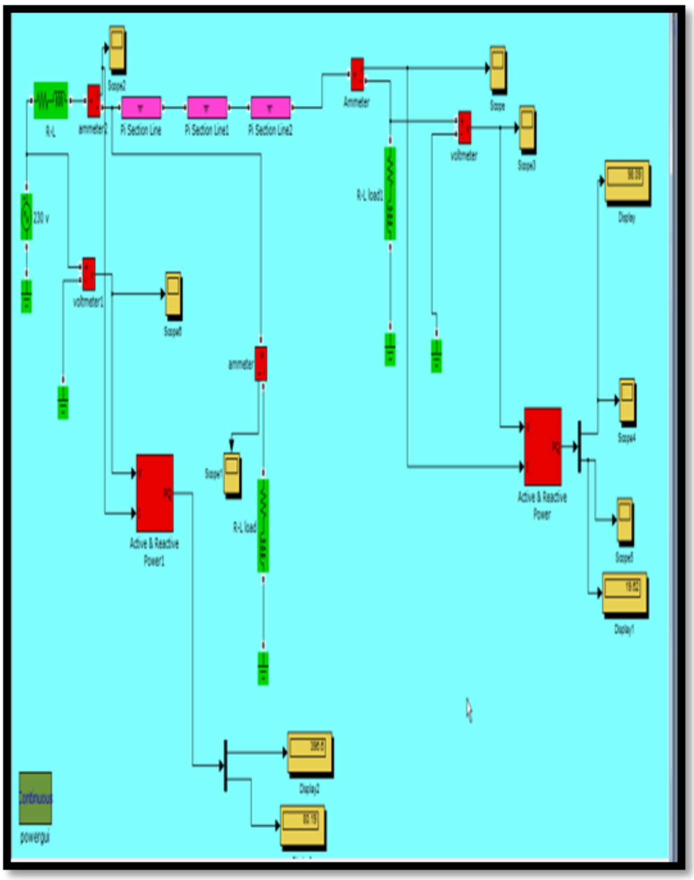

Figure 3: Simulation diagram

The distribution line is connected to the supply mains at one end and loads are tapped at different points along the path of distributors. Whenever an extra load is connected in parallel with the existing loads in a distribution line, the power flow in the distribution line gets affected.

The following results are observed by the above MATLAB simulation:

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As the simulation diagram shows a supply source of 230V is connected with existing load of 100W, and a tapped load of 100W at 1 km from the feeding point. Then the current in the distribution line (before tapping point) = 0.88 A
Current in the tapped load i.e.= 0.44 A
Active power in the distribution line P = 198.7 W

If tapped load is connected at a distance of 2 km from the feeding point.

Current in the distribution line = 0.88 A
Active power P = 198.5 W
Now if load is connected at a distance 3 km from the feeding point
Current in the distribution line = 0.88 A
Active power P = 198.1 W
The active power loss on 1 km = (200-198.7) =1.3 W
For 2 km. = (200- 198.5) =1.5 W
For 3 km = (200 -198.1) = 1.9 W

Hence we concluded that as the methodology shows that when extra load is tapped with the existing loads the active power loss in a distribution line goes on increasing as the tapping is done away from the feeding point.[5].

MATLAB Analysis for the KOTA CSEB substation to KOTA town:

In the software analysis we used software tools such as MATLAB simulation for analyzing the effect of tapped unauthorized load or power theft in the distribution line power flow.
The simulation diagram for the analysis of power flow is shown. This diagram shows the connections from KARGI ROAD, KOTA substation to KOTA town. Here one main step down transformer of 100 KVA, 132/11 KV is connected at the supply end through which 17 poles are connected in different manner. The distance between the each pole is about 40 m. And each pole is designated with some loads (single or 3-phase). In this simulation diagram we use a 3-phase V-I measurement device which measure the values of voltages and currents of all phase in each pole.

MATLAB Simulation Diagram of different poles with different loads

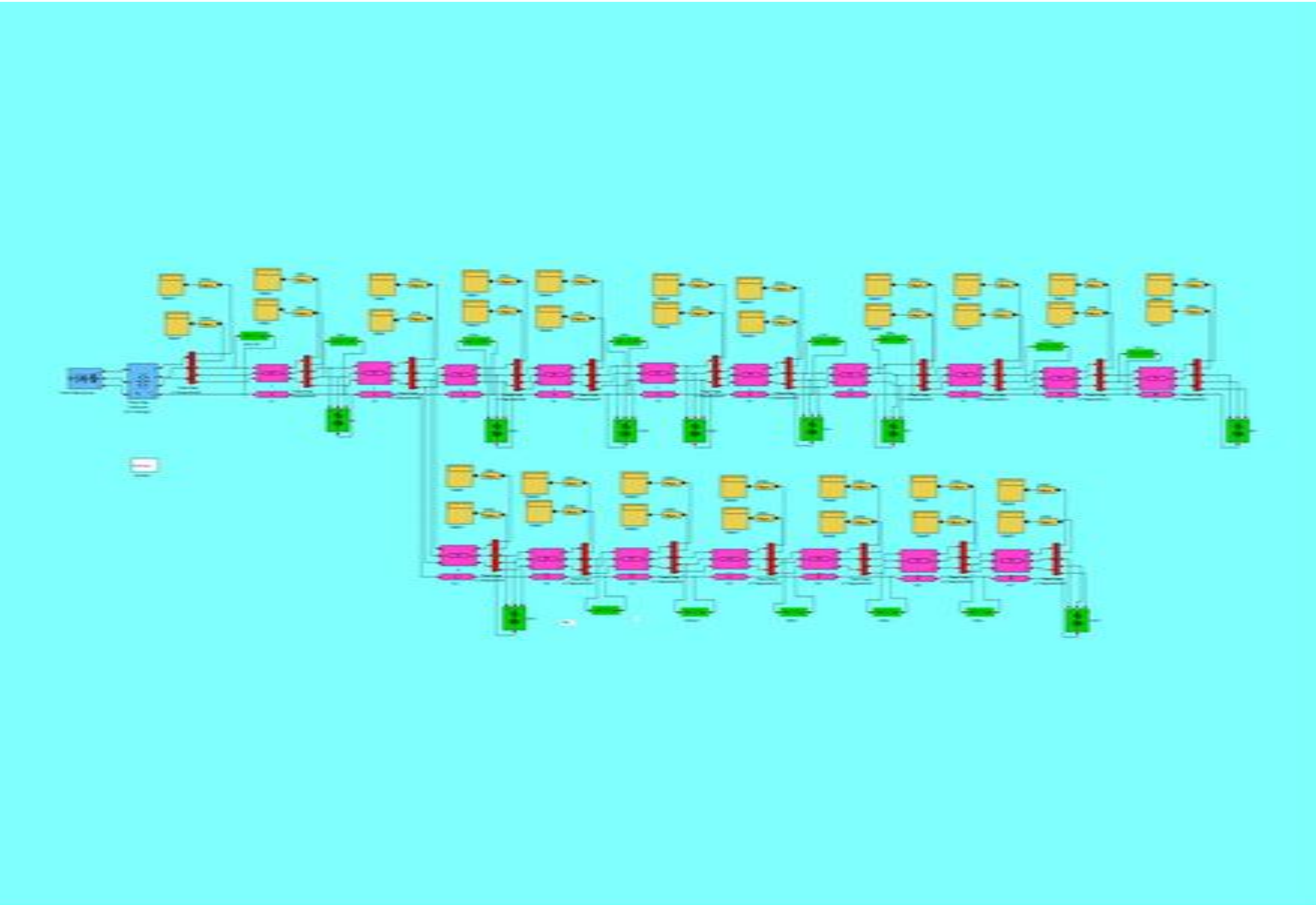

Figure 4: Simulation Diagram For Different loads at different poles

Details of the figure 4 Simulation Diagram:

In this diagram one 3-phase π section line is taken as 40 m of distribution line i.e. the distance between the two poles. The loads connected in different poles in different phases are as follows:

Pole No.	Load on R phase (Watt)	Load on Y Phase (watt)	Load on B phase (watt)	3phase load (KW)/ HP 1 HP = 746 watt
1	240	-	-	-
2	-	580	-	3 KW
3	-	-	-	-
4	-	-	2450	10 HP
5	1890	-	-	7.5 HP
6	-	-	-	10 HP
7	1720	-	-	4 KW
8	-	2580	-	5 HP
9	-	1720	-	-
10	-	120	-	-
11	-	-	-	8 HP
12	-	-	-	23KW
13	1780	-	-	-
14	-	1780	-	-
15	2830	-	-	-
16	-	-	6000	-
17	-	1520	-	-
18	-	-	-	3.5 KW
TOTAL Load	8640 W	8300 W	8450 W	63.713 KW

Table 4 : Connected Loads in Different Phases

III. RESULTS AND DISCUSSIONS

Table shows the total connected load in each phase i.e.
R phase has 8460 Watt
Y phase has 8300 Watt
B phase has 8450 Watt

With these connected load the currents flowing at starting (before 1st pole) are:

In R phase 120.4 Amp
In Y phase 120.3 Amp
In B Phase 121.7 Amp

Now we see the effect of extra tapped on the power flow (variation of voltage and current) in this distribution line. Here we check that by the power theft or by the unauthorized tappings what amount of current is changes in the distribution line so that the power in the distribution lines gets wasted as losses.

S.No.	Tapping on Pole Between	Tapped Phase with Amount of tapped load		Source Current(Amp)			Change in source current from normal Condition(Amp)		
		Phase	Amount (Watt)	I_R	I_Y	I_B	I_R	I_Y	I_B
1	1-2	R	2000	126.6	120.3	121.8	6.2	0.0	0.1
2	2-3	Y	1000	120.5	124.8	121.8	0.1	4.5	0.1
3	4-5	B	1800	120.6	120.3	127.0	0.2	0.0	5.3
4	5-6	Y	1000	120.4	123.2	121.8	0.0	2.9	0.1
6	5-6	R	2300	127.8	120.7	121.7	7.4	0.4	0.0
7	6-7	R	2500	127.8	120.7	121.7	7.4	0.4	0.0
8	8-9	B	500	120.6	120.3	123.3	0.2	0.0	1.6
9	9-10	B	1800	121.4	120.3	127.1	1.1	0.0	0.1
10	10-11	Y	2300	120.6	125.3	122.4	0.2	5.0	0.7
11	12-13	R	1200	124.0	120.4	121.7	3.6	0.1	0.0
12	13-14	B	2700	120.7	120.3	129.7	0.3	0.0	8.0
13	15-16	Y	800	120.4	122.6	121.9	0.0	2.2	0.2
14	17-18	B	1200	120.6	120.3	125.2	0.2	0.0	3.5

Table 5 : Change in currents due to tapping at different poles

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IV. CONCLUSION

Whenever an extra tapping is done on the distribution line the current in the distribution line increases which results in losses i.e. a large amount of power is wasted as the losses. From the calculations we observed that as the value of tapped load is increased in any phase, the current of that phase increases. While the current of other phases changes negligibly. Now if the value of that tapped load further increases, current increases again depending upon the tapped load. so the losses are increased with increase in tapped load. Hence load variation or with the tapping loads the flow of power in the distribution lines gets affected. Further we found that the value of current goes on increasing as the tapping is done away from the source side.

From the results we concluded that the distribution lines experiences a large amount of losses by tapping the loads or with the power theft. Hence the power theft is the major cause of losses. To minimize this loss, firstly we have to identify the location of power theft and then to take the proper action against the tapping. So that we minimize the losses in the distribution lines. and the consumers gets good quality of power with the reliability, good efficiency and with minimum losses. For this the circuitry is being developing for indicating the power theft and to prevent the power theft.

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