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Analysis of the Revenue Loss to the Electricity Supply Company during Parallel Operation of Two Adjacent Traction Sub-Station (TSS)

Amit Verma[1], Mr. Anand Goswami[2]

M.Tech Scholar, Department of Electrical & Electronics Engineering, Gyan Ganga College of Technology, Jabalpur, (M.P), India[1]

Asst. Professor, Gyan Ganga Institute of Technology & Sciences, Jabalpur (M.P), India[2]

Abstract: Indian Railway is one of the biggest consumer of electricity; it has a largest network of electrification in India. Each Traction Sub-Station(TSS) is located at a distance of 40 to 60 K.M. from other T.S.S, each T.S.S. has its own feeding zone and separate metering. Various tariff structures are followed in the market by different types of electricity consumer, but Railway follows the two part structure. In this structure, the total billing charges are split into two charges i.e; constant charges and variable charges. During Parallel operation of two adjacent Traction Substations (TSS) the Maximum Demand (MD) recorded in TSS having larger Train load is less and Maximum Demand recorded in TSS having light Train load is somewhat high as compared to De-parallel operation. This Suppression of Maximum Demand effect the total electricity bill of that particular TSS.

Keywords: Traction Substations (TSS), Neutral Section (NS), Maximum Demand (MD), two part tariff.

1. INTRODUCTION

For the analysis of electricity bill of TSS two traction Substations have taken here where in between there is some steep gradient portion. Distance between these two traction substations is near about 48 KM. And, the feeding zone of each TSS is separated by Neutral Section (NS).
Neutral Section (NS) is electrically dead and it consists of two section breaks back-to-back. So that there is a short section of overhead line that belongs to neither feed zone of TSS. When the train having heavy commercial load or the goods trains passing through the NS at steep path the locomotive starts crawling because of heavy mechanical load which starts to pull the locomotive back in absence of power at NS. Hence, the railway needs parallel operation of two traction substation by providing the supply at NS to avoid crawling of locomotive. With this parallel operation of two TSS located at either sides of NS, the maximum demand of each TSS is sharing with each other, because TSS-1and TSS-2 feeding supply to either sides of NS at parallel condition. Here, we will analyze the effect of Suppression factor on Electricity Bill by which Maximum demand of heavy Loaded TSS is suppressed.

2. SYSTEM MODEL

A single line schematic diagram showing in figure (a) & (b) with the assumed position of trains (Load) between the Traction Substations operating in parallel. From central railway records there are some particular values of OHE (Over Head Extension) impedance which are used for relay settings.

- Single track OHE without return conductor (RC) = $0.41\angle 70^0$ Ω/km.
- Double track OHE without RC = $0.24\angle 70^0$ Ω/km.
- Single track OHE with RC = $0.70\angle 70^0$ Ω/km.
- Double track OHE with RC = $0.43\angle 70^0$ Ω/km.

Impedance of 11.83% and the other one is 18.5 MVA with same percentage impedance of 11.83% and line reactance of the feeder. Figure (a) & Figure (b) showing Dongergaon –TSS & Burhanpur –TSS operating in parallel.In case-1(Fig (a)) assuming train load of 1:3 that there is one train load is at Dongergaon –TSS, and there are three trains running under Burhanpur –TSS, but because both TSS operating in parallel hence all three trains load is not only supplied by TSS-2, but it is also feed by TSS-1 depending on impedance of OHE.

Take 21.6 MVA transformers at both TSS for calculations.
Transformer impedance referred to 132 KV side = $(132)^2*0.1183/21.6 = j95$ Ω.
Overall impedance of double track OHE without RC referred to 25 kV side = $0.24\angle 70^0$ Ω/km.

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Overall impedance of double track OHE without RC referred to 132 kV side = $(132)^2 \times 0.24/(25)^2 = 7\angle 70^0$ Ω/km = (2.3 + j6.3) Ω/km.

Case-1(Fig-a): Assuming train load 1:3 in feeding zones of above TSS. Neutral Section is closed during parallel operation of 25 KV feeding line.

$I_1 + I_2 = 4000$ A. -------- (Eq.-1)

As the voltage drop in a closed loop between TSS-1 and TSS-2 is zero.

$I_1 \times j95 + (I_1 - 1000) \times [38 \times (2.3+j6.3)] = I_2 \times j95 + (I_2 - 2000) \times 10 \times (2.3+j6.3)$ -------------------------- (Eq.-2)

By solving equations 1 & 2 we get,

$I_1 = 1500$ A.

$I_2 = 4000 - 1500 = 2500$ A.

Current drawn from TSS-2 under de-parallel condition is 3000 Ampere.

Current drawn from TSS-2 under parallel condition is 2500 Ampere.

Hence, under parallel condition I_2 is suppressed by a factor = **3000/2500 = 1.20.**

Case-2(Fig-b) : Assuming train load 0:3 in feeding zones at above TSS. Similar, as above calculation if we calculate I_1& I_2 for train load 0:3 between TSS-1 & TSS-2.In this case,

$I_1 + I_2 = 3000$ A. -------- (Eq.-3)

We will have the values of I_1& I_2 is,

$I_1 = 690.4$ A.

$I_2 = 5000 - 690.4 = 2309.6$ A.

Current drawn from TSS-2 under de-parallel condition is 3000 Ampere.

Current drawn from TSS-2 under parallel condition is 2309.6 Amp.

Hence, under parallel condition the value of current I_2 drawn from TSS-II is suppressed by a factor = **3000/2309.6= 1.298**

For this, MPSEB penalize the Billing of Central Railway for parallel operation of TSS by multiplying the average value of the Suppressed factor on total Maximum demand Consumption during Billing Cycle. In this paper two cases have been taken with different train loads at different TSS and get the average value of 1.25 of suppression factor for analyzing the electricity bill.

3. PREVIOUS WORK

Research work for parallel operation of two adjacent TSS has been published before in my first research paper. On that I have evaluate the factor by which the maximum demand of two parallel operated TSS has been suppressed. This research paper covering how that suppression of maximum demand makes a revenue loss to the electricity supply company.

Add booster transformer impedance at the rate of 0.15 Ω per booster transformer, where these are provided.

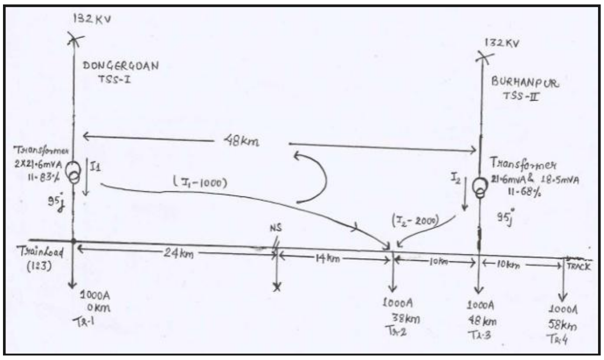

Figure (a)

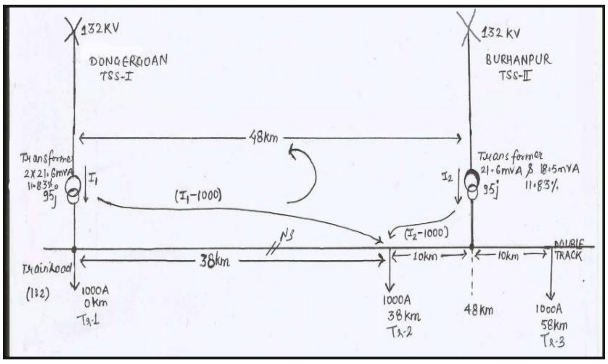

Figure (b)

We have taken a case of Dongergaon - Burhanpur TSS, they are at 48 KM from each other. There are two Transformers at Dongergaon -TSS capacity of both Transformers are 21.6 MVA having percentage impedance of 11.83%. At Burhanpur –TSS one Transformer is with a capacity of 21.6 MVA with percentage

4. PROPOSED METHODOLOGY

The tariff is the rate of electrical energy at which it is sold to customers. The electric supply company has to ensured that the tariff should be such that it is not only recovers total cost of generating and transmitting electrical energy but also earns profit on the capital investment of generation and transmission. There are various types of tariffs followed in the market, but railway follows two part tariff structure. In two part tariff, the total billing charge is split into two components i.e; fixed charges and running charges. The fixed charges depend upon the total power consumed by the customer over a month while the running charges are depend upon the number of units consumed over a month by the customer. Thus the consumer is charged at a certain amount per kW of MD + a certain amount per kWh of energy consumed.

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Total charges = Rs x A kW + Rs x B kWh where A & B are arbitrary constants. With the help of the factor of suppression which is calculated in this paper the electricity bill for traction substation can be analyzed. In Billing of parallel operated TSS, MD charges in Rs/KVA/Month are multiplied by the factor 1.33 + Energy charges in Rs/KWh. and the bill will be scrutinized carefully. Railways have to pay bill for MD×1.33 or 0.75×CD whichever is higher. When we have taken the average value suppressed current from above two cases. We get
1.20 + 1.2989 /2 = 1.24945 ≈ **1.25**.

5. SIMULATION/EXPERIMENTAL RESULTS

By, assuming the position of train load between two TSS operating in parallel and make some calculations with the help of basic electrical engineering laws and evaluate the value of suppressed factor of each case. Then calculate the average of the factor by which the Maximum Demand (MD) gets suppressed from de-parallel condition to parallel condition.

6. CONCLUSION

This Research paper explains how the Maximum demand of Traction substation having larger running train load is affected more as compared to the adjacent Traction substation running parallel with it. During billing, the chargers Rs/KVA of Maximum Demand will also gets suppressed due to less value of Maximum demand recorded in heavily loaded Traction Substation meters during its parallel operation. With the help of calculated average value of suppression factor the electricity bill generated for that particular Traction substation can be scrutinize carefully.

7. FUTURE SCOPES

In future, with this calculated suppressed multiplying factor MPSEB can decide under what conditions they permit Railways to parallel their TSSs. Maximum Demand (MD) recorded at the TSS running in Parallel can be suitably modified for the purpose of billing by taking Multiplying factor. Billing MD of each TSS will be computed by multiplying a factor of 1.3 to the actual recorded MD of each TSS.

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BIOGRAPHIES

Amit Verma has received his Bachelor of Engineering degree in Electrical & Electronics Engineering from SRIT Engineering College, Jabalpur in the year 2007. At present he is pursuing his M.Tech with the specialization of Power System from Gyan Ganga college of Technology, Jabalpur. His area of interest is Power system, Electrical Machine, Electrical Drives, Circuit Theory.

Mr. Anand Goswami, Assistant Professor, Gyan Ganga Institute of Technology and Sciences, Jabalpur. He has completed his Master’s of Engineering from Govt. Engineering College Jabalpur in the year 2012 with the specialization of Control System and completed his bachelor degree of Engineering from SRIT, Jabalpur in the year 2008 with the specialization of Electrical & Electronics. He has a teaching experience of 5 years.