# Modeling &Simulation of a 100/22 kV Transmission Substation for Energy Audit

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## Abstract

This paper determines the need of under taking performance analysis and audit of electrical energy of transmission system. A 50 MVA, 100/22 KV substation was selected and a detail study is carried out todetermine performance of various parameter. It is observed that the capacity installed on the substation was on lower side carried out. Today in industry there is continuous expansion in demand for energy to serve growing industrial needs. Energy audit process can be done using mathematical calculations of incomingoutgoing power and mathematical modeling in Electrical software's. The incoming & outgoing power from the central bus of the substation can be verified using practical in-house reading and by simulation. In this paper Modeling & Simulation of 100/22 kV Transmission is done and results are compared with actual monitored.

**Index term:** energy audit, performance analysis, transformer efficiency, station efficiency etc.

## INTRODUCTION

Electrical power is important component& standard all over the world to determine productivity, prosperity and strength the nation. Hence the need of electrical power has increased, but the capacity of power generation has not been able to speed up with the demand resulting in electrical power shortage. This happens due to less rate of increase in generation of power&energy reducesdue to large theft of power and transmission and distribution (T&D) losses, scarcity of the convectional sources of energy generation, poor utilization of non-convectional (renewable)sources, speedy increase in the population and its leaving standards, wastage of power due to lack of

awareness towards energy conservation etc. These reasons if combined with the degradation of power quality have further deterioration.

Following techniques can be adopted for reducing power shortage.

a.    Maintaining a qualitative power supply which is reliable, free from harmonics, and maintained within permissible voltage, power factor and frequency tolerance.

b.    Increase the power generation capacities.

c.    Undertaking the performance analysis of the electrical installation and improving their energy efficiency and also adopting energy conservation techniques.

Among the techniques suggested above, the last one is simpler, effective, and most economical. However it necessitates planning the use of electrical power in the most judicious way such that the energy usage as well as its wastage is minimized. For this an effective scientific methodology tool like Energy Audit needs to be adopted.

**System Development**

**Transmisson Substation**

50 MVA, 100/22 KV Substation is selected for this study which islocated at Lonavla, Dist. Pune Maharashtra (India). The exact measurement carried out at the site. This Substation has bus bar scheme of 100/22 kV rating. The Bus barScheme has a circuit breaker of 100kV Substation. There are two incoming bus bar of 100kV to feed the nine Distribution Substation. There are nine bays of 11kV rating. The total number of Transmission line of rating 100kV are two & Power Transformer of 50 MVA each.

Transformer details: Three phase, 50 Hz; type of cooling-OFAF; Line current HV-454.6 A; Line current IV-826.6A ,Line current LV 1837.0A No load voltage ratio HV/IV/LV-100/50/22 kV No. of taps-17,Percentage impedance-12.5, No load loss-101.4 kW, load loss-274.1 kW, No load current-0.06A vector group-YN, a0,d11;high voltage winding resistance-0.2388Ω, IV winding resistance-0.2936 Ω LV winding resistance-37.3790 Ω.Bus reactor details: Three Phase 50 Hz, Rated power MVAr-50, Rated voltage-100kV, Type of cooling-ONAN, Connection symbol-YN, Rated current 68.73A, Impedance / phase :-3528(+0-5% TOL).
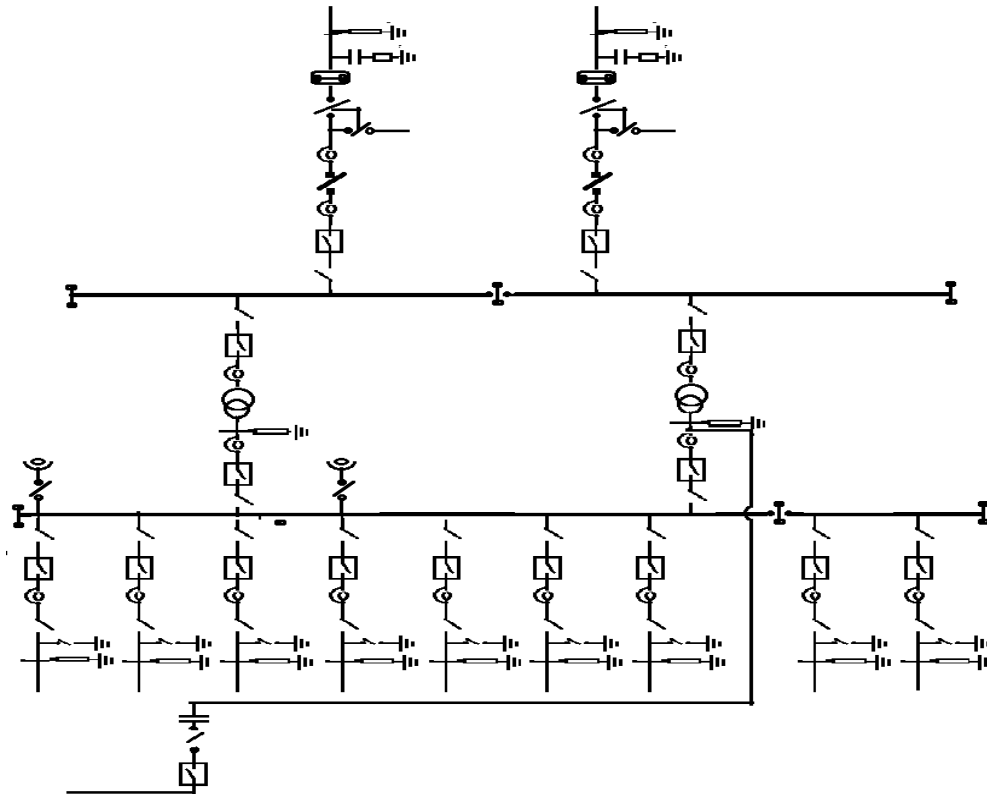
**Figure 1:** Single line diagram of Transmission Substation

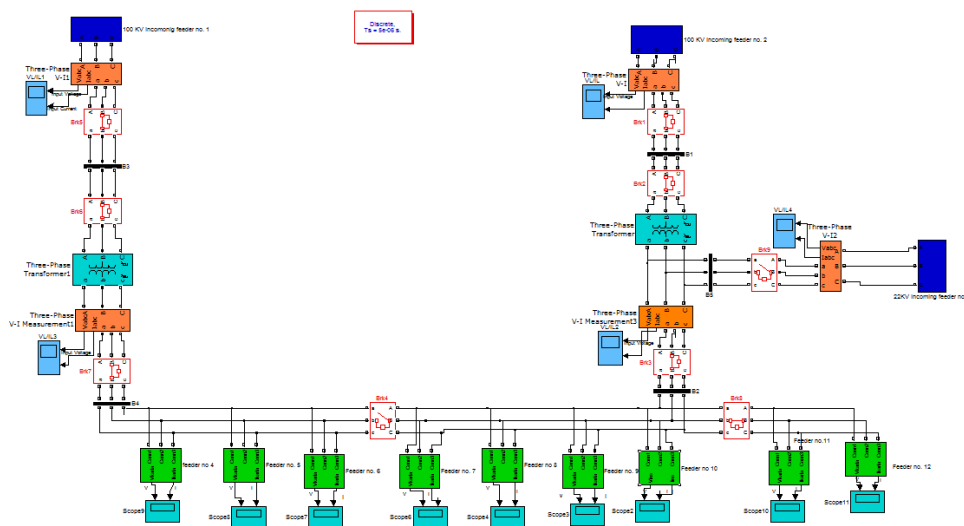## MATLAB Modeling of Transmission Substation



**Figure 2:** Model of100/22KV Substation in MATLAB Simulink software.

MATLAB simulation of the Transmission Substation is shown in the fig.2. In the simulation three incoming section and 9 outgoing section are shown. Among the three incoming connection feeder no.1 100kV and feeder no. 2 100kV are operated regularly. The feeder no.3 22kV incoming connection is operated in case of urgency. Thefeeder no. 1 feed supply to the three outgoing feeder, feeder no. 4, feeder no. 5, feeder no. 6. The 100kV feeder no. 2 incoming line feed supply to the six outgoing lines feeder no. 7, feeder no. 8, feeder no. 9, feeder no. 10, feeder no. 11, feeder no. 12. Third incoming line is operated in case of emergency only. The switching arrangement is made considering the energy requirement of various loads in different time of utilization depending on the conditions.

For every outgoing line, the simulation block is designed which is evaluated with reference to real parameters and it also verified by mathematical calculation.
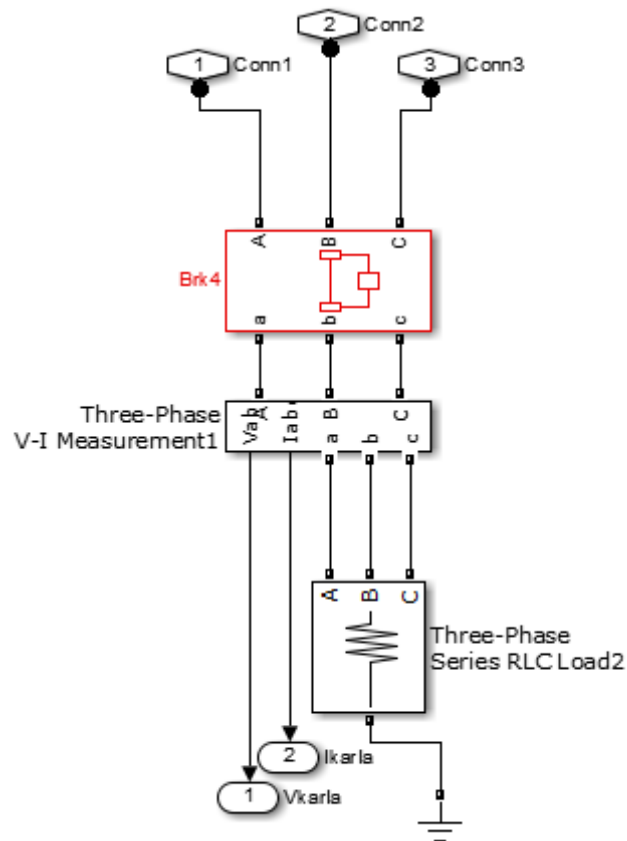
The outgoing block is as shown in fig. 3.



Figure 3: **Sub-block for a feeder**

This sub-block contains 3 phase incoming connections, one circuit breaker, measurement block for three phase voltage and current measurement and three phase load.

The Three-Phase Breaker block implements a three-phase circuit breaker where the opening and closing times can be controlled either from an external Simulink signal or from an internal control timer.

The Three-Phase Breaker block uses three Breaker blocks connected between the inputs and the outputs of the block.

The simulation is carried out and evaluated for the month of MAY. The maximum load on the system for the month May is determined from the simulation. The variation is shown in the Table no.1.

**Results of Simulation**
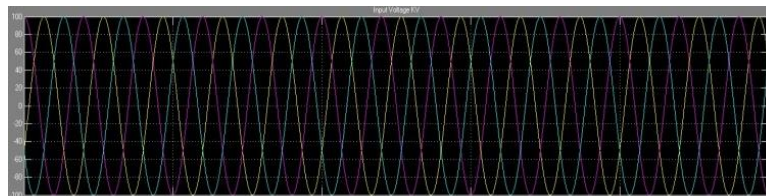

a) Feeder no 1 input voltage in volt
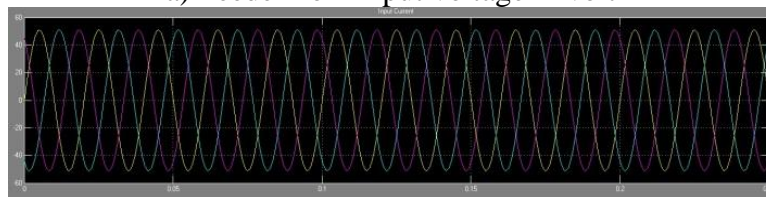

b) Feeder no. 1input Current in amp.


c)Feeder no.1 Step Dowden Voltage in Volt


d) Feeder no.1 StepDowden Current in Amp
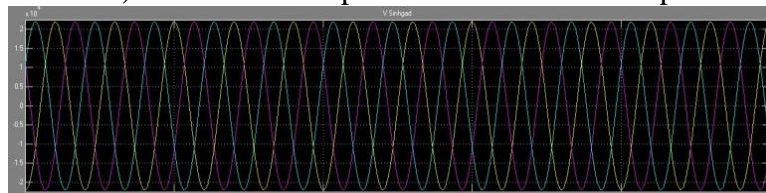

e) Feeder no.4 Voltage in Volt

f) Feeder no.4Current in Amp


g) Feeder no.5 Voltage in Volt


h)Feeder no.5 Current in Amp
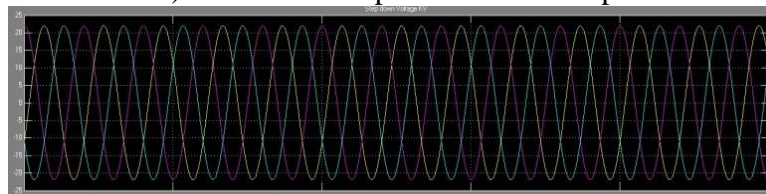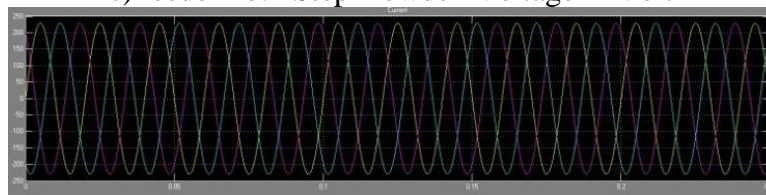

i) Feeder no.6Voltage in Volt


j) Feeder no.6Current in Amp
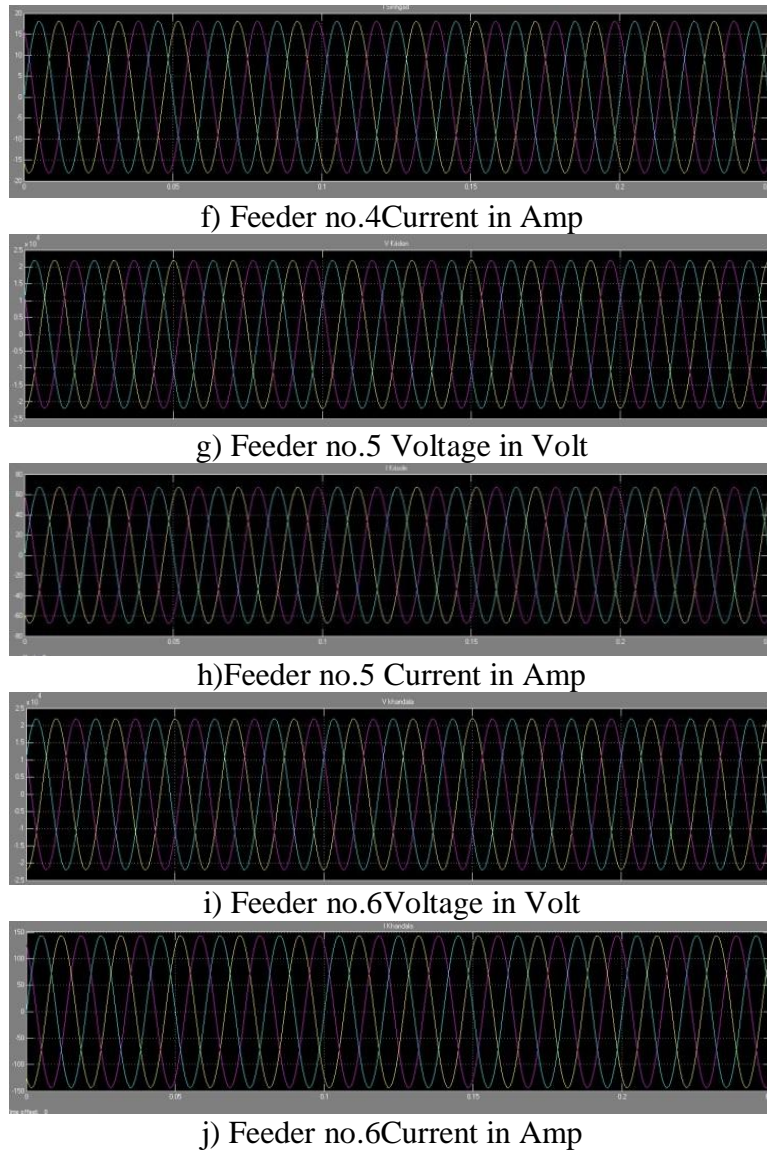
**Figure 4 (a, b, c, d, e, f, g, h, i, j):** Simulation Result of Substation

**Performance analysis of a Substation**
**Results and Comparison**

Losses in the substation are dependent on many factors which includes ratio of incoming and outgoing power, total current, time of day which further depends on the demand from the others feeders. There is linear relation between the period of the year and the location of the end consumer. The losses in the transmission substation system are mentioned in the figure no.3.

The availability of load on the transformer is shown in the figure no.4. The power availability can be determined from the following table. The load availability does not

always be predicted. The availability of transformer depends on the power which needed to be transmitted through the transmission substation.

## %  LOSS FOR YEAR



| MONTH | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| LOSS % | -0.512 | -0.57 | 0.456 | -0.293 | -0.0572 | -0.0244 | 0.373 | 0.326 | 0.402 | 0.312 | 0.607 | 0.068 |
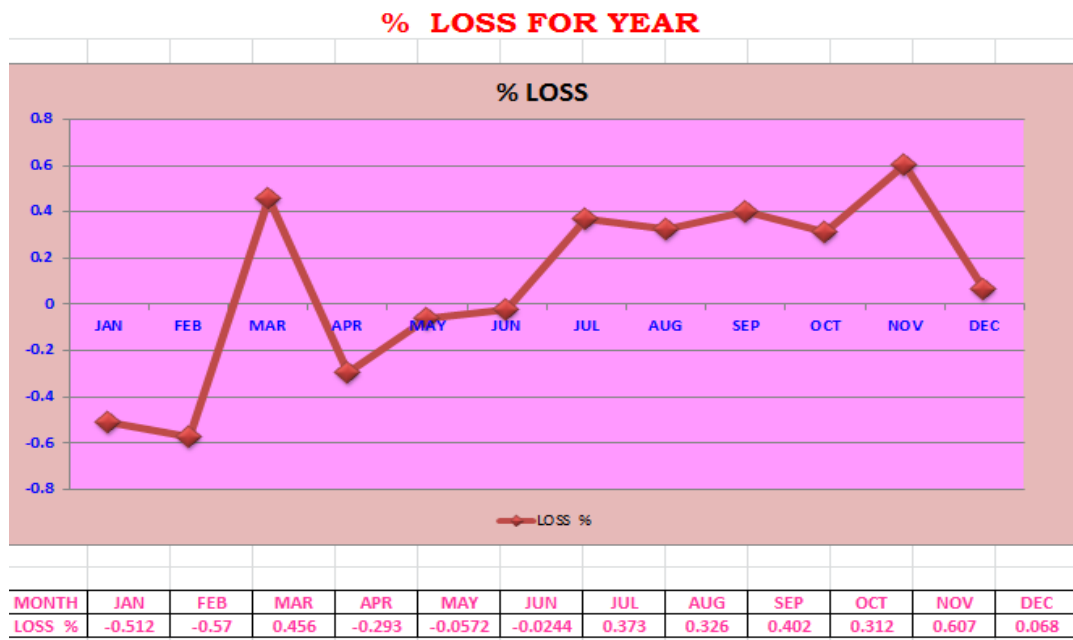
**Figure 3:** Graph showing the losses occurs in the substation in the 1-12 months.

## AVAILIBILITY OF TRANSFORMER



| MONTH | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| T/F - 1 | 100% | 100% | 99.73% | 100% | 100% | 99.98% | 100% | 99.88% | 100% | 100% | 100% | 100% |
| T/F - 2 | 100% | 100% | 99.81% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

**Figure 4:** Graph showing the availability of transformer in the substation.

Following table shows the maximum load of Outgoing feeder. The maximum load in MW and the current requirement is tabulated below Table 1: Table Showing Maximum load of 22 kV Outgoing Feeder.

**Table 1:** Maximum load of whole substation& Transformer.

### MAXIMUM LOAD OF 22 KV OUT GOING FEEDER

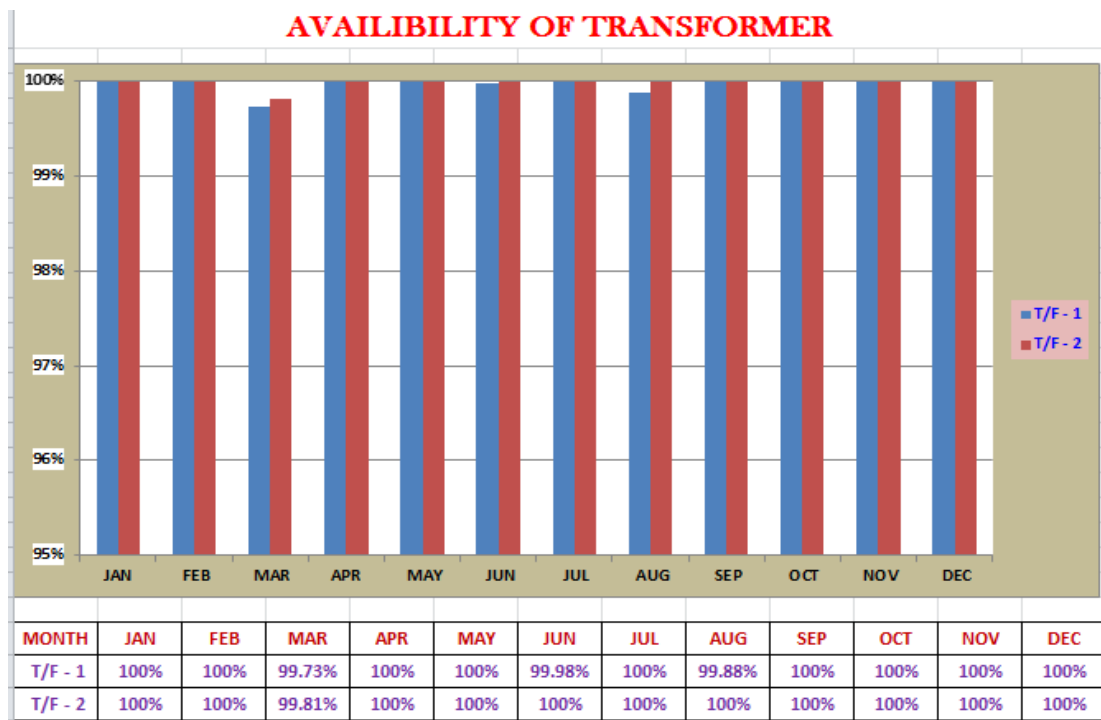| MONTH | Feeder no. 10 | | Feeder no. 9 | | Feeder no. 8 | | Feeder no. 7 | | Feeder no. 6 | | Feeder no. 5 | | Feeder no. 4 | | Feeder no. 11 | | Feeder no. 12 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AMP | MW | AMP | MW | AMP | MW | AMP | MW | AMP | MW | AMP | MW | AMP | MW | AMP | MW | AMP | MW |
| JAN | 30 | 1.03 | 50 | 1.71 | 15 | 0.51 | ON | ON | 85 | 2.91 | 65 | 2.23 | 30 | 1.03 | 55 | 1.88 | 170 | 5.82 |
| FEB | 30 | 1.03 | 45 | 1.54 | 15 | 0.51 | ON | ON | 80 | 2.74 | 65 | 2.23 | 30 | 1.03 | 55 | 1.88 | 170 | 5.82 |
| MAR | 30 | 1.03 | 45 | 1.54 | 15 | 0.51 | ON | ON | 85 | 2.91 | 70 | 2.4 | 30 | 1.03 | 55 | 1.88 | 175 | 6 |
| APR | 35 | 1.2 | 50 | 1.71 | 15 | 0.51 | ON | ON | 100 | 3.43 | 80 | 2.74 | 25 | 0.86 | 55 | 1.88 | 200 | 6.85 |
| MAY | 30 | 1.03 | 50 | 1.71 | 15 | 0.51 | 190 | 6.51 | 160 | 5.48 | 75 | 2.57 | 20 | 0.69 | 60 | 2.06 | 190 | 6.15 |
| JUN | 35 | 1.2 | 60 | 2.06 | 15 | 0.51 | 190 | 6.51 | 105 | 3.6 | 75 | 2.57 | 20 | 0.69 | 55 | 1.88 | ON | ON |
| JUL | 45 | 1.54 | 65 | 2.23 | 15 | 0.51 | 200 | 6.85 | 95 | 3.25 | 65 | 2.23 | 30 | 1.03 | 60 | 2.06 | 160 | 5.48 |
| AUG | 45 | 1.54 | 65 | 2.23 | ON | ON | 215 | 7.37 | 95 | 3.25 | 65 | 2.23 | 35 | 1.2 | 60 | 2.06 | ON | ON |
| SEP | 35 | 1.2 | 60 | 2.06 | ON | ON | 200 | 6.85 | 85 | 2.91 | 55 | 1.88 | 35 | 1.2 | 60 | 2.06 | 170 | 5.82 |
| OCT | 35 | 1.2 | 65 | 2.23 | ON | ON | 180 | 6.17 | 85 | 2.91 | 50 | 1.71 | 30 | 1.03 | 60 | 2.06 | 200 | 6.85 |
| NOV | 30 | 1.03 | 80 | 2.74 | 125 | 4.28 | 200 | 6.85 | 135 | 4.62 | 45 | 1.54 | 30 | 1.03 | 70 | 2.4 | ON | ON |
| DEC | 30 | 1.03 | 65 | 2.23 | ON | ON | 200 | 6.85 | 105 | 3.6 | 70 | 2.4 | 25 | 0.86 | 70 | 2.4 | 190 | 6.51 |

Maximum load of whole substation and transformer is given in the following table no.2. There are 2 transformer in this 100/22 kV transmission substation. Maximum load on a transformer is calculated individually and as a whole. The graph shows that the maximum load as a whole on a transformer is in the month of July & September.

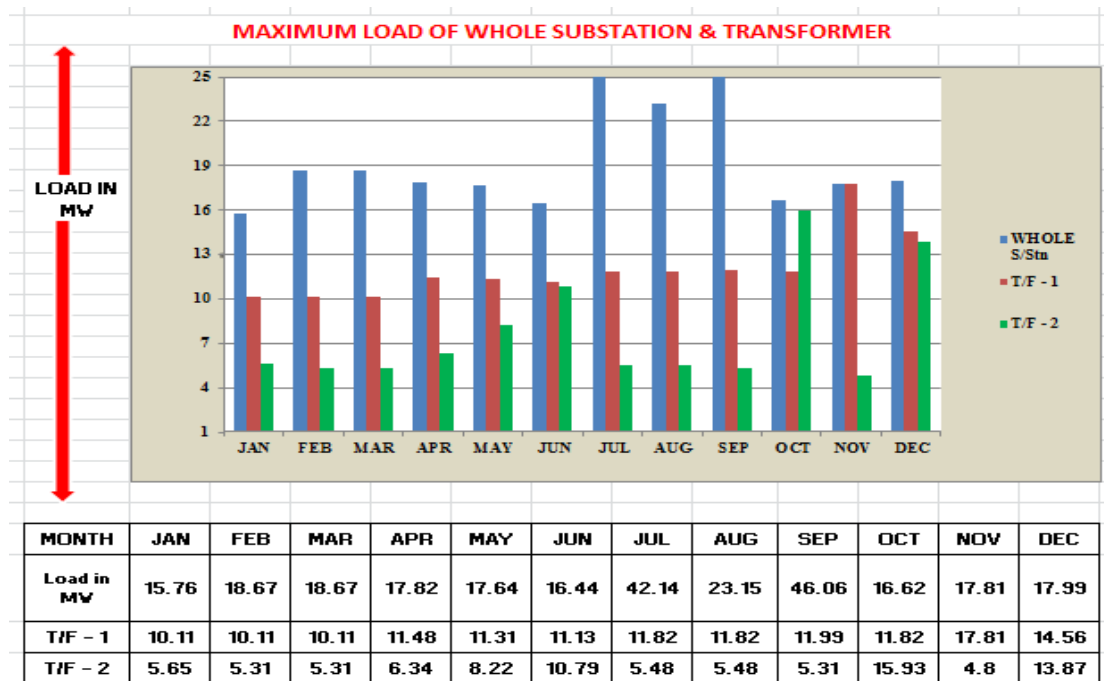**Table 2:** Maximum load of whole substation& Transformer.



| MONTH | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Load in MW | 15.76 | 18.67 | 18.67 | 17.82 | 17.64 | 16.44 | 42.14 | 23.15 | 46.06 | 16.62 | 17.81 | 17.99 |
| T/F – 1 | 10.11 | 10.11 | 10.11 | 11.48 | 11.31 | 11.13 | 11.82 | 11.82 | 11.99 | 11.82 | 17.81 | 14.56 |
| T/F – 2 | 5.65 | 5.31 | 5.31 | 6.34 | 8.22 | 10.79 | 5.48 | 5.48 | 5.31 | 15.93 | 4.8 | 13.87 |

**Table 3:** Table showing current consumption by a substation (Actual Current & Current consumption calculation by simulation)

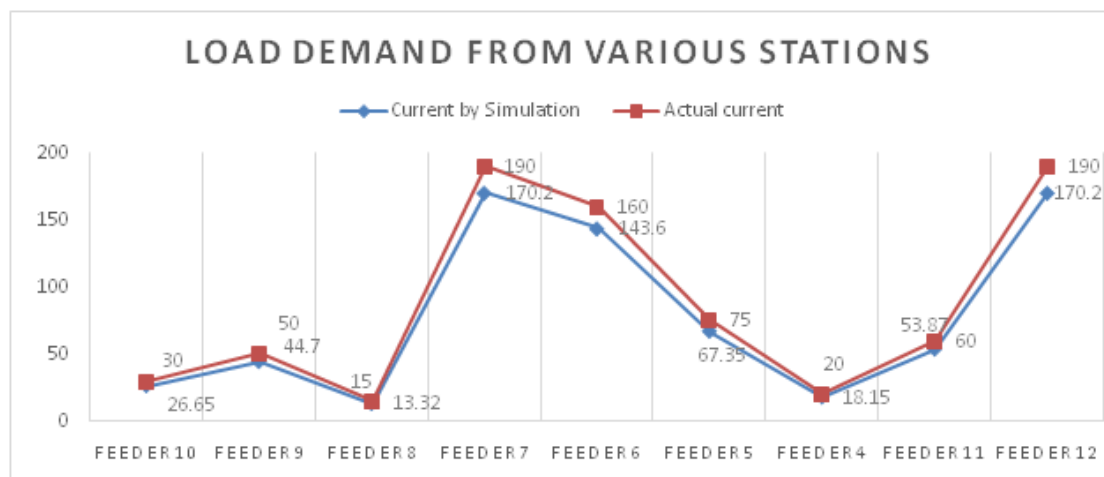| Sr. No | Outgoing Line | Current by Simulation | Actual current |
|--------|---------------|-----------------------|----------------|
| 1 | Feeder no.10 | 26.65 | 30 |
| 2 | Feeder no.9 | 44.7 | 50 |
| 3 | Feeder no.8 | 13.32 | 15 |
| 4 | Feeder no.7 | 170.2 | 190 |
| 5 | Feeder no.6 | 143.6 | 160 |
| 6 | Feeder no.5 | 67.35 | 75 |
| 7 | Feeder no.4 | 18.15 | 20 |
| 8 | Feeder no.11 | 53.87 | 60 |
| 9 | Feeder no.12 | 170.2 | 190 |



**Figure 5:** Graph showing relation between current consumption by sub-station practically & by simulation

From the above it is clearly seen that the load demand from the various stations is almost equal to the load demand calculated from the simulation of substation. In practical case the system draws more current due to some unavoidable reasons which includes copper loss, losses to loose connection, low power factor at the load end etc.

**CONCLUSION**

The Modeling & Simulation of 100/22kV transmission substation is carried out in the MATLAB Simulink Software. The value obtain from the Substation are found to be nearly equal to practical value.The Mathematical Modeling&Simulation are carried out & load demand calculations areverified actual data of the Substation. It observed that the maximum load on the substation in the month of September & the minimum load in the month of January.The implementation of this MATLAB Simulink dealing

is suitable for every Substation to identify & optimize the operation of Substation considering energy saving.

Actual losses can be estimated through this modeling and remedial measure can be suggested.

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