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Performance Analysis of the Microgrid System for an Educational Institute by Using ETAP Software

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Abstract
Integration of renewable energy into power grid systems by the use of microgrid are becoming attractive to supply electricity to remote areas in all aspects like reliability, sustainability, and environmental concerns; especially for communities living far in areas where grid extension is difficult so generation of renewable energy resources like solar energy to provide reliable power supply with improved system efficiency and significant cost reduction is best way. This paper reports the ETAP model of a conventional grid connected to Microgrid system of an educational Institute. The purpose of this work is to study the prototype model which is been designed according to some standard electrical conditions. This paper also provides the readers the understanding about the selection appropriate protective equipments, proper cable sizing and electrical parameters which results in a energy efficient design. In this paper we have considered an educational Institute which is connected to 33/0.4 kV conventional grid supply and to this system a 50 kW microgrid is connected.

Keywords: ETAP, Load flow, Short circuit, Voltage drop, Arc flash, IEC

1. Introduction

All the electrical network installation must compile some standard design parameters. Some of the parameters which has to be taken into account while designing the network are operating voltage levels, symmetrical load distribution, maximum system capacity, protection against fault such as short circuit, arc flash analysis and relay coordination analysis etc. There are different standards like IEC, ANSI standard etc.

In an electrical network different electrical devices are been integrated to carry out specific operations, in addition to these devices, cables, switch gears ,protective equipments are also required which requires electrical energy to perform the intended function.

Microgrid was among the latest technology which has lots of potential; for example, it can decrease the dependency on the centralized power system; and can replace it by smaller and more distributed generation (DG) located closer to load centers to meet their requirements effectively and efficiently. That is, everyone is a producer and consumer of energy at the same time; by doing so, they became energy independent from the overcharging of the utility companies.

In the proposed model the power grid is connected to the loads which are in a radial manner and the sequence of power flow can be interpreted as follows:

- Incoming supply of 33 kV is connected to the incoming Bus1

- Bus1 is connected to two no. of distribution transformers of each ratings 500 kVA and 1000 kVA respectively.
- Transformer1 and Transformer 2 are connected to Bus 4, Bus 5 respectively.
- Bus 4 is connected to the different load centers through respective low voltage circuit breaker of which have a load capacity of 367 kW.
- Similarly Bus 5 is connected to the different load centers through respective low voltage circuit breakers having a load capacity of 543 kW.
- Moreover a 50 kW Microgrid is connected to Bus 15 which a feeds a load of 26 kW institute market through low voltage circuit breaker.

From the above arrangement it can be noted that the flow of power is from the source side to the distribution side passing through required protective equipments which are connected to protect the system from faulty condition. For this reason many sensing and protective equipments are both connected in series and parallel to the network before the load. Second thing which is taken into account while designing a perfect electrical network is the electrical fire safety precautions that should be provided against electrocution. Hence for this reason we have to follow certain guidelines and standard provided by government agencies and testing agencies. So in the design, planning and execution the equipments, materials, devices, procedure should follow the standard conditions.

2. Electrical Design Procedure

The complete electrical design of the project is been carried out in the following steps:

Step 1 – Layout Design

The first step is to design the layout structure of the receiving side of the power and distribution side of the power. After that if some new loads are being added to the network then we have to set the type of conductor, its length, its reactance, its insulation value which connects the load to the system and after that we have to give the load specifications. These specifications include the make of load, power rating per node or design current, active, reactive power and diversity factor involved, if some distortion present in the circuit.

Step 2 - Maximum load demand calculation:

After completing the layout structure we have calculated the maximum demand at each load center considering the diversity factor also. As it is a three phase circuit to maintain the stability in the circuit the load has to be balanced in all the three phases starting from the incoming circuit to the distribution circuit, this have been achieved by moving, shifting or swapping the loads.

Step 3 – Selection of protective devices and the cable rating:

After the maximum demand by the load has been calculated, now we have to select the proper rating to the protective devices to be connected in the network and also the size of the cables, ampacity of the cable used for connecting the loads to the distribution system. Also the change in temperature was considered while selection of proper cable.

Step 4 – Debugging and Problems discrimination

After completing the design on the software, while running the design some error signals appears which has to be rectified by debugging the errors by making proper coordination between the protective devices and selection of proper rating of the equipments.

Step 5 – Design finalization and reports are generation:

After all the parameters of the equipments and loads are finalized, then the design is finalized and the report is been generated.

The diagram shown in Fig. 1 represents all the connection from the Grid substation to load centers, in which transformer1 feeds building1, building2, workshop1 of ratings 100 kVA, 150 kVA, 200 kVA respectively. Similarly Transformer2 feeds Girls hostel, Boys hostel, staff quarter, workshop 2, Academic building3, Institute Market of ratings 50 kVA, 100 kVA, 60 kVA, 250 kVA, 200 kVA, 32.5 kVA respectively.

Load flow study reveals that a total load of 906.8 kW is shared between transformer 1 and transformer 2 out of which Transformer1which is connected to Bus 4 shares a load of 376.4 kW among different load centers. Similarly

Transformer2 connected to Bus 5 shares a load of 530.3 kW among different load centers. Moreover Microgrid supplies 41.5 kW of load out of which 25.9 kW is consumed by Institute market through Bus 18 and remaining 16.4 kW is fed back to Bus 5

3. Network Description & Analysis

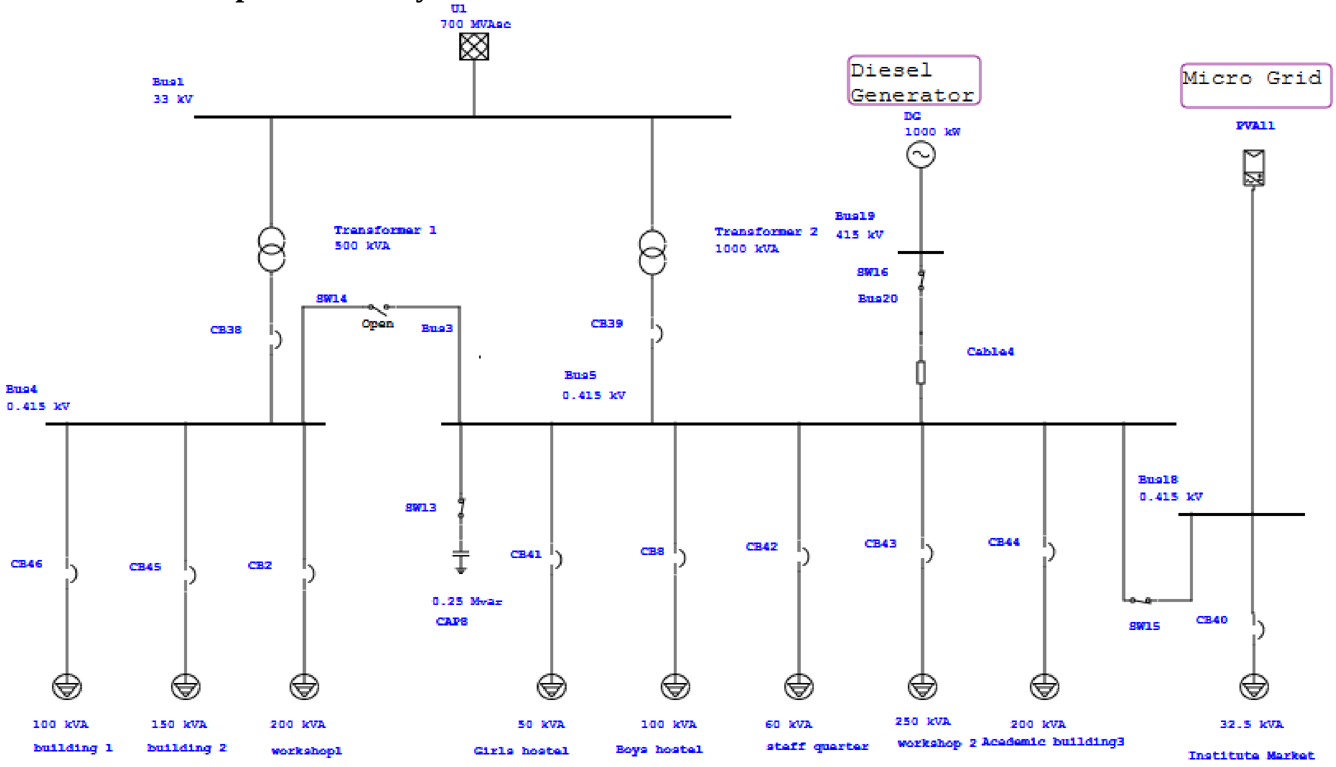

Fig. 1 Single line diagram

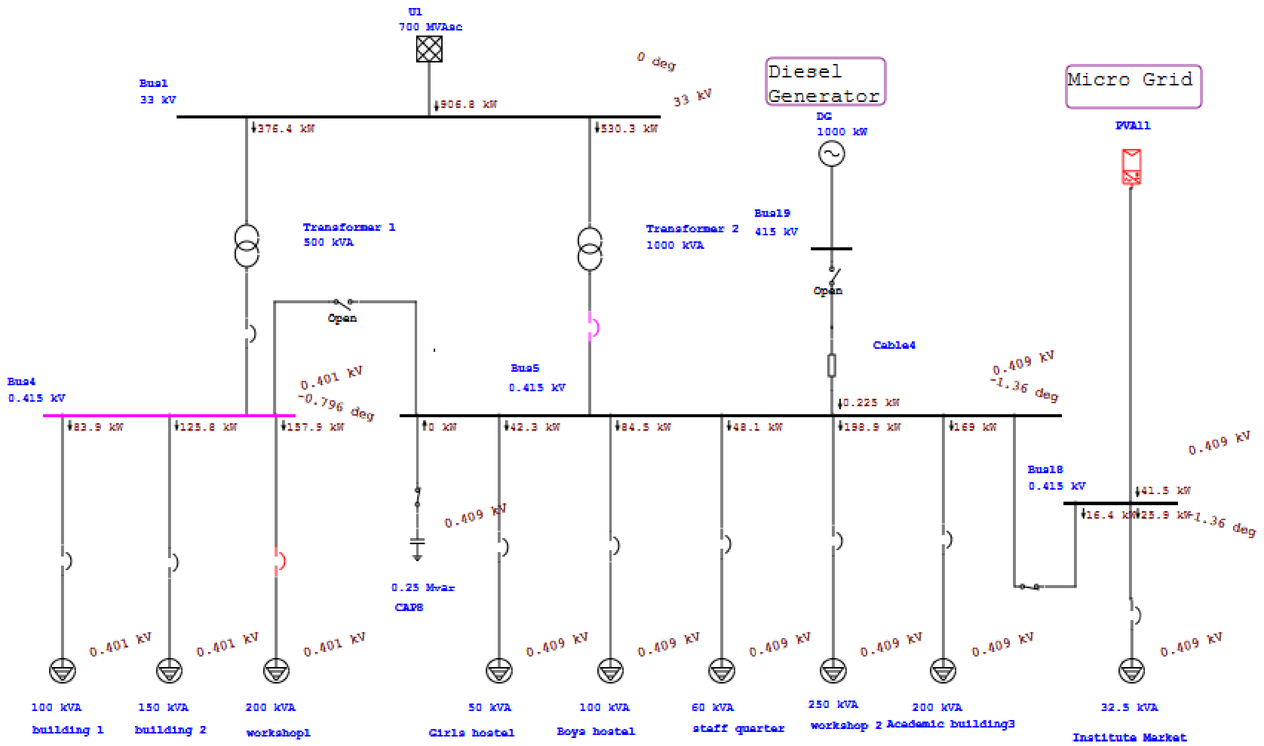

Fig. 2 Load flow analysis (without DG)

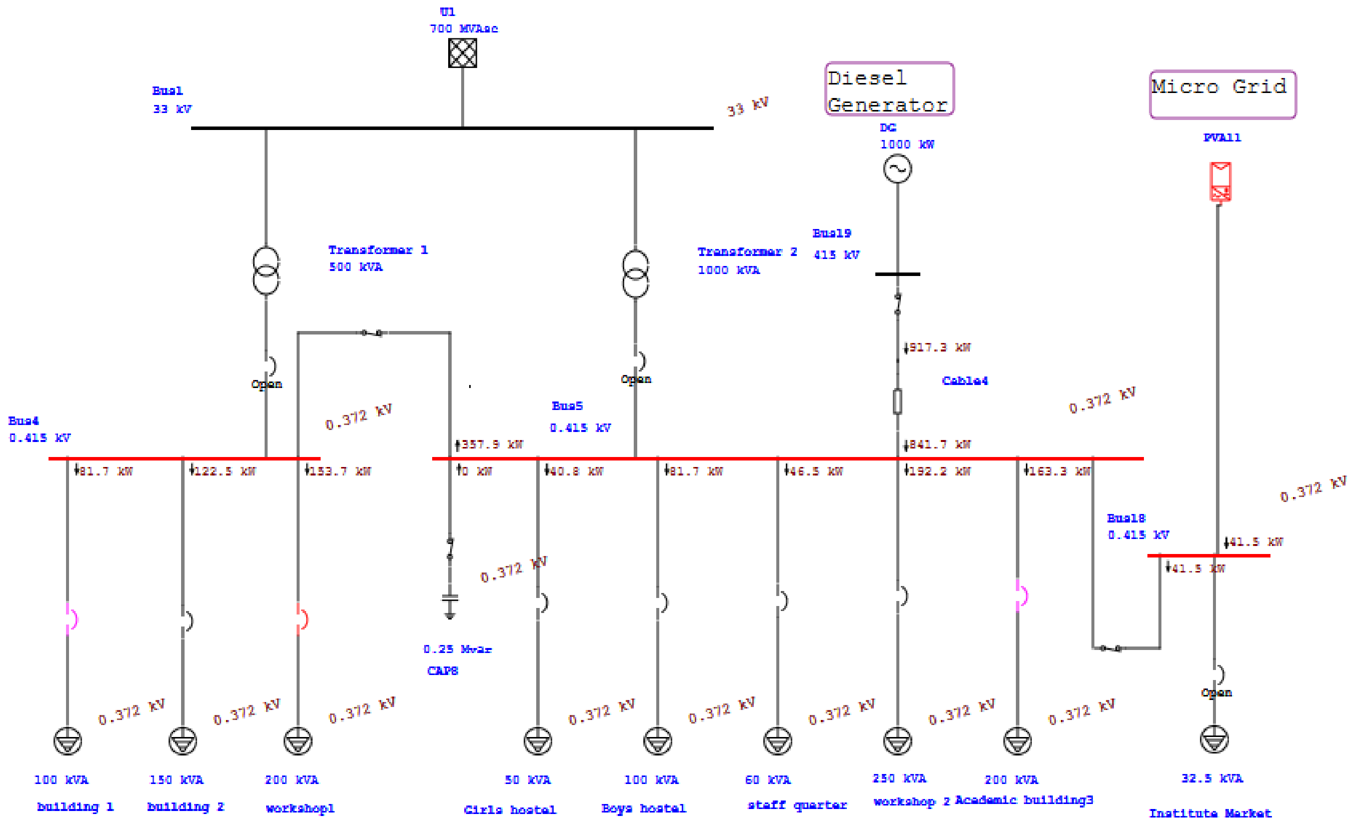

Fig. 3 The effect of DG on the Load flow analysis

The above figure shows the effect of Diesel Generator on the load flow analysis which reveals the fact that in case of Grid failure or during maintenance, the entire Institute load demand can be supplied by Diesel Generator without any interruption.

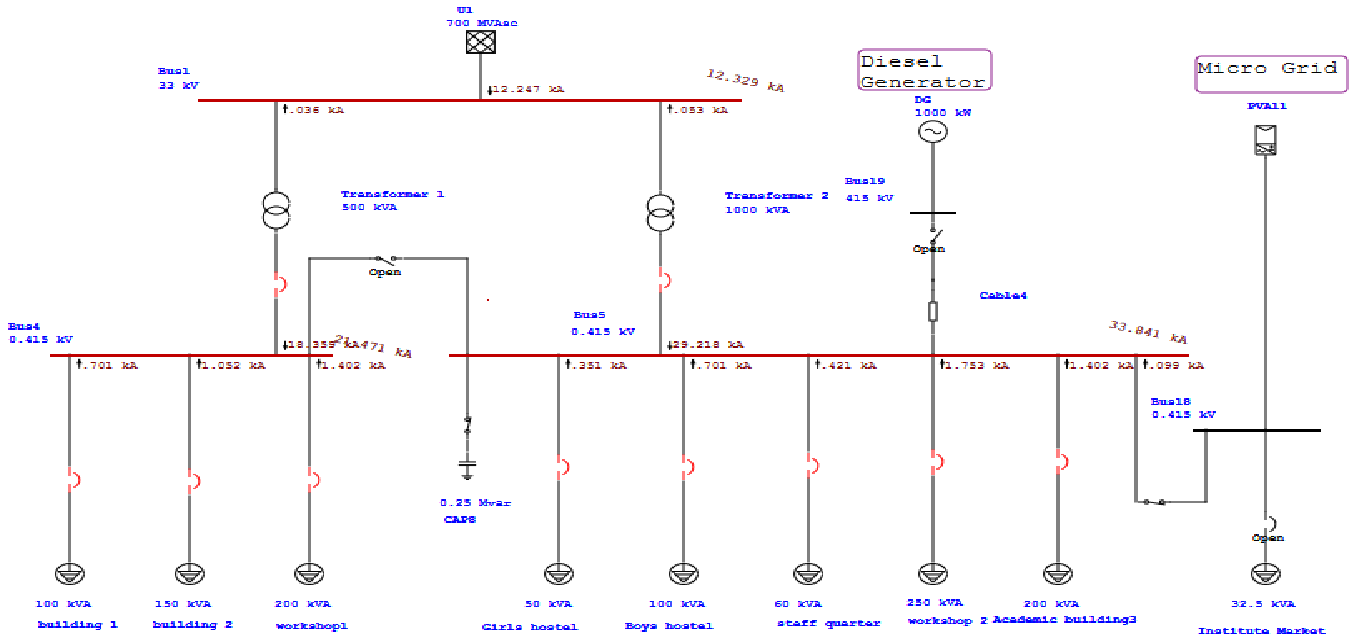

Fig. 4 Short circuit analysis

In order to perform the short circuit analysis, a 3 phase fault has been introduced in all the buses i.e. Bus1, Bus 4, Bus 5 and Bus 18 and as a result of this fault a short circuit current of 12.247 kA, 21.471 kA, 29.218 kA and 33.841 kA starts flowing in their respective buses. Moreover due to this short circuit condition it has been found that substantial amount of voltage drop takes place across the all the buses.

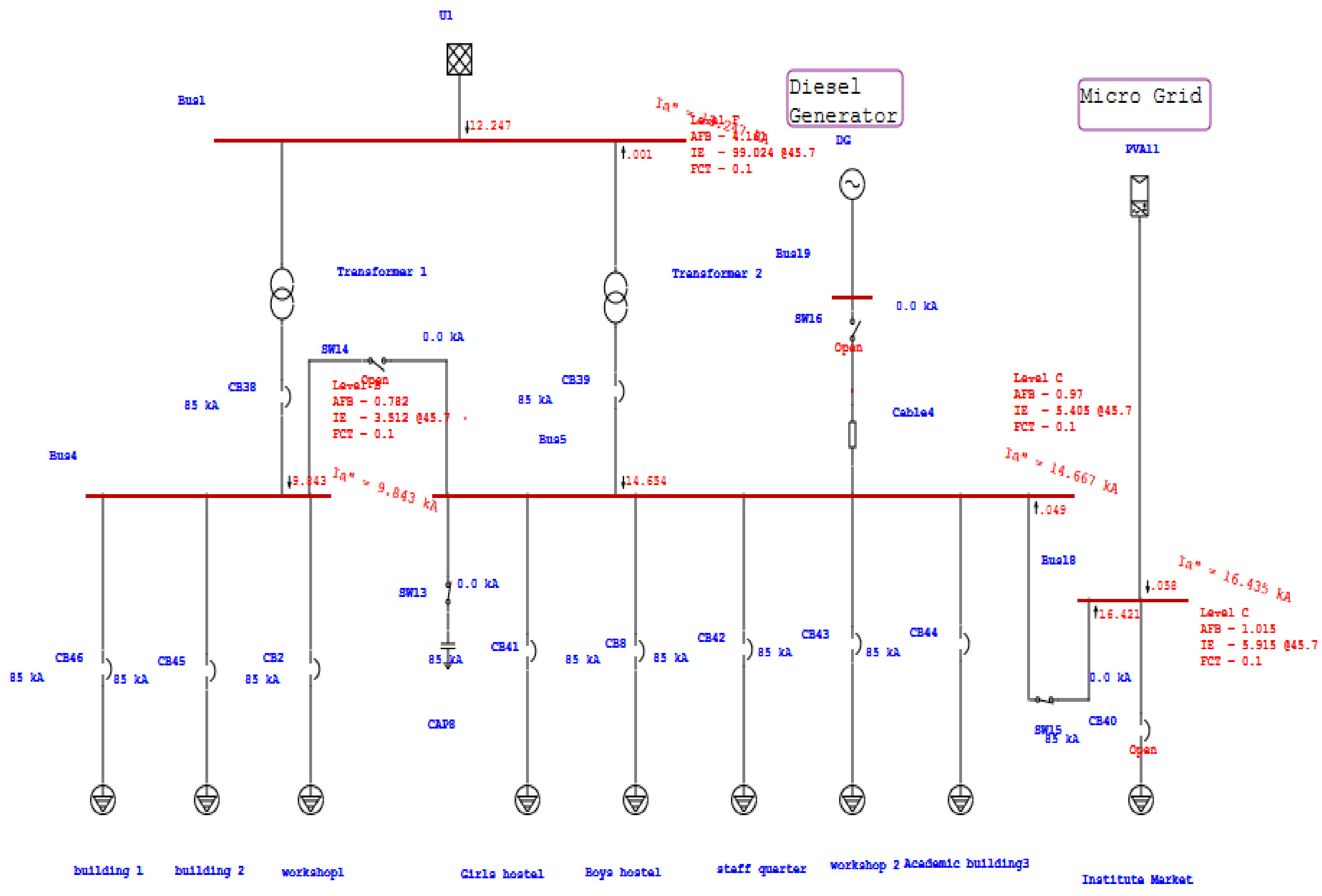

Fig. 5 Arc flash analysis

Arc flash analysis for all the buses is carried out as per NFPA standard and it is observed that depending upon incident energy value, level of personal protective equipment for all the buses is recommended. Moreover the fault currents during Arc flash at Bus 4, Bus 5 and Bus 18 is experienced to be 9.843 kA, 14.667 kA and 16.435 kA respectively.

4. Result Analysis

In the designed system, we have taken 5 buses which consists of a total of 9 lump loads. The total load connected to the system is 948 kW with an operating power factor of 0.91. It is also been observed that the system generates 447 kVAR of reactive power with a Power loss of 12.8 kW. Moreover bus1 carries a load of 881 kW with no drop in voltage across the bus where as the other three buses carries a load of 367 kW,543 kW and 42.3 kW respectively with a bus drop of 3.4%,1.44%and 1.44% respectively. Transformer 1 is 91.8% loaded with 367.4 kW load whereas transformer 2 is 55.2 % loaded with a load of 530.3 kW. All load terminal voltages are also within the limits.

5. Conclusions

The integration of microgrid with conventional power grid in an educational institute is been designed with the help of ETAP software and different performance analysis has been carried out, which includes the selection of cables, selection of protective equipments, safety parameters etc. In this paper fault analysis, arc flash analysis and load flow analysis was also carried out for ensuring the energy efficient electrical installation, compliance with the standard safety practices and cost effectiveness of the design. From this case study we can estimate the capital cost investment and operational cost of the system.

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