MATLAB simulation and analysis of back-up power supply

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Abstract - *This paper includes a MATLAB simulation and analysis regarding back-up power supply to any high-voltage level system load. In the forthput scheme, it is considered that on conventional basis, the grid would supply power to the load and in case of grid failure or power-cutouts, the DG set would supply power to the load and further when the grid power comes back, the DG set is to be turned OFF after synchronization*[1]*and the grid thereafter starts supplying power to the load solely. During the period of synchronization, both the power sources supply power to the load, during which initially the transients are observed which are reduced by adding a second-order band-pass filter which reduces the peak of transients which occur during the synchronization period.*

Key Words: Back-up power, synchronization, MATLAB simulation, DG set, filter.

1. INTRODUCTION

In today's era, there are mostly more than one sources of power for any system, which means that the redundancy of power supply is a critical parameter for any system along with reducing the dependency on a single power source which in turn increases the reliability and efficiency of the entire system. For loads such as data centres, the criticality of power supply is the most, where a failure of power supply for even a few seconds could put the company's data on stake. Also, data centres have separate back-up power systems separately for temperature and air-conditioning control.[2] Hence, back-up power supply to data centres are generally isolated from the other power supplies in order to increase the redundancy of power availability and increasing the reliability of the system.

For the proposed scheme, the MATLAB simulation has been done with the analysis of current waveforms during different time durations according to the automatic switching between the two sources of power[3] , one being the grid and the other being DG set, during the case in which the filter is present and the latter case in which the filtered output has been obtained.

2. BASIC BLOCK DIAGRAM

The basic block-diagram for the proposed scheme has been shown below. It includes one power source as a grid and the other power source being a generator set. The circuit breakers between both the power sources and the load are externally controlled via signal builders in which the pulse signals can be given at different time instants as per requirement.

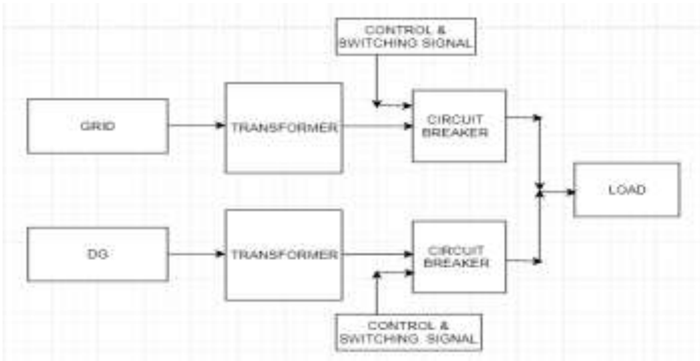

Fig -1: Overall block-diagram

2.1 Signal builder

Different types of signals such as step, ramp, impulse signals can be given via signal builders in which the time instants at which the signals are given along with their peak values can be set as per requirement. The output of the signal builder is connected to the circuit breaker which is externally controlled by this signal. As the grid fails at a certain time instant and comes back at another instant, hence 2 signals are added and given via signal builder. Here, the signal is set such that the grid is supplying power to load from t=0 to t=1.5 sec. and the grid fails at t=1.5 sec. and the grid come back at t= 4sec.

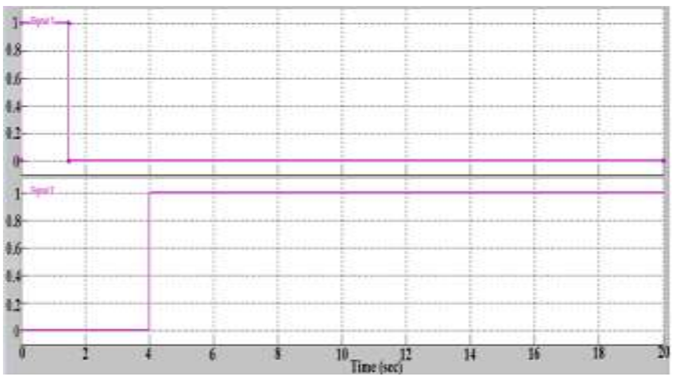

Fig -2: Signals to grid breaker

Now, as shown above, both the signals sent to signal builder are added and the final signal sent to grid circuit breaker is shown below.

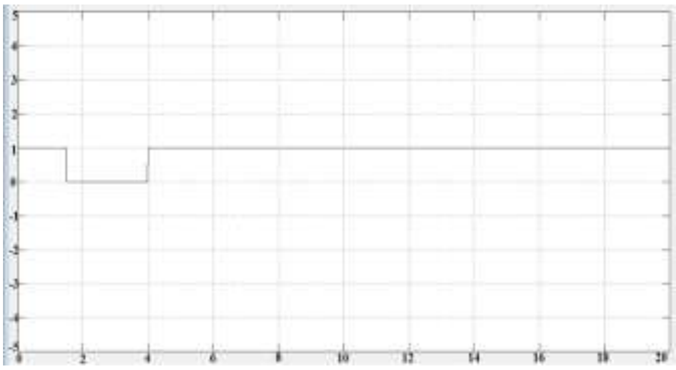

Fig -3: Final signal to grid breaker

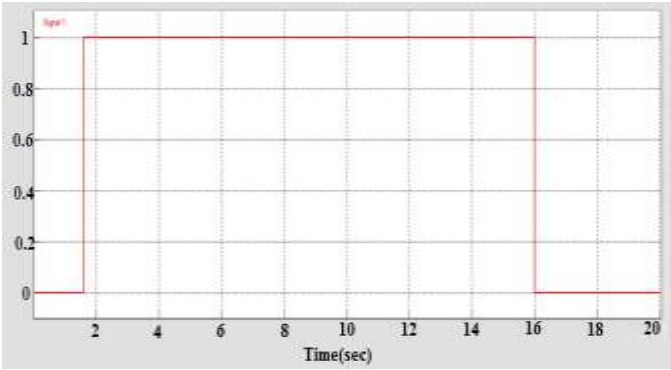

Fig -4 Signal to DG breaker

Similarly, the signal to the DG breaker is given at t=1.6 sec. which means that the DG starts supplying power to the load at t=1.6 sec. and the DG is switched OFF at t=16 sec. which means that t=4 sec. to t=16sec. is the time allotted for synchronization of both the power sources.

Table -1: Operating conditions of grid and DG breaker

Time (sec.)	Grid breaker condition	DG breaker condition	Remark
t=0 to 1.5	Closed	Open	Only grid is supplying power to load
t=1.5 to 1.6	Open	Open	No power source is there for 0.1 sec.
t=1.6 to 4	Open	Closed	Only DG supplying power to load
t=4 to 16	Closed	Closed	Both grid and DG supplying power to load
t=16 to 20	Closed	Open	Only grid supplying power to load

As seen from the above table, the different time durations during which the switching ON & OFF of the grid and DG breaker is carried out are mentioned along with the explanation of which source is supplying power to the load during the respective time duration.

3. SIMULATION RESULTS

The simulation results regarding the current waveforms before adding filter and after adding filter when each of the sources are supplying power to the load along with the load current and peak value of current have been shown below.

3.1 Results before adding filter

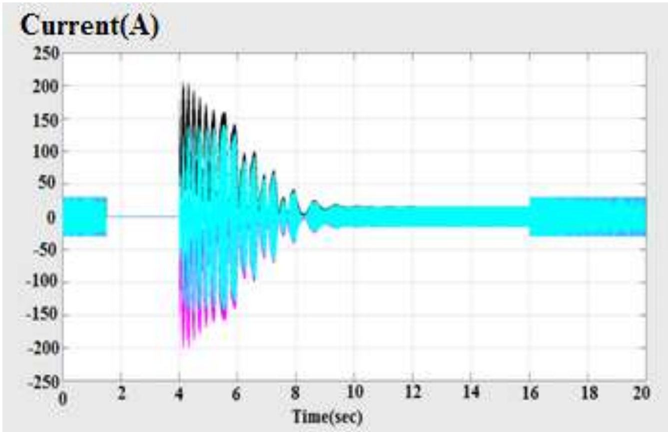

Fig -5 Current when grid is supplying power to load

As seen from the above waveform, the peak value of current is 30A when one of the sources is supplying power to the load, and when the DG is still ON despite the grid has come back during the synchronization period (t=4 to 16sec.), initially transients appear as both the sources are supplying together to load instantaneously, and thereafter within 4-5 sec., it gets stable and then the current can be seen as (30/2) = 15A, because as both the sources are supplying power to the load simultaneously; the current from each source gets halved. The value of current remains same whether from grid or DG.

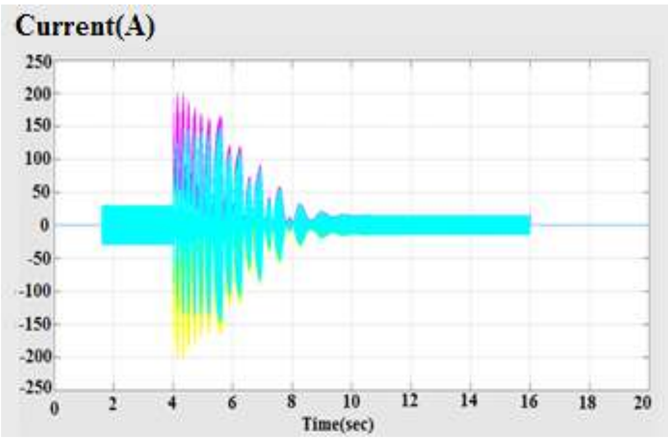

Fig -6 Current when DG is supplying power to load

The load has to be met continuously without any break in power, so the grid and DG are alternatively switched with each other as per demand and requirement, so the load current waveform should always be continuous which is observed from the above waveform except from the time during t=1.5-1.6 sec., where t=0.1 sec. is taken as the time in which there is no power supply and later the DG gets switched ON.

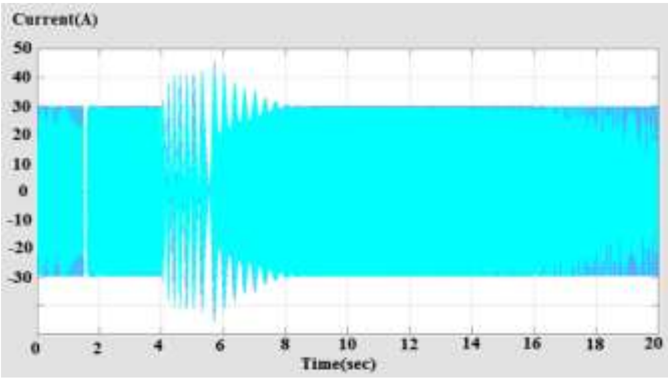

Fig -7 Load **c**urrent

3.2 Calculation regarding peak value of current

The calculation regarding the peak value of current when any one of the sources is supplying power to the load is shown below:-

P = (Γ3)*V*I*cos$^{\Phi}$.

The active load being 1.2 MW, V=33kV, power factor being approximately 0.97, the current can be calculated as :-

I = [(1.2)*1000000]/{(1.73)*33*1000*0.97}

I = 21.66 A (rms)

I = 21.66*1.414 ≅ 30A. (peak)

This is the value of current when one of the sources is supplying power to the load and when both are supplying together, the current gets halved as 30/2 = 15A. (peak)

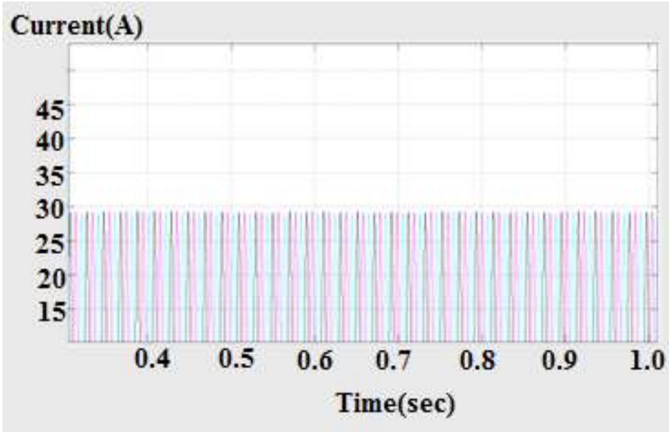

Fig -8 Peak value of current when one of the sources is supplying power to the load

3.3 Results after adding filter

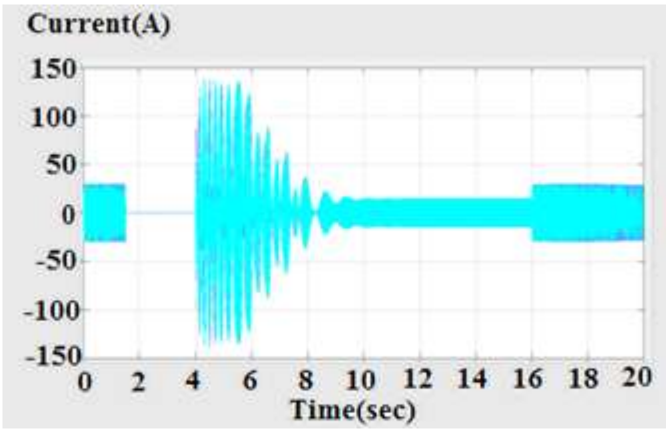

Fig -8 Current when grid is supplying power to load

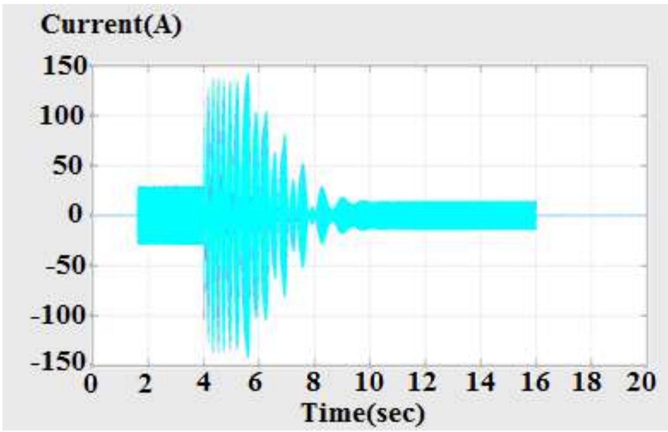

Fig -9 Current when DG is supplying power to load

Now, as seen above; on adding a second-order band-pass filter with natural frequency as 50Hz, it reduces the peak of the transients which were occurring during the synchronization period.(t=4 to 16sec.) Initially the initial peak of the transients was 200A and after adding filter, the filtered output has a initial peak of approximately 130A.

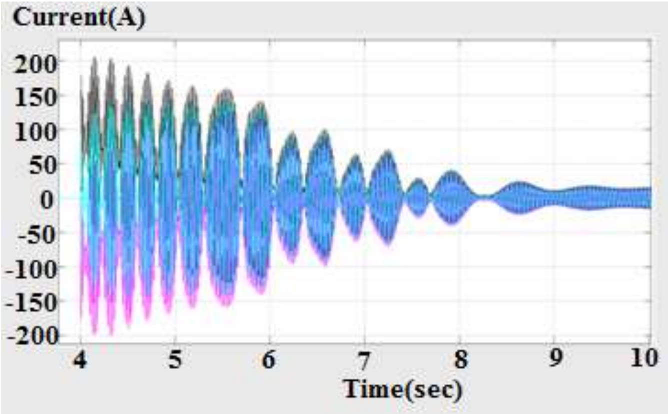

Fig -10 Peak value of transient before adding filter

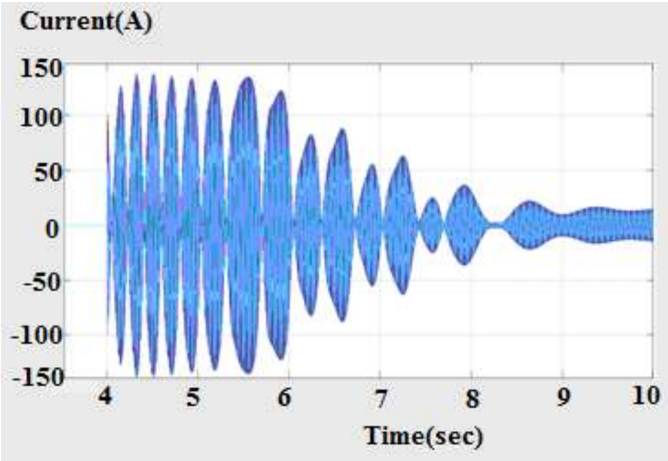

Fig -11 Peak value of transient after adding filter

As seen from above waveforms, the difference between the peak value of current before and after adding filter can be distinguished.

4. CONCLUSIONS

The basic simulation and analysis of the forthput scheme is done with respect to current waveforms and alternative switching between the grid and DG as per requirement in order to meet the supply continuity to the load and increasing the reliability of the system. Also, the transients which occur when both sources are supplying power to the load are reduced by adding a second-order band-pass filter which reduces the peak value of current occurring during transients.

This project can be extended by adding a renewable source of power in place of DG set in which both the sources could power the load simultaneously thereby reducing the dependency on the grid and hence increasing the reliability and efficiency of the entire system.[4]

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