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Analysis and Simulation of Battery Energy Storage System

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Abstract-: This paper inspects the analysis and simulation of energy storage system ie, Battery. The analysis and simulation of both the model is done based on battery modules, converter, multi winding transformer. Simulation model for different battery configuration is developed and results are compared and used based on the application. Comparison is carried out for classic system (BESS) and proposed system (RBESS) and used based on the requirement. The proposed system proves to be more effective and highly advantageous.

Index Terms-Battery energy storage system, Reconfigurable battery energy storage system, converter, transformer, grid.

1. INTRODUCTION

Electric energy is the most commonly used source of energy for home application and industries. Increasing population and industrial growth, increasing demand has caused depletion of traditional source which made it compulsory for the expansion of renewable energy resources for power generation. Traditionally frequency regulation in power system is achieved by balancing generation and demand in load. There is a requirement for clean and sustainable energy. This requirement has taken the world into a whole new concept of using renewable energy resources.

With this renewable energy resources we can meet the load demands, by providing power from this resources. The energy obtained from this resources are stored and used as per the requirement. Hence energy storage system play an vital role in the system. This storage system can increase reliability, stability and efficiency of the system and has lower replacement cost. Due to arrival of electric vehicles, battery has become one of the most important and cost efficient system and even in mobiles, batteries are used due to their flexible nature.

A battery is a device that produces electrons through electrochemical reactions consisting of positive and negative terminals. It transforms stored chemical energy into electrical energy. There are various types of batteries arriving depending on requirement and efficiency they are choose and used. [1]View of current and future energy storage technologies for power applications.[2]Reliability evaluation of generating systems containing wind power and energy storage. Energy storage system brings reduction in operating cost and increase their use ability including photo voltaic and wind generating electricity constant with peak load demand and it may facilitate the equipment. This improves existing transmission and distribution equipment and eliminates the need for expensive transmission and distribution equipments.

Conventionally in this design all the battery modules are connected in series to form a string. It should be noted that there can be more strings connected in parallel for a battery energy storage systems. All the battery modules are a DC/AC converter that are connected to the power grid through a three phase transformer. The DC/AC converter may consists several power electronics converter that are connected in parallel to reduce size of each converter.

2. BATTERY ENERGY STORAGE SYSTEM

A basic battery energy storage system is shown in the above figure.1which consists of a battery module, three phase DC to AC converter, three phase transformer, grid. The state of health gives performance of the battery. The power electronic components in a bi-directional DC-AC power electronic converter play a major role in battery energy storage systems.

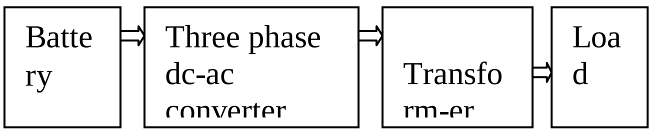

Fig 1: Block Diagram for Classic system (BESS)

Simulation models of BESS:

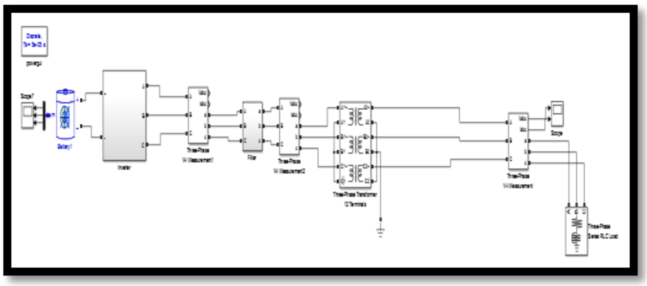

Fig 2: Simulation model of BESS for normal condition

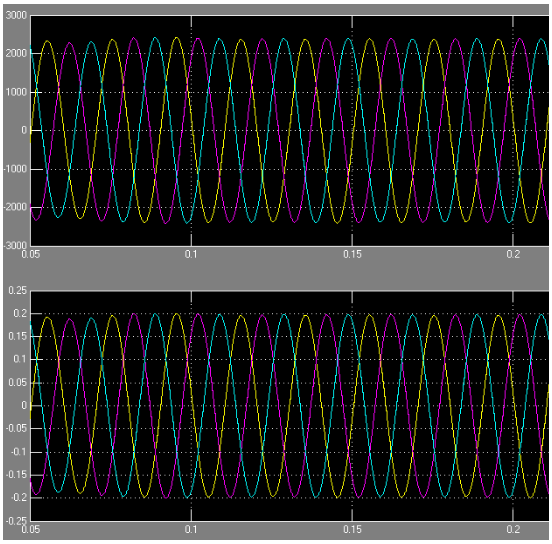

Fig 3:Voltage and Current results for normal condition

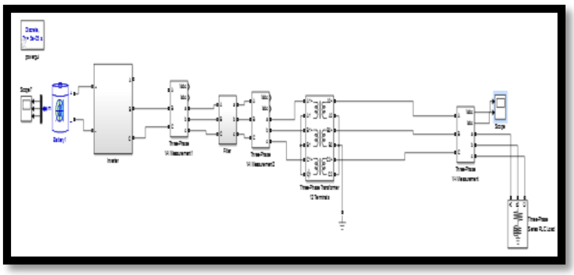

Fig 4: Simulation model of BESS for fault condition

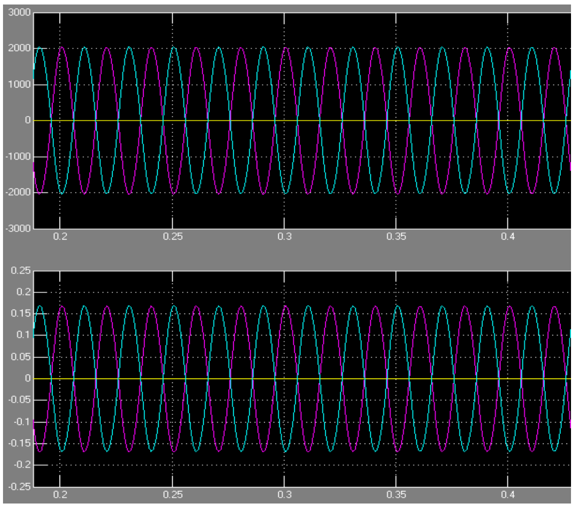

Fig 5: Voltage and Current results for fault condition

But this system is proved to be not so efficient as the connections are in series, hence if one module fails whole system gets affected and no output is obtained. This arrangement has various drawbacks. Therefore to overcome this drawback reconfigurable battery energy storage system (RBESS) is used. In this system if one of the model fails then whole system will not get affected.

3. RECONFIGURABLE BATTERY ENERGY STORAGE SYSTEM

RBESS consists of battery blocks, DC/AC power electronic converter and multi-winding transformer. The transformer can be single unit three phase transformer or three separate single phase transformer. Each batteries in RBESS are controlled by individual converter modules.

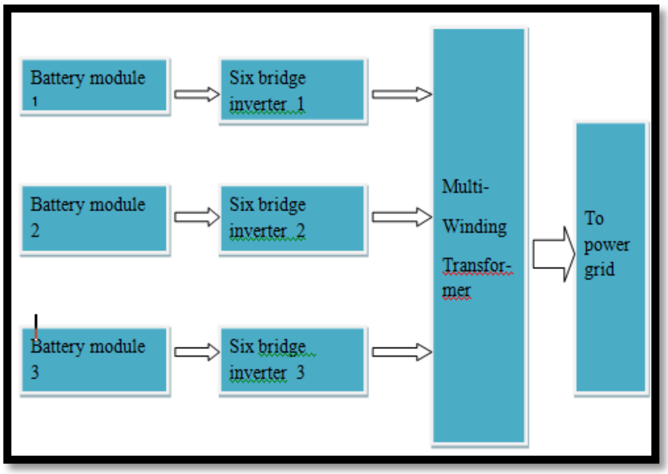

Fig 6: Block Diagram for RBESS

Simulation model of proposed system:

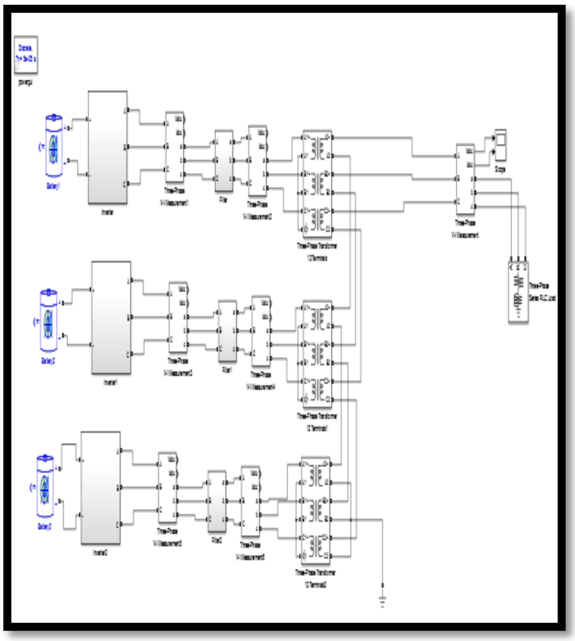

Fig 7: Simulation model for RBESS

Simulation model of RBESS:

It consists of three battery module, the output of the battery source is fed to the six bridge inverter. Each inverter having six thyristors or IGBT or MOSFET. Here we are using IGBT and each inverter are connected in parallel with a dc source. The output of the inverter is fed to the transformer in a separately connected manner. The output of transformer is connected to load.

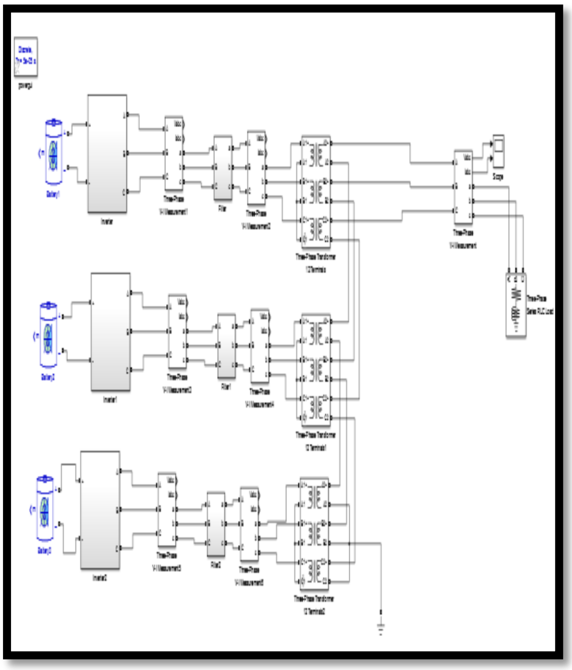

Fig 7: Simulation model of RBESS for normal condition

Fig 8: Voltage and Current result for normal condition

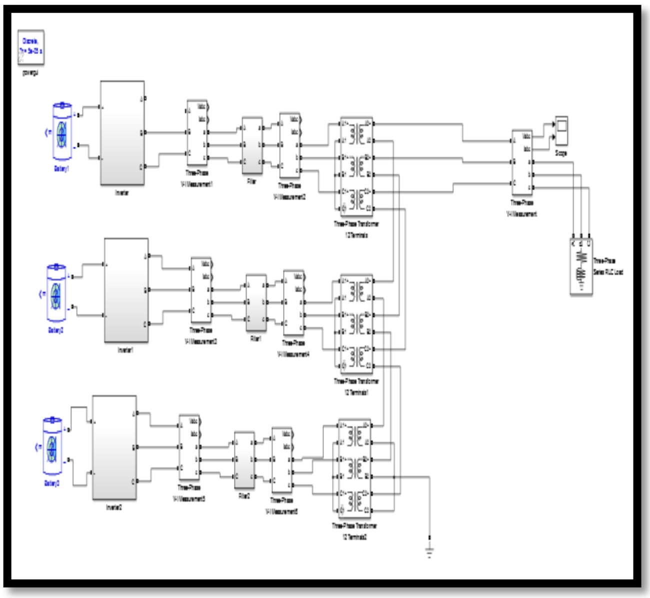

Fig 9: Simulation model of RBESS for fault condition

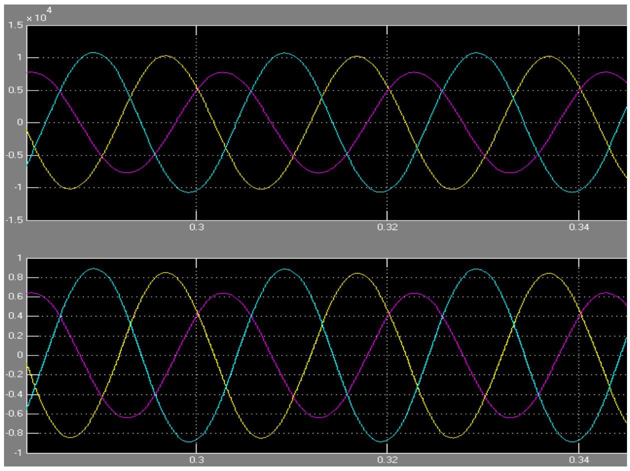

Fig 10: Voltage and Current result for fault condition

Table1: THD of both systems for 220V

THD	BESS	RBESS
For Normal	24.78%	23.35%
For Fault	0	24.14%

Table2: THD of both systems for 440V

THD	BESS	RBESS
For Normal	19.56%	18.98%
For Fault	0	19.38%

The THD analysis shows that RBESS has less percentage value for normal condition as compared to fault condition. Hence by using RBESS configuration we can get lower total harmonic distortion and a efficient system. The state of health of the battery module is calculated using the formula given below

$SOH = Q / Q_{ini} = (Q_{ini} – Q_{fade}) / Q_{ini}$

Where Q and Q_{ini} are the maximum charge capacity of aged and new battery cells. Q_{fade} is the capacity loss of the battery cells. This model is based on the assumption of under constant operating conditions. It is the ratio of maximum charge capacity of an aged battery to maximum charge capacity when the battery is new. When the SOH of battery falls below a certain value then it is said to be end of life (EOL) of the battery.

4. CONCLUSION

The comparison results shows that RBESS is more efficient and reliable. The battery can fail after repeated use but this is not in case of RBESS. The results shows that reliability of battery module can be improved by decreasing the number of cells connected in series or parallel.

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