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Tri-axial Seismic Simulation of Solar Inverter – Productivity Improvement

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Abstract

Often, earthquake is a tri-axial event, as in, it excites the system in all three directions. Evaluation of big systems like high capacity solar inverters for such events through testing is quite expensive. Trend these days is to qualify the system using CAE simulation, in contrast to testing. Simulation of big systems is always a challenge, as it becomes computationally expensive due to high node count and large number of modes in the frequency range of interest. In this work, seismic analysis is performed using commercial FEA software ANSYS. Conventional way of seismic simulation in ANSYS is to first excite the system separately in the orthogonal directions and then compute the tri-axial response by superposition of responses in individual directions. In this paper, based on the response spectrum analysis, a tri-axial seismic analysis methodology is proposed and implemented on complicated high capacity solar inverters. Proposed methodology calculates a resultant mode participation factor from mode participation factors due to excitation in individual directions and then performs the mode combination. It was observed that computational time was reduced to 1/3rd without any compromise in the accuracy of response. Also, proposed simulation methodology doesn't require separate static analysis to account for the effect of missing mass. This further increases the productivity of a seismic engineer performing a finite element analysis.

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Keywords: Seismic analysis; Solar inverter; Productivity improvement.

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1. Introduction

Seismic qualification of the electrical systems is becoming a requirement by government and customers, especially when the size of system is big like high capacity solar inverters and transformers. As per the standard, seismic qualification can be performed either by performing physical tri-axial shaker-table testing or by dynamic simulation using the finite element method [1, 2]. Shaker-table testing is expensive, time consuming and becomes difficult as the size of the system increases. Also, being a proactive study, dynamic simulation can reduce the overall design cycle time unlike the physical shaker-table testing, wherein all the failure redesigns are reactive and costly affairs.

In this paper, the analysis methodology for seismic qualification as prescribed by IEEE standards [2] is discussed for the high capacity (1500–1670 kW) solar inverter manufactured by Eaton. ANSYS, a commercially available standard finite element software for analysis of structural system under dynamic loading conditions, is used for seismic analysis. Seismic loading is a tri-axial transient in nature. It is a common practice to convert the transient loading into frequency domain loading to reduce the computational time. Conventional way of simulation is to first evaluate the response due to loading in individual orthogonal directions. Resultant response is then calculated by superposition of these responses. In this paper, a tri-axial seismic analysis methodology is presented which significantly reduces the computational time.

2. FE modelling

Three dimensional CAD model of the solar inverter is shown in Figure 1, which is used for developing the FE model.

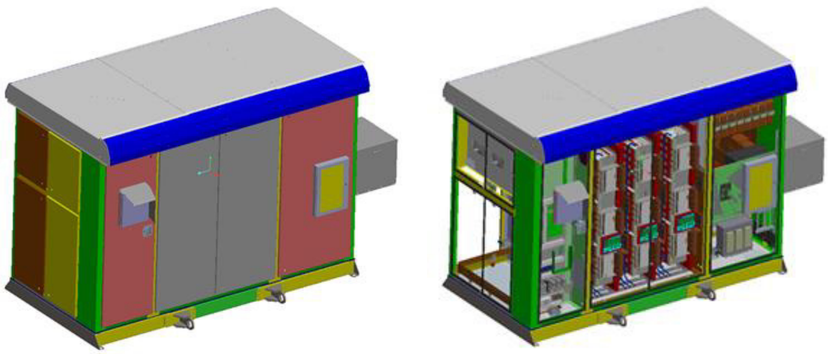

Fig 1.Three dimensional solid model of solar inverter in Autodesk inventor.

The model is aligned to the universal coordinate system. The solar inverter consists around 15000 components and hence it was impossible toconsider all these components for FE analysis. So the first step was to get rid of the components that were insignificant. Also, FE model generated using 3D element could have consumed huge computational resource. Hence, in order to reduce the DOF and computation time, a simplified FE model of the solar inverter was developed using 1D, 2D, 3D elements and lump masses appropriately. It was made sure that the developed FE model properly captured the dynamics exhibited by individual component & assemblies. The FE model built for analysis is shown in Fig 2. Major structural components constituted around 31% of the total assembly weight and they were modelled explicitly for finite element analysis. The built FE model had 0.23 million elements and 0.63 million nodes.