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# Performance Analysis of SCIG Coupled With Wind Turbine with and Without Fault Using Three Phase Dynamic Load

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***Abstract***

*In this paper we analyze the performance of SCIG when STATCOM and dynamic load are connected with WECS: (1) With Fault and (2) Without fault we find that the time taken is less and we get the smoother response. This also includes simulation of 9MW wind farm power using Squirrel Cage Induction Generator (SCIG) by variable pitch wind turbine. All these scenarios have been simulated with the help of the simulation program using MATLAB and its inbuilt components provided in Simulink library.*

***Keywords:*** *Squirrel cage Induction Generator (SCIG), three phase Dynamic Load, Static Synchronous Compensator (STATCOM)*

## I. INTRODUCTION

The wind is a by- product of solar energy. Nearly 2% of the sun's energy reaching the earth is converted into wind energy. Wind energy is one of the speedily growing renewable energy sources. The Indian wind energy sector has an overall installed capacity of 21,141.36 MW (as on March 31, 2015). In terms of wind power installed capacity, India ranks 5th in the World.

The electrical power generation structure contains both electromagnetic and electrical subsystems. Apart from the electrical generator and power electronics converter it generally contains an electrical transformer to ensure the grid- voltage compatibility. However, its layout depends on the grid interface and on its electrical machine type.

### A. Fixed speed WECS

Fixed-speed WECS work at constant speed. That means, regardless of wind speed, the wind turbine rotor speed is fixed and is determined by the grid frequency. Fixed- speed WECS are typically equipped with *Squirrel cage induction generators (SCIG)*, soft starter and capacitor bank and they are connected directly to the grid, as shown in "Fig. 1". This WECS configuration is also known as the *"Danish concept"* because it was developed and is widely used in Denmark.

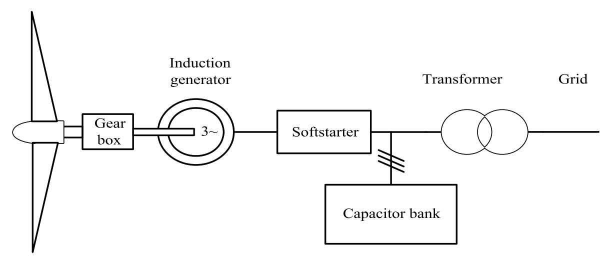


Figure 1. General structure of a Fixed- speed WECS.

SCIG are advantageous because they are mechanically simple, have high efficiency and its maintainence expenditure is low. Thereby, they are very robust and stable. In order to limit the reactive power absorption from the grid, SCIG based Wind Energy Conversion System are equipped with capacitor banks. The soft starter's function is to smooth the inrush currents during the grid connection.

SCIG-based WECS are designed to gain maximum power efficiency at a unique wind speed. Fixed-speed WECS have limited controllability (in terms of rotational speed), since their rotor speed is fixed, almost constant, plunge to the grid frequency.

## II. SIMULATION OF WIND FARM USING SCIG

A Simulation of wind farm having 9MW power using Squirrel Cage Induction Generator (SCIG) by

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variable pitch controlled wind turbine is shown in Figure 2. This model contains a wind farm of 9 MW which is consists of six 1.5-MW wind turbines, connected to a 25-kV distribution system exports power to a 120-kV grid through a 25-km 25-kV feeder. The wind farm of 9-MW is simulated by three pairs of 1.5 MW wind-turbines. The Wind turbines use squirrel-cage induction generators (IG). Here the stator winding is connected directly to the 60 Hz grid and the rotor is driven by a variable-pitch controlled wind turbine. In order to establish the generator output power at its nominal value the pitch angle is controlled for winds exceeding the nominal speed (9 m/s). In order to generate power the speed of the Induction Generator must be little above the synchronous speed. The Speed varies approximately between 1 Pu (at no load) and 1.005 Pu (at full load). Each wind turbine consists of a protection system monitoring current, voltage and machine speed.

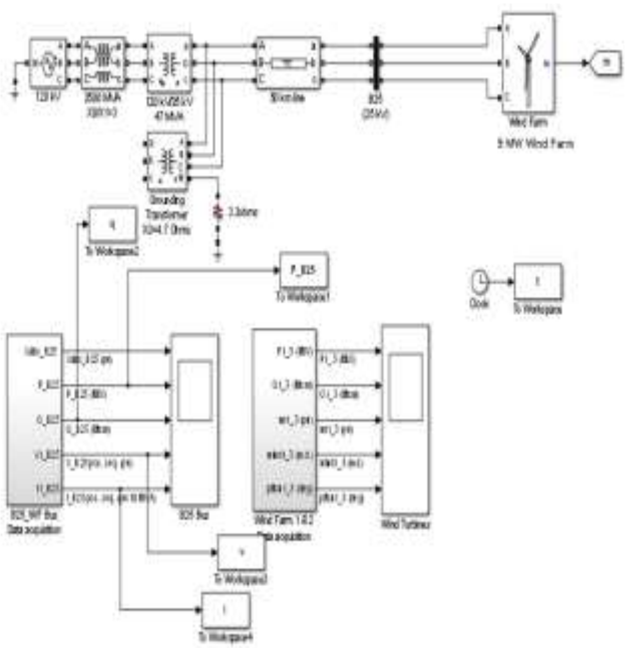

**Figure2. Model of wind farm using SCIG**

## III. SIMULATION OF WIND POWER MODEL USING THREE PHASE DYNAMIC LOAD

A three-phase, three-wire dynamic load is implemented by Three-Phase Dynamic load block, whose Real power P and reactive power Q vary as function of positive-sequence voltage. The zero-sequence and Negative currents are not simulated. In this, the three load currents are therefore balanced, even under the unbalanced load voltage conditions.

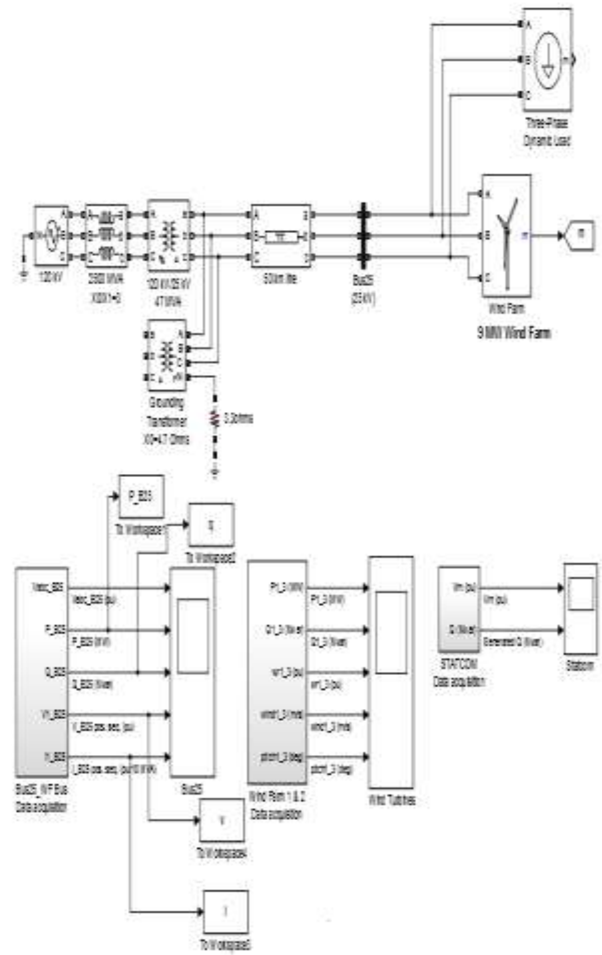

**Figure3. Model of wind power using three phase Dynamic load.**

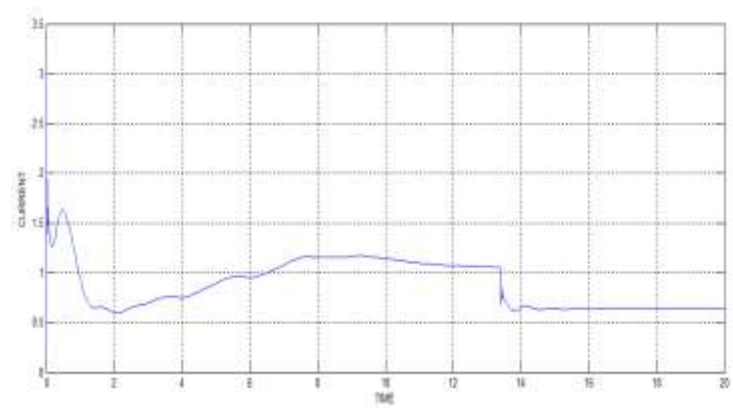

**Figure 3(i) Current waveform**

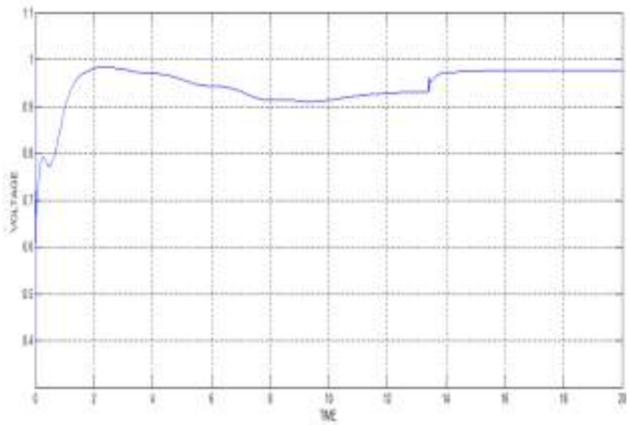

**Figure 3 (ii) Voltage waveform**

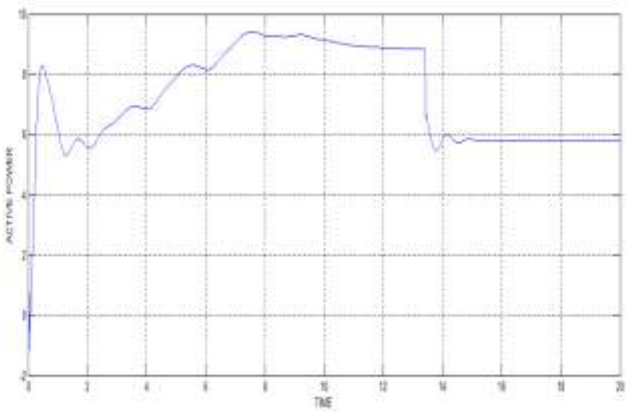

**Figure 3 (iii) Active power waveform**

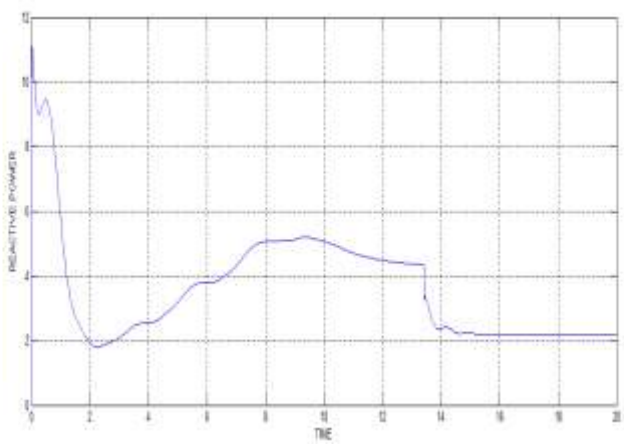

**Figure 3 (iv) Reactive power waveform**

## IV. THREE PHASE DYNAMIC LOAD WITH FAULT

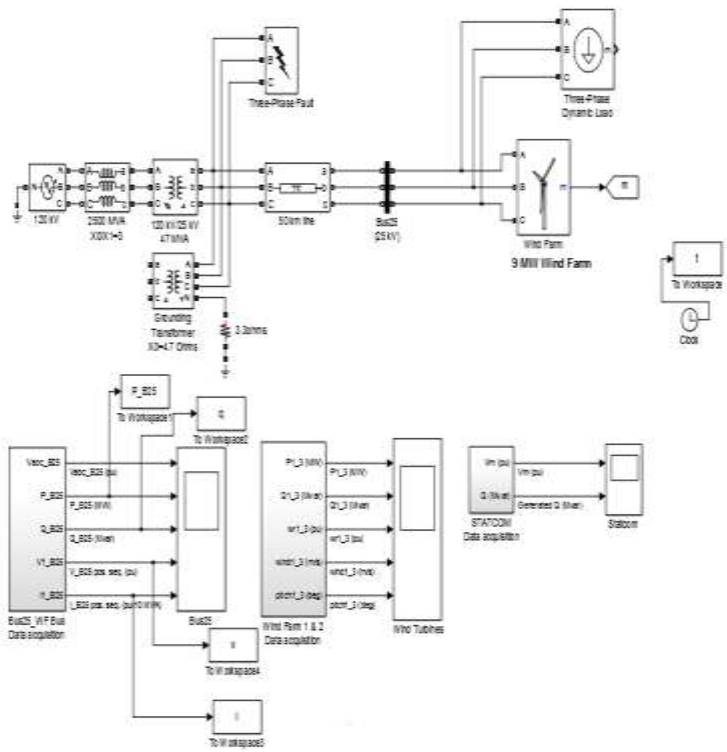

**Figure 4. Model of Three Phase Dynamic load with fault**

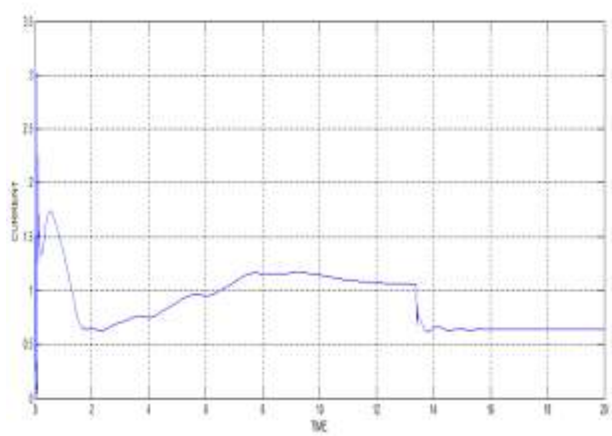

**Figure 4 (i) Current waveform**

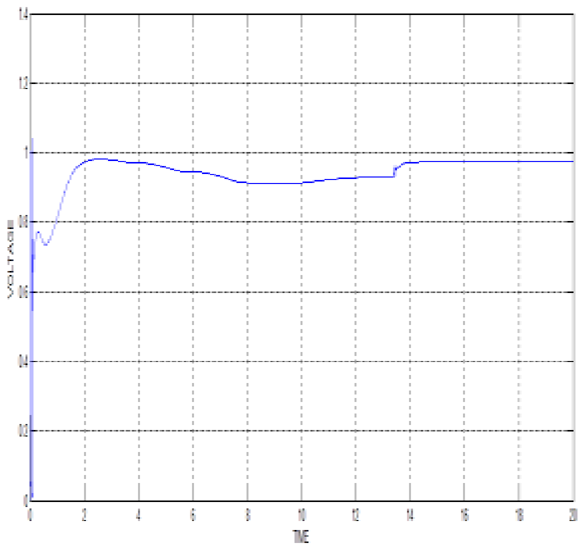


**Figure 4 (ii) Voltage waveform**

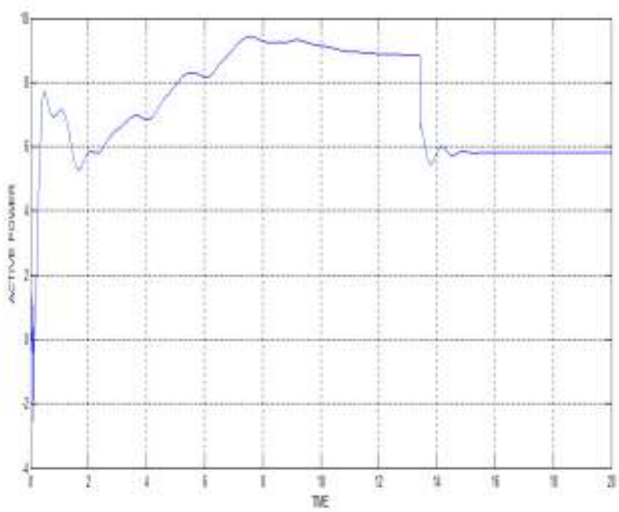


**Figure 4 (iii) Active power waveform**

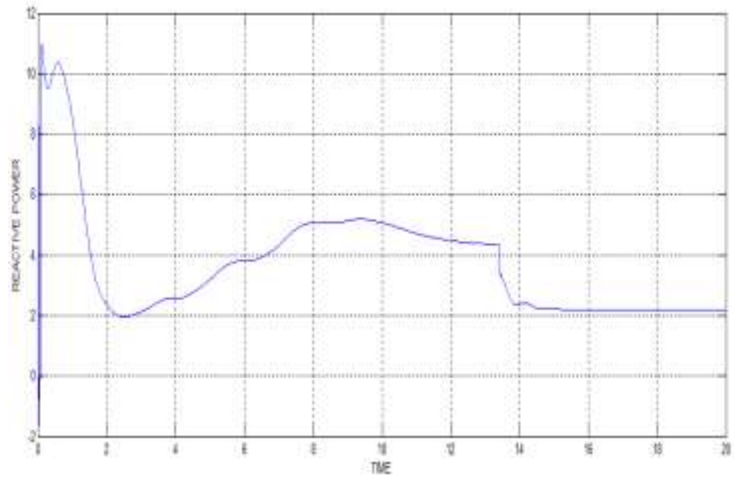


**Figure 4 (iv) Reactive power waveform**

## V. THREE PHASE DYNAMIC LOAD WITH FAULT AND STATCOM

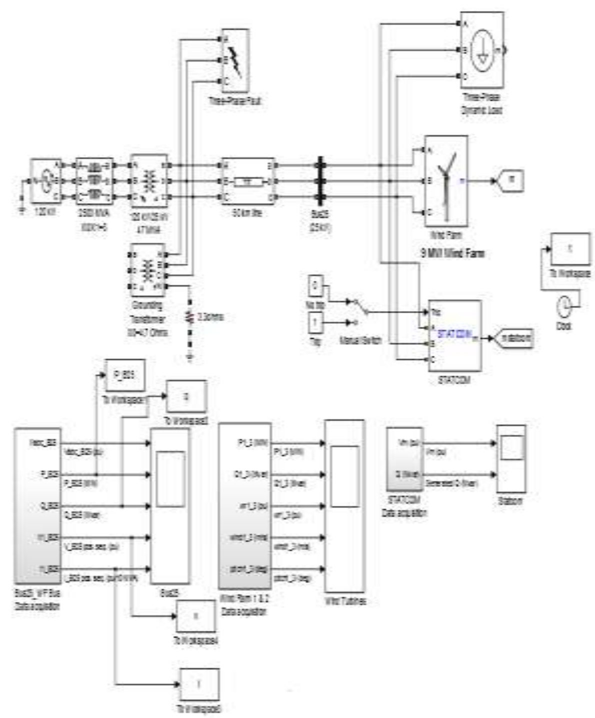


**Figure 5. Model of Three phase Dynamic load with Fault and STATCOM**

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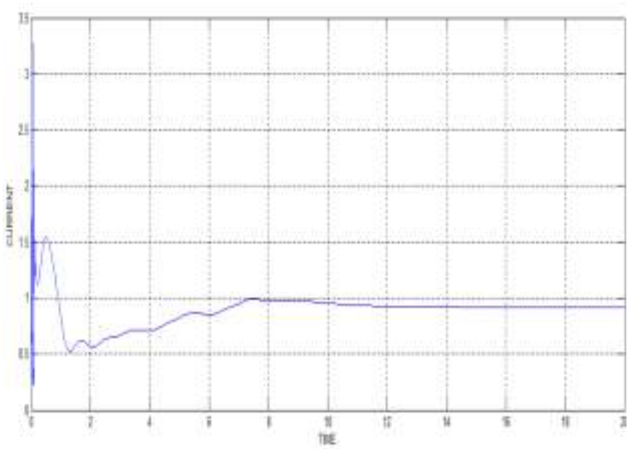


**Figure 5 (i) Current waveform**

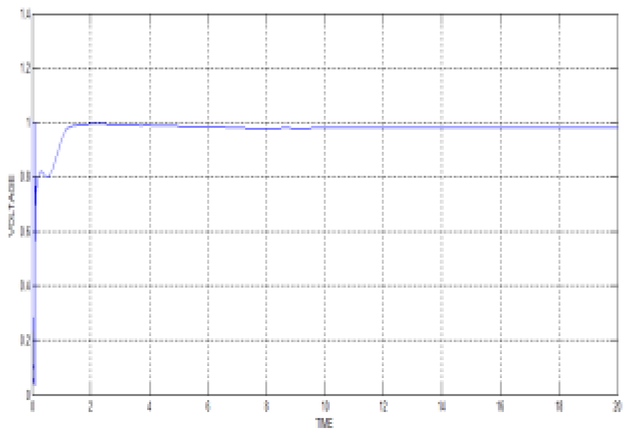


**Figure 5 (ii) Voltage waveform**

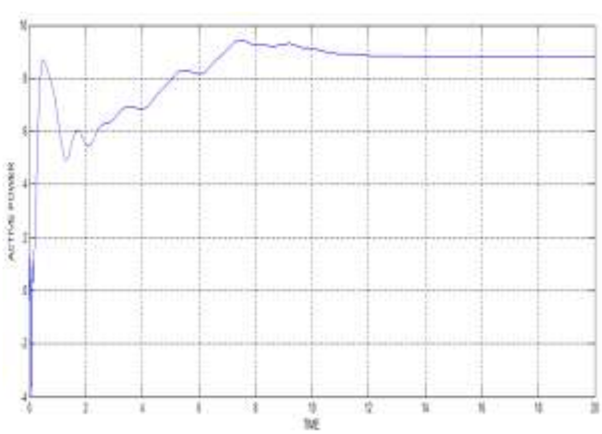


**Figure 5 (iii) Active power waveform**

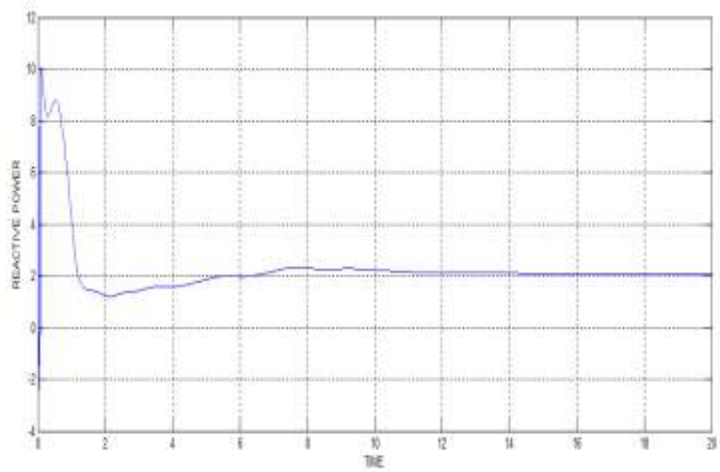


**Figure 5 (iv) Reactive power waveform**

## VI. CONCLUSION

When dynamic load is connected then the current saturates at t=14s and becomes 0.6pu,voltage becomes 0.998pu when saturates at t=14s,active power becomes 6MW and reactive power becomes 2.05MVAr.When the fault is occurred along with dynamic load then the current becomes 0.6pu and saturates at 14.3s,voltage becomes 0.998pu,active power becomes 5.9MW and reactive power becomes 2.1MVAr.WhenSTATCOM,Fault,Dynamic load are connected then the current becomes 0.998pu and saturates at t=10s,voltage becomes 0.998pu and saturates in very less timei.e.t=2s,active power becomes 9MW at t=12s and reactive power becomes 2.1MVAr at t=10s.

***TABLE 1. A Comparative Table Showing the Performance analysis for each of the discussed case***

| PARAMETERS / VARIOUS CASES | CURRENT | VOLTAGE | ACTIVE POWER | REACTIVE POWER |
|---|---|---|---|---|
| **SCIG WITH DYNAMIC LOAD** | **At the time of starting, current increases then decreases and finally saturates and becomes 0.6pu.** | **The voltage waveform, at the time of starting decreases then increases and finally saturates at t=14s, becomes .998pu.** | **The active power waveform, at the time of starting increases suddenly then decreases and finally saturates at t=14s, becomes 6MW** | **The reactive power waveform, at the time of starting decreases rapidly then increases and finally saturates at t=14s, becomes 2.05MVAr** |
| **SCIG WITH DYNAMIC LOAD AND WITH FAULT** | **At the time of starting decreases then increases and finally saturates at t=14.3s, becomes 0.6pu.** | **The voltage waveform, at the time of starting decreases then increases and finally saturates at t=14s, becomes .998pu.** | **The active power waveform, at the time of starting decreases then increases and finally saturates at t=14s, becomes 5.9MW.** | **The reactive power waveform, at the time of starting increases then decreases and finally saturates at t=14s, becomes 2.1MVA r.** |
| **SCIG WITH DYNAMIC LOAD, FAULT, AND WITH STATCOM** | **The current waveform, at the time of starting decreases then increases and finally saturates at t=10s, becomes .998pu.** | **The voltage waveform, at the time of starting decreases then increases and finally saturates at t=2s, becomes .998pu.** | **The active power waveform at the time of starting decreases then increases and finally saturates at t=12s, becomes 9MW.** | **The reactive power waveform at the time of starting increases then decreases and finally saturates at t=10s, becomes 2.1MVAr.** |

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