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System Recovery Time Improvement using SEIG and STATCOM

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Abstract:- *Increasing demand for electrical power and its need for reduction of distribution costs leads to frequency and voltages standardization. In our proposed work, we modeled a distribution generation system to propel the two self-excited induction generators with the help of renewable wind energy source as power input. Self-excited induction generator (SEIG) works just like an induction machine in the saturation region excluding the fact that it has excitation capacitors connected across its stator terminals. For electricity generation these machines are ideal choice in stand alone variable speed wind energy systems, whereas in the reactive power form the grid is not available. In this work, we have actually studied the overall behavior of the system by changing consumer loads and also applying faults in system in between lines. The effective behavior of transmission system with the use of STATCOM is shown in the experimental results*

Keywords: -Wind Energy, SEIG, STATCOM

I. INTRODUCTION

In today's innovation and the future force to be reckoned with frameworks are expansive, and are interconnected and contains a huge number of transports and several generators. Power framework insurance gadgets shape an extensive part of the force framework. Environmental and in addition financial components represent the fundamental establishment of force framework furthermore transport this, new transmission line development are required to support expanding load request. The utilization of FACTS (Flexible AC transmission system) gadgets in a force framework can defeat constraints of the present mechanically controlled transmission frameworks. By presenting mass force exchanges, these interconnected systems help us to minimize the need to develop power plants and empower neighboring utilities and areas to exchange power

A. Wind Energy in Generating Electricity

Generation of power through wind was started in the nineteenth century, due to consumption of fossil fuels at high rate this lead to innovation of new ideas related to wind energy. Since the fuel prices were increasing day by day so in 1974 many countries along with their industry started working to advance this technology so that it can be used on large commercial scale Advancements in wind energy system was obstructed because of high assembling cost due to this specialists began focusing on making low cost turbines, which were made from small turbines , a prompting generator, a gearbox and a mechanical basic control technique. With these advancements wind energy system become more cost efficient and more number of people started using this.

As an after effect of detailed examination on Wind Energy Conversion System another era of WECS was created on bigger scale. In mid 1980s, wind turbine with rotor ranges of around 10 to 15 meters, and generators of 10 to 65 KW, were introduced. Today, designers are making systems, which has capacity of 200 KW to 2 MW with rotor blade size of around 47 to 80 meters. Now a days wind turbines system has become more efficient than earlier wind turbine systems it can create 120 times than early turbine outlines. Vast turbines don't turns as quick in contrast with little wind turbines and relatively delivers less noise

II. PROPOSED WORK

We have considered STATCOM for shunt controlling, Similarly SSSC has been considered to study the series attachment of control with generation lines. This strategy is based on injecting the series voltage in quadrature with the

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transmission line current allowing it to function similar to that of a variable series capacitor. This fixes the phase angle of the series injected voltage to be in quadrature with the transmission line current. By varying the magnitude of the series injected voltage that is in quadrature with the transmission line current, the real power flow can be controlled

A. Self excited induction generator(SEIG)

The advancement in the wind energy technology has been the main player behind the effective utilization of the induction generator, in stand-alone mode, as a principal source of generation due to some of its characteristic advantageous features over the synchronous generators [8]. These features are low cost, operation at all speed, lack of brushes, rugged construction, less maintenance, light—weight, reliability, operational simplicity, asynchronous operation, self-protection against short-circuit collapses [9]. The fault current level drops to zero due to the collapse of the excitation-voltage with the collapse of terminal voltage.

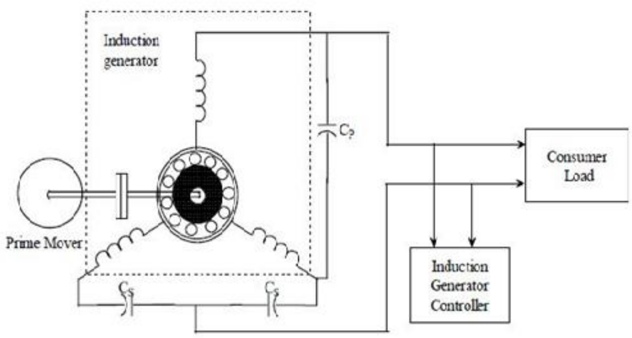

Figure 1: Schematic diagram of Single phase SIEG [10]

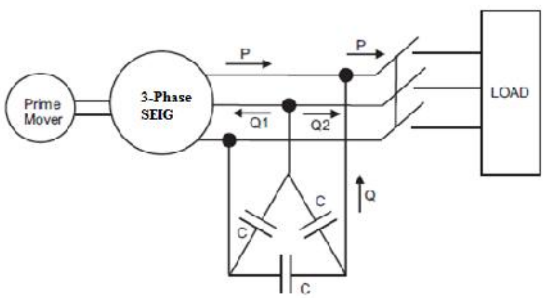

Figure 2: Schematic diagram of three phase SIEG [11]

In an SEIG the magnetizing current is supplied from the stator side, therefore the rotor ampere-conductor loading is less in comparison to that of in the synchronous generator. It offers an inherent advantage owing to the fact that it is more difficult to cool the rotating member. There is a better heat transfer between rotor conductor and rotor core due to minimal electrical insulation over the rotor conductors [12].

B. STATCOM

STATCOM is a DC-AC voltage source converter with an energy storage unit, usually a DC capacitor. Power electronic switches are used to derive an approximately sinusoidal output voltage from a DC source. The power circuit diagram of a VSC-based STATCOM is illustrated in Figure 3-4 where six IGBTs with its anti- parallel diodes and a DC-link capacitor are used to produce the three-phase voltage. The STATCOM is coupled to the ac power grid via coupling inductors Lc. The coupling inductors are also used to filter out the current harmonic components that are generated by the pulsating output voltage of the power converter.

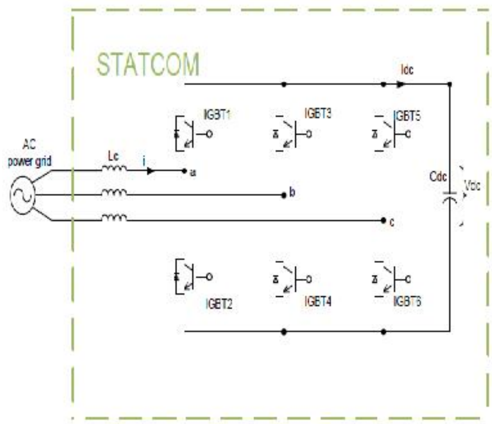

Figure 3: Power circuit diagram of a STATCOM

III. RESULTS AND DISCUSSIONS

As our main focus is to consider the changes in load side of the system and corresponding output at different locations using STATCOM, we consider a constant rotor speed of 2900 of combined SEIG generators. Hence 1450 rpm is needed to be provided by single SEIG.

Results for Rotor current I_{ra}, Stator current I_{sa}, Electromagnetic torque E_m and rotor speed w_m

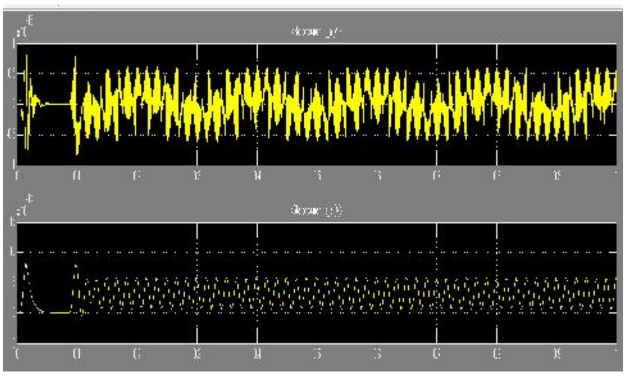

Figure 4: (a) Rotor current I_{ra} (b) Stator current I_{sa}

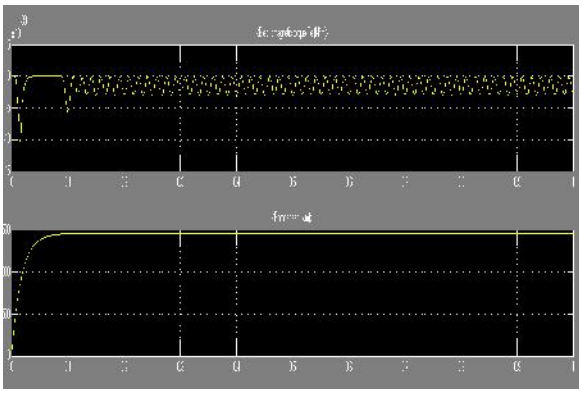

Figure 5: (a) Electromagnetic torque E_m (b) rotor speed w_m

Self-excited induction generator (SEIG) works just like an induction machine in the saturation region except the fact that it has excitation capacitors connected across its stator terminals. These machines are ideal choice for electricity generation in stand-alone variable speed wind energy systems, where reactive power from the grid is not available. The induction generator will self-excite, using the external capacitor, only if the rotor has an adequate remnant magnetic field. In the self-excited mode, the generator output frequency and voltage are affected by the speed, the load, and the capacitance value in farads. When capacitors are connected across the stator terminals of an induction machine, driven by an external prime mover, voltage will be induced at its terminals. The induced electromotive force (EMF) and current in the stator windings will continue to rise until the steady-state condition is reached, influenced by the magnetic saturation of the machine. At this operating point the voltage and the current will be stabilized at a given peak value and frequency. In order for the self-excitation to occur, for a particular capacitance value there is a corresponding minimum speed. So, in stand-alone mode of operation, it is necessary for the induction generator to be operated in the saturation region.

Case I

Output results without three phase faults with three types of consumer loads switching on and off according conditions

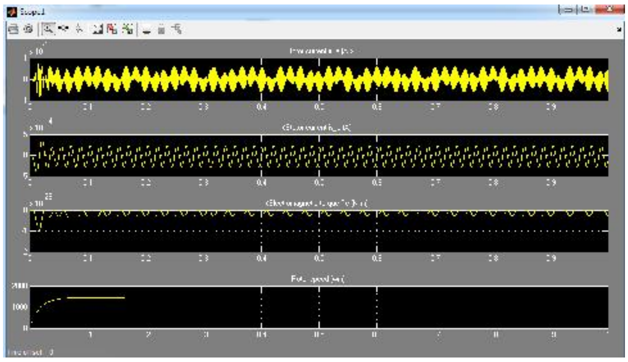

Figure 6: (a) Rotor current Ira (b) Stator current Irs (c) electromagnetic torque (Te) (d) Rotor speed wm

As we seen in figures above, the generation system achieves constant rotor speed after few micro-seconds and maintains it up to end. From Figures above, it can be observed that the phase voltage slowly starts building up and reaches a steady-state value as the magnetization current or rotor current Ira starts from zero and reaches a steady-state value. The value of magnetization current is calculated from the instantaneous values of stator and rotor components of currents .The magnetization current influences the value of magnetization inductance and also capacitance reactance line. From Figure above we can say that the self-excitation follows the process of magnetic saturation of the core, and a stable output is reached only when the machine core is saturated. In physical terms the self-excitation process could also be explained in the following way. The residual magnetism in the core induces a voltage across the self-exciting capacitor that produces a capacitive current (a delayed current). This current produces an increased voltage that in turn produces an increased value of capacitor current. This procedure goes on until the saturation of the magnetic field occurs. The different waveforms without any fault in the system are described below.

1. Load one ON during whole duration of 1 second

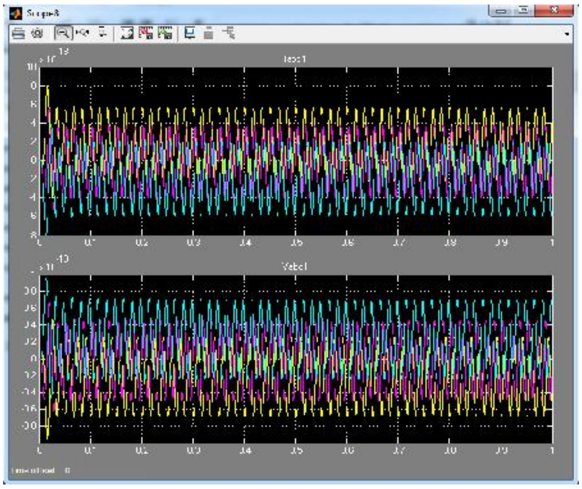

Figure 7: (a) Three phase current waveform at bus no. seven (b) Three phase voltage waveform at bus number seven

As there was no fault in the system during this duration, the current and voltage profile in this bus has no oscillations and outputs are pure sinusoidal in nature. At start of the system there was some fluctuations which are caused due to starting point of wind generators which become stable after few micro-seconds from starting point and reach its stable speed of 1450 rpm each in that time.

2. Load two off 8kw for first 10/60 seconds as there is three phase breaker and single phase breaker in the line in which single phase breaker set on at time 20/60 second and three phase breaker set on at time 10/60. Therefore this load has two phases on in between 10/60 and 20/60. After that it consumes full load from the system.

The waveforms at this level are shown below

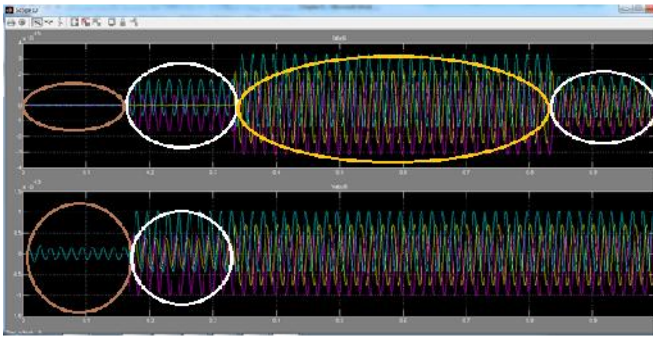

Figure 8: (a) Three phase current waveform at bus six (b) Three phase voltage waveform at bus six

3. Load three makes on at 20/60 time at off at 50/60 time with the help of three phase breaker no. 3
As seen in the figure below

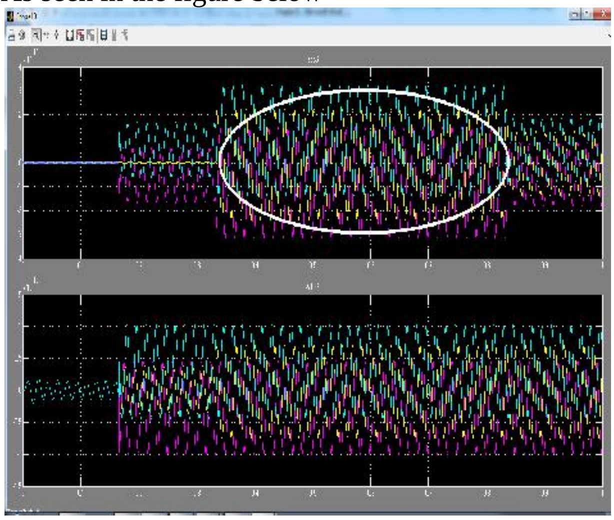

Figure 9: (a) Three phase current waveform at bus six (b) Three phase voltage waveform at bus six with ellipse showing on position of this load

4. Root mean square voltage of the generation system V_{rms} has been shown below

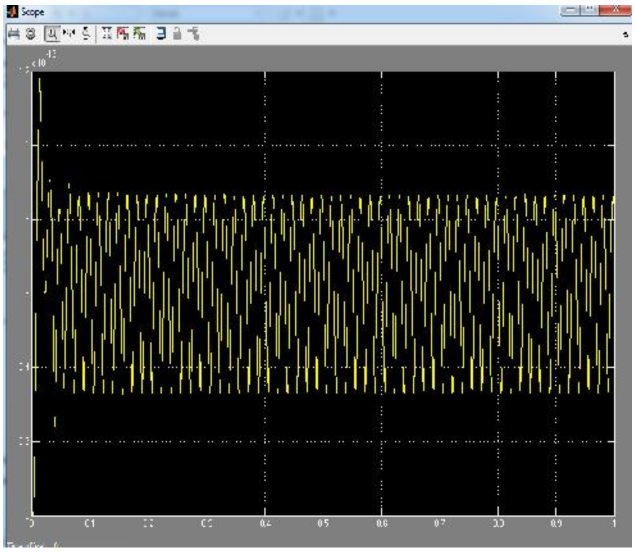

Figure 10: root mean square voltage at generator output

The RMS voltage tells the effective value of a varying voltage. The steadiness shown in the diagram conveys there are no fluctuations at the output however there is small fluctuation in the starting, as there is no fault in the system.

5. Three phase Line voltages and current at generator output are:-

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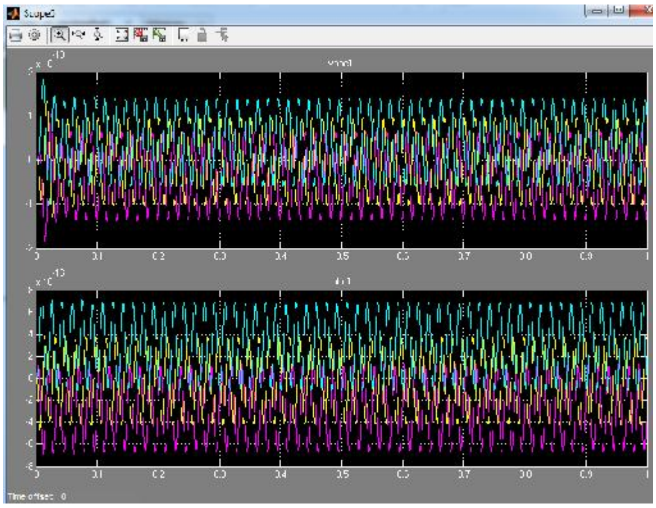

Figure 11: (a) Phase to ground three phase line voltages (b) Phase to ground three phase line current

As we seen above there are no fluctuations or harmonics in line voltages and current waveforms. And the output given by generators are pure sinusoidal in nature where each phase has a shift from others, however pure sinusoidal.

Case II

Outputs at different points with three phase faults are show and explained below:

1. Three phase fault at bus six in between duration

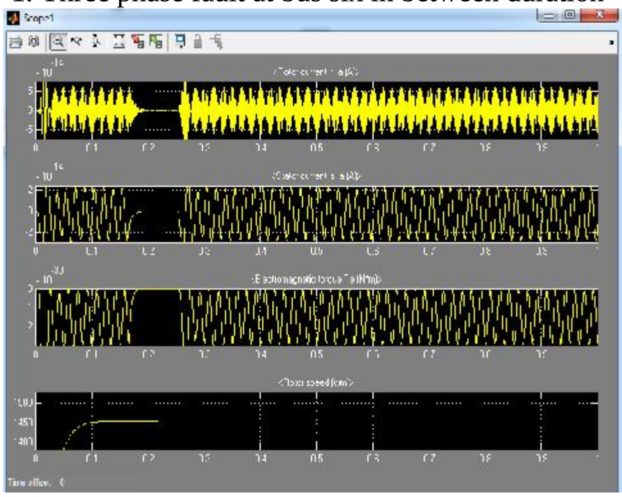

Figure 12: (a) Rotor current Ira (b) Stator current Irs (c) electromagnetic torque (Te) (d) Rotor speed wm

As seen in the figure above, All three waveforms (except rotor speed) reaches zero when there is a fault in the system and re-gains the same speed after the termination of three phase line fault.

2 .The other waveforms at different points are shown below with three phase line fault on from 10/60 to 15/60 seconds of running time

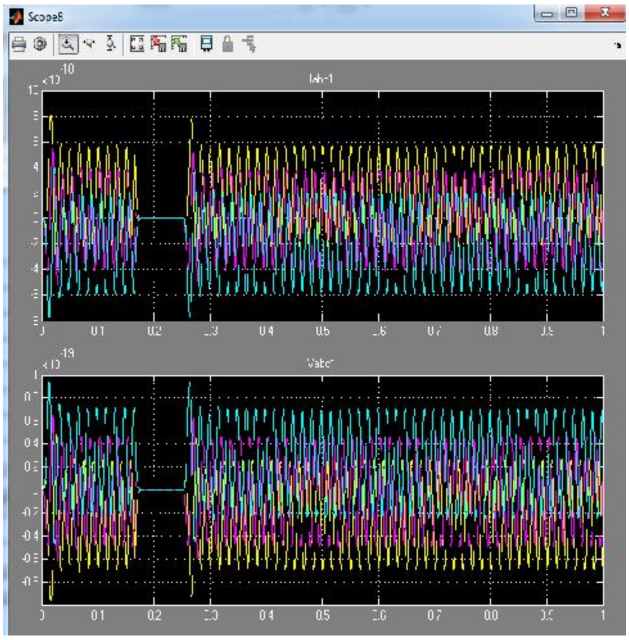

Figure 13: (a) Three phase current waveform at bus no. seven (b) Three phase voltage waveform at bus number seven with fault in bus number five.

The figures shown tell the effect of fault on these waveforms while there is fault and the instant fault stops. This shows the effectiveness of the proposed system that how it compensates the effect of fault in few microseconds of time when the fault is eliminated.

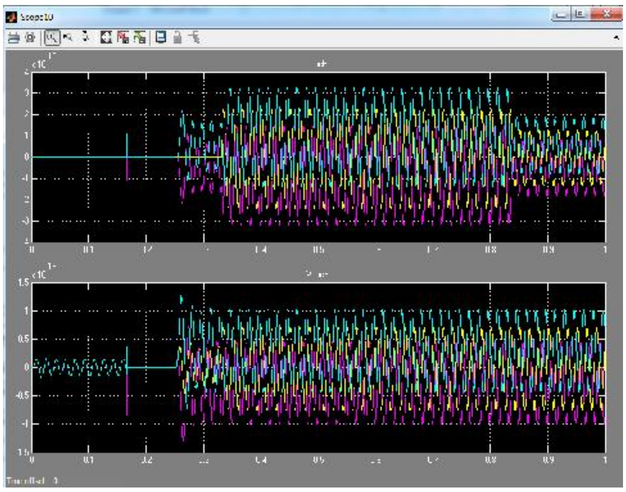

Figure 14: (a) Three phase current waveform at bus six (b) Three phase voltage waveform at bus six with fault at bus five

This figure shows the bus where there are multi single phase and three phase breakers in the circuit and all circuit breakers have been closed and opened at different spell of time. The waveforms shows the stability of the system when different number of loads need to be attached and remove from the transmission line. The system does it smoothly so that it does not affect in power slumps to other existed loads

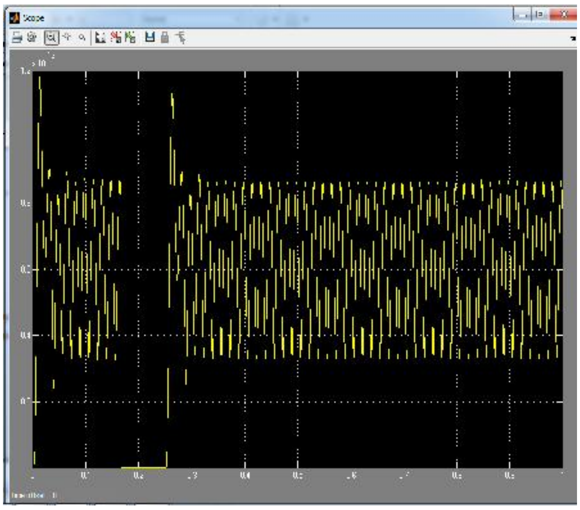

Figure 15: V_{rms} at bus number five

As seen from the figure above, the fault causes instant fluctuation in the RMS voltage value and how the system re gain its actual frequency when the fault has been removed.

IV. CONCLUSION AND FUTURE SCOPE

A.Conclusion

In this work, we have modeled a distribution generation system with the help of renewable wind energy source as power input to propel the two self-excited induction generators. In saturation region this SEIG works similar to induction machine if and only if excitation capacitors are connected across its terminal..Sometimes there are Voltage collapse in such type of transmission systems when system is faulted, heavily loaded or a sudden increase in the demand of reactive power. Instability in voltage is the major cause behind system voltage collapse. To avoid voltage collapse there are some ways either we should reduce the reactive power or we should provide additional reactive power to the system before it reaches the voltage collapse point. In this work, we have studied the whole system behavior by changing consumer loads as well as by providing system faults in between lines. In our results we have shown how current and voltage vary with respect to faults and different load conditions.

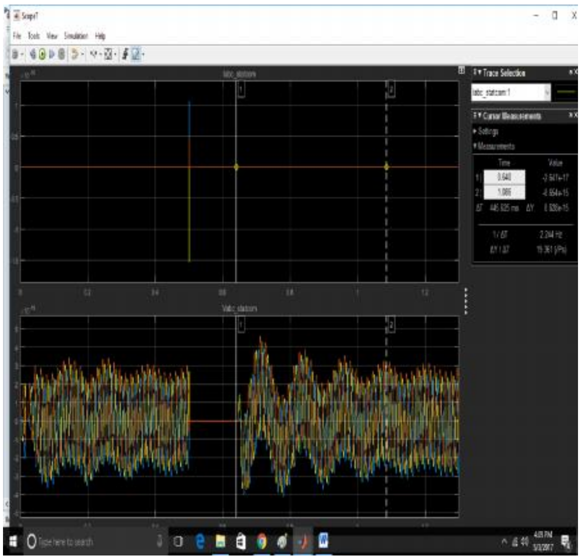

Figure 16 :Fault is applied at 30/60 sec to 38.4/60 sec

From this figure it is concluded that fault is removed at .640 second and signal reaches its stable form at 1.086 second . So the total time taken by signal to reach its stable state is .0446 seconds and the Total Harmonic Distortion in this signal is 0.08% only.

Table 1.1 Comparison Table

Parameter	Base paper	Work done
Total Harmonic Distortion	2.1%	0.08%
Time taken (sec)	0.66sec	0.446 sec

B. Future scope

Further study can be done on this topic .There are some other devices which can be used in place of STATCOM i.e. SSSC (static synchronous series compensator) etc. In future, this same system can be used to explore and study just by replacing STATCOM with SSSC device. The simulation can also be studied by varying rotor speed and considering the change in behavior of wind energy source and its effect can be studied in transmission systems.

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