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Enhancing Motor Starting Capability Supplied with Diesel Generator Using Statcom

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Abstract

This paper proposes a very efficient device known Static Compensator (STATCOM) as an alternative to starters in induction motor. The starting current causes voltage sag, power factor reduction, high rating of diesel generator. The main problem in industries is installation of high rated diesel generators than what actual rating is required. This high rating increases the cost of diesel generator which is not affordable for low rating motors. The STATCOM decreases the starting current to its full load current and can be used for all applications. A simulation model is designed for the system with STATCOM which is then verified with calculated results.

Keywords- Starting current, Full load current, Static compensator (STATCOM)

Introduction

Industries are totally dependent on motors of different ratings. To run those motors in case of supply failure we need some backup supply so that the production is not stopped. For the backup supply, Diesel Generators are used. The Diesel Generator cost varies with the ratings of generators. The higher the rating higher is the cost. Nowadays the Diesel generators used are of higher ratings than the actual rating which is required because the Induction motor starting current is 5 to 6 times of Full Load current, so to start the motor Diesel Generator rating required is also 5 to 6 times than the actual rating. Hence the cost factor increases as the rating increases.

The starting current can be reduced using different starters such as Star-Delta starter, DOL starter, Stator Resistance starter Autotransformer starter and Soft Thyristor starter. Among these starters the DOL starter can be used for below 5 Hp motors. Working principle of starters is just to provide reduced voltage at starting and then load the motor on full voltage once the back emf is build. The starting current is reduced to full load current of 2 to 3 times with the help of starter. But here the STATCOM will reduce the starting current to full load current. Nowadays, FACTS devices are evolving and have a sufficiently great impact on improvements of dynamic stability. STATCOM is one of the most successful member of the FACTS family, which is capable of supplying and absorbing reactive power and speed of transient response is enhanced. Static compensator response fast within few seconds unlike starters when the voltage is reached to maximum value. Static compensator is source of controlled reactive power. It gives the desired reactive power absorption and generation by electronic processing of the voltage and current. The STATCOM comprises of converter, capacitor, and coupling reactors. Parallel connection is adopted by the STATCOM to the system. Static compensator uses pulse width modulation technique to generate pulses for triggering the thyristor. There is no reactive-power exchange, if the system current is equal to STATCOM current. The capacitor is charged from the flow of real power into the STATCOM, by supplying some losses of converter because of switching and the DC capacitor is charged to a desired DC voltage level. Then the line voltages and currents are measured in starting for both the system. The Starting line currents are found to be larger in the system without STATCOM and the starting line current is then compensated in system with STATCOM

The simulation model is designed for a system having generator and induction motor. Two simulation models are designed first the simulation model for system without STATCOM and second the simulation model for system with STATCOM. Then the simulated results are verified with the calculated results.

Literature review

In [1],the power quality issue from the wind power generation is solved and the power quality is improved by using static compensator. This paper contributes the power injection theory and so is referred. Voltage has long been regarded as a crucial component of the response of the power system and as a crucial element of the stability and security of the system. Therefore, it is impossible to separate voltage instability and collapse from the broader issue of system stability. In [2] paper the hybrid system of solar and wind power quality is improved by using STATCOM. It is observed that in a very short time, the STATCOM's dynamic response changes from capacitive to inductive functioning in [3]. The[4]is used to limit the oscillations and injection of voltage to consequently improve the harmonics by using static compensator, this helped to decrease the ripples from the STATCOM.

However, capacitors can only inject reactive power. The capacitor output will only contribute to a rise in voltage if the voltage rises and there is no load to use the reactive power Furthermore, in [5], since they generate significant overvoltages during short circuits, capacitors can be hazardous. The only source of reactive power correction cannot therefore be a fixed capacitor. In order to create a unique control strategy based on a bidirectional flow of active and reactive power system, the proposed method entails connecting a static compensator (STATCOM) to the SEIG stator terminals. Several studies have focused on the dynamic SEIG behaviour to address the system's shortcoming. The output voltage was maintained constant by the authors using a compensating mechanism. This approach is based on circuits with passive parts.

In [6] the saturation of power from different places is necessary to balance, this deteriotes the power quality, hence need to stabilize which is done by using static compensator. The connection of static compensator is at the point of grid. The common coupling point is used for voltage regulation and is done with the help of static compensator in [7].Also, STATCOM is used for reductions of voltage due sudden increasing in load. Transients are controlled by using static compensator when the system is subjected to severe three-phase faults from [8]. Mobile support for fast voltage response and regulation is given by static compensator. This enables the transmission system to maintain stability. A brief description of a mobile static compensator is given the next paper with all its components and arrangements from [9].]. For a self-excited induction generator STATCOM is used to control both voltage and frequency. Results from simulations based on a bidirectional flow of reactive and active power for a particular control strategy are produced. Additionally, a reliable control strategy of infinite bus system that connects STATCOM for a single-machine is suggested in [10].

Methodology

MATLAB-SIMULINK software is used to create a model for Enhancing Motor starting capability using STATCOM. The main highlight of paper is to use static compensator over starters. For each component of the system, a simulation model is prepared. There are four components in the system which are a Synchronous Generator (Diesel Generator), Induction Motor, STATCOM, and pulse generator. For implementing the Simulink model, a 10 HP, 400 V, 0.8 p.f. lagging, Pole-2, RPM-3000, 3-Phase Induction motor has been selected. Then the starting line current is simulated for a system with and without a static compensator. It has been surveyed that the Diesel generator has been ordered for 10 HP motor is 50 KVA which costs around 4 lakhs 60 thousand. Hence the cost is estimated at around 4 lakhs 60 thousand. Also from the survey, it is been observed that the STATCOM is used for various purposes like reducing the harmonics and maintaining the stability of the system. But here STATCOM is used as a starter.

Simulink has a subsystem, a MATLAB module that we will be using. A four-sided structure is required to complete a particular endeavor. Here a subsystem is a STATCOM, the heart of our system. As an option, you caneither allow to remove a system from subsystems and ports or a port . We can generate pulses with the help of the PWM block in Simulink or compare two waveforms directly, one is modulating wave and the second is a carrier wave. Here the carrier wave is a triangular wave and modulating wave is a sinusoidal wave.

A. Static compensator

By using STATCOM the starting current is reduced to full load current by absorbing reactive power to the system. In STATCOM , a DC capacitor is connected of relatively small value. The reactive power is been stored in a capacitor. If the system line current is greater than the amplitude of STATCOM, the current flows from the system to STATCOM and The converter generates system inductive-reactive power. If the system current is equal to the STATCOM current, the reactive-power exchange is zero.The capacitor is charged from the flow of real power into the STATCOM, by supplying some converter losses because of switching and charging the DC capacitor to a desired DC voltage level. Charging and discharging of the capacitor during the course of each switching cycle takes place. On the other hand, it can also be used to maintain certain voltage levels under heavy loading conditions and under lightly loaded conditions it is used to diminish the line over voltages. Figure 1 shows the Simulink model for STATCOM.

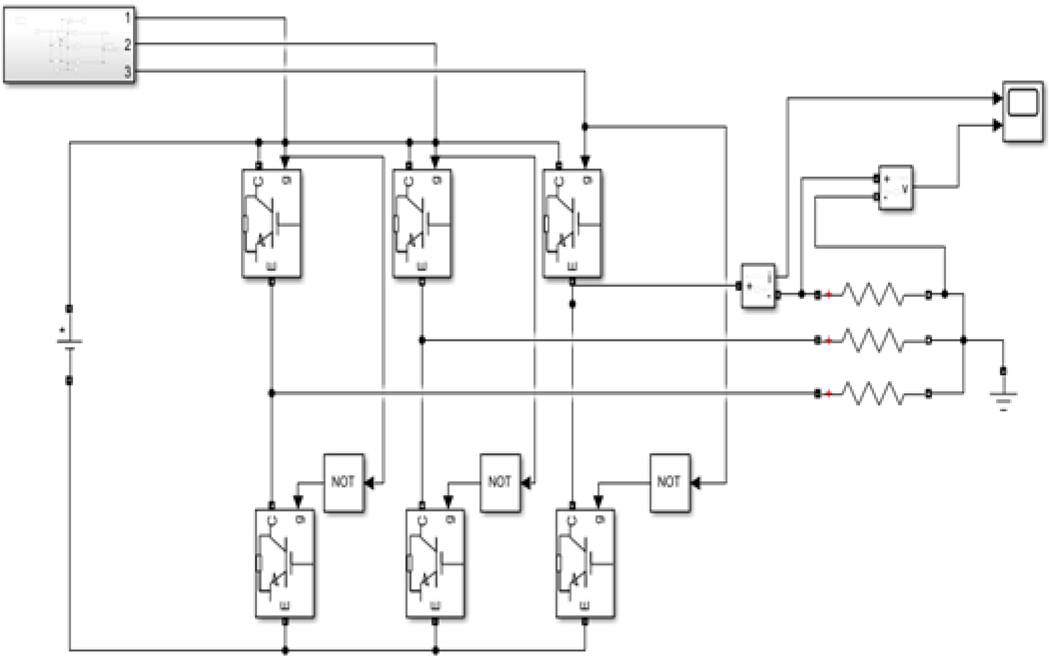

Figure 1

B. *Pulse width modulation*

The subsystem of the STATCOM model is PWM. The frequency of modulating wave is 50 HZ and the carrier wave is 20 kHz. The pulse is generated from the PWM technique and is fed to converters from ports 1,2,3 as shown in figure 2. These pulses trigger the converters and then the reactive power is supplied or absorbed by the STATCOM.

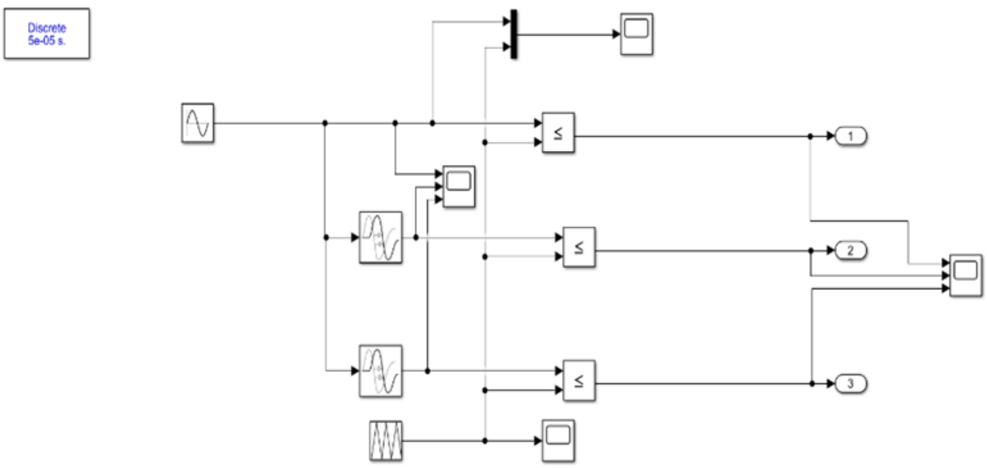

Figure 2

Design of simulation model

A simulation is performed for starting current by using the Simulink model of a system. A system without and with STATCOM is compared for high starting currents in the system without the STATCOM model and compensated for high starting currents in the system with the STATCOM model.

A. Implementation of Simulink model with and without STATCOM.

The simulation model implemented is shown in figure 3.According to the specification sheet the constant block represents the mechanical input and the excitation voltage.The excitation voltage is 48 v and the mechanical input power is 21KW. Hence the constant block of 48 and 21000 is connected. The bus selector selects the generator and motor parameters thatare to be measured. Hence stator currents are measured from the generator side and rotor currents are measured from the motor side. Two parameters, starting current and power factor are measured for both the system i.e with and without statcom systems. The VI measurement block is used to measure the line currents before connecting STATCOM and after connecting STATCOM. These measured values are further given to subsystem results. This model has two subsystems i.e STATCOM and Results. STATCOM supplies the reactive power of 40KVAR. Hence the capacitor value is calculated to be 100 microFarad. This reactive power decreases the starting current 67.7A to full load current 13.5A. One more parameter is measured before and after connecting STATCOM i.e power factor. Power factor before connecting STATCOM was 0.16 and that after connecting STATCOM is changed to 0.8.

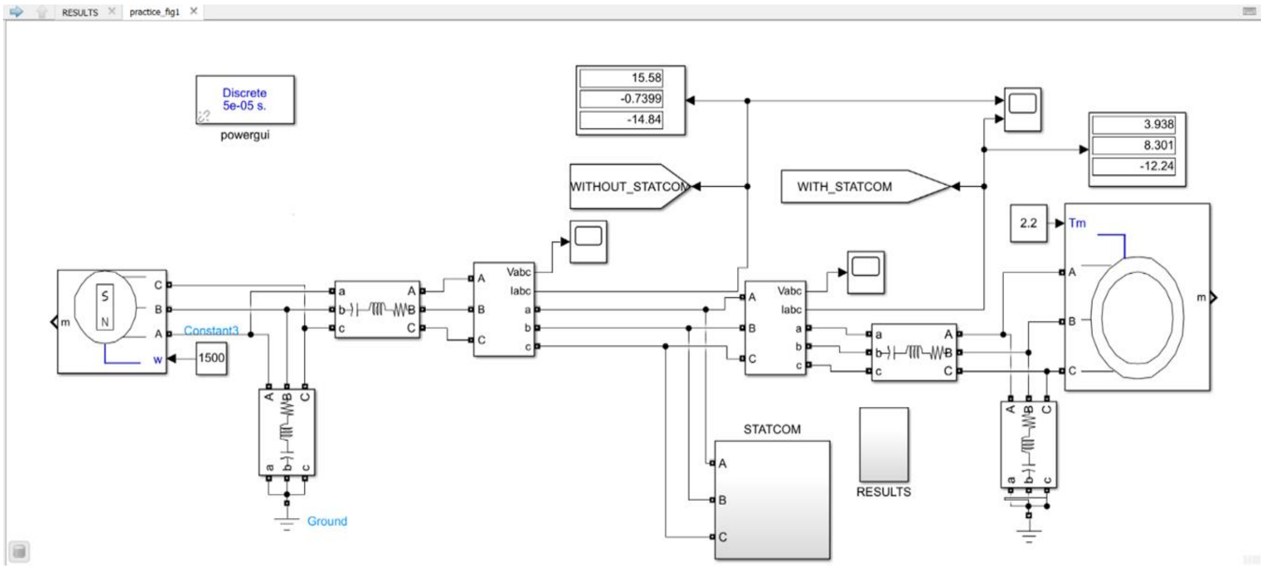

Figure 3

B. Calculations

1. Starting current

- P(KW) = 10 *(0.745) = 7.5KW
- S(KVA) = KW/Pf = 9.37KVA

- full load current $I_L = P/(\sqrt{3}*V_l\cos\phi) = 13.04A$.
- Starting current $I_{Lstarting}$ = 5* full load current = 67.74A
- Starting S (KVA) = $\sqrt{3}*V_L*I_{Lstarting}$ = 46.84KVA

2. Diesel generator rating to start 10 HP motor without STATCOM = 50 KVA
3. Diesel generator rating to start 10 HP motor with STATCOM = 20 KVA
4. Capacitor rating of STATCOM

- Initial power factor =KW/($\sqrt{3}*V_{LL}$* starting current)= 0.16
- $\Phi_1=\cos^{-1}$ (initial Pf) = 80.79
- $\tan(\phi_1)$ = 6.16
- Required power factor = 0.8
- $\Phi_2= \cos^{-1}$ (Pf) = 36.86
- $\tan(\Phi_2)$ = 0.75
- $Qc = P(\tan\phi_1 - \tan\Phi_2)$ = 40.575KVAR
- $Xc = V^2 / Qc = 3.94\ \Omega$
- C= 1/2πf Xc = 100 µF

Results of enhancing motor starting capability

In this section, three parametrs are verified by calculated results and they starting current, full load current and power factor correction.From the figure 4, it is shown that the starting current is 67.73A and full load current is 11.78A. It is shown in the figure 5 that starting current is reduced to the full load current i.e 11.78A after connecting STATCOM.

The subsystem- results shown in figure 6 calculates the power factor of the system.The four tags are imported from the practice simulink model. The four tags are "without_STATCOM","without_STATCOM1"and "with_STATCOM", "with_STATCOM1".This are showing the currents and voltage when STATCOM not connected when STATCOM is connected. .Then these values of voltages and currents are fed to calculate active and reactive power without STATCOM and with STATCOM. From reactive power and active power, apparent power is calculated and then after power factor is calculated in Simulink mathematical operations.The scope in figure 6 shows the power factor reduction when static compensator is not connected and also power improvement to 0.8 when static compensator connected.

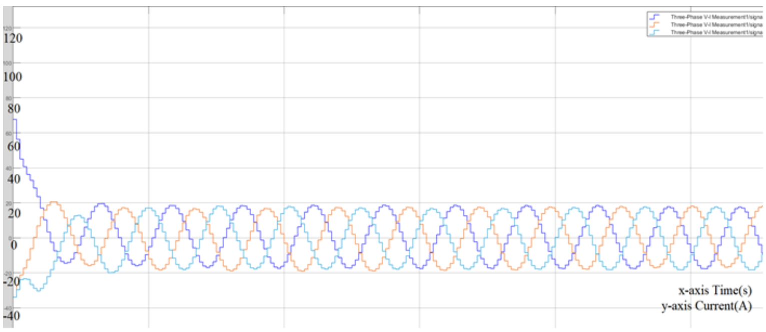

Figure 4

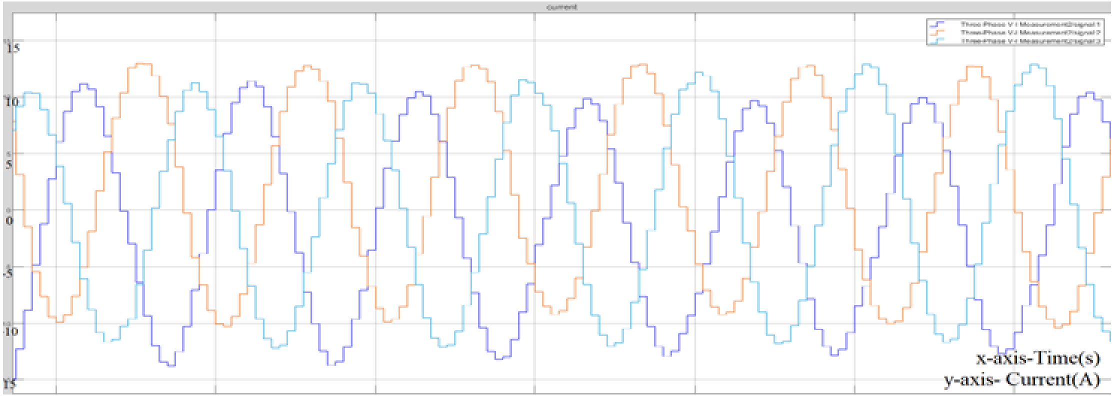

Figure 5

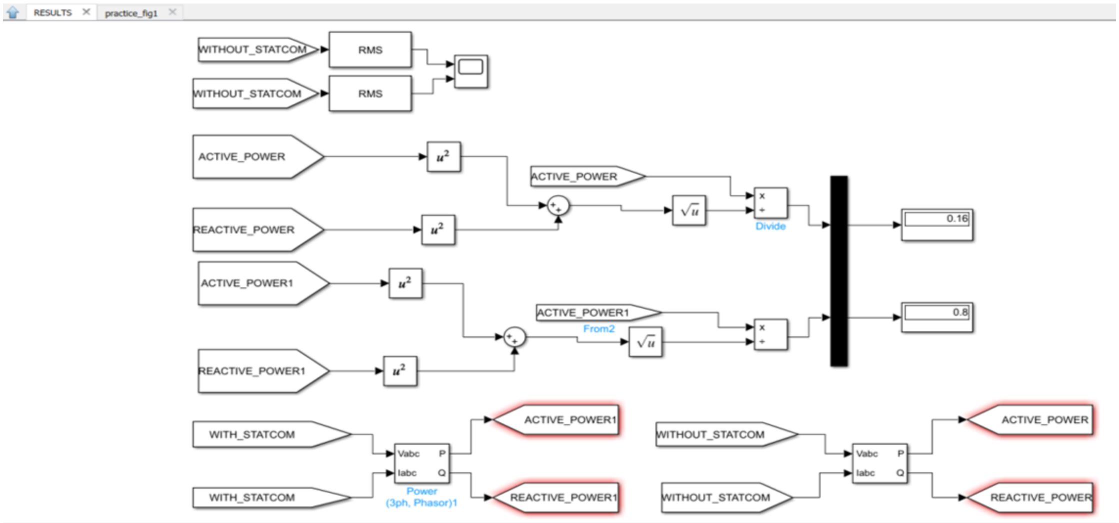

Figure 6

Conclusion

Hence the Simulink results are verified with the calculated results, the starting current of simulation results is 67.73 which is similar to that of calculated value i.e 67.74. Also the full load current of Simulink results is 11.57 which is closer to value of calculated results i.e 13.57. One more parameter is verified which is power factor reduction, the power factor is reduced to 0.16 due to high starting current as per the calculated value. This reduction in power factor is improved to 0.8 by connecting STATCOM in parallel. Hence stated that STATCOM can be used as an alternative to starters and the rating of Diesel Generator to start a 10 HP motor was 50 KVA and now can be reduced to the actual rating of Diesel Generator i.e 20 KVA.

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