PERFORMANCE OF ASYNCHRONOUS MACHINE WITH DSTATCOM CONTROLLERS

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Abstract

This paper presents the performance of Direct Torque Control Drive (induction generator) with distribution static synchronous compensator (DSTATCOM) device on the dynamic behavior of distribution networks. The performance of a DSTATCOM as a voltage controller, voltage and frequency controller is analyzed. The impact of these controllers on the stability and protection system of distribution networks with distributed generators is studied. Simulation is to be carried out using DSTATCOM as voltage controller and voltage & frequency controller.

Index-Terms: Custom power devices, distributed generation, distribution static synchronous compensator (DSTATCOM), DTC Drive.

I. INTRODUCTION

Current power distribution systems are experiencing increased installation of distributed generators and application of custom power devices [1]–[7]. The most common type of distributed generation employs ac rotating machines [5]–[7].

Custom power devices have been adopted for the purpose of improving power quality and reliability [1]–[4]. Among these new devices, special attention has been given to the equipment based on the voltage-source converter technology. A representative example of such devices is the distribution static synchronous compensator (DSTATCOM).

In view of these developments, it has become important to understand the possible dynamic interactions among distributed generators and custom power devices. The goal of this paper is to investigate the main impacts of these devices on the stability performance and protection system of a distribution network.

The simultaneous usage of ac generators and DSTATCOM devices is analyzed. The stability studies were carried out using the phasor solution method for network representation, and electromagnetic (EM) transient analysis was employed in the protection studies.

II. DSTATCOM CONTROLLERS

A DSTATCOM, which is schematically depicted in Fig. 1, consists of a three-phase voltage source converter shunt connected to the distribution network through a coupling transformer [1]–[4]. This configuration allows the device to absorb or generate controllable reactive power.

The DSTATCOM has been utilized for voltage regulation, correction of power factor, and elimination of current harmonics [1]–[4].Consequently, the output voltage control may be executed through the pulsewidth-modulation (PWM) switching method.

In this work, the performance of DSTATCOM devices acting as a voltage controller and voltage frequency controller is investigated.

A. DSTATCOM Voltage Controller

The voltage controller analyzed in this work is exhibited in Fig. 2, which employs the dq0 rotating reference frame because it offers higher accuracy than stationary frame-based techniques [3].

In this figure, are the three-phase terminal voltages, are the three-phase currents injected by the DSTATCOM into the network, is the root-mean-square (rms) terminal voltage, is the dc voltage measured in the capacitor, and the superscripts indicate reference values.

Such a controller employs a phase-locked loop (PLL) to synchronize the threephase voltages at the converter output with the zero crossings of the fundamental component of the phase-A terminal voltage.

Therefore, the PLL provides the angle to the abc-to-dq0 (and dq0-to-abc) transformation. There are also four proportional-integral (PI) regulators.

The first one is responsible for controlling the terminal voltage through the reactive power exchange with the ac network. This PI regulator provides the reactive current reference, which is limited between capacitive and inductive.

This regulator has one droop characteristic, usually, which allows the terminal voltage to suffer only small variations.

Another PI regulator is responsible for keeping the dc voltage constant through a small active power exchange with the ac network, compensating the active power losses in the transformer and inverter. This PI regulator provides the active current reference

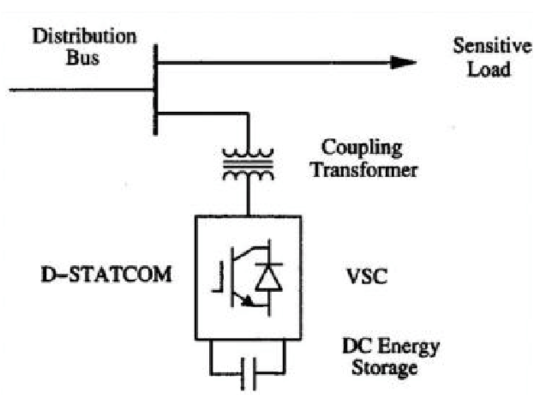


Fig 1: DSTATCOM Block Diagram

.*B. DSTATCOM Voltage & frequency Controller*

Mostly, uncontrolled turbines are used in off-grid applications because the use of speed governor leads to high installation cost. Therefore, the micro units with uncontrolled turbines generate nearly constant power. In all such schemes, surplus power is dissipated as heat in the dump resistor through power electronic converters. This is because of the low power rating and need for simple controllers.

However, in high-power three-phase ratings, dissipation of such large amount of power would not be feasible and one may have to resolve to some energy storage mechanism. Battery-storage systems are being suggested.

It uses two separate modules known as distribution static compensator (DSTATCOM) and VFIMD for voltage and frequency control, respectively. The performance of DSTATCOM does not affect the VFIMD’s performance. The system frequency can still be controlled even if the DSTATCOM is disconnected due to maintenance or repair work. Moreover, in this decoupled VFC configuration, the full-rated VSC (i.e., DSTATCOM) is not required and its rating is decided by the system maximum reactive power requirements only.

The performance has been demonstrated through simulation studies only; no experimental validation of the proposed concept has been demonstrated.. Therefore, in this paper, the performance of a direct torque controlled (DTC) drive based VFC is investigated for the voltage and frequency control of IG in power generating system.

For quick and efficient operation, the motor operates in the DTC mode. This versatile scheme of the VFC for IG ensures constant voltage and frequency at load terminals at all consume loads. This VFC is a combination of a DSTATCOM and a DTC VFIMD. The DTC technique is very simple to implement resulting in less processing time, fast dynamic response, and parameter independence.

The proposed DTC-based VFC scheme is implemented for a 3.7-kW, 230-V, and 50-Hz IG system, and the performance is demonstrated under various conditions such as steady state and dynamic conditions with a variety of loads.

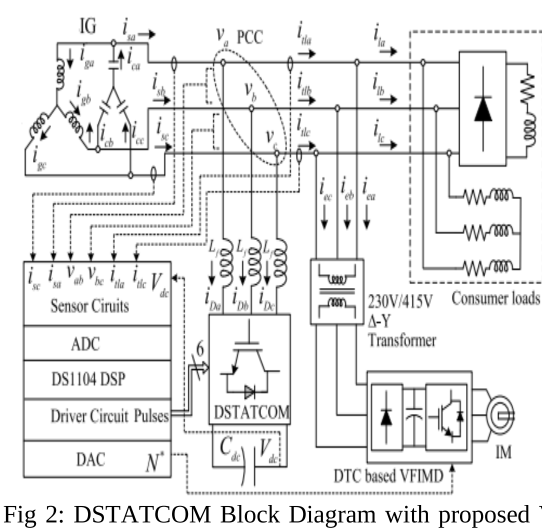


Fig 2: DSTATCOM Block Diagram with proposed VFC Controller

III. *DSTATCOM Model*

The DSTATCOM was represented by a simplified dynamic model based on controllable three-phase ac voltage sources. The main advantage of the simplified dynamic model is to allow the utilization of larger integration steps without sacrificing accuracy. Moreover, such a model is suitable for dynamic studies using either phasor or instantaneous variables for network representation.

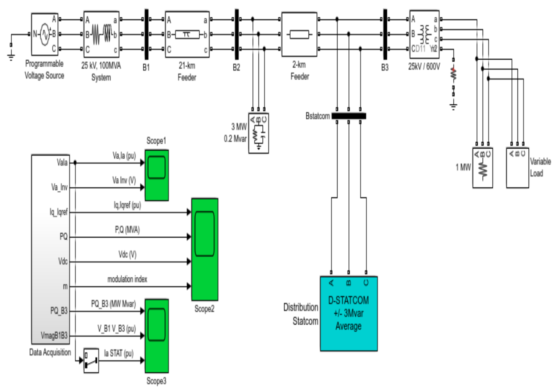


Fig 3: Simulink model of DSTATCOM

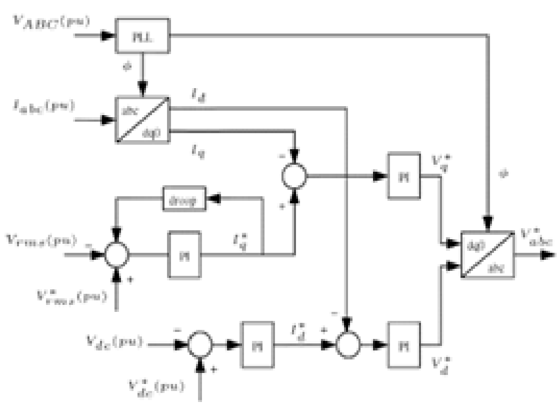


Fig 4: DSTATCOM Voltage Controller

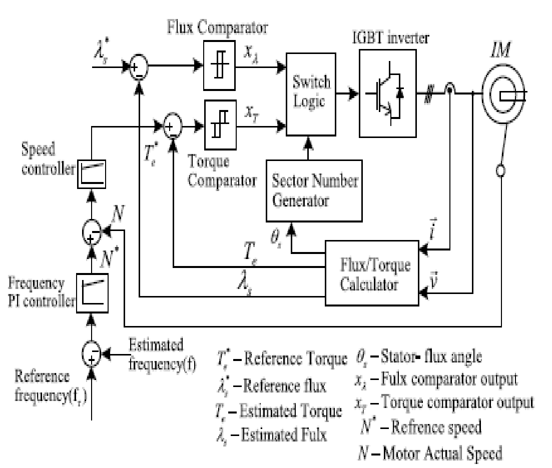
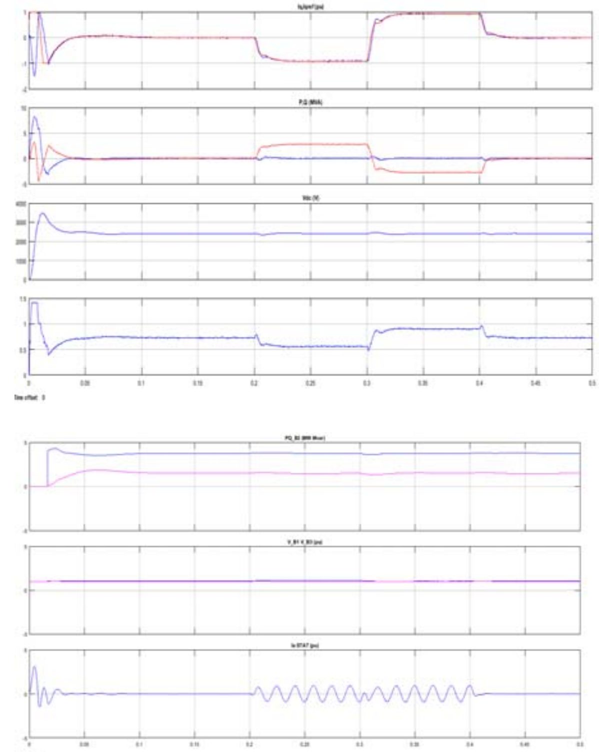


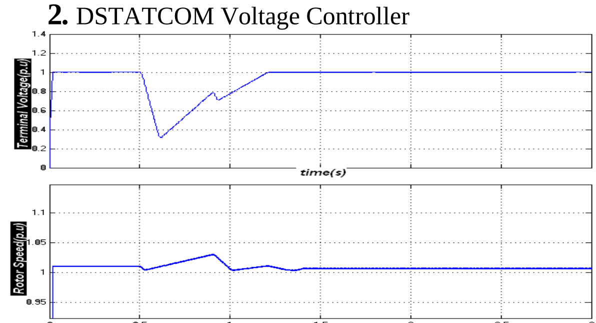
Fig 5 : Schematic diagram of DTC VFIMD

IV. Simulation Results

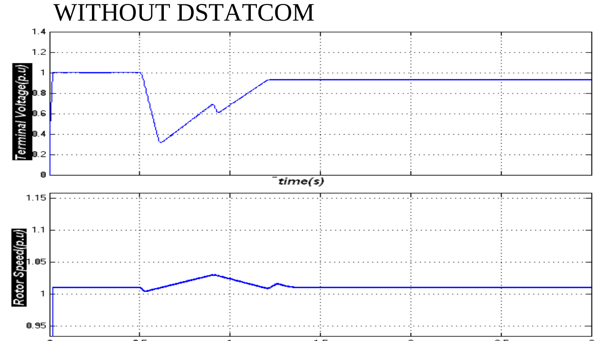
1. Basic DSTATCOM Controller



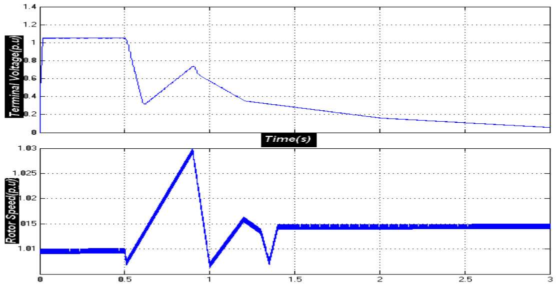
2. DSTATCOM Voltage Controller



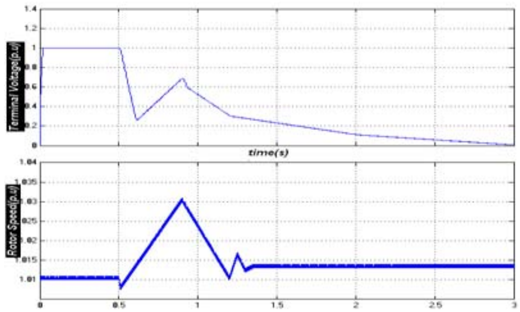
WITHOUT DSTATCOM



3. DSTATCOM Voltage & frequency Controller



WITHOUT DSTATCOM:



This case is equal to the previous one, except that the induction generator was injecting 30 MW into the network at the fault moment. The terminal voltage responses are presented in Figure. It can be observed that only the case with the DSTATCOM voltage controller is stable. Without the DSTATCOM, the system becomes unstable due to a lack of reactive Power.

In the other situations, the DSTATCOM acts as a variable reactive power source. However, the reactive power injections are completely different from each other, as shown in Fig. where the consumption of reactive power by the DSTATCOM is represented by positive values and the generation by negative values.

VI. CONCLUSION

The main conclusions obtained from this work are the following.

The performance of Induction Generator is tested with proposed voltage controller and voltage& frequency controller. The proposed techniques are helpful in regulating the voltage and frequency of proposed system. The proposed VFC is helpful in small scale micro hydro power generation using induction generators for remote area power supply.

The DSTATCOM regulates the system voltage through reactive power compensation. Moreover it mitigates the harmonics produced by consumer loads.

A DSTATCOM voltage controller can significantly improve the voltage stability performance of induction generators without increasing the short-circuit currents provided by them.

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