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SCHEME AND STUDY OF A MODEL PREDICTIVE CONTROLLER FOR STATCOM TO SOLVE THE STABILITY ISSUES OF A SINGLE MACHINE INFINITE-BUS.

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Abstract. This paper preface the model of linearized Single-machine infinite-bus power systems with (STATCOM) stating the usage of the model in inspecting the damping effect of the STATCOM and planning a STATCOM controller toward improving the stability of power system alternation. The power arrangements are deliberated in single-machine infinite-bus. To elucidate the speculative setting up of Model Predictive Control (MPC) and its practice in power system an attempt has been arranged to increase MPC controller intended at Single machine Infinite bus system (SMIB) together with FACTS devices. Explaining the effect of the constraints and tuning the weight. The recommended process is held with MATLAB simulation outcomes.

Keywords Power system stability, FACTS, system model, MPC.

1.0 INTRODUCTION

STATCOM is recognized with the regular that the voltage-source using inverter generates a controllable AC voltage source later the transformer leakage reactance consequently that the change of voltage through the reactance produces reactive and active power between the transmission system and the STATCOM to be swapped. The STATCOM is a particular of the substantial devices of FACTS and could be pointed at compensation of power systems of the dynamic system in the direction of giving amount of voltage and augment the stability [1-3].

Single-machine infinite-bus power systems equipped with a STATCOM model of a power system is known on behalf of the three foremost types of FACTS devices linked to the arrangement: "TCSC" Thyristor-controlled series compensator, "VC" static VAR compensator and "PS" Thyristor-controlled phase shifter. So as to check the damping functions for the above three FACTS the model has been castoff for the design and the investigation [4, 5]. Consequently, in this paper, the Single-machine infinite-bus power systems equipped with a STATCOM model is obtained, which result to have the matching framework by way of the unified model for TCSC, SVC and TCPS. Accordingly, the STATCOM fits on group devices of FACTS to be denominate through the SMIB model. Notice, though, there are vital deviations midst of devices of FACTS. The foremost is among TCSC and SVC as a foundation of the controlled-impedance and the TCPS and STATCOM as a foundation of the controlled-voltage. The next modification is that STATCOM has progressed as of the converter conformation of source of the voltage in the switch-mode through a device of energy-storage (DC capacitor) although TCSC, SVC and TCPS are recognized on controlled phase of diodes/ thyristors that do not have one device of energy-storage.

2.0 Single Machine Infinite Bus power system equipped with a ATATCOM

In the paper, the cast-off model is acknowledged for single-machine infinite-bus. The Presentations of STATCOM of the model equipped in the power system inspected and confirmed through an example SMIB power system. A diffident analysis describes that the voltage regulator of the STATCOM DC- improves negative damping to the fluctuations of power-system, which is certain through both nonlinear reproduction and calculation of eigenvalue. To respond to the outcome of negative- damping transferred by means of the voltage regulator of STATCOM DC, a stabilizer of STATCOM is positioned over on the voltage regulator of STATCOM AC, which is measured, and its significance is established through both nonlinear reproduction and eigenvalue calculation.

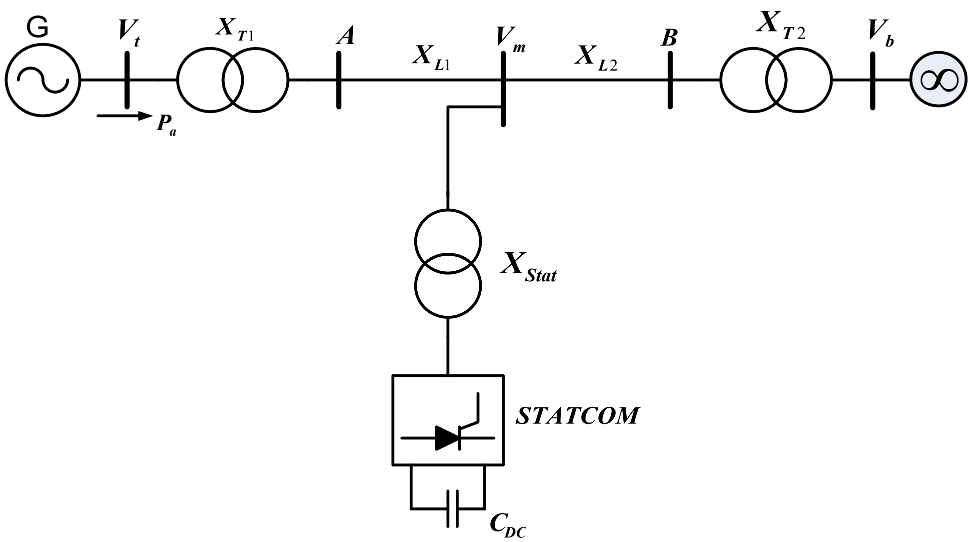

Figure 1.1: A *STATCOM equipped in a single machine infinite- bus of power system.*

A single machine infinite bus (SMIB) system with a STATCOM linked by a transformer is displayed is (**Figure 1.1),.**

The succeeding presumptions have been made for constructing the dynamic model of the arrangement [6]

The electromechanical swing equation for the generator are:-

$$\dot{\delta} = \omega_0(\omega - 1). \quad (1)$$

$$\dot{\omega} = \frac{1}{M}[P_m - P_e - D\omega]. \quad (2)$$

The dynamics of the current controller is :-

$$\dot{I}_S = \frac{1}{T}\left[-I_S + Ku\right] \tag{3}$$

Where,

$$P_e = \frac{e_q{}'V_m}{x_d{}'+X_1}\sin\theta + \frac{V_m^2}{2}\frac{\chi_d{}'-\chi_q}{(x_d{}'+X_1)(x_q+X_1)}\sin 2\theta. \tag{4}$$

$$V_{md} = \frac{(X_1+x_q)V\sin\delta + I_s X_2 \sin\theta(X_1+\chi_q)}{X_1+X_2+X_3}. \tag{5}$$

$$V_{mq} = \frac{(X_1+\chi_d{}')V\cos\delta + e_q{}'X_2 + I_s X_2\cos\theta(X_1+\chi_d{}')}{X_1+X_2+X_3}. \tag{6}$$

$$V_m = V_{md} + jV_{mq}. \tag{7}$$

Where, "δ" is the load angle in radian, "ω" is relative speed, M is the inertia constant in seconds, D is the damping constant, "P_e" is delivered electrical power, "I_s", u, K and T are the output current, control er output, gain and time constant of STATCOM, respectively. "V_m" in "Eq. (4)" is the terminal voltage of the STATCOM, "x'_d"and "x_q"are the direct and quadrate reactance of the generator, respectively. "X_1"and "X_2" are the addition of the reactance of the transformer and transmission line as shown in (**Figure 1.2),** The phase difference, θ between direct axis and quadrate axis of the generator is:

$$\theta = \tan^{-1}\left(\frac{V_{md}}{V_{mq}}\right). \tag{8}$$

Where"V_{md}" and "V_{mq}"are the direct a quadrate axis components of V_m, respectively. By linearizing equations (2 – 8) around an equilibrium point, one gets

$$\Delta V_m = Kv_{m\delta}\Delta\delta + K_{VmIS}\Delta I_s. \tag{9}$$

$$\Delta P_e = K_{Pe\delta}\Delta\delta + K_{PeIS}\Delta I_s. \tag{10}$$

Here, $$KV_{m\delta} = \frac{\partial V_m}{\partial I_s}. \quad (11)$$

$$K_{VmIS} = \frac{\partial V_m}{\partial I_s}. \quad (12)$$

$$KP_{e\delta} = \frac{\partial P_e}{\partial \delta}. \quad (13)$$

$$K_{peIS} = \frac{\partial P_e}{\partial I_s}. \quad (14)$$

The STATCOM current controller output is stated as :

$$\Delta u = -C_u \Delta V_m + C_\omega \Delta\omega. \quad (15)$$

Where, "C_u" and "C_ω" are the voltage and speed control of the control transfer function in the loop respectively. See (**Figure 1.2**).

The remote signal "$\Delta\omega$" is not willingly obtainable to STATCOM, nevertheless, it can be created through confined quantifiable variables such as terminal voltage of the STATCOM and current across the lines of transmission [7].

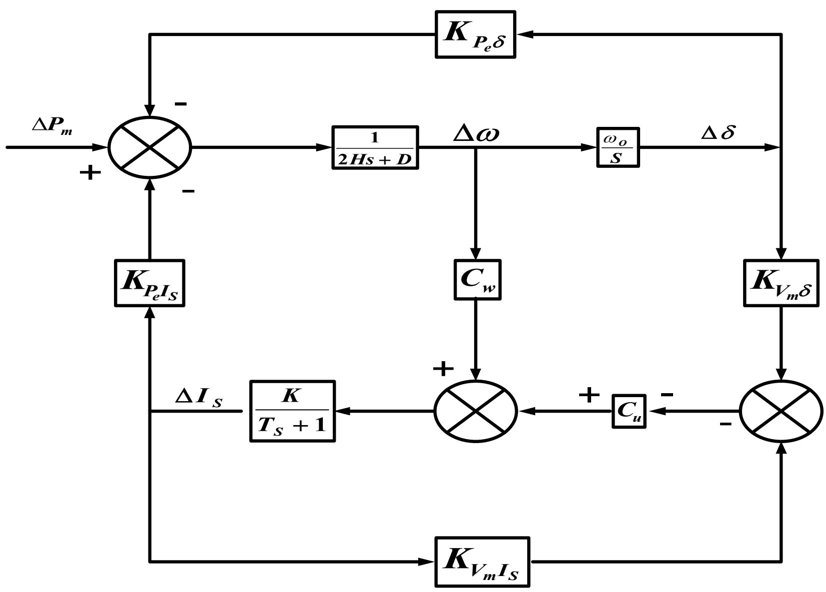

Figure 1.2: Block diagram of the linearized system

3.0 The Model Predictive Controller Indication

The output voltage of the voltage source converter can be matched through smearing suitable triggering pulses. This is refined through MPC.

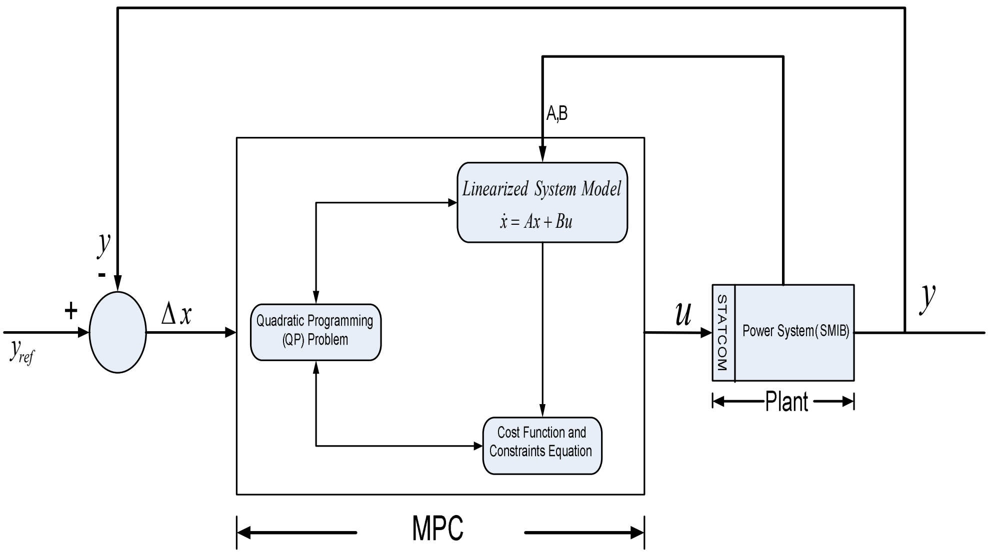

Figure 1.3: Block diagram of MPC with plant

The block figure of MPC with STATCOM and SMIB (Plant) is displayed in **Figure (1.3),** The MPC detect the mistake in the production and the matrices A and B from the linearized power system model with STATCOM. The strategy is articulated as a quadratic programming (QP) problem a constrained cost function is used.

The MPC design problem is controlled through the MPC toolbox obtainable in “Matlab”. The strategy and performance assessment of the MPC is showed based on changing the following parameters: Model and Horizons, Constraint and Weight Tuning.

The discussion include each one and its influence on the MPC result and what will occur if a minor deviation is applied at the values of these constraints.

TABLE 1.1: Case 1 Values

Case 1	
Control interval	0.1
Prediction horizon	10
Control horizon	2

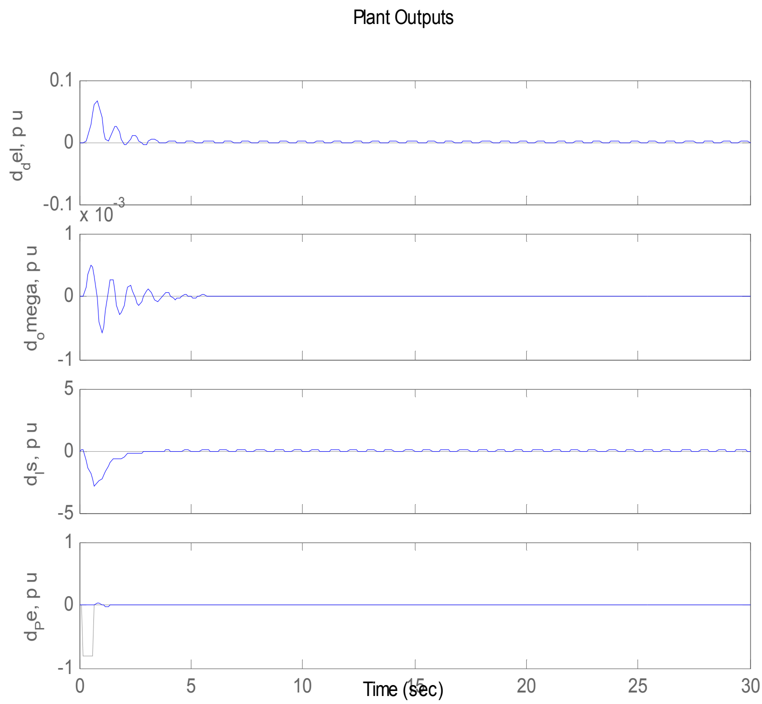

Figure 1.4: Plant output for case 1

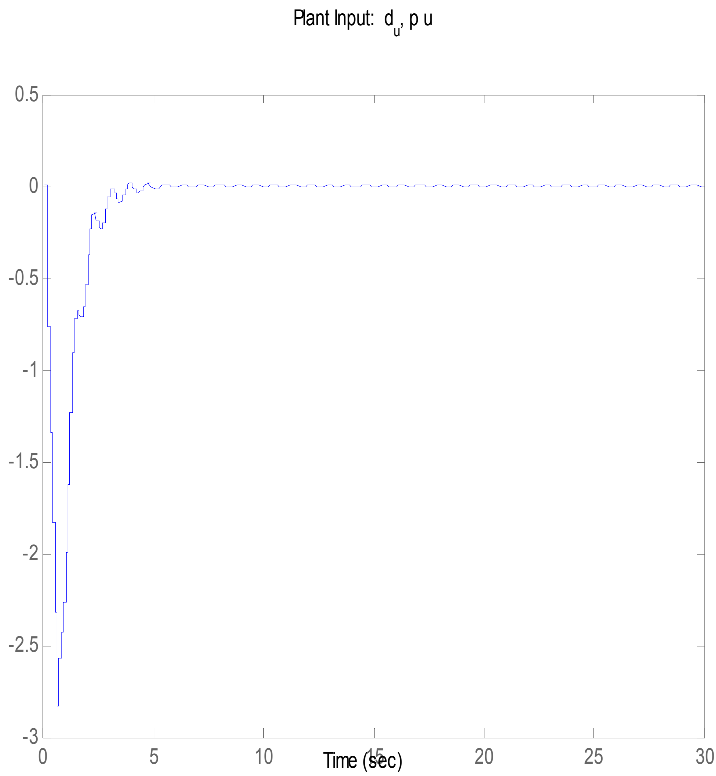

Figure 1.5: Plant input for case 1

3.1 CHANGING OF CONSTRAINTS

Constrains for the controller are the rate of change of weight matrices for the input and output variables. Maximum up rate and maximum down rates are the maximum rate at which a manipulated variable (u) can change from one step to the next step.

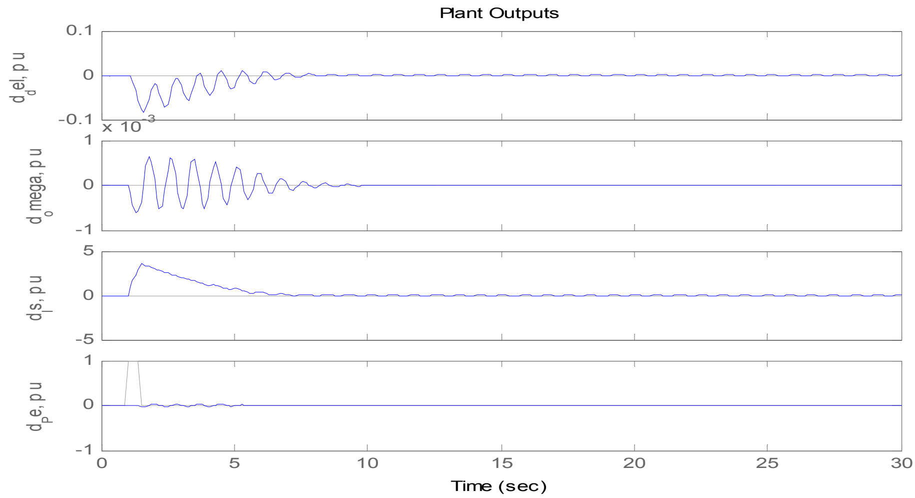

Figure 1.6: Plant output for the selection of Max up rate and Max down rate

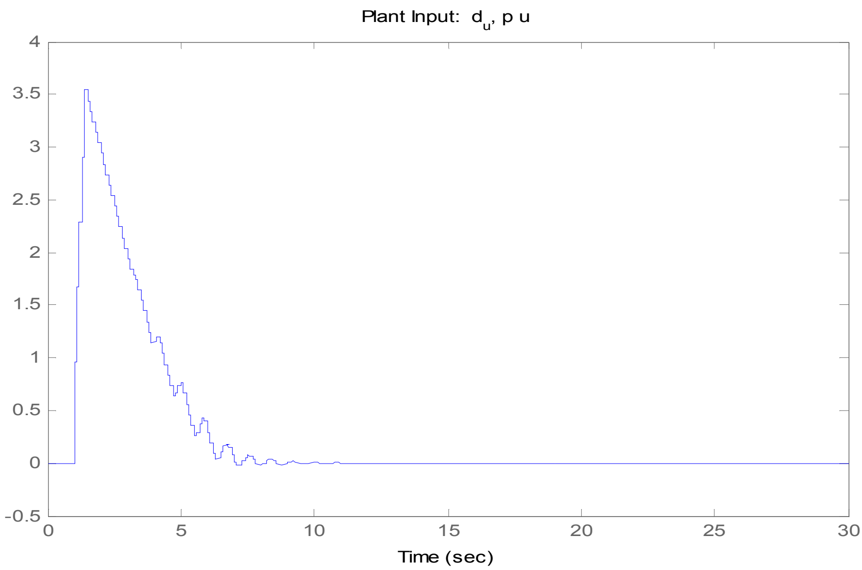

Figure 1.7: Plant input for the selection of Max down rate and Max up rate

The use of MPC for STATCOM is shown for the SMIB system. The controller designed was tested for a number of disturbance conditions. The MPC design has been found to be very effective for a range of operating conditions of the power system. The performance of MPC for SMIB system is tested by varying the control and prediction horizon and changing the control interval **Figure (1.4), Figure (1.5)**,.

It is found that variation of control interval up to a certain extent gives satisfactory result. The variation of prediction horizon has little impact on the controller performance **Figure (1.6), Figure (1.7),** unless it is made very large.

4.0 CONCLUSIONS

The practice of MPC for STATCOM is exposed for the SMIB structure. The controller aimed was verified for an amount of disturbance circumstances. The MPC scheme has been set up to be very operational designed for a variety of functioning conditions of the power system. The show of MPC for SMIB system is well-known through changing the control and prediction horizon and altering the control interval. It is originated that disparity of control interval up to a confident degree provides acceptable consequence. The deviation of prediction horizon has a slight effect on the controller presentation except it is made very large.

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