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Reactive Power Flow Control Using Voltage Dependent Reactive Power Control Strategy in PV Based Distributed Grid System

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***Abstract*— Utilization of grid connected photovoltaic systems is facing rise in voltage and reverse power flow problems which are indirectly complicating the reactive power flow control in power system network. It is highly needed to develop an appropriate solution which can control reactive power and for better voltage regulation. In this paper, the reactive power flow control is obtained with the help of reactive power centralized management system in a high voltage distribution along with characteristics of voltage dependent reactive power with photovoltaic system. The control of rise in voltage and reverse power flow is obtained at the medium voltage level which results in reactive power control interchange between in medium and high levels of voltages. The proposed system consists of two radial feeders at the grid connected PV system. The proposed system is modelled using Simulink and the results are provided to explain the reactive power control by controlling rise in voltage and reverse power flow.**

***Index Terms*— Grid connected Photovoltaic system, rise in voltage, reverse power flow control, reactive power control, radial feeders.**

I. INTRODUCTION

As the non-renewable energy sources such as coal, crude oil etc. are limited and they might be exhausted soon [1] and hence the necessity of discover and develop the optimum utilization of renewable energy sources to produce required power is playing a vital role [2-3]. Since, the power generated using renewable energy sources like solar, wind etc. are not stable [4] throughout the day or for a period and it results in causing various power quality issues [5].

In India, presently about 5000 trillion KWh energy [6,7] is capable to produce using solar systems such as solar thermal, solar photovoltaic etc. Photovoltaic systems are connected to distributed grid which no more reactive power source is not involved and causing rise in voltage, reverse power flow and its effect shows on reactive power at the grid [8,9].

Different reactive power management controls at distributed grid are centralized, decentralized and local strategies [10]. These reactive power control strategies able to applicable to regulate voltage levels in the distributed grid. There are several reactive power control methods like variable displacement factor dependent active power method, constant power factor method, the active power dependent reactive power regulation method and the voltage-dependent reactive power regulation method [11] are widely used to obtain optimal reactive control in the PV based distributed grid system.

II. REACTIVE POWER FLOW CONTROL METHODS

Due to instability of the PV system and it is connected distributed grid, several power quality issues were raised and mainly rise in voltage and reverse power flow issues causing disturbance to the power quality of the entire power system network. It means, the receiving voltage can be more at the end of the feeder than near the power transformer side.

The voltage rise due to the PV systems can be given by

$$ðV= [\ X*(Q_L+Q_{PV}) + R*(P_L+P_{PV})]\ ÷[V_N]$$

Where ðV = Voltage change across the line,
R = Resistance of the distribution line,
X = Reactance of the distribution line,
PL = Active power consumption with load,
QL= Reactive power consumption with the load,
P_{PV} = Active power of the PV System,
Q_{PV} = Reactive power of the PV system,
and
V_N = Nominal Voltage at Distributed Grid.

From the above equation, it can be observed that the reactive power of PV generation Q_{PV} can be used to regulate the voltage level at grid. The voltage control by reactive power regulation is obtained by the ratio of the system resistance to the system reactance (R/X ratio) in distribution system. Hence, reactive power control method is more useful in the middle distribution system than the low voltage distribution system due to having a lower R/X ratio. The reactive power control methods to support the voltage level can be obtained in various methods. few of these methods are

A. Constant Power Factor Method:

In this method, reactive power is injected when only active power of PV system presents. But this method results in unwanted reactive power consumption [12] and line losses.

Reactive power control is obtained by

$$Q_{PV} = P_{PV} * \tan Ø$$

where

Q_{PV} = injecting the reactive power of PV System,
P_{PV} = The active power of the PV System,
and
$Ø = \cos^{-1}$ (power factor).

B. Dependent voltage reactive power characteristics method Q(V):

This method directly involves in injection of required reactive power [13] by PV system. It is given by

Table no-I: Reactive power with different conditions of voltages

Quantity	Obtained by	Condition
Q_{PV}	$Q_{PVi\,MAX}$	$V<V_1$
	$Q_{PVi\,MAX}*(V-V_1)/(V_1-V_{MIN}) + Q_{PVi\,MAX}$	$V_1 \le V \le V_{MIN}$
	0	$V_{MIN} \le V \le V_{MAX}$
	$Q_{PVi\,MAX}*(V+V_{MAX})/(V_{MAX}-V_2) + Q_{PVi\,MAX}$	
	$-Q_{PVi\,MAX}$	$V > V_2$

Where,
Q_{PV} = Reactive power of distributed grid,
QPVi,max = Maximum reactive power of PV System
QPVi,min = Minimum reactive power of PV System,
I = The number of PV system,
V= Grid voltage,
And
V_1, V_2 = Voltage limits.

III. PROPOSED TECHNIQUE

In this paper, reactive power control management and voltage regulation is analyzed in the PV based distributed grid system using voltage dependent reactive power control strategy. Proposed technique is designed using Simulink and discussed with the results obtained for reactive power flow control as well as voltage regulation. With the proposed method to control reactive power flow and to obtain better voltage regulation along with reduction in reactive power consumption and line losses. Figure 1 shows the proposed block diagram of reactive power flow control in PV based distributed grid.

The required amount of reactive power is selected at HV/MV transformer. The change in reactive power is calculated by

$$ðQ = Q_G - Q_F$$

Where,
Q_G = Total reactive power from load and line losses,
Q_F = Fixed value for limit reactive power on the grid.

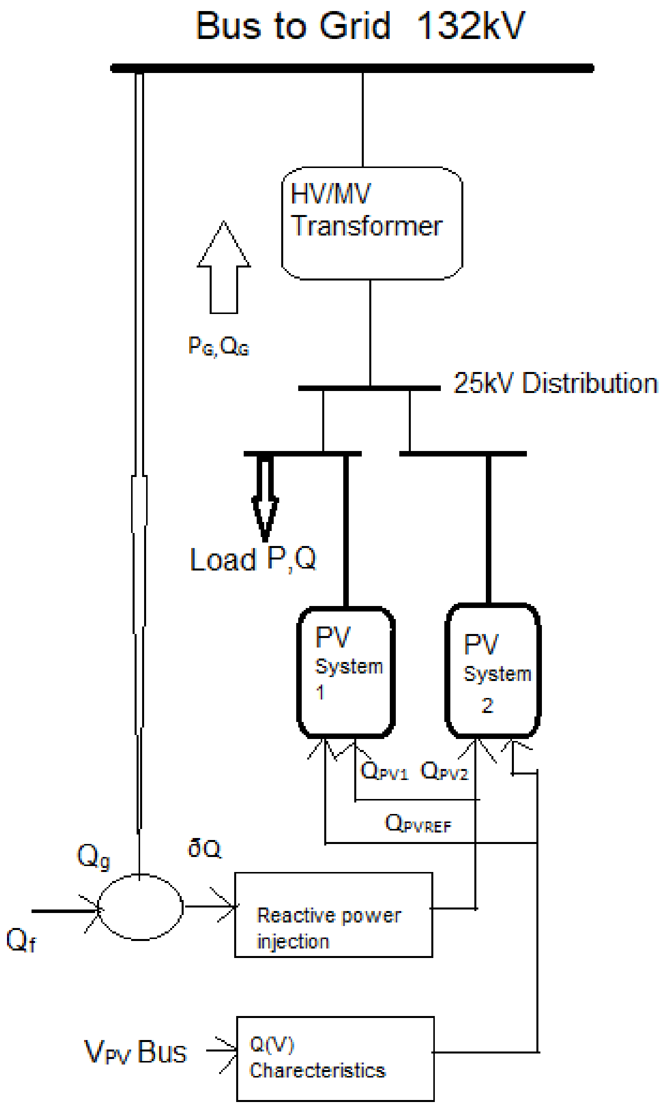

Fig. 1: Block diagram of reactive power flow control in PV based distributed grid.

Bus voltage is regulated by using reactive power control. The controller has estimated the reactive power set point and the limits within the operation area with respect to the voltage dependent reactive power characteristics Q(V). The reference value for reactive power Q_F according to the voltage limits as shown in table no.1. The circuit consists of 132KV distribution grid which connected by 50MVA, 132KV/25KV power transformer. The length of distribution lines 25KM and the size of cables are considered with 185 sq.mm of space areal cables. The system has two PV subsystems named as PV1 and PV2.

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In this PV1 subsystem supplies to a load. Centralized reactive power flow control technique is used to obtain required reactive power control for both PV1 and PV2 subsystems.

IV. RESULTS AND DISCUSSION

The proposed circuit is designed in Simulink and the results are shown in fig.2 and fig.3.

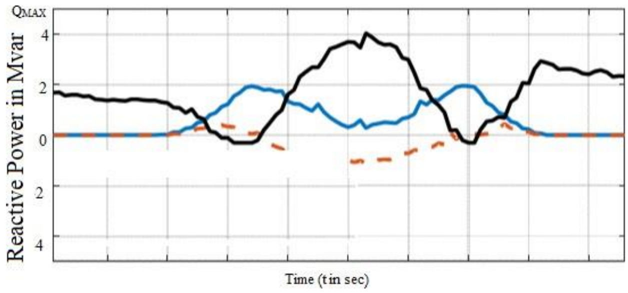

Fig. 2 : Reactive power injection with respect to grid for PV1 and PV2 sub systems.

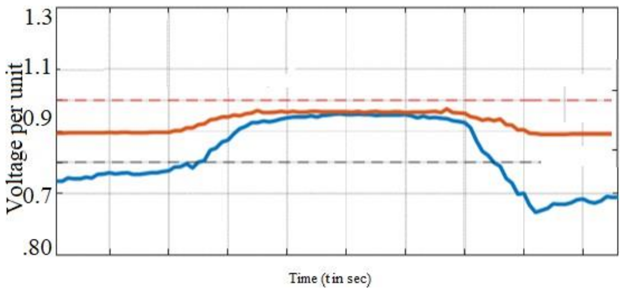

Fig.3: Voltage regulation overserved at both PV1 and PV2 subsystems.

Centralized reactive power flow control technique is applied to achieve the results. The changed Q(V) characteristics help to provide the reactive power on the distribution grid and regulates the bus voltage of PV system. Fig. 2 and Fig.3 shows the magnitude reactive power and voltage regulation. In Fig. 2, results of the proposed control method can inject or consume the reactive power on a distribution grid. The PV1 and PV2 injects the reactive power to support the distribution grid during the time period. Fig. 3 indicates that the proposed control method can mitigate the rise in voltage during the time period. The proposed control method can maintain stability and reduce the rise in voltage.

V. CONCLUSION

in this paper, different types of reactive power control strategies for a PV based distributed grid were discussed. In this paper, the proposed method uses the centralized reactive power flow control strategy and with modified voltage dependent reactive power Q(V) characteristics.in simulation results, reactive power in MVAr and voltage regulation for shown for the proposed strategy, which better than the other strategy.

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Shravankumar Venumula had completed M.Tech (EPE) in 2010. his interested area in research is Renewable Energy-Power quality.