

Fuzzy Based Reverse Power Flow Control in ST-Fed Distribution Grid

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Abstract: In the recent trends there is a vast increase in the Distributed Grid, in the distributed grid there will be a reverse power flow from MV grid to LV grid due to the variation of the load. The reverse power flow from LV to MV grids is due to high DG power production and low load consumption. The Smart Transformer controls the voltage waveform in LV grid, and it can offer the possibility to avoid the reverse power flow. By using a Smart Transformer the reverse power flow can be limited to some extent. By use of this Smart Transformer there is no need of step-up or step-down voltage and controlling can also be done. By using Fuzzy Logic Controller at the MV side the harmonics are reduced. In this paper the mitigation of reverse power flow is carried out using a Fuzzy Logic Controller. Simulation work is carried out with MATLAB/Simulink Software. It is found that reduction in stability time from 0.15 second to 0.05 second is achieved and constant DC voltage is achieved without any transients.

IndexTerms - Smart Transformer (ST), Fuzzy Logic Controller, Fuzzy sets, Phase Locked Loop (PLL).

I. INTRODUCTION

In the last few years, there is a drastic change in the energy supplies to the system. The production of energy using small generators in the centralized power plants is increased. Renewable energy sources such as solar, wind, hydro have become the major part in the generation of electricity. For illustration 15% of energy share depends on the renewable energy sources in Germany. The distribution grid, the distributed grids are designed in such a manner, that they doesn't change the production of energy. As a result, the LV grid are connected by a large amount of distributed low power sources in the last few years, which causes some stability problems in the grid such as: reverse power flow in transformer, voltage improvement, unpredicted isle operations, empathetic tripping, etc.

In reverse power flow circumstances the Medium Voltage (MV) and Low Voltage (LV), power in the MV grid reverses. This is due to the production of more power, and the pressure of the load is less. It increases the voltage till the upper restrictions with the help of Distributed System Operator (DSO).

Distribution grid is the ultimate stage of the electrical grid in which electricity can be distributed to homes, industry, and different finish use product. Distribution is the method of reducing power to safe customer-usable levels, and delivering the electrical power to the grid. The ability level is reduced by reduction transformers that lower the voltage of the electricity from dangerous levels (over 1kV) to safer levels (100 - 400 V). The complete distribution grid includes lines, poles, transformers, change and protection circuits that deliver safe wattage.

There are mainly four types of distribution grid as follows:

- Extra-high-voltage-level: The 380kV or 220kV electricity flows into the transmission grid from the power plants and from abroad. This stage is reflected as the Extra-high-voltage level.
- High-Voltage level: The range of voltage between 36kV and 150kV is reflected as high-Voltage level.
- Medium-Voltage level: The range of Voltage between 1kV and 36kV is referred as the Medium-Voltage level.
- Low-Voltage-Level: Any voltage below 1kV is reflected as Low-Voltage level. This the voltage at which the electricity reaches the power sockets of households.

Fuzzy logic is a suitable method to chart an input and output spaces. The Fuzzy Logic is similar to Boolean Method which was given by the author Lotfi Zadeh in year 1965 which is basically resembling the theory of mathematics of the fuzzy logic system(fuzzy sets), which is the concept obtained by traditional theory of sets. The initiation of the perception in diploma inside

the examination of the state, hence allowing the state in the country apart from proper or fake, fuzzy logic judgement offers a totally flexible for the interpretation that helps to keep in mind incorrectness and vagueness.

II. METHODOLOGY

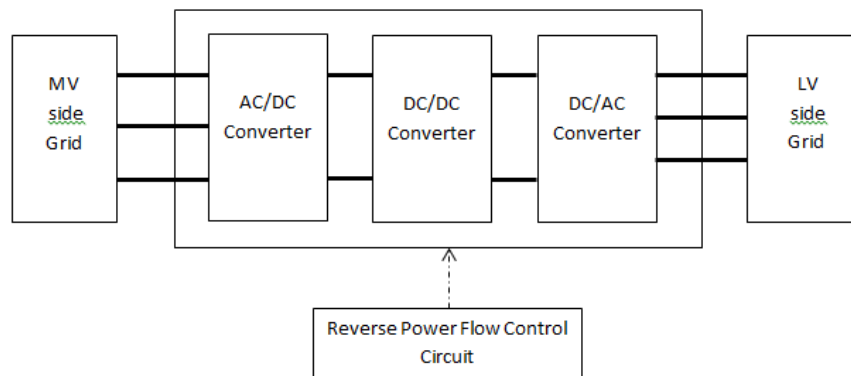


Figure 1.1: Block diagram of the proposed system

The block diagram for the proposed system is shown in the Figure 1.1. It consists of the following components with Fuzzy Logic controller in Reverse Power Flow Control circuit

In this paper the Smart Transformer is the combination of three converters which are as follows:

- Rectifier (AC-DC)
- Bidirectional Converter(DC-DC)
- Inverter(DC-AC)

The paper consists of a ST which is having three converters since ST can control the output voltage automatically using Bidirectional DC-DC converter.

1. **RECTIFIER (AC-DC CONVERTER):** It is an electrical device that converts AC into DC. It produces the output voltage double as the input by using the bridge rectifier as in the case of full wave rectifier using centre tapped transformer. This circuit won't require this for the resemblances of low cost rectifier. Half wave and full wave rectifiers are also used in getting the rectified signals.
2. **BI-DIRECTIONAL DC-DC CONVERTER:** A bi-directional dc-dc converter is a power electronics based device that converts input dc source from one level to another level. They are used in both low & high power applications. They are used in various portable devices like mobile phones, laptops which require dc power for the operation. These converters regulate the output voltage. They are also used for the voltage conversion at 50Hz frequency.

This converter is called as bidirectional DC-DC Converter because it will operate in two basic modes which are

1. Buck Mode
 2. Boost Mode
3. **INVERTER (DC-AC CONVERTER):** An inverter is a DC-AC converter. It has a DC source symmetrical to a battery or the controlled rectifier output.
 - The generated output voltage waveform of the inverter may be a square wave, semi square wave or low mutilated sine wave.
 - The generated voltage is often controlled with the help of drives of the switches.
 - PWM inverter is used to monitor the output voltage of the inverter.
 - If there is no sinusoidal waveform of the generated voltage of the inverter contain music at that non-sinusoidal point.
 - By using some control plans the harmonics can be decreased.

Due to the drawbacks of Current Source Inverter as they cannot withstand the reverse power flow voltage, hence Voltage Source Inverter is preferred.

The proposed Smart Transformer (ST) is a three-stage power electronics transformer transforms the voltage from the MV to the LV grid, makes available the DC grid connections, provides new services to the distribution grids like the load identification and control and offers new solutions to current problems, like the possibility to deal with the reverse power flow conditions.

Although several topology solutions can be studied for each stage, the control strategies do not differ substantially. The MV side keeps the MV DC link voltage fixed to the nominal value, absorbing or injecting the needed power in the MV grid. Moreover, the MV converter controls the reactive power injection in the MV grid. The ST can work under constant power factor, or provide reactive power support injecting reactive power. The reactive power set-point can be set locally by a V/Q droop controller, or remotely from a centralized controller. The DC/DC converter absolves two duties: to transform the voltage from MV to LV and to control the voltage level of the LV DC link. The DC/DC regulates the power flow between the two DC stages in order to keep the LV DC link voltage.

III. SIMULATION AND RESULTS

The simulation of the proposed is obtained using MATLAB using Simulink.

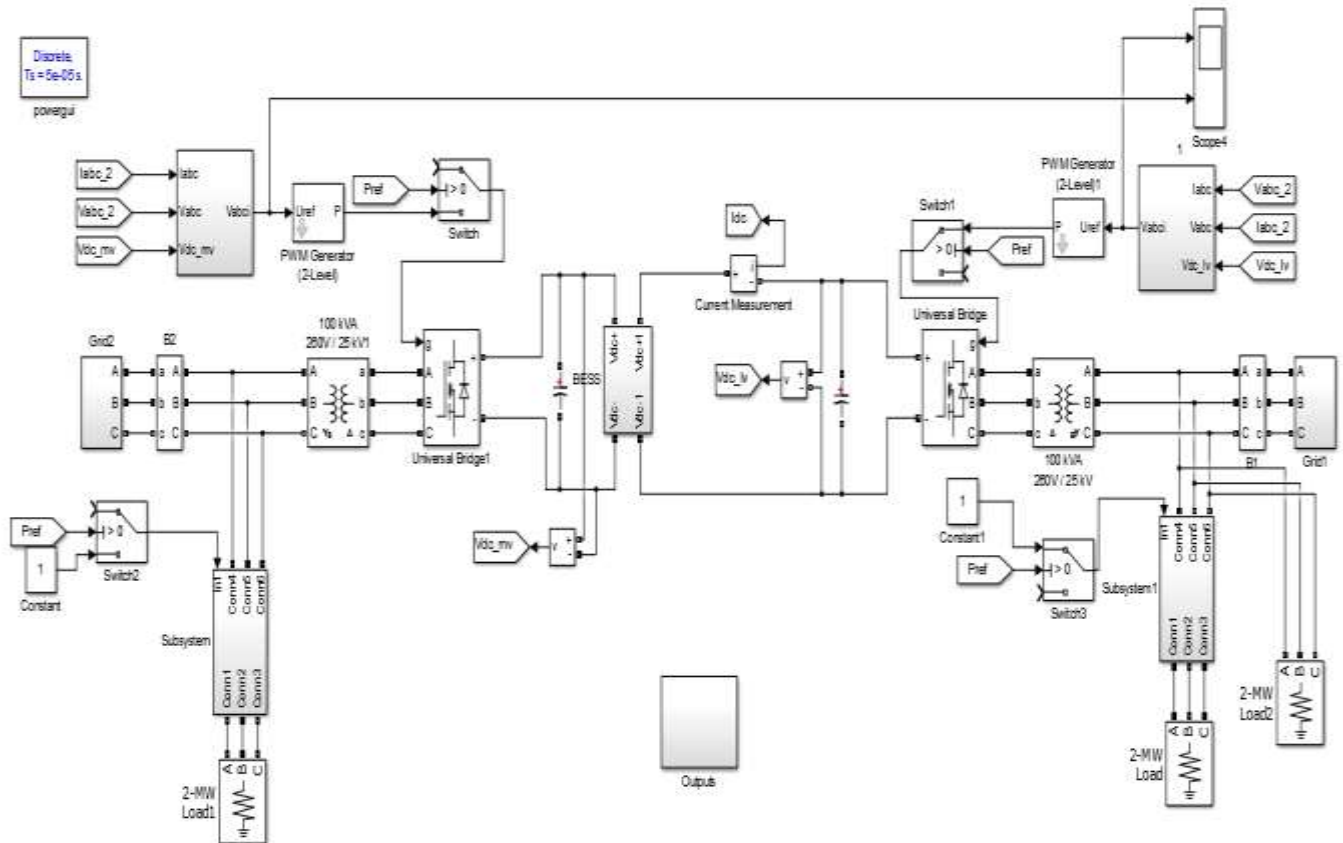


Fig3.1: Simulated circuit of reverse power flow control in MV grid.

The simulation of reverse power flow is done by using Fuzzy logic controller and PI controller; the controller part of Fuzzy logic block is shown in below fig.3.2. The control strategy of the existing system is done by using Fuzzy Logic controllers, in real power flow when the DC voltage 1p.u. is being compared with the DC voltage of MV which is being converted into p.u. with the help of the gain, then the error signal is being sent to the fuzzy logic controller.

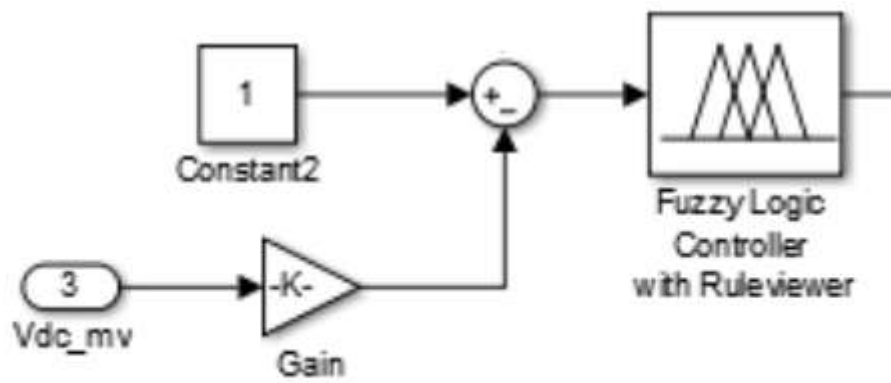


Fig3.2: Fuzzy Logic Controller

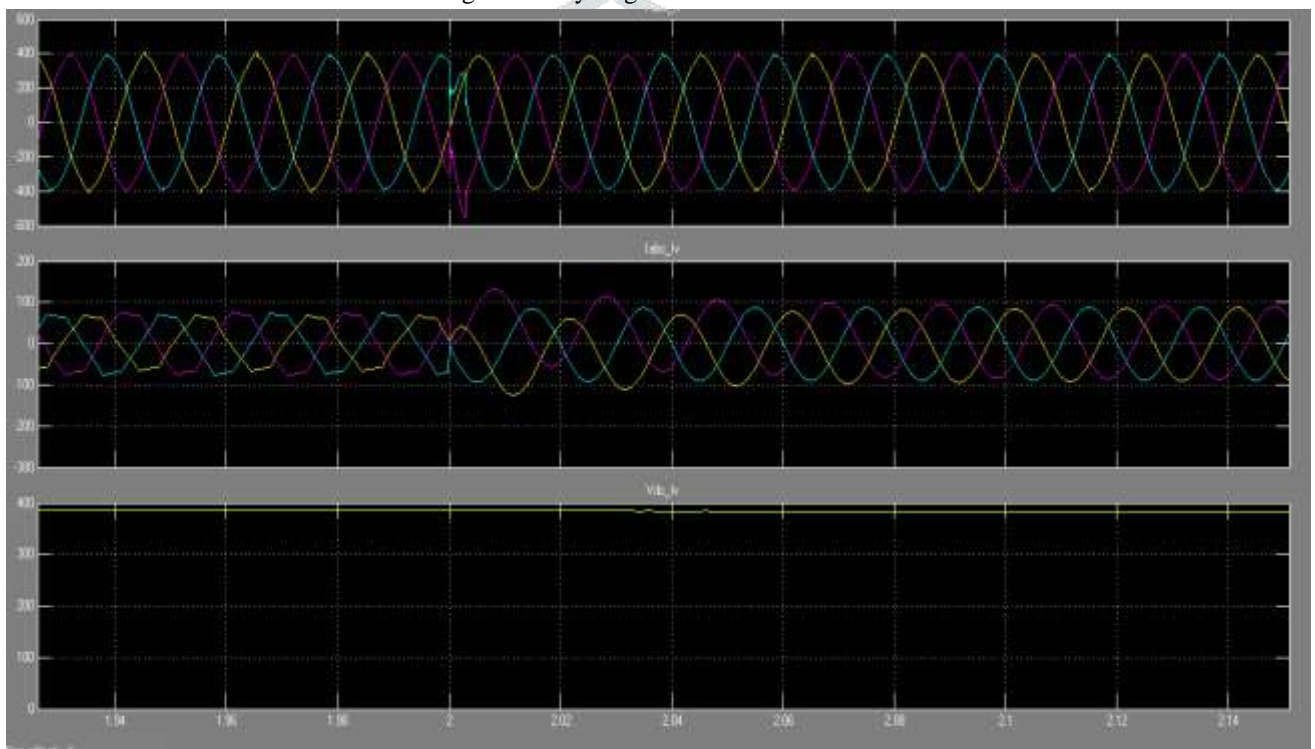


Fig3.3: Waveform of Current and Voltage at LV grid

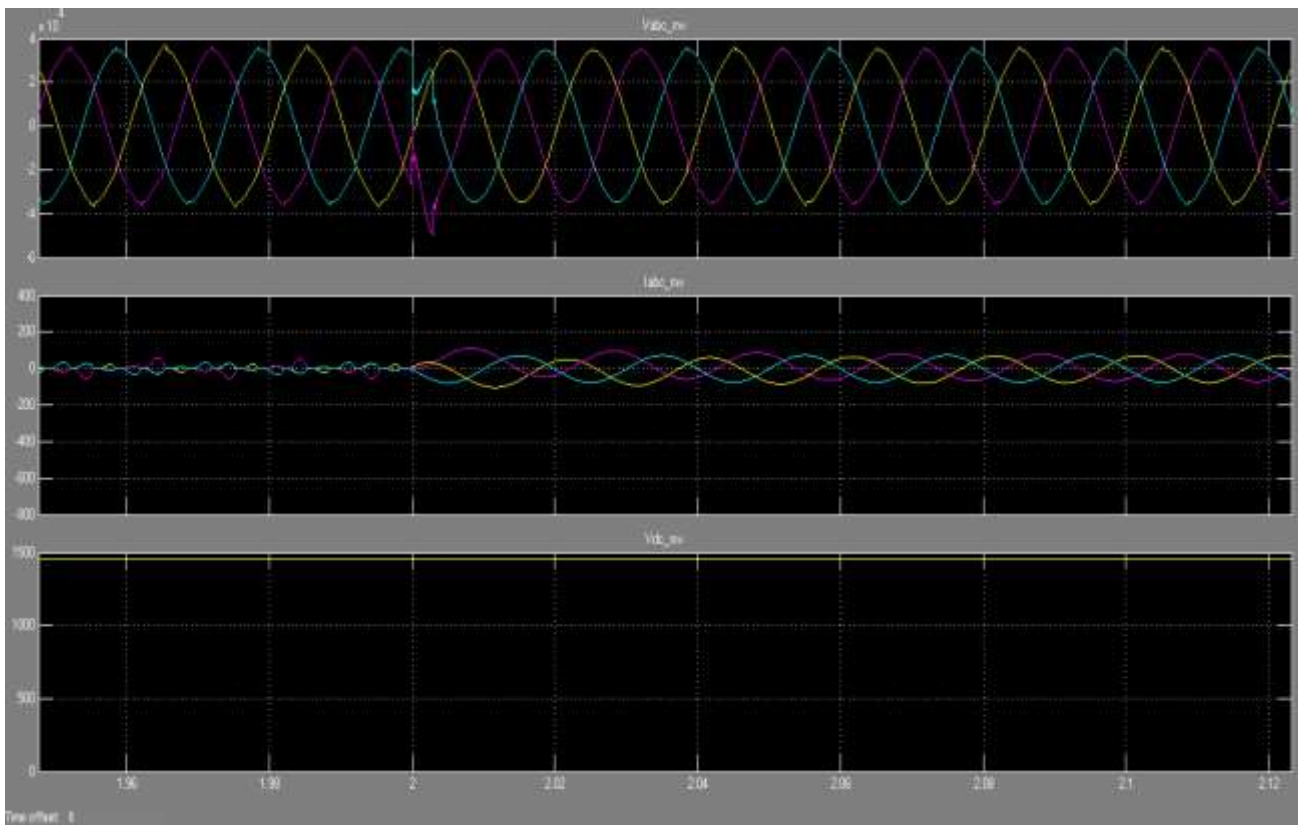


Fig3.4: Waveform of Current and Voltage at MV grid

IV. CONCLUSION

In this research work reduced harmonics, steady state stability within less time period is achieved. Compared to PI controller the time period is reduced from 0.15seconds to 0.05 seconds by using Fuzzy Logic Controller. Hence Fuzzy Logic Controller is more prominent because of its performance and stability of the system. Fuzzy Logic helps to achieve constant DC voltage without any transients when the power flow is reverse biased.

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