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Designing Of A Smart Transformer

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Abstract: As an integral part of the Smart Grid, smart transformers both work independently to constantly regulate voltage and maintain contact with the smart grid in order to allow remote administration if needed and to provide information and feedback about the power supply and the transformers themselves. Through a process known as voltage optimization, a smart transformer provides the exact amount of power that is needed, and responds instantly to fluctuations within the power grid, acting as a voltage regulator to ensure that the optimized voltage is undisturbed. Because they directly reduce energy consumption, smart transformers therefore directly reduce greenhouse gas emissions as well. As a recognized Smart transformer are a ready and significant source of LEED Points for any business or organization in pursuit of LEED certification. This makes them an important part of any energy retrofit or lighting retrofit. While smart transformers immediately reduce power consumption by providing a stable, optimal power supply that supplies electrical equipment with its ideal voltage, they also protect electrical equipment from power fluctuations – thereby helping electrical equipment last longer. In this paper we discuss on a continuous and discrete smart transformer which is accurate and fast respectively. The continuous smart transformer has a continuous turn ratio and it controls the microgrid side voltage without voltage steps, there for it increases the system accuracy and on another side discrete smart transformer has discrete turn ratio, the output is regulated between several discrete values and discrete smart transformer is less accurate.

Index term: smart transformer, microgrid, voltage droop control, on load tap changing transformer, smart transformer control strategies

I. INTRODUCTION

Micro grids are future power systems which provide clear and economic power to the utility network. In a microgrid, energy sharing between a producers and consumers is point to point system. Smart transformers are programmed to, as a default, provide an voltage optimized power supply that directly addresses their facility's energy needs. Additionally, through their smart grid connectivity, smart transformers can be administered dynamically, allowing facilities to monitor and manage the transformers directly during periods of power fluctuation, and helping them ensure that their power supply remains voltage optimized even when new demands are being placed upon it. Most appliances are designed to work with a percentage of voltage away from the base. A smart transformer delivers voltage directly at the base, which means appliances work at their most efficient – they last longer and use less power. But it requires a large investment on additional communications and also decreases the system reliability. There for to make a system more controllable and less communications a ST concept is introduced [1]. ST is located at the PCC of the system, which controls the voltage in certain limits. ST also mitigating the voltage increases and decreases [7]. Basically a smart transformer is MV/LV transformer which is equipped with electronically operating tap changer [2]. By the help of this it changes its taps position online and with small voltage steps in order to reach at desired value. There for the voltage at LV side is not directly linked with MV micro grid.

2. OVERVIEW OF SMART TRANSFORMER CONCEPT

In order to reduce the communication data for controlling the power, the ST concept is presented. ST is a device which is the controlled online tap changing transformer that is connected at the point of common coupling of the microgrid, as depicted in fig.1. It is smart in the sense that its control strategy is able to control its microgrid side voltage [3]. In medium-voltage networks, basically on load tap changer transformers (OLTCs) are already in the place so STs require only little modification. But in the low voltage networks, mostly manual tap changer transformers are used, therefore voltage control is offline and not automatically.

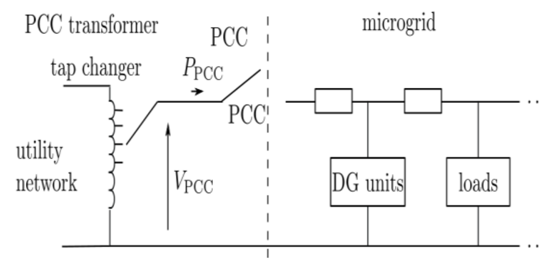

Fig. 1: Smart transformer located at the PCC of the microgrid [1]

And this will increase the system load which makes the system unreliable and less accurate. Therefore many tap changing transformers at the beginnings of the low-voltage lines. By increasing demand of DG units and risk of overvoltage also increased. Therefore ability of automatically tap changing transformer is more interesting and is more effective, faster and cheaper. Hence all manual transformers are upgraded to OLTCs. The OLTCs with smart control strategy, i.e., the ST, controls the PCC power by controlling the micro grid side voltage. If grid is equipped with voltage droop control than these elements automatically change their input/output power. The VBD control strategy, illustrated in Fig. 2, has originally been introduced for a stable operation of low voltage islanded microgrids [2]. For the active power control of the DG units, Vg/Vdc droop controller and P/Vg droop controller combination is consisted in VBD with Vdc the dc-link voltage, where the power of the dc link is provided by the available renewable energy and Vg the terminal voltage of the DG unit. The former enables power balancing of the DG units' ac and dc side and an effective usage of the allowed tolerance on the variations of terminal voltage from its nominal value for grid control. By using P/Vg droop controller voltage limit violations are avoided by changing input power of the unit. It is combined with constant-power bands that delay the active power changes of the renewable (wide constant-power band) compared to those of the dispatchable DG units to more extreme voltages.

3. SMART TRANSFORMER REALISATION

A. General principle

Basically the power exchange between the micro grid and utility network is by a ST. with the help of ST we can exchange power bidirectional and also gather information to determine the power set points for power exchange. To control the power of the micro grid ST controls the micro grid side voltage working as an OLTC. Hence the voltage based control of the micro grid DG units is coupled to a voltage based control of the ST.

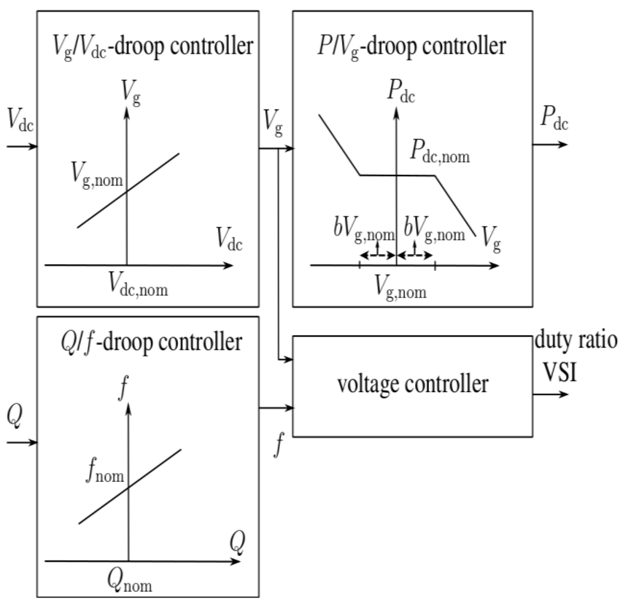

Fig. 2: Voltage based droop control strategy [1]

B. Continuous smart transformer

To build a continuous transformer first, a variable voltage is obtained by a carbon brush which is rotated on silver plated commutator on the circumference of a ring core transformer. To drive these brushes a motor is connected to brushes and works on a ‘up’ and ‘down’ command. The output voltage is can be adjusted both in positive and negative directions. This involves the use of a additional winding on the side of carbon brush. This configuration provides the control on voltage over a wide range. In practice, however, the transferred power of a transformer is limited due to current limitations in the windings. This causes limitations to the increase of voltage when power is transferred from the side with carbon brush to the side with fixed connection since extremely lowering the brushes can cause a very high current in the side with carbon brush in order to transfer the same power as is desired on the side with fixed connection. In commercially available variable transformers there is fixed number of additional windings above the fixed connection point. There it is difficult to transfer a large voltage from a fixed point to a carbon brush side. And also it is difficult to decrease a large voltage from the side of carbon brush to the side of fixed connections. Other limitations are occurring from accuracy, due to limited number of turns on a coil. The accuracy of the system can be improved by the use of additional isolating transformer. By the help of this additional isolating transformer we can increase and decrease the voltage. To provide the controlled voltage to primary side of the isolating transformer than variable autotransformer is used. This makes the ST much more accurate for the same accuracy of the brushes drive mechanism. By using double pole change over switch between two transformers will determine if the isolating transformer provides a voltage increase or decrease. Advantage of this is that it makes the system more accurate.

C. Discrete smart transformer

To make these types of transformer one step down isolating transformer is required in which by using step switch secondary can be made variable. The principle of these transformers is same as OLTCs. Secondary is made variable by using switch is due to installation of taps on primary is difficult. We can judge the direction of current on secondary by using change over switch. This tells us that, isolating transformer provide voltage increase and decrease. The power variation is by step by step hence the name discrete transformer. Because it is made by electronic switches there for they can work much faster than conventional OLTCs.

5. CONCLUSION

As the demand of energy increasing day by day, this results in decreasing the quality of the power and also increase in different type of faults occur on the system. This will makes the system unreliable and slow downs the system. To prevents system from faults and to make the system more reliable smart transformer are used. In this paper, two major concepts, the continuous and the discrete ST, are developed and built with focus on the use of the ST as a power controller between utility grid and micro grid and also focus on the control strategies of smart transformer. The continuous ST has the advantage that the control of power can be more accurate, where the discrete ST has the advantage that the control of power is fast. . It is proven that the power exchange between utility grid and microgrid is being realized by changes in the microgrid-side voltage. A smart transformer attenuates the voltage fluctuations and provides the improved power to the customers.

5. REFERENCES

[1] Wim Willems, Tine L. Vandroorn D. M. De Kooning; “Development of a Smart Transformer to control the power of a Micro grid”, 4th IEEE PES Innovative Smart Grid Technologies Europe, 6th-9th Oct 2013, Copenhagen.

[2] T. L. Vandoorn, J. D. M. De Kooning, B. Meersman, J. Guerrero, and L. Vandevelde, “Voltage-based control of a smart transformer in a microgrid,” IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 1291-1305, Apr. 2013

[3] T. L. Vandoorn, B. Meersman, L. Degroote, B. Renders and L. Vandevelde, “A Control Strategy for Islanded Microgrids with dc-link Voltage Control,” IEEE Trans. Pow. Del., vol. 26, no. 2, pp. 703-713, Apr. 2011

ISSN 2347-4289

[4] T. L. Vandoorn, B. Renders, L. Degroote, B. Meersman, and L. Vandevelde, “Active load control in islanded microgrids based on the grid voltage,” IEEE Trans. Smart Grid, vol. 2, no. 1, pp. 139-151, Mar. 2011

[5] J. Faiz and B. Siahkolah, “New Controller for an Electronic Tap Changer - Part I: Design Procedure and Simulation Results,” IEEE Trans. on Power Delivery, vol. 22, no. 1, pp. 223-229, Jan. 2007

[6] J. Faiz3 and B. Siahkolah, “New Controller for an Electronic Tap Changer - Part II: Measurement Algorithm and Test Results,” IEEE Trans. on Power Delivery, vol. 22, no. 1, pp. 230-237, Jan. 2007

[7] P. Kadurek, J. F. G. Cobben, W. L. Kling, “Smart medium and low voltage transformer for future grids”, IEEE International Symposium on Power Electronics, Electrical Drives, Automation and Motion, 2010