

Simulation Analysis of Balanced and Unbalanced System for Microgrid Voltages, Currents and Power

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Abstract— The quality of power is the major issue in the power system. The issues related to power quality are more attentive in microgrid system. So the power value is very much affected by the magnitude and phase disturbances of three phase voltage and current respectively. So the design of smart meter is applicable to look over these values and control the situation. This device successfully used for almost most of the disturbances such as harmonics in voltage and current, unbalancing in voltage and current, voltage lead and lag etc. The optimization techniques to improve the Power Quality in the transmission and distribution system for microgrid using smart meter is analyzed and studied first by observing on MATLAB/SIMULINK simulation.

Key words: Microgrid, Power Network, MATLAB/SIMULINK, Harmonic Distortion, Balanced System, Unbalanced System

I. INTRODUCTION

Smart meters are widely used in power grid, which plays an important role in building the smart power grid and its stability is the key to stable operation of the grid. However, the reliability prediction of the smart meters is difficult to be performed due to its huge number and it cannot be tested one by one. In order to study the prediction method, according to the working principle of smart meters, a simulation smart meter model based on Matlab/Simulink software is presented in project. And related experiments are performed to measure the power values under different loads, the voltage measurement, current measurement, harmonic distortion, and hence, the correctness of the presented module is verified.

II. POWER NETWORK, BALANCED SYSTEM, ELECTRIC POWER CHARACTERISTICS

A. Power Network

An electric power system is a network of electrical components used to supply, transfer and utilize electric power. An example of an electric power system is the network that supplies a region's homes and industry with power for sizeable regions, this power system is known as the grid and can be broadly divided into the generators that supply the power, the transmission system that carries the power from the generating centre's to the load centre's and the distribution system that feeds the power to nearby homes and industries. Smaller power systems are also found in industry, hospitals, commercial buildings and homes. The majority of these systems rely upon three-phase AC power—the standard for large-scale power transmission and distribution across the modern world. Specialized power systems that do not always rely upon three-phase AC power are found in aircraft, electric rail systems, ocean liners and automobiles. Electric power is the product of two quantities:

current and voltage. These two quantities can vary with respect to time (AC power) or can be kept at constant levels (DC power). The ability to easily transform the voltage of AC power is important for two reasons: Firstly, power can be transmitted over long distances with less loss at higher voltages. So in power systems where generation is distant from the load, it is desirable to step-up (increase) the voltage of power at the generation point and then step-down (decrease) the voltage near the load. Secondly, it is often more economical to install turbines that produce higher voltages than would be used by most appliances, so the ability to easily transform voltages means this mismatch between voltages can be easily managed.

B. Balanced System Grid

One of the main difficulties in power systems is that the amount of active power consumed plus losses should always equal the active power produced. If more power would be produced than consumed the frequency would rise and vice versa. Even small deviations from the nominal frequency value would damage synchronous machines and other appliances. Making sure the frequency is constant is usually the task of a transmission system operator. In some countries (for example in the European Union) this is achieved through a balancing market using ancillary services. In other words simply balance system can be defined as, when voltage magnitude, current magnitude of all three phase are equal and 120° phase apart. In active power oscillations is introduced which oscillates power and voltage, current value is less can be known as balances system.

C. Electric Power Characteristics

The electrical characteristics of the power supply describe the quality of the power supply's outputs, and its ability to handle special situations such as disruptions or disturbances to its input power, or variations in the loads the power supply drives. Different cases for balanced and unbalance system generates the characteristic for voltage, current, and power with respect to time. These can be observed in following figures below in form of simulations results on MATLAB.

III. SIMULATION RESULT FOR BALANCE GRID VOLTAGE AND BALANCE GRID CURRENT

Balance system can be simply defined, where, voltage magnitude of all three phases are equal and are 120° apart. Again current magnitude of all three phases is equal and 30° apart. So further when voltage, current and power is measured on graph with respect to time, it is noticed that graphs are linear and calculated voltage value and current value in V_{rms} and I_{rms} are balanced. Power value is also seen linear.

Figure.1. indicates the 3-phase voltage measurement with respect to time where time t=0 to 100. From graph all three phases R, Y, B seemed to be equal in amplitude which is calculated by

$$V = \sqrt{2} * V_{rms} = \sqrt{2} * 230 = 325.269 \text{ V}$$

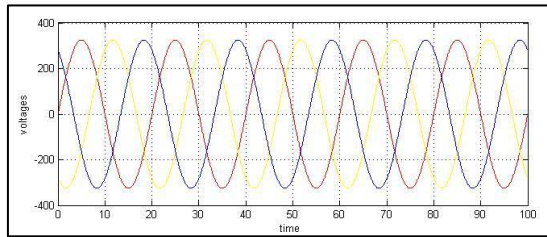


Fig. 1: Balance grid voltage.

Figure 2. shows simulations result for current with respect to time. It is calculated by $I = \sqrt{2} * I_{rms}$, where I_{rms} is taken 10 value so we get, $I = 14.14A$. By varying I_{rms} value we can observe the current peak value at different points

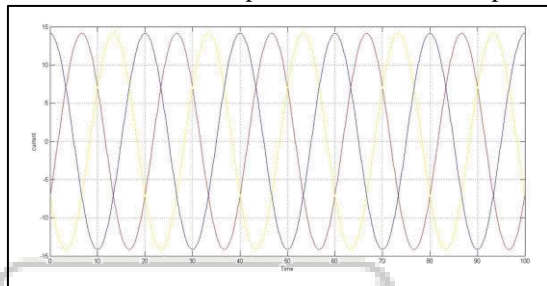


Fig. 2: Balance grid current

Figure.3. shows simulation for power value where we can see that power is balance due to equal magnitude and phase of voltage and current. The graph is seen linear for power with respect to time plotted at 6000. It is calculated by,

$$\text{Power} = 3 * V_{rms} * I_{rms} * \cos(30^\circ)$$

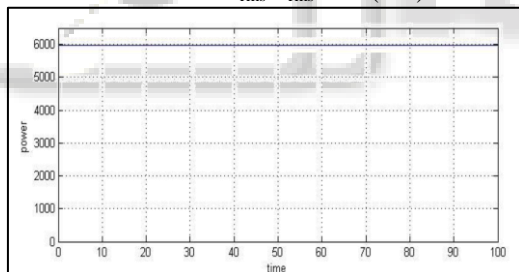


Fig. 3: Power under balance

IV. SIMULATION RESULT FOR UNBALANCE GRID VOLTAGE AND UNBALANCE GRID CURRENT

In case of unbalanced condition, oscillation is introduced which oscillates power and this results in small values in voltage and current. The supplied voltage will remain always the same but changes and variation is noticed in magnitude (or amplitude) of voltage or current value which can be seen in figure.4. and figure.5. respectively. These variations/distractions occur due to change in amplitude or phase of voltage or current value of any three individual phases or more than one phase. Similarly, figure.6. shows unbalanced power with respect to time where the graph is non-linear and oscillates with distortion. This can be compared with the balanced condition which implies that for a balanced condition power is linear, while for an unbalanced condition power is non-linear which oscillates in positive and negative sequences and is analyzed and detected.

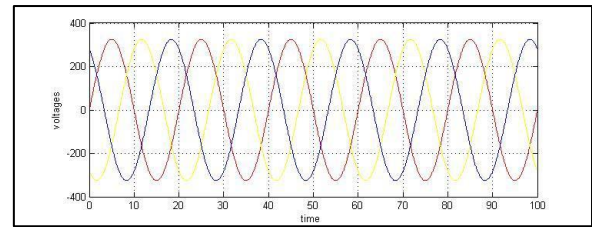


Fig. 4: Unbalance grid voltage.

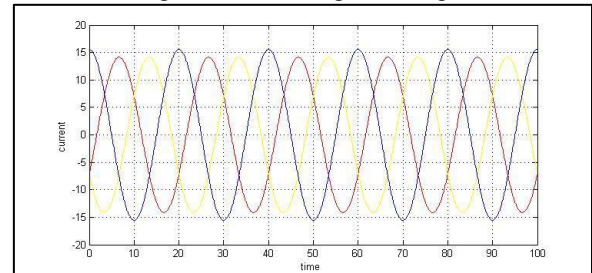


Fig. 5: Unbalance grid current.

This is an unbalanced case of power where, due to variations in magnitude or phase, an unwanted signal occurs in the graph of power. We can notice that in a balanced condition power is linear at 6000, while in an unbalanced condition a distorted wave is seen like a sine wave.

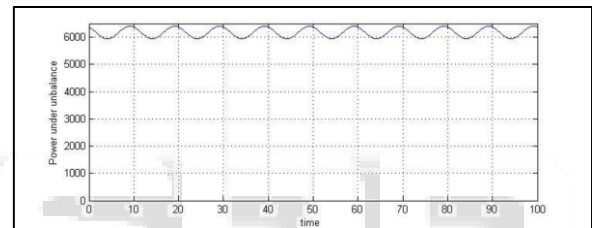


Fig. 6: Unbalance Grid Power

V. SIMULATION RESULT FOR HARMONIC DISTORTION, LOWER ORDER HARMONICS

If the case is balanced, but apart from 50Hz frequency, harmonic distortion is introduced. This result is seen in the following figure.7. Due to harmonic, i.e. frequency is distorted, which produces non-linear loads or a bad quality of signal. This distortion can be 5th or 7th lower order harmonic distortion.

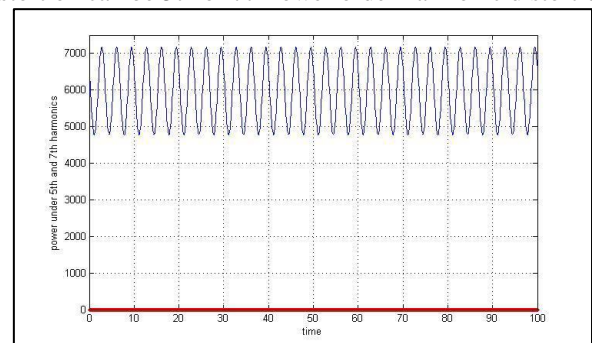


Fig. 7: Three phase power with 5th and 7th harmonics

VI. SIMULATION RESULT FOR HARMONIC DISTORTION, HIGHER ORDER HARMONICS

Here in figure.8. and figure.9. shows simulation for current and power which is for higher order 11th and 13th harmonic distortion. Similar to that of lower order harmonic distortion, here also load quality is oscillated due to the introduction of harmonic.

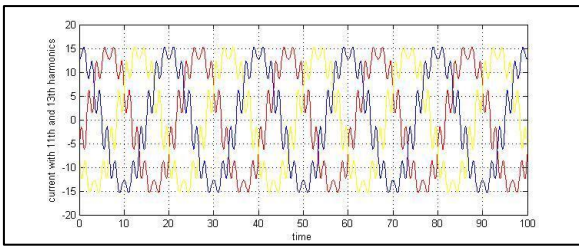


Fig. 8: Three phase current with 11th and 13th harmonics

For Fig.9 is simulation for 3phase power for 11th and 13th harmonic which occurred due to harmonic frequency and its amplitude is distorted.

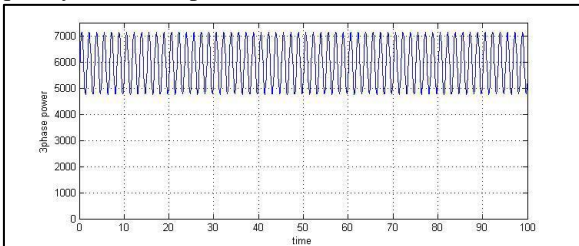


Fig. 9: Three phase power with 11th and 13th harmonics

VII. CONCLUSION

Power mainly consists of two components i.e. Voltage and Frequency and the PQ also depend on these components. Power system presentation depends on the flow of real and reactive power and adequate control method is required to control the flow of real and reactive power in the system. So from different studies we have concluded that the problems in distributed power like voltage and current magnitude/phase, total harmonic distortion are all compensated by designing smart meter which is briefly explained in paper of smart meter module to monitor microgrid parameters. For balanced system, power is experimental in balanced condition. While when distortion is introduced in magnitude or phase of voltage and current respectively, then power results is distorted. Similarly for harmonic i.e. frequency is replicated, current and power get distorted when lower and higher order distortion is introduced which can be observed over simulations. The performance of smart meter is checked in MATLAB/SIMULINK using various variations in parameter of voltage and current.

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