Power Quality in a Smart Grid Distribution System using Automatic OLTC

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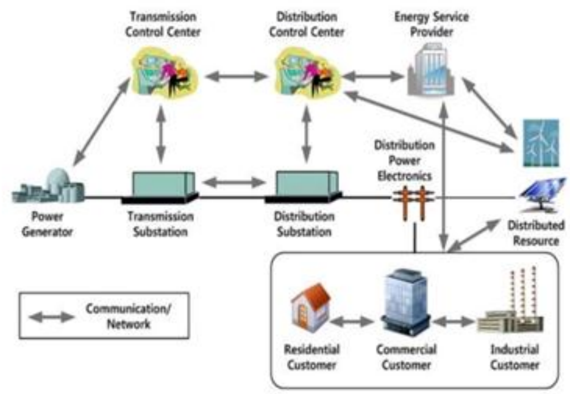
Abstract- **This paper is mainly focused on distribution of power with quality throughout the day. It is proposed in this to provide automatic control circuits to operate the available On Load Tap Changers (OLTC) effectively. The available taps and its voltage levels may be analyzed and suitable applications solution will be automatically generated to select and operate the desired tap to deliver the quality of power to meet the system voltage close to the rated voltage. These programs may be pre-loaded to operate OLTC"s at the power generating stations, Sub stations. Micro controllers are system based controllers may be installed to operate the OLTC"s from 11Kv to 400Kv power and distribution transformers. Universal motors or step drive motors or servo motors may be operated by the controller on auto with the aid of programs pre-loaded. No manual commands and controls needed if the OLTC is put on auto mode**

In the distribution transformers also all the tap positions may be effectively utilized by providing automatic OLTC"s with the aid of local operated controllers or remote operated auto controllers. In this paper voltage transducers are used to sense the voltage and ADC to convert into digital signals. These digital signals are fed to the controller or interfaced computers. Controller or the computer programs checks the present voltage and its required suitable controls from the available solution data table. The necessary controls are generated and operated the drives to operate the on load tap changing devices. These controls are being initiated at the moment of deviation occurs in the system voltage desired quality band. It is also planned to include the high resolution advance graphics files in C programs to represent the present status of the OLTC with its connected tap position. The taps operated and the voltage levels may be recorded and represented graphically with time scale.

Index terms- OLTC On line tap changer. ADC analog to digital converter, SG smart grid, DS distribution system, UM universal motor

I. INTRODUCTION

Smart Grid is the modernization of the electricity delivery system so that it monitors, protects and automatically optimizes the operation of its interconnected elements – from the central and distributed generator through the high-voltage network and distribution system, to industrial users and building automation systems, to energy storage installations and to end-use consumers and their thermostats, electric vehicles, appliances and other household devices. Smart grid is the integration of information and communications system into electric transmission and distribution networks. The Smart Grid in large, sits at the intersection of Energy, IT and Telecommunication Technologies



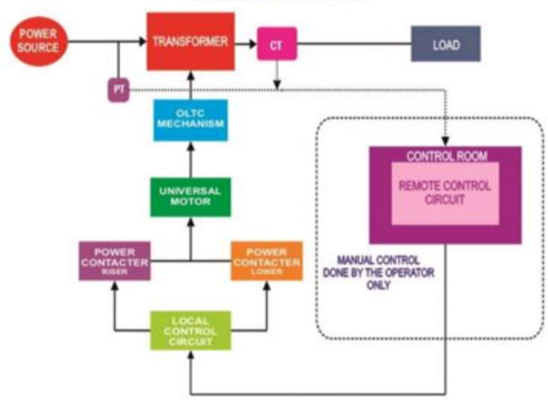
Some of the enabling technologies & business practice that make smart grid deployments possible include:

1. Smart Meters & Meter Data Management.
2. Field area networks & integrated communications systems.
3. IT and back office computing.
4. Data Security.
5. Demand Response & Distributed generation.
6. Renewable energy

To maintain the voltage throughout the day, the variation of load is the main criteria. It is more in the peak hours, medium in the rest of the hours and less in the midnight to early morning. This variation is due to the industrial and residential load patterns. In this paper, it is achieved to maintain the quality of power throughout the day by operating the transformers with multiple taps. An automatic changeover circuit is provided to change the taps and to deliver the voltage at the consumer end which is within the desirable range.

In the present system is to achieve quality of power distribution, the system voltage which is maintained within the extended range by operating the available On Load Tap Changers (OLTC) in predefined intervals. These OLTC facilities are available only at the Power Generating stations and Sub stations. OLTC facilities are available from 11Kv to 400Kv and the operations are carried out from the local through remote control rooms only by manual mode. Universal motors or step drive motors or servo motors are used to operate the taps without any power blink or disturbances. There is no auto operated OLTC‟s available in the generating station and substation levels.

EXISTING SYSTEM

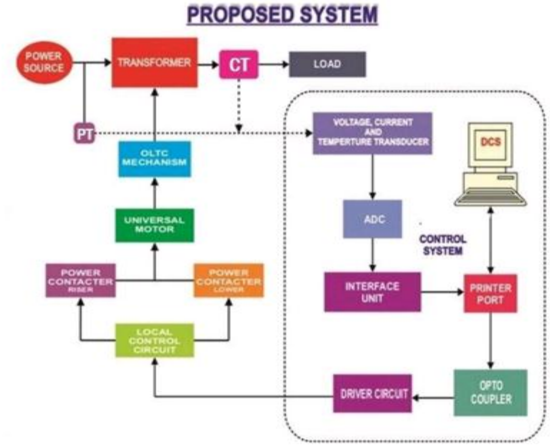


In the distribution transformers, even the manufactures are by default designing transformers with multiple taps to operate at desired voltage levels. Due to the operational and other inconvenience the transformers with specified tap is extended to distribute the power continuously. The others taps are not effectively utilized and which are kept as idle. Due to this the system allowed to operate at the wide range of voltage and struggles to deliver the quality of power. The existing system is shown in fig 2

II. PROPOSED SYSTEM

This paper is mainly focused on distribution of power with quality throughout the day. It is proposed in this paper to provide automatic control circuits to operate the available OLTC effectively. The available taps and its voltage levels may be analyzed and suitable applications solution will be automatically generated to select and operate the desired tap to deliver the quality of power to meet the system voltage close to the rated voltage. These programs may be pre-loaded to operate OLTC‟s at the power generating stations, Sub stations. Micro controllers are system based controllers may be installed to operate the OLTC‟s from 11Kv to 400Kv power and distribution transformers. The schematic is shown in Fig: 3

PROPOSED SYSTEM



Universal motors or step drive motors or servo motors may be operated by the controller on “Auto” mode with the aid of programs pre-loaded. No manual commands and controls are needed if the OLTC is put on “Auto” mode. In order to improve the voltage at the consumer end, the voltage drop across the transformer (step up transformer with multiple tap outputs) should not fall below the specified level. The transformer which is to be included in the paper is provided with five taps (normal, boost and advance tap in first stage and super boost & super advance boost levels in second stage) to regulate the voltage level. Computer receives the distribution voltage through the voltage transducer and ADC activates suitable taps to maintain the desired voltage levels. Transformer temperature is also monitored and alarm is generated in case of excess temperature increase in the transformer windings.

In the distribution transformers, also all the tap positions may be effectively utilized by providing automatic OLTC‟s with the aid of locally operated controllers or remote operated auto controllers.

III. MATERIAL AND METHOD

Design feature of this paper is broadly subdivided into two categories. They are,

1. Hardware Design
2. Software Design

Hardware design consists of Transducer, ADC and Power supply board. Software design comprises of programming features, which in turn governs the parameters of the transformer.

List of Components:

This list of components for building the model is mentioned below

1. Diode
2. Resistor
3. Voltage regulator
4. Electrolytic Capacitor
5. Transformer
6. Relay
7. Opto isolator
8. Integrated circuits
9. Connectors
10. Lamp load
11. Light emitting diode
12. Transducer
13. Transistor
14. Buzzer

IV. WORKING OF DRIVE CIRCUIT

Controller gives the command to the circuit through the interface unit. This command helps to drive the relay circuit. When the sufficient voltage is applied it runs the drive circuit. Diode here is used for free-wheeling purpose to prevent the relay from damping the transistor. Out of the seven inputs of the ADC the three inputs for voltage, current, temperature are chosen by the binary inputs in the program of the controller. The signal received from the controller is given as the input to the drive circuit. If any fault conditions is sensed by controller then a closed path is formed across the relay to generate a trip signal.

The 230V AC input supply is given to relay coil with single or dual rating contact. Usually the relay coil is designed in such a way that it can transmit a maximum voltage of 250V (dc). When the fuse status is good condition then the relay coil will not be energized and the switch will be in closed state. Therefore, the output will be 0V and logic ‟0‟ will be displayed in the computer. In case if there is any fault, the relay coil will be energized and the switch becomes open.

Under this condition, 5V will be flowing in the circuit and logic „1‟ is displayed in computer. On the other hand, the other end of fuse, the step-up transformer with dual output is used for adjusting the voltage level in case of voltage drop at the consumer end. The Relay and isolation driver circuit is shown in fig 4.

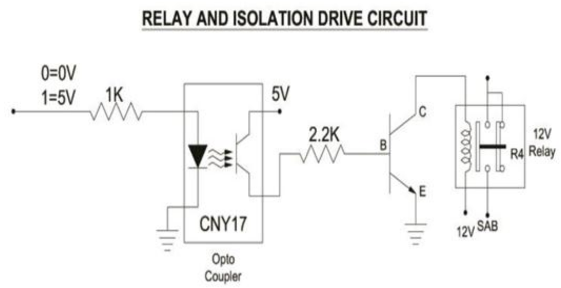


Fig 4: Relay and isolation driver circuit

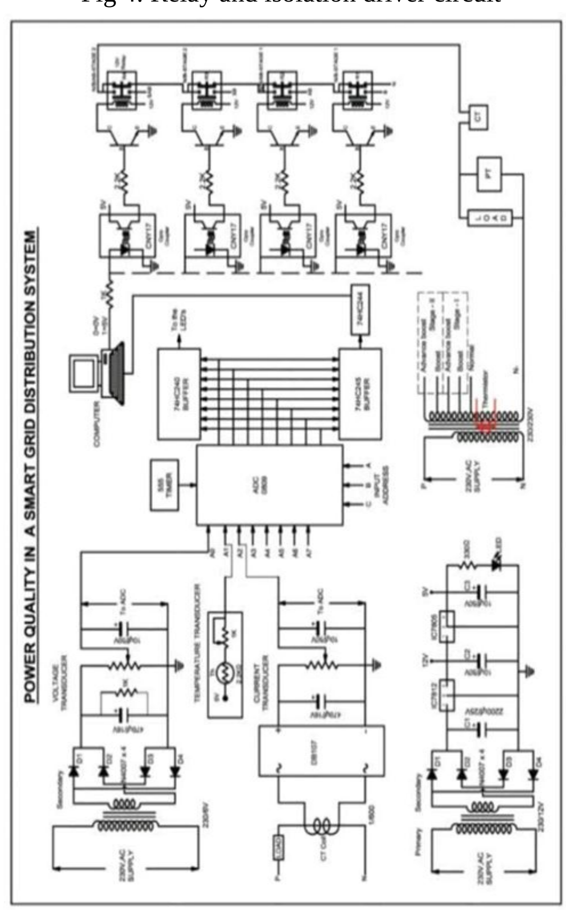


Fig 5: Schematic diagram of Power Quality in Smart Grid Distribution System

V. ADVANTAGES

1. Constant Quality of power is delivered throughout the day.
2. It is possible to maintain desired ranges of Voltage.
3. Temperature sensors in the transformer windings help us to detect the abnormalities in the winding at the early stage.
4. It helps to safeguard the devices and appliances against low and high voltages thus avoiding the component damages.
5. The failure rate of the transformer may be decreased.
6. Industrial zones get quality of power throughout the year.

VI. RESULT

Let us go through the power readings at different load conditions. The voltage of 230 volts (nominally) is used. So, we have considered the upper and lower limits as 240V and 220V respectively. Choosing any of the voltage in this range, gives us different current values. If the voltage received from the source is below 220V, it is called as under-voltage. If the voltage received from the source is above 240V, it is called as over-voltage. Using these criteria, we have calculated the power output for each of load conditions. The required parameters to calculate power are voltage and current. Also, to vary the voltage drop across load, we can vary the number of taps. This tap selection may be made via an automatic tap changer mechanism and controller.

Here we are taking 5 examples to demonstrate how the output of the power increases using taps. The stage remains 1 up till the use of 2 taps. If the number of taps used is 3 or more than 3, then the Stage gets upgraded by 1. That is the stage becomes 2. In each of the stage, the load is increased by 40W to observe the changes in power output.

In this paper voltage transducers are used to sense the voltage and ADC to convert into digital signals. These digital signals are fed to the controller or interfaced computers. Controller or the computer programs checks the present voltage and its required suitable controls from the available solution data table. The necessary controls are generated and operated the drives to operate the on-load tap changing devices. These controls are being initiated at the moment of deviation occurs in the system voltage desired quality band.

As a project model, it is proposed to make a transformer of 230 volts primary and secondary of different tapings close to 230 volts on its secondary side extended to the load of 230 volts. The transformer is allowed to operate its mode Normal, Boost, Advance Boost and Super Boost/super Advance Boost. As a paper model, it is decided to develop a software program in C /C++ and to interface the hardware with the computer in parallel port. The hardware consists of multi tap transformer and its drive circuits. The drive circuit is equipped with switching transistors and miniature relays. The drive circuits are connected to the computer port through opto-couplers for isolation purpose.

VII. CONCLUSION

The smart grid paper model deals with automatic voltage control to maintain the smart grid system and the consumers to get the quality of power under all circumstances by changing the transformer tapping by measuring the grid voltage with the aid of the ADC and necessary interface circuits. The transformer provided in the smart grid paper model consists of multi tapping which is automatically changed by the computer with the aid fast switching drive circuits to maintain the grid voltage close to the rated normal voltage and thereby frequency also can be maintained close to normal frequency of 50 Hz. In real time transformers with multi-tap may be used to make the smart grid system very smart to match all the situations which are all expected. Smart transducer and changeover circuits provides trouble free smart grid to facilitate for the consumers for their availability of power all times and the failures occurs can be automatically communicated to the smart grid computer to restore if any failure happens. In this paper, all the information is passed on to the smart grid computer as hardware and digitals. The improved communication available in the present trend may transform the smart grid presented in the paper into very smart one.

One of the power quality criterion is that the voltage at the selected points of a network should be kept within the prescribed limits. The most common mode of voltage regulation is the application of transformers with on-load tap changers.

Due to the development of Distributed Generation (DG), which is installed in Medium Voltage Distribution Networks (MVDNs) such as generators based on renewable energy (e.g., wind energy or solar energy), voltage control is currently a very important issue. The voltage is now regulated at the MV bus bars acting on the (OLTC) of the HV/MV transformer. This method does not guarantee the correct voltage value in the network nodes when the distributed generators deliver their power. In this paper an approach based on Sensitivity Theory is shown, in order to control the node voltages regulating the reactive power exchanged between the network and the dispersed generators.

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