AUTOMATING CONSUMERS' CONNECTIONS TO THE DISTRIBUTION NETWORK FOR ENHANCED PERFORMANCE

O.M. Popoola[1], A. Jimoh[2], D.Nicolae[3]

Abstract – *Trial and error approach which involves service interruption is usually carried out to resolve unbalance on phases in power distribution system. This approach might improve the phase voltage and current but the resultant effect (change) does not last for too long; thereby reduces the market value in terms of quality and reliability of supply. To enhance the performance of the secondary distribution system there is a need for an automating technology. The aim of this paper is to introduce a method and technology developed for resolving imbalances in a secondary distribution system as a result of the uneven distribution of single phase load across a three phase power system. The technology developed is able to monitor, acquire/display collected data and perform self changing switching actions electronically. This action is in form of rearrangement or transfer of consumer loads for optimal performance of the distribution feeder. The proposed switching technology is based on open- transition switch that enables transfer or rearrangement of consumer loads in a three-phase system within milliseconds with supervisory control system. The following methodologies: System Simulator - Matlab (Simulink), Virtual Instrumentation-Lab VIEW and Hardware implementation were applied for the validation of the proposed technique.*

***Keywords**: Automated technology, Current imbalances, Load balancing, Phase arrangement, Static transfer switching.*

I. Introduction

Electric utilities are facing the demands of reducing costs and improving the quality as well as consistency of supply. The distribution network is an important part of the total electrical supply, as it transports electric power from the distribution station to the customers. Conversely, it has also been reported that 80% of the consumer service interruptions are due to failure in the distribution network. This is as a result of subjection to load variations which might be due to load growth and the delay/non response to the need for construction of new substations and feeders within the system [1]. The distribution systems have suffered from the following maladies, mainly: voltage and current imbalances being a major factor; poor voltage regulation; peak power/energy losses; conductor heating/equipment damages; very high unaccounted energy losses (20 - 40% against international standards of 8 -10%) [2]…[4]. Different methods from the standpoint of feeder loss reduction and load balancing have been proposed, researched, and presented for improvement of distribution network reconfiguration; however these were mainly on the primary distribution system [2…11].

The distribution network is normally instituted at the primary side or medium voltage level of distribution network; however it has little or no significant influence on the problem created at the secondary side or the low voltage levels. Although, technically these single-phase loads are arranged such that the 3-phase system is balanced; the fact, however, is that 100% balanced operation all the time is impossible. At best what happens is that the unbalanced is maintained within a statutory level. Unbalance in the secondary distribution network increases the severity of the problems of voltage drop, power losses and large current in the neutral wire [12], [13],[17].

Normally, to attain load balancing on phases, a conventional trial and error approach is used. This involves field measurements and the application of one's judgment. Using this approach, the phase voltage and current unbalances might improve, however the resultant change usually does not last for a long period of time [14]. With this approach service interruption is unavoidable; hence the rearrangement of consumers' load distribution points on phases cannot be performed frequently so that a level of service supply can be maintained to the consumers.

Although a method by Adisa, Siti & Davidson [15] for assisting one's judgment in the conventional trial and error approach was presented, however this is still insufficient as a result of the time-varying characteristic of load.

An optimal solution in the form of automation implementation using artificial intelligence, telecommunication and power electronics equipments in power systems will guarantee continuous dynamic load balancing along the low voltage secondary feeder thereby relieving overload in the three-phase system with minimal service interruption; and reduce real power losses. This

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will be technically advantageous as well as economical for the utilities and the customers.

This paper addresses a method and technology for implementation, intended for enhancing performance of the low voltage distribution network.

The paper commences with the problem formulation, followed by the proposed solution method; and the validation of the proposed technique as carried out at our laboratory in South Africa. The remainder of the paper is devoted to deductions and realization of the automating technique to reduce unbalance to a minimal level at the LV distribution network [15], [16].

II. Problem Description

Recent researches has shown that, modifying the radial structure of the primary feeders from time to time by changing the on/off status of the sectionalizing and tie switches to transfer load from feeder to another may improve the operating conditions of the overall system significantly. This usually has no considerable effect on the secondary side of the distribution network, especially its reliability.

Majority of the consumers at the secondary distribution are single phase loads. Often times these single phases are arranged or grouped to have a balanced three phase systems, however, unbalance still occurs due to unequal (unevenly) load distribution among the phases of the feeder during time of use . Hence the need to evolve a technique to minimize the unbalance effect (reduce power losses, voltage drop and etc) by transferring loads from the heavily loaded to less loaded phases randomly.

In formulating this problem, certain predefined objectives must be satisfied in the redistribution of the load among phases [17], [18],[19]. In this case the objective functions that are considered are discussed in the following:

II.1 Objective Functions to be achieved

a. Total Complex Power Unbalanced

In a three phase load system, the complex powers are expressed as $\bar{s}_i^j$ ($j = a, b$, c) for the loading of each phase. The unbalance of these three complex powers can be evaluated as follows:

$$\bar{s}_i^{ul} = \sqrt{(1/3)\sum_{j=a}^{c}\left|\bar{s}_i^j - \bar{s}_i^{id}\right|^2} \quad \dots (1)$$

Where $\bar{s}_i^{id}$ represent the ideal per phase loading and

$$\bar{s}_i^{id} = (1/3)\sum_{j=a}^{c}\bar{s}_i^j \quad \dots (2)$$

This is considered for a typical feeder i^{th}. thus an evaluation of $\bar{s}_i^{ul} = 0$ indicates that the complex power of i^{th} feeder is balanced. The total complex power unbalance can be evaluated from:

$$s_T^{ul} = \sum_{i=1}^{n}\bar{s}_i^{ul} \quad \dots (3)$$

Where n is the number of feeders within the object feeder. $\bar{s}_T^{ul}$ is used to evaluate the complex power unbalance of a feeder and the value of this describes the load balance situation at every feeder. Thus minimization of $\bar{s}_T^{ul}$ is an objective function in the proposed method.

b. Average Voltage Drop

A good load balance will generally reduce the voltage drop. Reducing the voltage drop is also an important objective for a distribution engineer to achieve. The average voltage drop is expressed as:

$$V_d = (1/m)\sum_{i=1}^{m} VD_i \quad \dots (4)$$

Where m is the number of load points for the feeder under consideration and

$$VD_i = \sum_{j=1}^{m}\left|\left(V_{rated} - V_j^p\right)/V_{rated}\right| \quad \dots (5)$$

Where V_{rated} is the rated phase voltage; V_j^p is the magnitude of the phase voltage at load point *i* and VD_i is the average of the three phase voltage drop at load point *i*.

c. Voltage unbalance Factor

The total voltage unbalance factors for the zero and the negative sequence are expressed as:

$$VUF^0 = \sqrt{(1/m)\sum_{i=1}^{m}\left(V_i^0 / V_i^+\right)} \quad \dots (6)$$

$$VUF^- = \sqrt{(1/m)\sum_{i=1}^{m}\left(V_i^- / V_i^+\right)} \quad \dots (7)$$

d. Total Line Loss

Minimizing the system loss and improving the operational efficiency are usually major objectives of a power utility. Hence the minimization of line losses is also an objective function considered in the redistribution of loads presented in this work.

$$P_{loss} = \sum_{i=1}^{m} r_i^2\left(P_i^2 + Q_i^2\right)/V_i^2 \quad \dots (8)$$

Although conventional trial and error approach is used for improving load balancing on the secondary level, the duration of the effects of the balancing varies from one distribution feeder to another due to the single phase loads that continually change across the three-phase feeder [9,10], apart from the time, human resources and etc spent on achieving it.

The main aim of this study is to research and propose a method and technology for automatically minimizing the unbalances in the feeders and enhancing the secondary distribution network performance with the view to achieve the following:

- Rearrangement of consumers loads among the phases uniformly so as to achieve load balance at the secondary distribution level.

- To eliminate or reduce trial and error (manual operations) methods.
- Evolve techniques or system for ensuring continuous dynamic on-line load rearrangement with minimal service interruption.
- Ensure that unbalance is within the specified limit as:

$$VUF = \left[\max\left(V_{ab}, V_{bc}, V_{ca}\right) - V_{mean}\right] / V_{mean} \leq \%\,\text{limit} \qquad \ldots (9)$$

Where V_{ab}, V_{bc}, V_{ca} represents the line to line voltages and V_{mean} = *mean* (V_{ab}, V_{bc}, V_{ca}).

II.2. Phase and Load Balancing

Usually the load consumption of consumers connected to a feeder fluctuates, thus leading to the fluctuation of the total load connected to each phase of the feeder. This in turn implies that the degree of unbalance keeps varying. To balance the phase currents in every segment and reduce the neutral line current is a very difficult task for the distribution engineers considering the fact that they do not have control over the utilization by the consumers. Trial and error approach is based on expert knowledge and judgment which involves the analysis of variety of interrelated meter indications to detect abnormal conditions such as circuit overloads, improper line voltages, etc. Other factors required in the exercise include the knowledge of voltage regulations, load flow analysis and minimization of circuit losses; use of mathematics to calculate resistive and reactive loads and phase relationship to identify unbalanced low efficiency load, circulating currents and undesirable conditions.

With the correct technology and provision of the required input information(s), most of these activities can be programmed to be performed by a dedicated microcontroller or processing unit.

III. Proposed Technique

In the development of a technique for rearrangement of consumer load to minimize unbalance in a low voltage distribution system, the key operational activities identified in relation to the feeder system includes monitoring and acquisition of data; processing and communication of signal and data; control and switch transfer.

These activities can be achieved by separate functional units namely: (1) the switching unit and (2) sensing unit which together with the supervisory control station forms the intelligent unit package for the proposed technology.

The block diagram in Figure 1 & 2 shows the interaction of the functional units of the proposed technique and a typical scheme layout of a consumers' connection to a feeder.

To assist in the knowledge of performance capabilities, operation features, and integration of functions of the intelligent unit package a practical and economic reality, a detailed design (illustrated by a block diagram) of the proposed technology is shown in Figure 3.

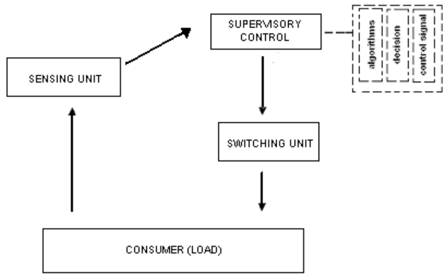

Fig 1: Proposed System Block Diagram

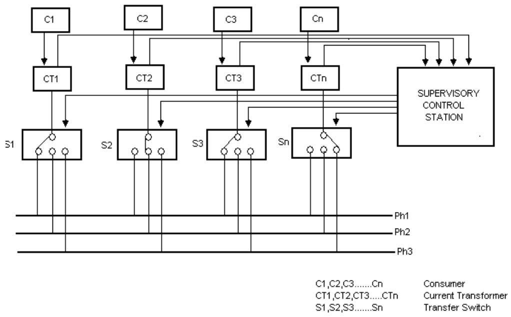

Fig 2: Typical model layout scheme of the proposed system

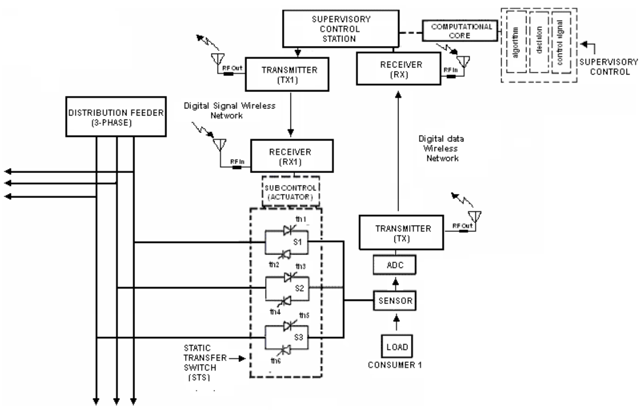

Fig 3: Schematic diagram of the proposed Technology

The package consists of the following main components:

- Switching device: Made of three phase ac static switch as well as operating mechanism (actuator-control unit) that is capable of opening and closing the switching device remotely (digital signal processing).
- Sensing unit: This unit depending on the problem formulation and solution technique or algorithm, which may be current or any other quantity at the consumer's connection node is required for monitoring of the system conditions; collection of input data; conversion of analogue sensor signal into digital data that can be recognized by microcontroller; and communication with the supervisory control station.

- Supervisory Control unit: consists of embedded microcontrollers for effective co-ordination, computational and control of other intelligent units.
- Communication unit: a means of data communication between the switching unit, sensing unit and the supervisory control station.
- And lastly, uninterruptible power supply unit capable of powering all components of the package.

The fundamental concept of the proposed technology is based on the open-transition switch that enables the transfer or rearrangement of consumer loads in the three-phase feeder system within milliseconds. This is made possible through supervisory control system for effective co-ordination, computational and control of other intelligent units.

III.1. Construction of Proposed Technology

Starting with the switching unit as shown in Figure 3, this comprises mainly the static transfer switches (STS) and the sub control. The static transfer switch is made of two pair of thyristor connected in inverse parallel for each phase. During normal operation one of the static transfer switches is in ON mode or close position (example S1) allowing the conduction of current to the load (consumer) while the other two pair of static transfer switches (S2 & S3) are in the OFF mode or open. When the rearrangement (transfer) operation is required due to overload on the current phase (example S1) being used, S2 or S3 is turned on to conduct the current to the load from the phase that can accommodate the existing consumer and balance (or minimize the unbalance) of the three phase feeder. Then the current in S1 is blocked at the first zero crossing. The control actions sent from the supervisory control (SC) is carried out through a logic switching circuit acting as the operating mechanism or better known as the actuator. The actuator is part of the sub control.

The sub control (S_bC) is interlinked with the SC and located on the line. It is designed to acquire data, switching status and transfer same to the SC through a communication interface (Wireless Broadband Access link) and also to perform switching action. The monitored information (from the sensing unit design) and the command (control) signal to switches S1 or S2 or S3 to perform a transfer operation from Phase 1 (Red) to Phase 2 (Blue) or Phase 3 (Yellow) when the preferred source voltage or current deviates from the pre-set upper or lower limit is sent from the SC via the S_bC.

III.2. *Operating and Control Scheme*

As shown in Fig. 3 and 4, voltage sensing device continually monitored the voltages on each of the phases while current transducer monitored the current on the phase on which the load is connected. The monitored information is transmitted from the sensing unit via (using) wireless communication to the SC station where decisions are taking based on the solution algorithms. These decisions are in relation to the problem of finding a condition of balancing as expressed mathematically by Siti et al. [6] using current system for a random point of connection "k" in a network with 3 phases and shown in the equations 10, 11 & 12.

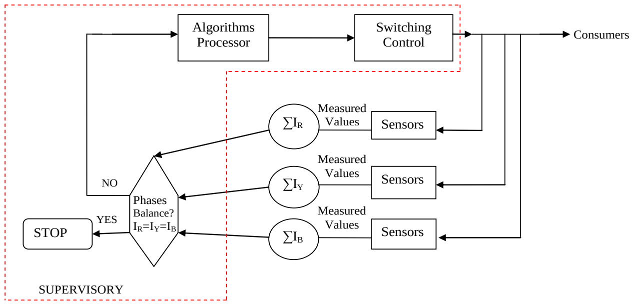

Fig 4: Flow process of the proposed system

$$I_{ph1k} = \sum_{i=1}^{3} sw_{ki} I_k + I_{ph1(k-1)} \qquad \ldots (10)$$

$$I_{ph2k} = \sum_{i=1}^{3} sw_{ki} I_k + I_{ph2(k-1)} \qquad \ldots (11)$$

$$I_{ph3k} = \sum_{i=1}^{3} sw_{ki} I_k + I_{ph3(k-1)} \qquad \ldots (12)$$

where, I_{ph1k}, I_{ph1k} and I_{ph1k} represent the currents (phasors) per phase (1, 2 & 3) after the k point of connection; sw_{ki} are different switches; while I_k represent different load currents connected to the distribution system at point *k* of connections.

In the case of unbalance, the SC sends the command signal to S_bC of the switching unit for the static transfer switch (S1) of load I_k via wireless communication to open, while within a micro second a signal is sent to S2 or S3 of the same load I_k to close.

IV. Software Validation

The validation to test the operation and behavior of the proposed technology was carried out using the Simulation and Virtual implementation methodologies.

IV.1. Simulation

The operation of the proposed system was modeled using the MATLAB 6.5 version as shown in Figure 5. The simulation results shown in Fig. 6 below consists of three-phase source; a constant impedance load with a power factor of 1. Ideal thyristor' were used for the design of the switching circuit. Anti-parallel thyristor are used to create the ac switch (static).

a. Transfer during Voltage Unbalance.

Under normal conditions, static switch (S1) is turned on and current flows from the primary source to the load; when current unbalance is detected by the supervisory control; the gate signal is removed from S1. Since switch S1 has a higher voltage potential than ac switch S2, the gating signal of S2 must be held off until ac switch S1 naturally commutates (allowing finite time to elapse). The minimal transfer time, in this simulation, is between to 3-5 msec from the start of the unbalance due to high inductive load as shown in Fig. 6; the maximum transfer time could be 17 msec which is not considered as a voltage dip [20].

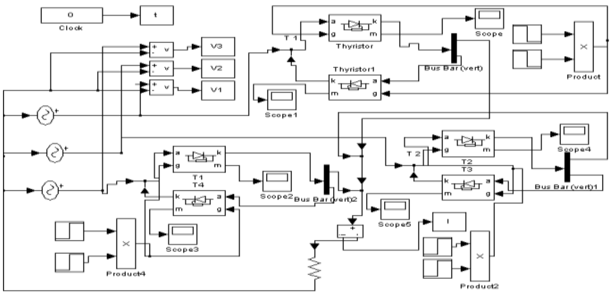

Fig 5: Simulation model design of the proposed scheme

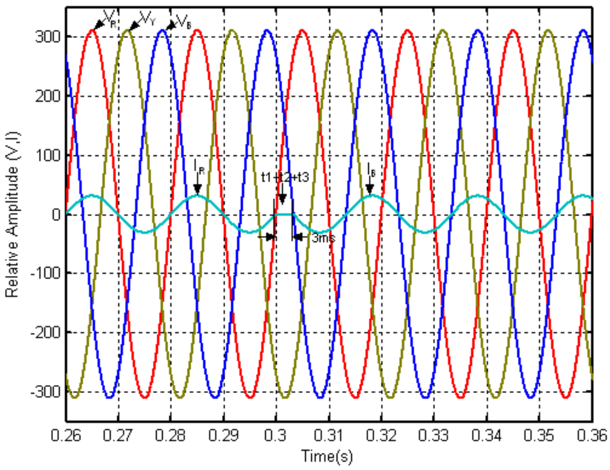

Fig 6: Current transfer operation

IV.2. Simulation

In this section adaptive representation of the proposed technology and its multiple execution operation was simulated and studied in relation to the focus of this paper.

The virtual implementation was carried out using a Workstation-Intel Pentium CPU 1.90 GHz, 256 MB of RAM having a version of Lab View 7.0. The process control, as well as acquisition, processing, storing and reporting of all data, is achieved through the virtual instrument (VI).

For the distinct blocks, different virtual instruments were created using the block diagram approach in Figure 7. The program with the functions in the virtual instrumentation are created and shown as module. The module is made of various subs VI; to facilitate and perform different operations; and communicate with other sub VI. The modules and some of the task performed are outlined below:

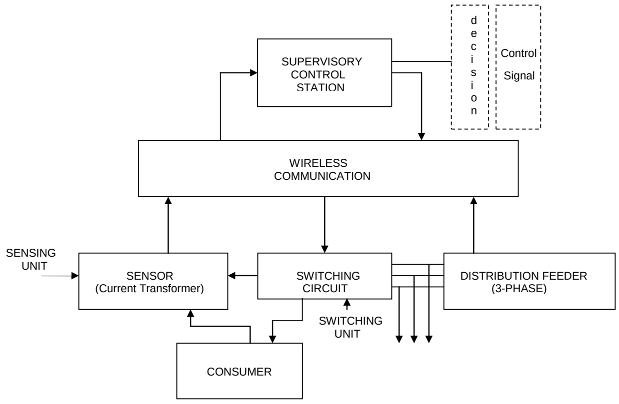

Fig 7: Block Diagram Outlining the Approach in Lab VIEW

i. Module 1: VI for source supply
   - Generates and produces the instantaneous voltage.
   - Display of numerical data and phase indicator of the variation of the instantaneous voltage on a computer screen.

ii. Module 2: VI for fundamental of AC circuit, monitoring of the system variables and part of the sensing unit.
   - Generates the phase voltage, the line voltage and line currents.
   - Monitoring of line current for decision making at the supervisory control station and conveyance of decision for any necessary action.
   - Computation of the active, the reactive and apparent power using the resultant numerical capture data of the I-V display after the phase angle is determined.

iii) Module 3: VI for the switching operation (switching unit) of the proposed technique
   - Development of a switching unit as shown by the logic circuit operating on the Boolean properties and principles; and signal to perform transfer operation.

iv. Module 4: VI to monitor phase displacement and transfer. This is facilitated by the case structure interlinked with Module 3 and phase transfer reflected in module 4 outputs.

v. Module 5: VI for Monitoring and Graphical display of the I-V characteristic in terms of unbalance.
   - Linearization of the I-Vs scans through a program inputted into the objects in Lab VIEW.
   - Characterization of the performance of the three phase supply (feeder) in relation to unbalance.

vi. Module 6: VI for Synchronization of the Activities of the Proposed Technology

VI block panel model of the proposed technology as shown in Figure 8 was developed using the module outlined above. Different scenarios were carried out in order to verify the operational performance of the proposed technique as computational and graphically shown in Fig. 9 and 10

a. Test : Rearrangement of Consumers for Optimal Performance of a Three-Phase Feeder

Figure 9 and 10 represents unbalanced scenarios in a three Phase feeder network. The first scenarios (Fig. 9) represents an unbalance state due to the ensuing unequal load among the phases –Red, Yellow (White) and Blue (Z_1, Z_2, Z_3). Figure 10 shows an unbalance scenario on the distribution feeder attributed to the resultant load distribution on a particular phase - the consumer loads (Z_{21}, Z_{22}, Z_{23}) on Yellow Phase which eventually affects the total load Z_2, Z_1, Z_3 of each phase thereby making the feeder unstable.

Signal (waveforms) of the phase voltage, the line voltage, the load current and the numerical data (values) of the electrical input and output parameters for each scenario are displayed on the computer screen as shown. An initial sampling rate of 10 Hz at every 10 samples of data gave very sluggish signal plot response. This was stepped up during the test to a sampling rate of 1000Hz using 100 samples at a lag time of 100ms which was use for logging data/test.

Result & Observation

The unbalance scenarios in Figure 9 & 10 with a value of 0.021(2.11%) & 0.020(2.02%) were resolved using the proposed technology, as shown in Fig. 11 & 12.

Loads were arranged such that the resultant load on each phase is equal or approximate as shown in Figure 11; the Consumer using switch 1 is switched to the BLUE phase from the RED phase, Consumer using switch 2 is still on the YELLOW phase as previous and Consumer using switch 3 is switched over to the RED phase.

In Figure 12, the consumer load (Z_{21}) is transfer or changed from the YELLOW Phase to BLUE Phase which can accommodate the load thereby achieving minimal unbalance on feeder according to the statutory standard.

For the computation of the unbalance at the supervisory control, the ANSI definition of voltage unbalance among the other standards but expressed in terms of current unbalance was applied for operational and demonstrative purpose. Other standards can be applied.

$$\text{Current unbalance} = 3(I_{max}-I_{min})/(I_R+I_Y+I_B)*100\% \quad (13)$$

where I_R, I_Y and I_B are the phase current of R, Y, B, I_{max} and I_{min} are the calculated maximal and minimal phase currents.

Conclusion

From the different scenarios, the transfer of consumer within the phases was accomplished within millisecond due to automation of the switching device, while computational function was able to show the state of the feeder at any point in time in both numerical value and display (indicator) forms, thereby assisting the operator to known the feeder state at a glance.

From the waveforms, the signal for transfer operation and the control algorithms are factors that aid the act of the proposed technique. Summing up the observations, proposed technology performance is dependent on the computational aspect of the unit and the transfer time (which is inclusive of when the signal is received for transfer).

V. Experimental Implementation

For the implementation of switching unit of the proposed technology using electronic components, the schematic diagram in Fig 13 was used. The test was performed with and without the safety device using a variable three phase power supply at 220 V rms; incandescent lamp of 100 W 230 V as load; a rotary switch for change of phase. A Tektronics 2000 series digital oscilloscope 4 channels as was used as the test facility (Fig. 14).

Hardware Result

The real time voltage and current waveforms of the test circuit of Figure 14 is shown by the oscilloscope and graphical output in Figure 14 & 15. The three - phase voltage supply is shown by the waveform in Light Blue, Red and Dark Blue. Each having a peak value between 290 and 311V as shown by a division of 10 V representing 100V on the y-axis; the resultant $V_{rms} \approx 205$ V – 220 V. The phase displacement is ±120°. The magnitude of the current (I_{rms}) is ≈ 0.455 A – 0.5A or peak value of 0.65 A as shown by the green sinusoidal waveform. The output shows that there are some transient’s effects as a result of the use of the triac.

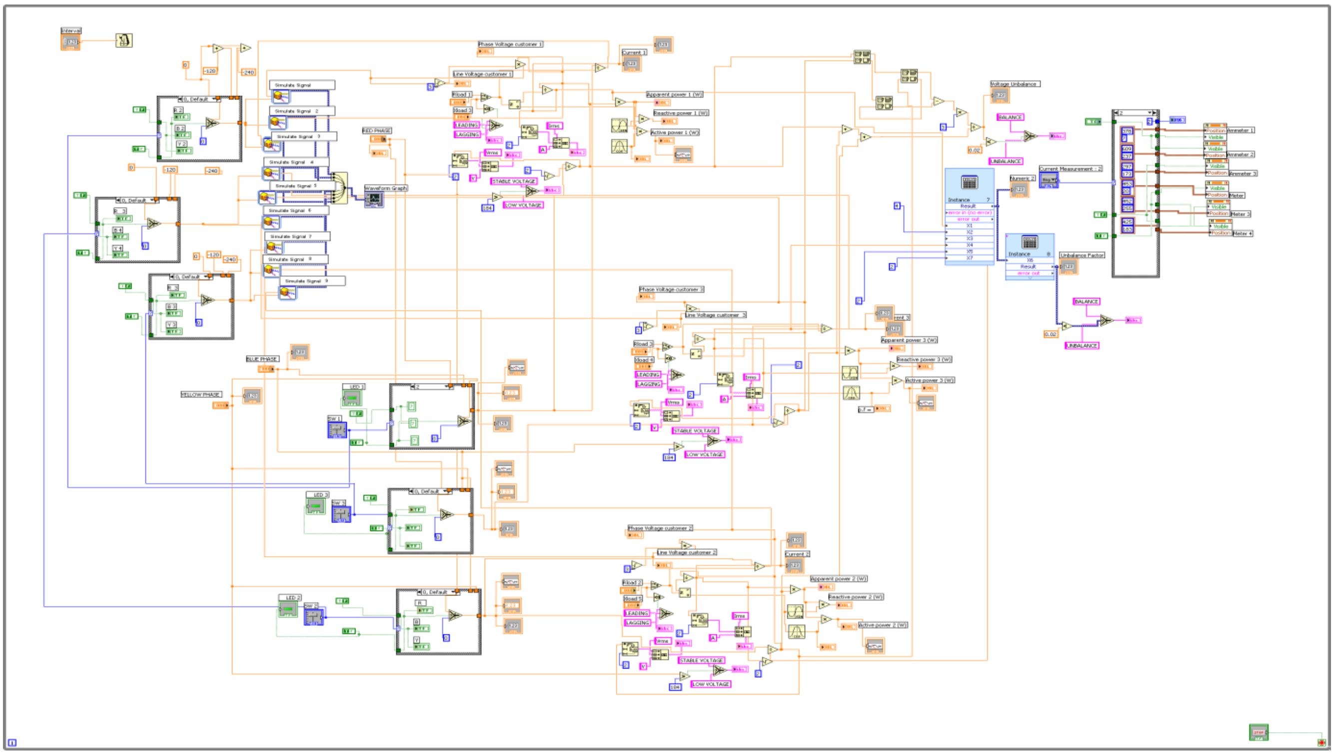

Fig 8: Proposed Technology for Optimal performance Block Panel

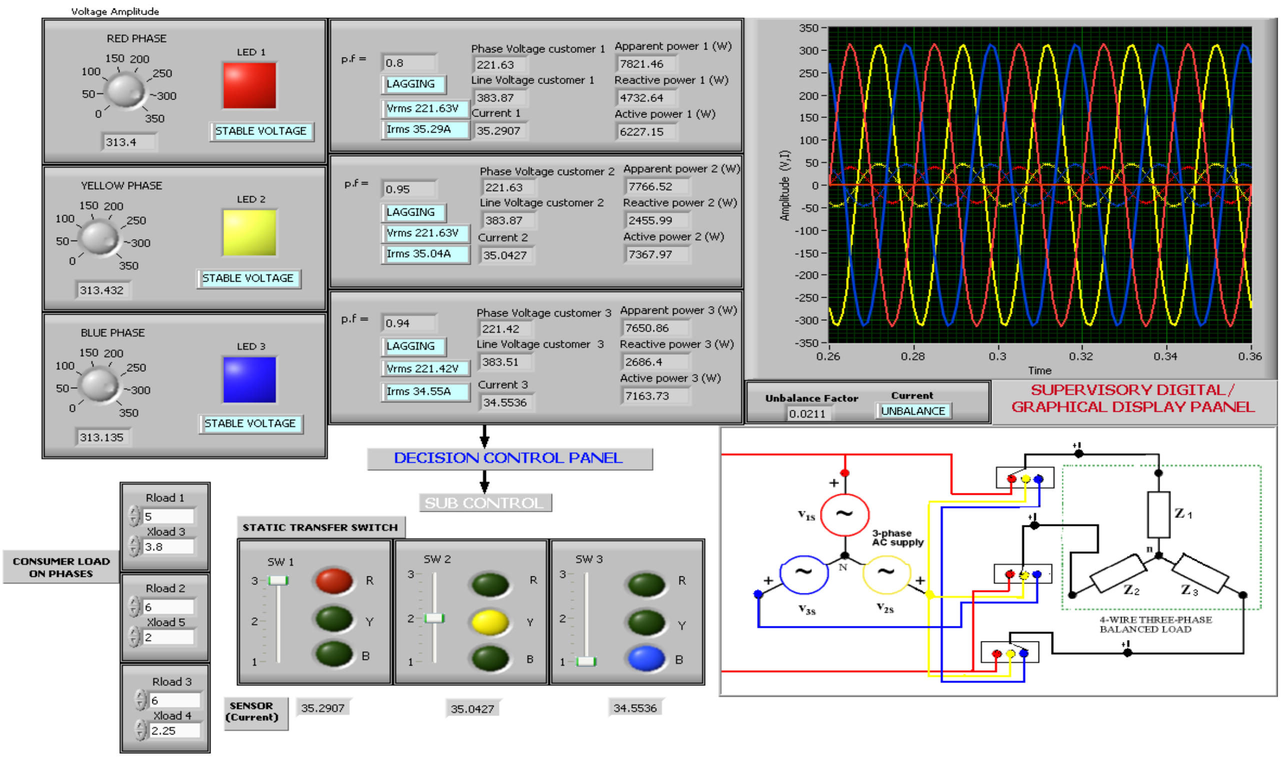

Fig 9: Unbalance scenario on the LV distribution feeder (3-Φ)

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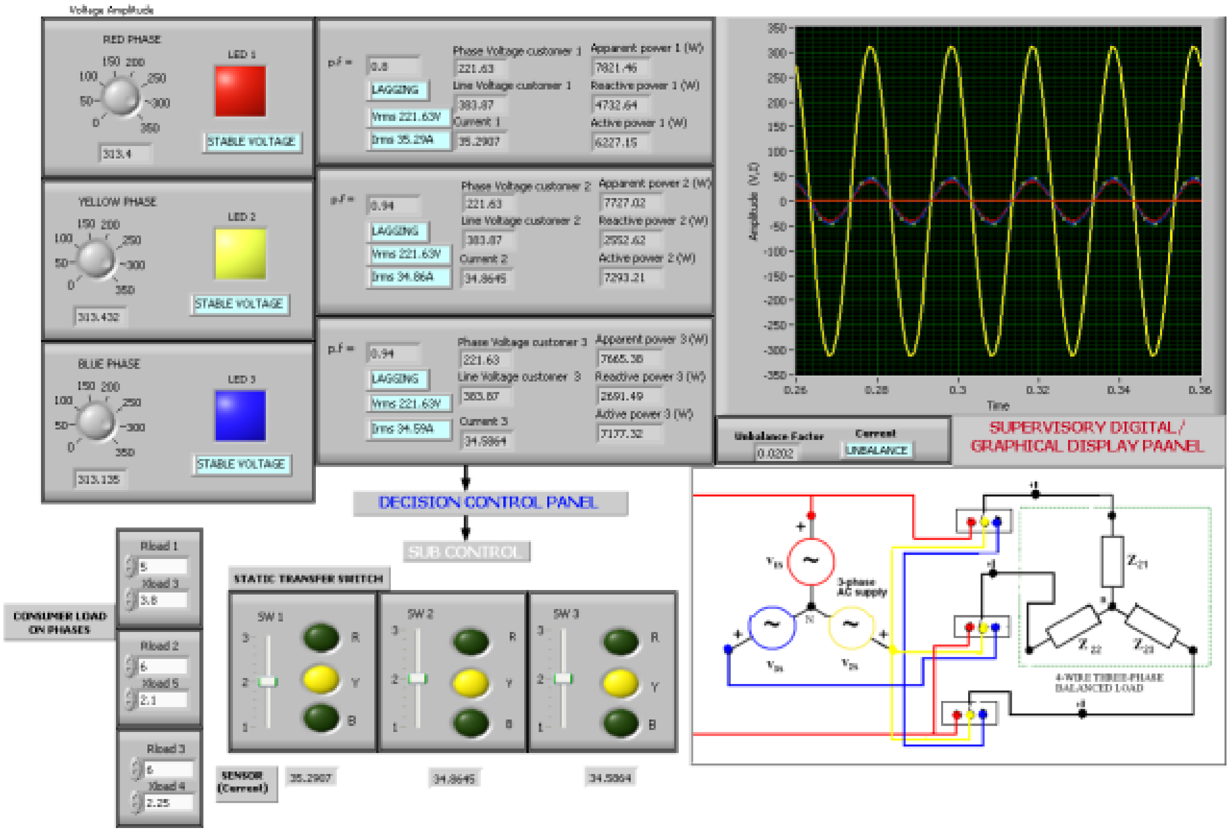

Fig 10: Unbalance scenario on LV feeder (uneven load distribution on a phase)

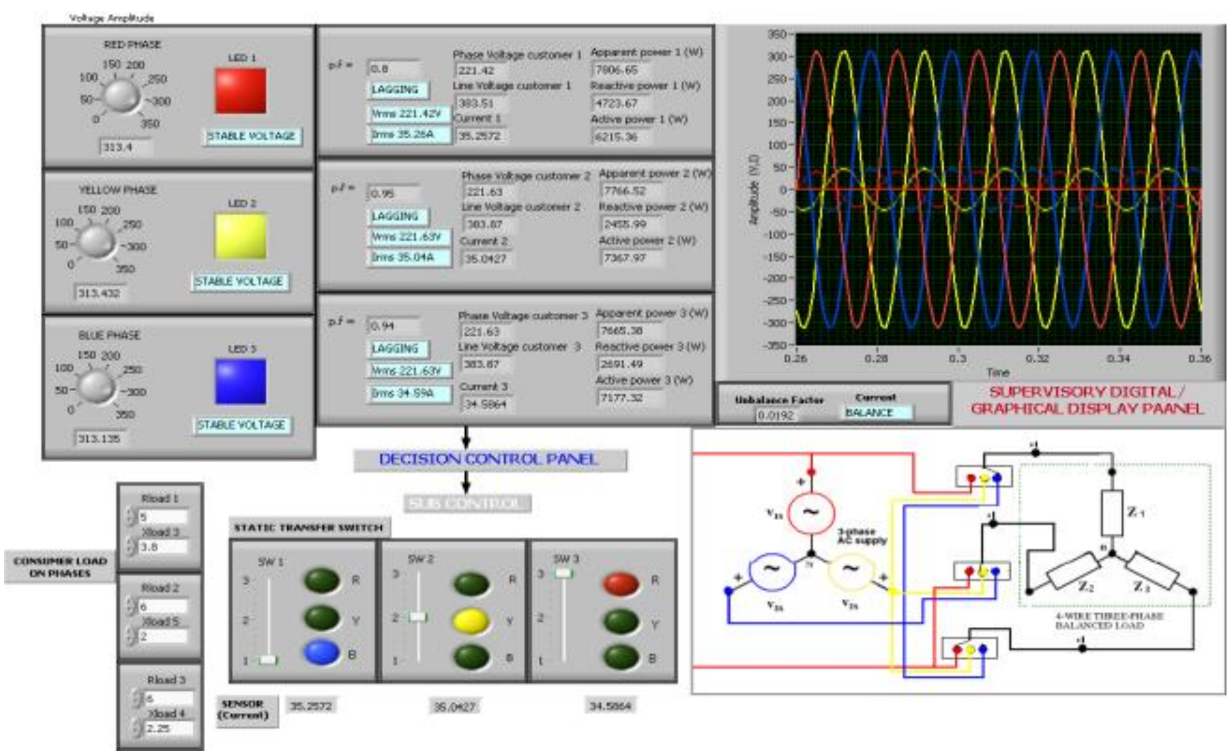

Fig 11: Change of Consumer Phases to achieve Balance on the Three Phase Feeder System (Blue, Yellow and Red)

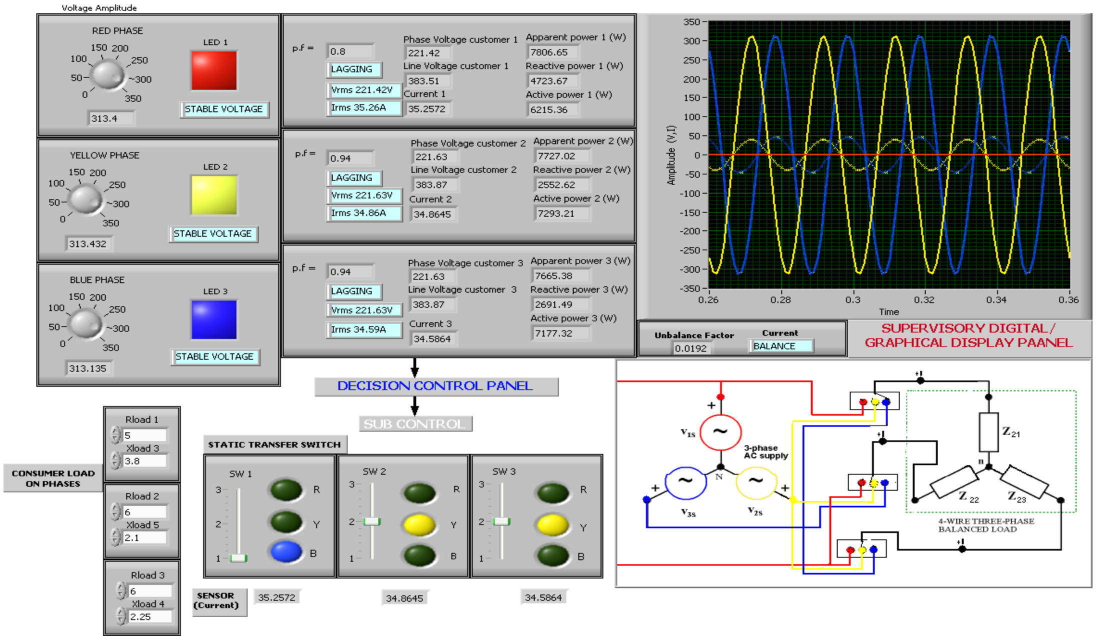

Fig 12: Change of Consumer (Z_{21}) from Yellow Phase (Z_2 consumers) to Blue Phase to minimize Unbalance on (3-Φ)

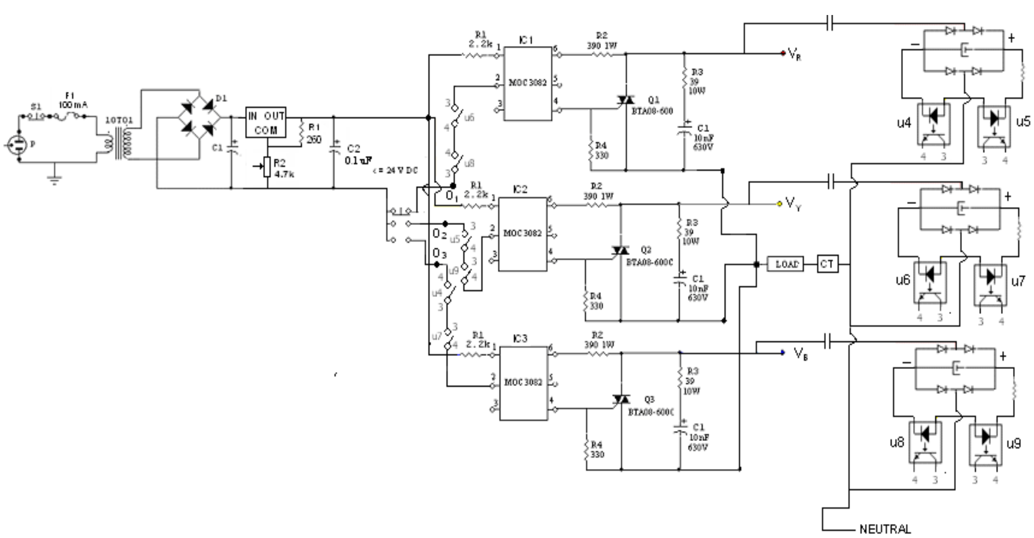

Fig 13: Schematic diagram incorporating the Safety device

Transfer

Fig 14: Experimental Set Up of the Proposed Scheme at the Laboratory

Transfer Operation of the switching unit

The transfer operation of the proposed switching technology is shown in Figure 15. The transfer time shown was more than the 5 msec. This is due to the use of a rotary switch; as well as the commutation time of the switch (triac or thyristor) being taking into consideration. This time can be considerably reduced using an automatic or remote control device to at least 5 ms as depicted in Figure 6. As shown in Figure 15 and 16, the load current is in phase with the supply voltage when transfer operation takes place.

The transient generated or transmitted from the power supply (load circuit) did not affect the signal circuits as demonstrated by the transfer operation waveform in Figure 16. This was as a result of the opto-coupler MOC 3084 that has the capability of being use with static transfer switch) in the interface of logic system or control with equipment power from low voltage ac source.

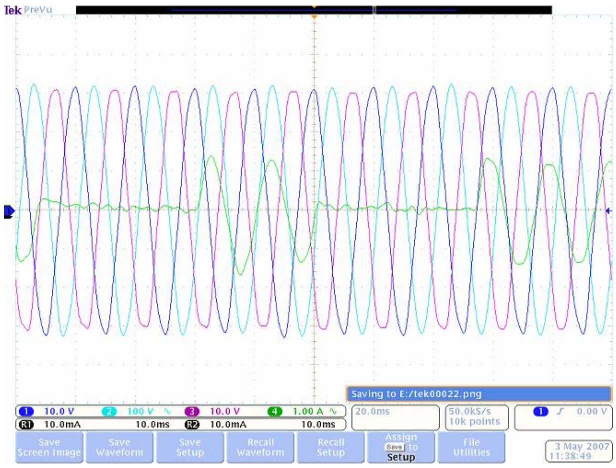

Fig 15: Transfer of Load from one Phase to another Phase

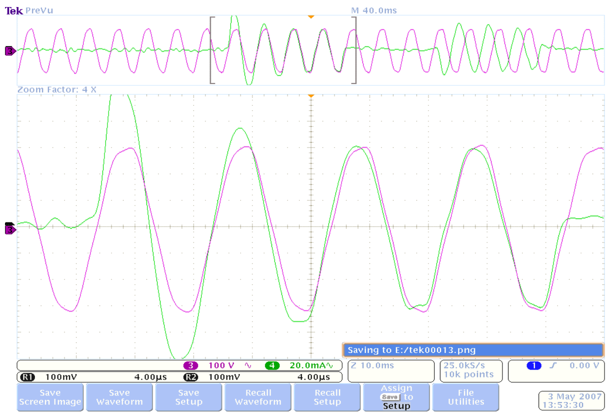

Fig 16: Surge current as a result of load being connected

Although there was considerable time for the switch to naturally commutates, there is a need to consider the safety of the following: the customer both in terms of individual and equipment; the distribution system (Three-Phase Feeder) as well as the proposed technology; and also how to assist the operational personnel in the distribution station. In order to achieve that, a safety device was introduced as shown in Figure 13, bearing in mind that one of the purposes of this proposed technology is to ensure continuous dynamic on-line load arrangement with minimal service interruption.

<u>Design and operation of the safety device</u>

Two Opto-isolator switches having their dc supply from the source supply of each phase but integrated and connected as shown (example, u4 and u5; u6 and u7; u8 and u9) in Figure 14 are incorporated into the proposed technology switching unit for safety purpose.

Under normal conditions, assuming S1 is turned on (u4 and u5 in normal closed position (NC)) and current flows from the primary source to the load. When unbalance is detected, S1 is turned OFF by removal of the gate signal; S2 receives a gate signal to start conduction to accommodate the load. Assuming S1 is still turned ON due to the commutation time, u5 and u9 (S2 switch) will remain in the open position until the commutation process is achieved before closing. At no time will there be the possibility of two phases being in the ON mode at anytime. The resulting waveform to depict the operation has been shown in Figure 15.

VI. Economic Consideration and Viability

This proposed scheme does not entail any recurrent expenditure (running costs) while the capital cost of the scheme in terms of implementation will be easily paid off within a short period in time. This is as a result of the elimination of technical problems and overhead costs (labor cost for repairs, transportation, travel expenses, loss time and etc). The continuous supply to consumers and elimination of unanticipated capital cost will definitely increase the energy revenue generation capacity of the power utility.

The technologies for the key operational activities such as metering sensors, data acquisition devices, micro controllers, static power switches, data communication (wireless) and actuators are already in existence; playing major roles in smart grid systems operation. Due to their applicability in different operations and developments nowadays, their respective cost is minimal thereby making the actualization of this scheme realizable and cost effective.

VII. Conclusion

The methodology proposed for rearrangement of consumer on phases was illustrated, simulated and demonstrated on a proposed scheme using various methodologies. Deductions inferred from the results obtained are as follows:

- The transfer operation has shown by the result obtained to be dependent on the following: the unbalance detection time (t_1) for an unbalance system; Opening time (t_2) of the switch S1 which is dependent on its characteristics; and the commutation time (t_3) of the switch.
- The triggering action according to the computer simulations is dependent on the mode of control-digital signal processing (a function of the problem formulation solution technique (algorithm).
- On-line rearrangement can be achieved with minimal service interruption (see Figure 11 & 12).

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- The computation analysis of the state of the Feeder was achieved without any application of one's indulgent and judgment (see Figure 9, 10, 11, and 12).

Earlier discussions have establish the need to minimize unbalance in the distribution system, however solution and approaches proposed were designed to deal with feeder reconfiguration from the standpoint of power loss reduction and load balancing mostly on the medium voltage distribution network; but with little emphases on the method of implementations and the technology for implementation for the low voltage distribution network.

The main aim of this study which was to propose and research a method and technology for automatically enhancing the performance of the feeders in the secondary distribution network has been accomplished.

The idea of using automatic and remote technology based on the open-transition switching concept has been implemented with great success and shown to be attainable as shown from the results obtained and deduced in the course of the work. With reference to the term of the focus of this research, the reliability and functionality of the proposed technique has been demonstrated, tested and found to be adequate.

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