Intelligent Load Balancing Using Spacer and Datalogger-Controlled Junction Box for Reducing Loss in Smart Distribution Grids

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Abstract: One of the very important methods since the advent of the electric power industry is the balancing of loads of the distribution posts, and its importance and necessity is rising on a daily basis. In doing so, traditional techniques are currently adopted where the balancing team visits the location of the posts and measures loads from external feeders of the distribution post at the peak of the load. Then, in case there exists unbalance in the post, they list it in their balancing agenda. But in the presented method, current measurement information is sent to the spacer and junction box by means of dataloggers of distribution frames via an information control circuit. Phase shift command will be sent to the respective electronic circuit and SSR after processing and the grid is automatically balanced in the shortest period of time. This makes for the balancing of the phases and the minimization of the null wire current. In addition to grid loss reduction, there will be no technician team costs who should carry out the load balancing.

Keywords:smart grid**,**balance , spacer,reduce loss, Datalogger

Introduction:

The residential and commercial distribution grids of most of the loads are single-phase. Hence, their connection lies between one of the phase wires and the null wire. The number of junctions is often unequal on each of the phases and in case it is equal, they have different consumption owing to the different consumptions of single-phase consumers. Therefore, there is usually a current passing through the null wire and that is why the distribution grid is generally unbalanced. The unbalance of this system gives rise to various consequences including increased loss, three-phase equipment heating, voltage drop as a result of unbalance, null wire carrying a current, and decreased electric power quality. In particular, from the perspective of power quality criteria, this problem represents itself as the ratio of the zero sequence size to the positive sequence outside the standard limit. A method is put forward that decreases the adverse effects of unbalance.

One of the factors causing loss in the distribution grid is load asymmetry. This is important because it creates loss in the following forms:

a- Excess current passing through the null wire and increased RI^2 loss

b- Zero and negative currents being developed in the grid: When zero and negative currents are developed, loss in motors and generators increases and the transformers get closer to saturation. This, in turn, increases loss and decreases their feeding capacity. The methods presently employed for decreasing loss caused by load asymmetry are as follows:

a- Using wires with greater section area for the null wire where load asymmetry is high and uncontrollable

b- Training the electric power company's wiremen and electrical technicians and obliging them to perform proper division of the subscribers on the phases of the low-voltage grid

In this method, given the large bulk of work, geographical dispersion, the feeding of all posts being impossible at a time or a limited time, workers' lack of accuracy, and the large bulk of work, it happens from time to time that the load of several posts remains unbalanced for a long period. This causes electrical energy loss and other damages in the distribution section.

To overcome this defect, the distribution frames are equipped with a mechanism with characteristics described below. At present, the load status of the low-voltage grid equipment is controlled in this way that the balancing teams carry out a scheduled biannual loading in summer and in winter. This is of paramount importance in terms of regarding the allowable load of the distribution grid equipment and preventing it from damage. Moreover, it is much cheaper, faster, more economical, and more precise to install one of these devices than investing on traditional techniques. The need for this project is felt more and more on a daily basis and, in the end, using this method or similar ones would be inevitable. The approximate benefit-over-cost value of this project can be investigated as follows:

Assuming the smallest loading team to comprise 3 people including the driver and half an hour for the loading of each post, we have:

A=Man-hour of personnel in the current and old systems

B=Transportation costs

C=Energy loss:

The economic viability of the above plan on a single post can be calculated by the following relation:

A+B+C=The costs of the traditional existing method:

Economic viability for a single post = saving 1.5 man-hours + saving in transportation costs + saving in energy loss

Owing to the nature of equipment loading at the present state and the time gaps between loadings as well as the lack of constant, proper recording of the loadings, certain problems often ensue such as voltage drop, one of the phases becoming fully loaded, increased loss, and damage to equipment.

It should be noted as an explanation that, in this plan, these displacements are carried out with electric power connected. A rapid system that works like a fast on-off recloser is utilized. Thus, the subscriber experiences electric power connection and disconnection in form of a recloser connection and disconnection.

The work process is described below:

In view of the fact that dataloggers are installed in low-voltage electric power distribution frames for measuring voltage, current, and power index and identifying the consumption pattern, the measured current information is processed and commands are issued for the displacement of phases. At first, the phase with the highest load is determined and commensurate with the highest and lowest difference in phase the load is transferred to lower phase in order for it to approach the mid phase. This process continues until an acceptable difference is achieved. On this basis, an 8-wire control circuit is used for the command 6 wires of which can encode 64 subscriptions pertaining to each low-voltage feeder. After sending, the subscription codes whose phase needs to change are decoded by a circuit that lies in the intelligent spacer or the junction box. The seventh wire determines the displacement status of the junction cable. In case it is one, the respective phase is displaced clockwise and in case it is zero, the respective phase is displaced counter-clockwise. The eighth wire is used for the start and end of the balancing operation. It is noteworthy that the on command is issued to the SSR when the off command is issued to the two SSRs pertaining to the two other phases. The subscriber’s consumption pattern has been given to the datalogger in advance and planning has been done according to the consumption of each subscriber. In case a new subscription is handed out, the respective code is activated.

Description:

Before describing the entire circuit, the components are introduced:

1- Intelligent spacer:

To carry out the project, it is assumed that at most 64 subscriptions are handed out on each low-voltage feeder in the long run. The encoding is done by 6 wires for the command and 1 wire for the balancing method. The code is decoded by the detection circuits inside the spacer. There are three power electronics command circuits inside the spacer. According to the electrical command received, one phase is connected and two other phases remain disconnected. An intelligent spacer is shown in the figure that is installed on the grid for each junction.

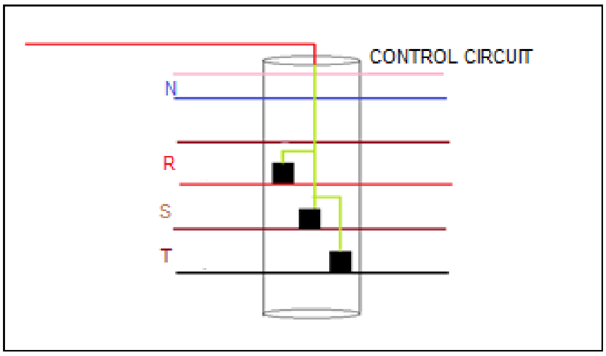

FIGURE.1.SMART SPACER

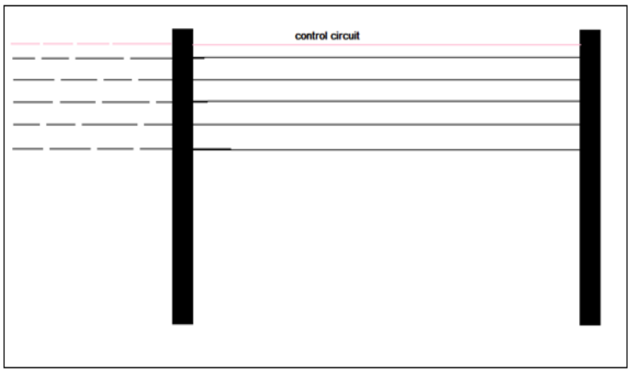

Figure 2 – Implementation of the control circuit including 4 pairs of command wires

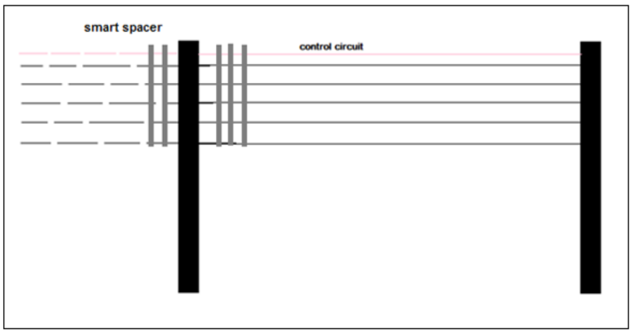

Figure 3 – Installation of 5 intelligent spacers for 5 junctions on the grid

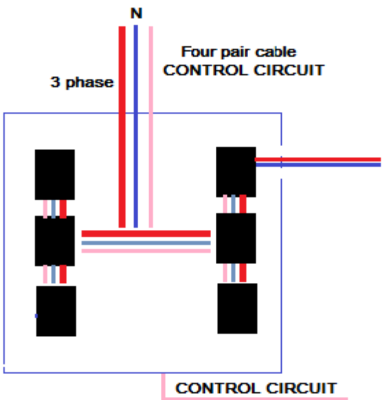

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Figure4.At certain points, an intelligent junction box can be used instead of an intelligent spacer provided that six junctions are purchased.

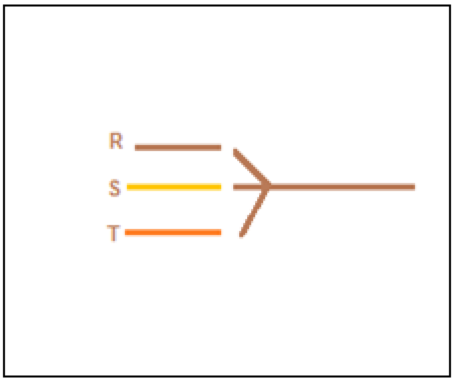


Figure 5 – Circuit schematics of three-phase electric power selected commensurate with the load of one phase

Figure 6 – Datalogger installable on an aerial post

In case self-supporting cables are utilized for the implementation of the grid, no spacer can be installed on the grid.

Figure.7.

To this end, a cover, on which one to three junctions can be installed, is installed on the cable.

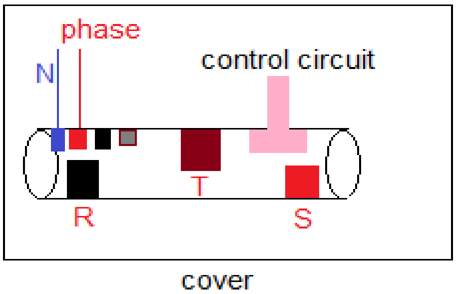


Figure8.

The following figure illustrates the stages of automatic balancing.

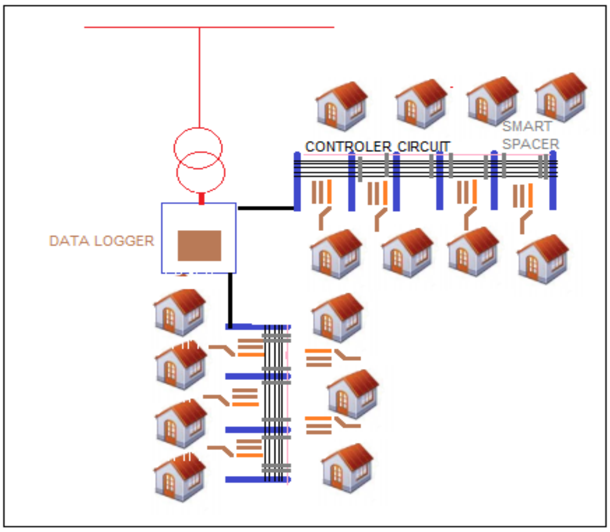
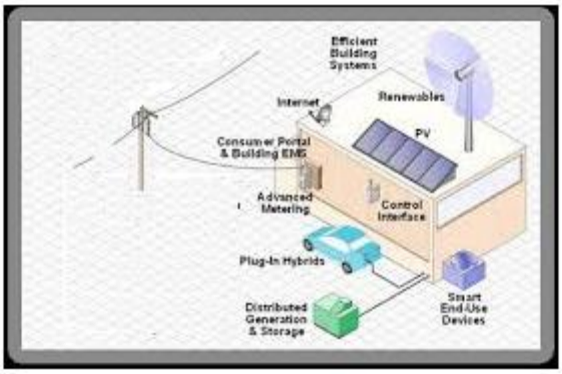


Figure.9



Given the fact that live-line working is used in many occasions on the low-voltage grid and the command circuit needs to be disconnected, it can be deactivated from inside the frame so that balancing would not be performed. Command is issued via the eighth wire. In case it is zero, automatic balancing operation halts and the intelligent spacer and the datalogger are disconnected.

The flowchart of the plan is as follows:

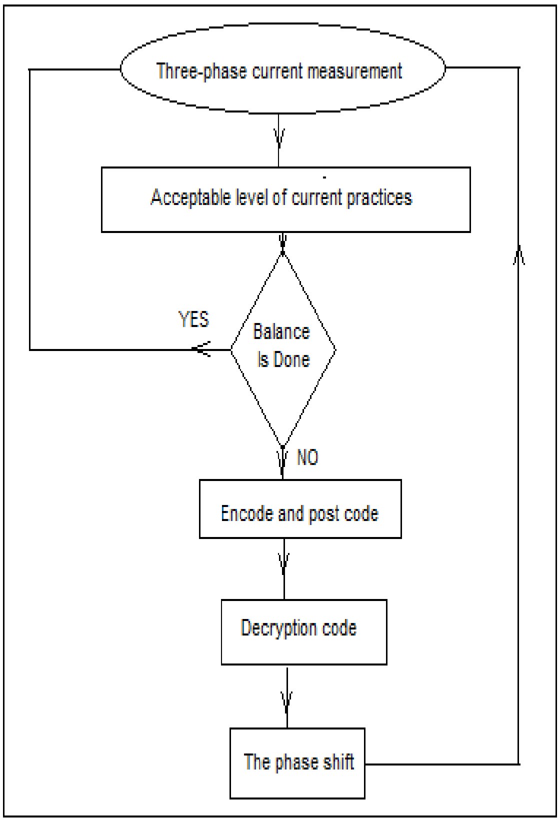


Figure.10

The overall circuit schematics is as follows:

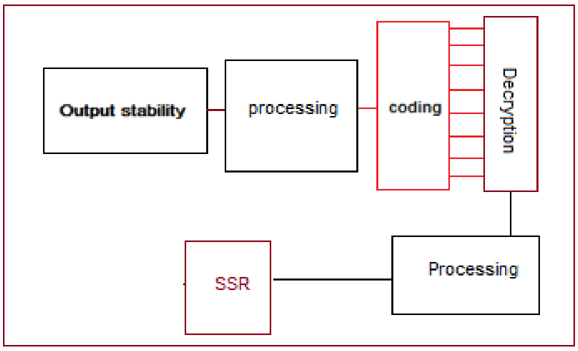


Figure.11

Solid-state relay

A solid-state relay (SSR) is an electronic switching device that switches on or off when a small external voltage is applied across its control terminals. SSRs consist of a sensor which responds to an appropriate input (control signal), a solid-state electronic switching device which switches power to the load circuitry, and a coupling mechanism to enable the control signal to activate this switch without mechanical parts. The relay may be designed to switch either AC or DC to the load. It .serves the same function as an electromechanical relay, but has no moving parts

Packaged solid-state relays use power semiconductor devices such as thyristors and transistors, to switch currents up to around a hundred amperes. Solid-state relays have fast switching speeds compared with electromechanical relays, and have no physical contacts to wear out. Application of solid-state relays must consider their lower ability to withstand momentary overload, compared with electromechanical contacts, and their higher "on" state resistance. Unlike an electromechanical relay, a solid-state relay provides only limited switching arrangements (SPST switching).

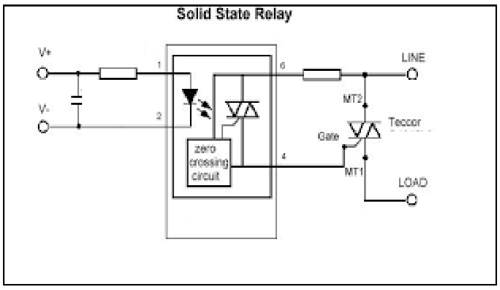


Figure.12

Control circuit is as follows:

It should be mentioned that the following circuit can be used for managing load consumption in addition to automatic balancing and indebted subscribers can be disconnected.

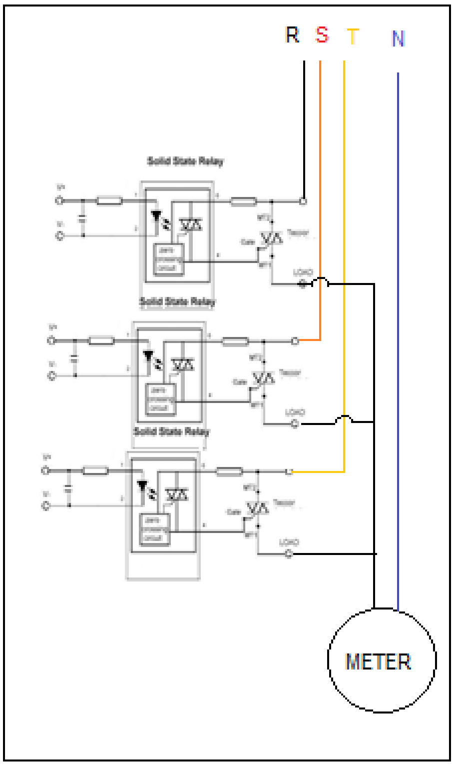
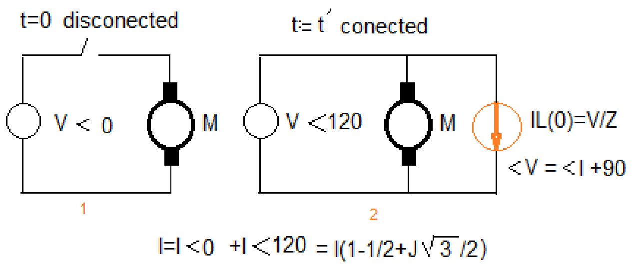


Figure.13

Reaction motor loads in the project:



t=(120/180*1/f)
pf=0/9

Conclusion

Load balancing is presently done traditionally in the distribution grid in accordance with the geographical conditions in hot and cold seasons and at load peak. Furthermore, the connection/disconnection team are constantly disconnecting indebted subscribers who have high consumptions at times. The balanced load is variable and causes increased grid loss. In the presented method, load balancing is done automatically. The above circuit can be activated or deactivated manually or from a distance by sending a text message. The above circuit also makes possible the disconnection of indebted subscribers from a distance. The control circuit consists of four pairs of wires. Six wires are used for encoding, one wire for specifying the displacement phase. If the remaining wire is energized, the balancing operation and the defined code are decoded. In case it is not energized, the balancing operation stops and no processing is performed.

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