Design of Self Powered Device for Shunt Tripping Circuit Breakers in Unmanned Substation

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Abstract- In Power Distribution Utilities, substations do not have auxiliary power supply like Battery bank and few times it is difficult to maintain the functioning of same. If timely maintenance of the Battery bank is not carried out, it may drop out from the system leading to the erratic behavior of the switchgear or shut down of the substation leading to power outages and direct revenue loss to the Utility.
Series Tripping Arrangement can be used to override this issue, in which the tripping requirement of Circuit Breaker is delivered by Current Transformers output, normally mounted in the Switchgear Panel. Some disadvantages are attached with Series Tripping Arrangement, so there is a need to design Electronic Series Trip Arrangement, involving Numerical Relays & Intelligent Power Sources, used in conjunction with Shunt Tripping Coils, without any substantial financial burden to the utility. This solution should be made compatible with present control panel and systems

Keywords- Circuit Breaker (CB), Series Tripping Mechanism, Current Transformers (CT), Shunt Tripping Mechanism, Self-Powered Device, Switchgear, Protective relays, Control power

I. INTRODUCTION

Rapid development of power grid and the increase in demanded security level, transformer construction is innovating itself towards man-less unattended systems. Presently, self monitored transformer substations mainly tend to develop towards five level automations i.e. remote measurement, remote communication, remote control, remote adjusting and remote viewing. Also, Transformer substation has gradually made remote viewing using video monitoring system realized. [1]

Substation automation is a mix of unmanned management and control system. The interest on substation automation provides numerous benefits to utilities. SCADA providing additional capability and information that can be used for improved operations, maintenance and efficiency in substation. Process level the power line function extracts the information from auxiliary switches, sensor or transducers in the substation and send them to upper level device, called bay level device. The other major task of this level is to receive the command for control from bay level device and execute it at the appropriate switch level.

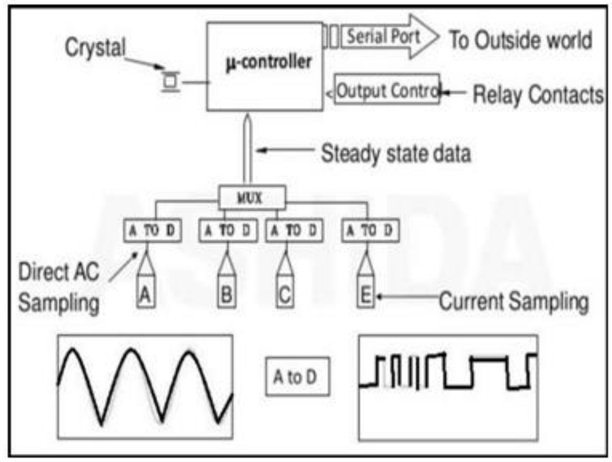

Fig.1: Numerical Relay

Bay level functions acquire the data from the bay then mainly act on the primary (power circuit) equipment of the bay. The different conceptual subparts of a substation are bay level devices. They are monitoring and control unit and protection unit. Bay level devices collect data from the same bay or from different bays and perform actions on the primary equipment in its own bay. The goal of user interface design is to produce a user interface which makes it easy to explain, efficient and user friendly to operate the machine in the way which produces the desire result. So it means that the operator needs to provide minimal input to achieve the desired output. Most modern numerical, microprocessor based relays are comprised of a core set of next functional blocks [12], as shown in image below:

Most numerical relays have multiple processors for different functions. V&I parameters are processed by a dedicated digital signal processor in conjunction with an analog-to-digital data acquisition system and interposing current and voltage transformers. Digital parameters are required to be handled like a variety of current and voltage ratings, actuation speed, actuation thresholds and different output types. Communications to station computers/HMI, usually requiring a variety of physical interfaces (e.g. RS485, etc.) as well as a variety of protocols (e.g. Modbus, IEC-870-5etc.). Usually required power level to support a wide range of AC and DC voltage inputs are around 24-300 V DC, 20-265 V AC)

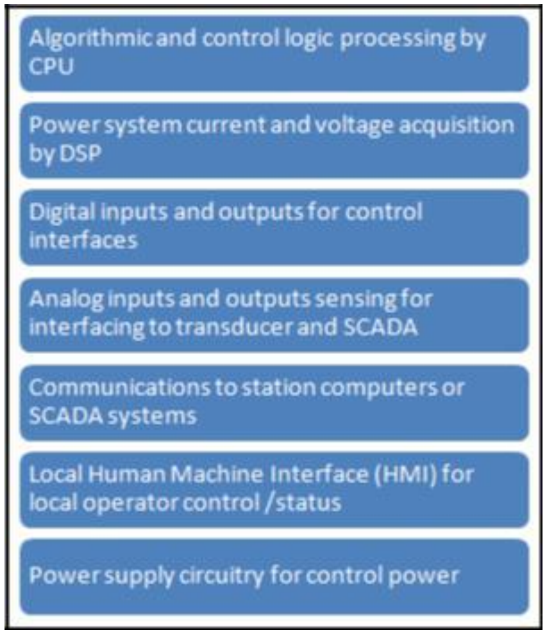

Fig.2: Numerical Relay requirements

II. SUBSTATION BATTERY AND CHARGER MAINTAINANCE

Storage batteries are used to supply stored energy for procedure of substation protective relaying. They are maintained at a fully charged level by self-regulated battery chargers installed to maintain a specific DC bus voltage. Battery chargers are not reliable system for DC current, in operations related to protection apparatus. It is so because; any fault can easily slow down the charger supply voltage up to an extreme case of charger nonfunctioning. Failure of the battery to perform its intended function can result in local service interruption, significant damage to substation equipment and in some cases wide spread outages or major system disturbances. Not having adequate battery capacity available at all times is equivalent to removing relay protection and should be approached with extreme caution. The heart of a substation is the battery bank. If this were to fail, this is what could happen:

1. *An electric utility could expose all feeders associated with the station to a condition where they could not ever trip in a fault.*
2. *Any backup devices, such as the main breaker on the low-voltage side or the high-voltage side protection of the power transformer, would all be inoperative.*

If in the highly unusual situation where the battery supply must be disconnected in an energized station, and time is not of the essence, obtain permission from the supervisor. Prompt attention to any abnormal situation involving DC systems is essential and maintenance related to batteries and chargers should be of the highest priority. Maintenance activities include such things as visual inspection, checking and restoring electrolyte (water) levels, measuring individual cell specific gravity (for lead acid designs), temperature and voltage readings, cleaning and retorquing terminal connections, etc. The self-powered supply circuit proposed in this paper can adequately utilize the energy that should have been wasted in conventional power supply circuits. It can collect energy to supply the controller integrated circuits, which has important significance.

III. SHUNT TRIPPING CIRCUIT BREAKER

A shunt trip device is an optional accessory in a circuit breaker that mechanically trips the breaker when power is applied to the shunt trip terminals. The power for the shunt trip does not come from within the breaker, so it must be supplied from an external source. Some circuit breakers allow field installation of a shunt trip kit; however others require factory installation when the breaker is ordered. Check the specific breaker type for available ac and dc shunt trip voltage ratings and for the method of installation.

A shunt-trip breaker, in addition to the internal instantaneous over-current and time-over-current protective functions, has an externally powered solenoid that will trip the breaker when energized. This is normally tied to a safety interlock system that will shut power off to the affected equipment when, for example, a protective cover is opened or removed. A limit switch or other similar device will be used to detect if the cover is in place or not. It is held open by the cover. If the switch closes, the breaker is tripped and the machine is rendered electrically safe. [3]

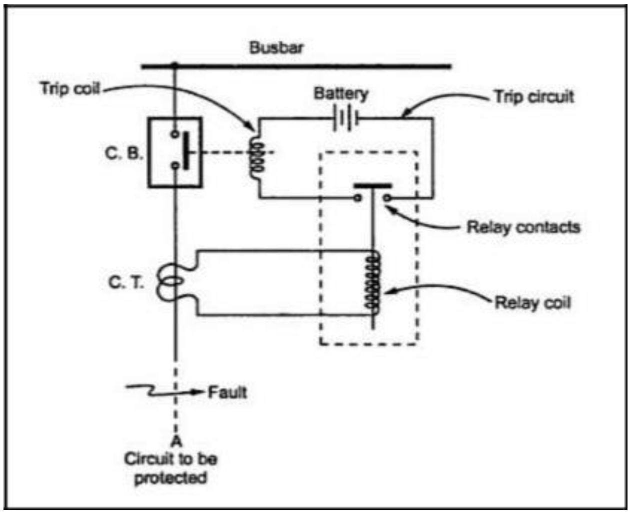

Fig.3: Shunt Tripping Circuit Breaker

IV. LITERATURE REVIEW

A major component in a power distribution substation of a utility is the Indoor Vacuum Circuit Breaker. Typically any medium voltage switchgear, from 3.3kV to 33kV, operates on the principle of shunt tripping of breakers in case of fault. However, the main requirement for achieving shunt tripping is availability of auxiliary supply in the substation. This is required for operating the shunt tripping coil as well as the protection relays. The auxiliary supply is generally taken through a DC Battery of appropriate voltage – 30V / 48V /110V / 220V. These are rechargeable Lead – Acid batteries and are charged through a station battery charger. The batteries as well as the battery chargers need periodic maintenance. [4]

Most of the utility substations are unmanned; so it is very difficult for utilities to maintain the battery and battery chargers. Also, budget for maintenance is rarely available with most of the public utilities, owing to the precarious financial position. To circumvent this problem, most of the utilities prefer to install Series Tripping Switchgear. In the series tripping switchgear, the current punch required to operate the tripping coils is obtained from the Current Transformers (CT). [5] Since the relays required for series tripping arrangement are electro–mechanical, no precise control / selectable tripping curves / fault data storage; communication is possible. Though the series tripping switchgear has served the Indian utilities for a long time, the need to automate the switchgear to ultimately achieve the goal of the Nation Electricity Policy could not be served with the series tripping switchgear. At the same time, the utilities were reluctant to install shunt tripping switchgear because of the need of auxiliary supply in the substations. [6] To bridge this gap, a need was felt to develop switchgear which will retain the advantages of a series tripping arrangement with facility to incorporate latest numerical communicable relays, which will ultimately enable the utilities to implement SCADA and DMS (Distribution Management System). [7]. Numerical communicable protection relays which can store; communicate fault data with the master control station for analysis and proactive measures for avoidance of network tripping. To achieve the above objectives, a system is needed which combines the advantages of both series tripping and shunt tripping switchgear. The typical objectives or requirements of the utilities are summarized in figure 4.

V. METHODOLGY OF DETAILED SYSTEM

The function of a circuit breaker is to isolate the faulty section of the power system in case of abnormal conditions such as Over Load; Short Circuit. A protective relay detects abnormal conditions (through Current Transformers) and sends signal to the trip coil of Circuit Breaker. Circuit Breaker trip and the faulty section get isolated from the system. Relay and Trip coil requires an external supply for its operations. This supply is usually provided through a station battery and charger unit. Self power device draws power from current transformers associated with the breaker. AC power is converted in to the DC and it is stored; and supplied exclusively to tripping coil of Circuit Breaker (CBs) during supply and load condition. In the event of fault, O.C. / E.F. relay picks up, its contact closes & completes the loop of trip circuit. The shunt trip coil energizes i.e. receives the necessary voltage from the Self Powered Device and it trips the Circuit Breaker.

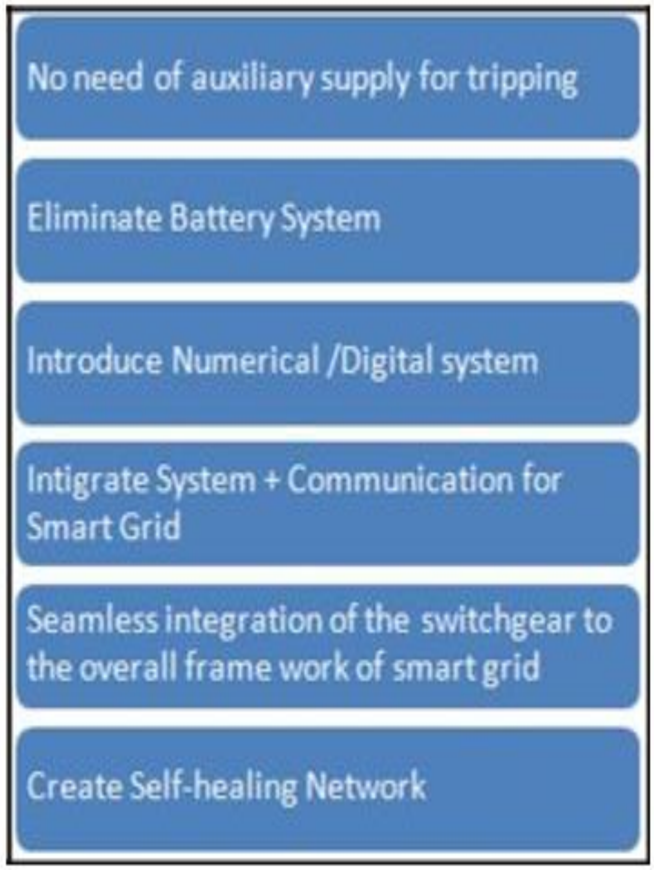

Fig.4: Requirements of Utilities

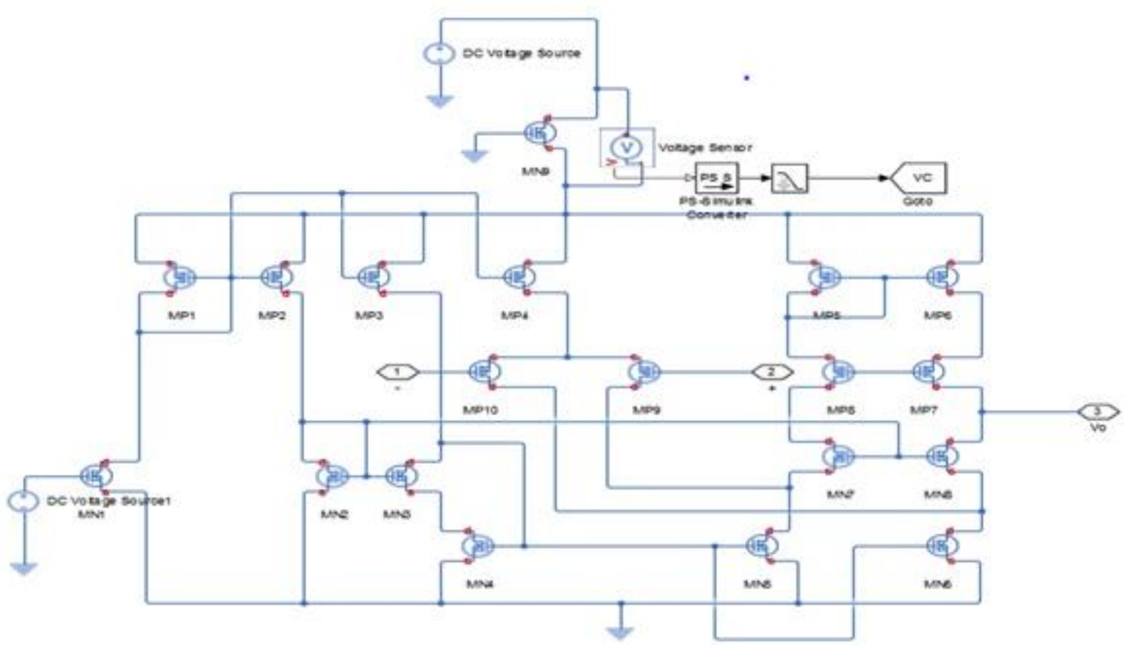

Fig.5: System Design

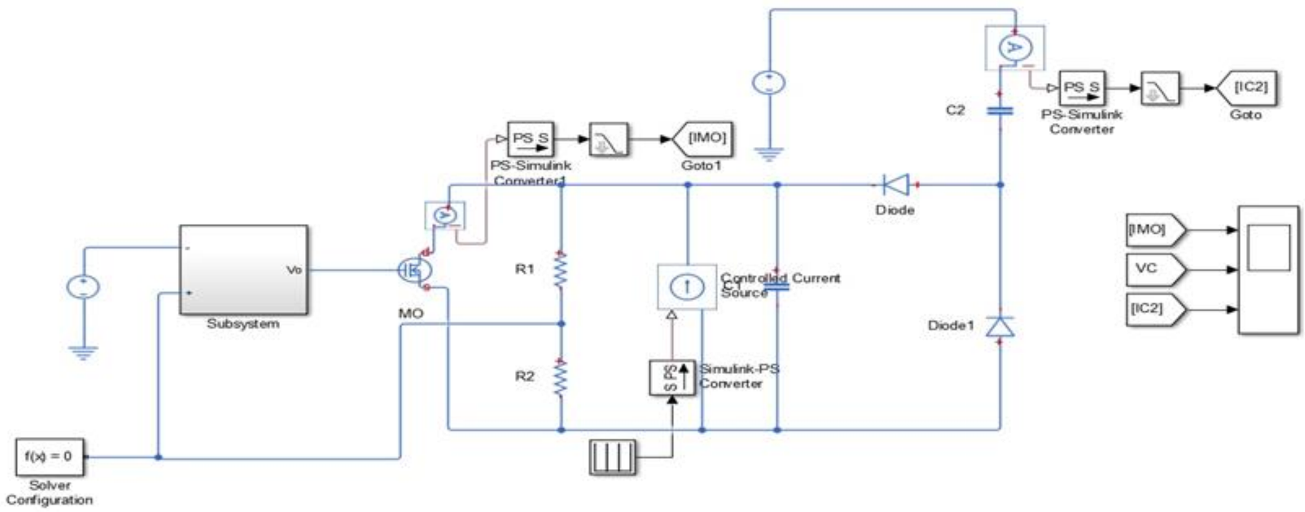

Fig.6: System Implementation

VI. CONCLUSION

A self-powered supply circuit for high-voltage switching mode power supply (SMPS) has been discussed in this article. The designed supply circuit is realized by the energy recycling of power MOSFET switching procedure. Initially the *dV/dT* at the drain terminal of power MOSFET is detected. Then a rectified current is generated by proposed structure. With the help of dynamic current matching clamping (DCMC) technique, a stable internal supply voltage is come into being. The proposed self-powered supply circuit is validated, which demonstrated that the presented circuit in this paper can improve the performance of SMPS remarkably without using any high voltage device and auxiliary winding.

VII. REFERENCES

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