

An Approach for Enhancing the Power Quality and Fault Ride-Through Capability of Distributed Power Systems

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ABSTRACT: The spurious undesirable power fluctuations caused due to numerous abnormal reasons like leakage, faults and ageing of the lines may not only often influence the quality and quantity of power being supplied but also shows a severe impact on the robust and sustainable operation of the Distributed Power System (DPS). This will lead to a heavy loss to the consumers appliances and industries as it disturbs the production process.

In this paper in order to resolve the above issues we proposed an interactive approach for enhancing the distributed power quality and fault Ride-through capability of a giant class PDS using Synchro-Phasor Control Units (SPCUs) which determines the power quality deviation due to fault based on the analysis of voltage and current phasors of the individual transmission lines. The method exploits the nodal voltage and mesh current analysis where the phase voltage, impedance and admittance matrices of the network and its dual circuit are developed and utilized for smooth detection and isolation of the fault without affecting the network. In addition, this method not only detects and isolates the faults but also corrects the conventional and reactive power losses and fluctuations in DPS. The proposed algorithm is schematically developed and implemented in the Matlab Environment..

KEYWORDS: Power Quality, Fault Isolation, Quality Correction, Distributed Power System and Power Distribution.

I. INTRODUCTION

Faults and machine malfunctions have an effect on the power quality in the electrical power systems and leads to losses for both electric utilities and customers [1]. In Distributed Power System (DPS) [4], safety and secure operation of the system highly rely on the level of power system operating condition monitoring. In conventional approaches the measurements provided by the remote terminal units (RTU) at the substations are sent to the control center. This data include real/reactive power in different lines as well as bus voltages and branch currents. The unmeasured states of the system are then estimated by state estimators that reside in the control center. Normal observability in power system is defined as knowing the voltage phasors of all the buses. Fault observability [18], on the other hand, is defined such that a system becomes fault observable when the voltage at two ends of each line and the current at any end of the line are determinable. Fault situating in power systems has been a noteworthy subject for power and assurance designs as of late for the reason of system unwavering quality. Power engineers dedicate a great deal of time to create distinctive Fault finding calculations so as to defeat this test in power system. In any case, it ought to be referenced that in dispersion systems, because of huge varieties of Fault impedance, Fault area issue has a larger number of difficulties than in transmission and age systems [4]. Besides, it isn't monetarily practical to power distribution systems with cutting edge staggering expense insurance hardware.

Protection devices have been generally used to help fault area in power frameworks. Jinsang et al. remove the size of fault current and fault sort from PQ observing devices to find the fault [15]. A strategy to find the fault line segment in power distribution systems utilizing Fault Indicators (FI) is introduced in [16]. After the faulted line is

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recognized, existing flaw area strategies can be received to ascertain the fault area. An approach talked about in [17] can be used to choose the most appropriate fault area technique under a rundown of confinements and necessities. Jun et al. give an approach to decide fault area dependent on data accessible from account devices and feeder database [18]. Fault areas are positioned and contrasted with one another with scan for the genuine fault area.

The DPS normally accepts the power from various non-renewable and renewable power generation units. The non-renewable type of power generation units supplies the power with almost required quality controlled by the system with the proportional consumption of the non-renewable energy resources. Generally the strength and quantity of the renewable energy resource will vary continuously from time to time and season to season. Thus the strength and quantity of the renewable energy resource cannot be maintained as constant. Hence the generated power levels from the renewable energy resources will vary accordingly. Since the renewable power generation units are also used as the power source for the DPS, the variable power levels from the generation units may cause the injection of the reactive power levels. Whereas the non-renewable energy resource based power generation units[4] will inject the active power components. The undesirable injection of the reactive power levels against the active power levels may cause spurious fluctuations in the quality of power being supplied by the DPS. Power Generation Units plays important role in delivering the power to the DPS. However, power losses and voltage magnitude must take into consideration in order to produce reliable power to consumer.

II. RELATED WORK

Renewable generation and versatile burdens are dubious, control streams are much of the time turned around, and bus voltage magnitudes can change impressively. For instance, the power created by a photovoltaic (PV) network[3] with discontinuous cloud inclusion can shift by 15% of its name plate limit inside one-minute interims. Not the same as transmission matrices, bus voltage magnitudes in circulation frameworks are especially influenced by dynamic power varieties. On a crisp morning, sun based age may effectively surpass nearby interest (particularly at noontime off-top hours) and cause over-voltages ; though medium-term vehicle charging could prompt genuine voltage hangs . Albeit precluded by current gauges, the power hardware of PVs can be told to give reactive injections also. Consequently, reactive power pay by means of DG units has been a functioning exploration region recently. Every single past plan expand on rough network models. Being an example of the optimal power flow (OPF) problem[5], responsive power the executives is a non-curved issue, yet a few arched relaxations have been proposed . In spiral circulation frameworks, OPF can be surrogated by a semi definite program (SDP)[7] or by a second-order cone program (SOCP) utilizing either polar directions, or the branch stream demonstrate. By and large a smaller scale matrix is a goliath class control appropriation arrange which wills supplies its capacity to every one of the areas encompassing it. Unfeasible reactive power injections can cause amazing drop in the nature of the power being provided by the smaller scale framework network[6]. This power quality oscillations not just influences the power quality in power frameworks and cause misfortunes for both electric utilities and clients. A few calculations were proposed to make up for the reactive power injections and the execution of which was not attractive. Notwithstanding the responsive power injections, some of the time the successive line faults because of a few catastrophic events and climatic conditions may cause the sudden drop in the power quality and can destruct the power distribution system, aggravates the nature of intensity provided to the utilities. In this project in order to resolve the above issues we proposed an interactive approach for enhancing the distributed power quality and fault Ride-through capability of a giant class power distribution systems using Synchro-Phasor Control Units(SPCUs)which determines the power quality deviation due to fault based on the analysis of voltage and current phasors of the individual transmission lines.

III. PROPOSED WORK

In this work, we proposed, developed and implemented a novel high performance interactive approach for enhancing the distributed power quality and Fault Ride-Through capability of a large scale Power Distribution System (PDS) using a SPCU unit which monitors the power quality oscillations due to faults based on the analysis of voltage and current phasors of the individual transmission lines. Since the DPS is a giant class power distribution system, it accepts the power in large quantities from various power generation units of both renewable and non-renewable type. The Non-

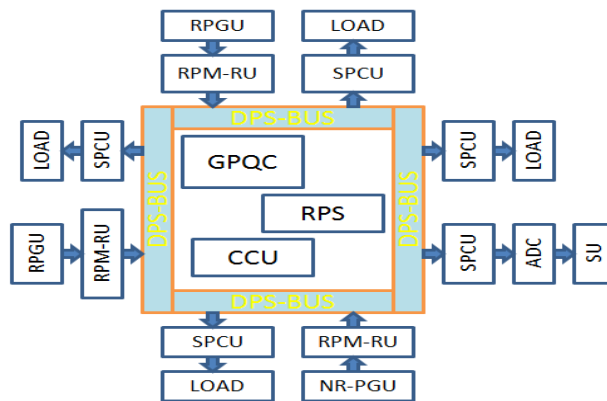
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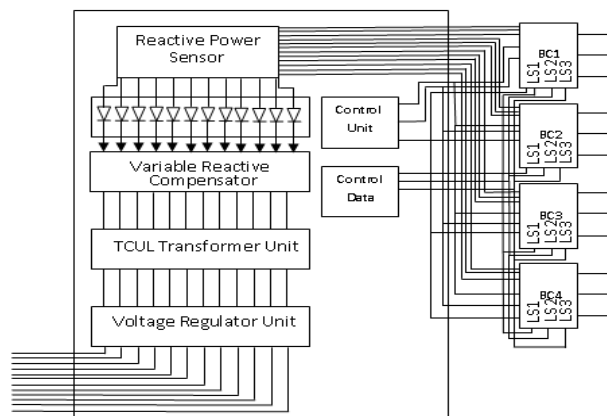
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Renewable Power Generation Units(NRPGU) can supply the power at required rated quality and quantity through the proportional consumption of the Non-Renewable energy resources. But the power supplied by the Renewable Power Generation Unit(RPGU)s vary in quality and quantity from time to time, season to season as the quantity of the renewable energy resources vary accordingly. As a result, these renewable power fluctuations will cause a reactive power flow into the DPS. Thus the RPGU unit injects the reactive power flows into the DPS Network.



Fig(1): The Schematic Block Overview of the Proposed System

The reactive power flows injected into the DPS network may often significantly counterfeits the active power flows thereby resulting in the reduction of the quality of power being supplied by DPS[13].As a solution to this problem we proposed this approach. The proposed approach implements a DPS with 12 line IEEE ring bus architecture as shown in fig(1). The ring bus architecture enables the DPS to collect power from various power generation units and supplies it to various regions around it. All the individual power generation units are interconnected to the DPS through the proposed Reactive Power Management and Regulation Unit(RPM-RU). The proposed RPM-RU unit cancels the reactive power injections from the DPS to power generation units and restores the DPS power quality to the rated level. A separate bus branch is drawn to each surrounding region from the DPS and each bus branch is put under the control of an identical Synchro-Phasor Control Unit(SPCU). The DPS will have a complete control and command over all SPCU and RPM-RU units as illustrated in fig(1) with the help of three control signals drawn from all the RPM-RU and SPCU units .RPM-RU_CN, RPM-RU_S and RPM-RU_ES are the three control signals corresponding to each RPM-RU unit representing the control, status and error status respectively.



Fig(2): Schematic Internal Circuit of the RPM-RU Unit.

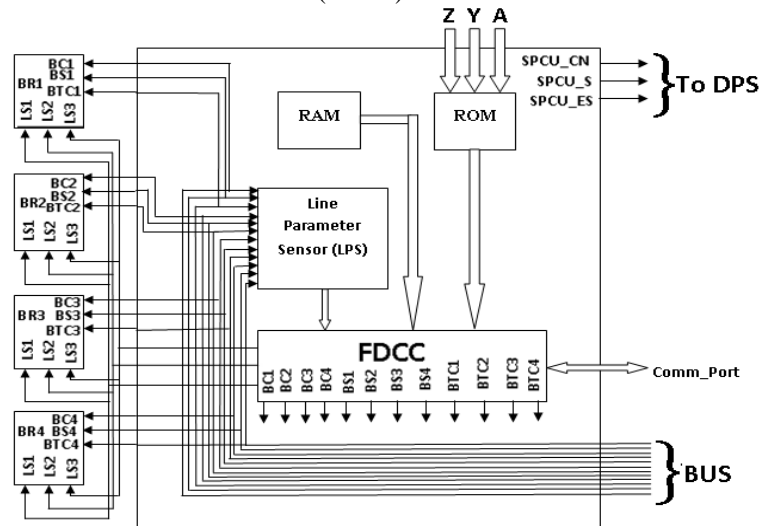
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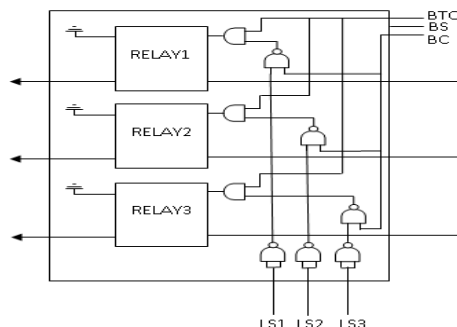
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In a similar manner SPCU_CN, SPCU_S and SPCU_ES are the control, status and error status respectively of the corresponding SPCU unit. The schematic internal architecture of the proposed RPM-RU unit is shown in fig(2), which internally consists of a Reactive Power Sensor(RPS) which senses the reactive power injections and informs the same to the Variable Reactive Compensator(VRC) unit. The VRC unit continuously compensates the reactive power flows and allows only the rated quality power to the DPS. Now the Tap-Change-Under Load Transformer unit is brought into the operation to restore the degraded power levels to their rated levels and the Voltage Regulator Unit(VRU) regulates the oscillating power flow to the stable regulated level. The control unit controls all the internal blocks and its associated breakers. The fault protection operation of the DPS are controlled and monitored by the SPCU unit whose schematic architecture is shown in fig(3). Each SPCU unit consists of a RAM unit, a ROM unit, a Line Parameter Sensor(LPS), a Fault Detection and Correction Circuit(FDCC) and the associated breakers as shown in fig(3).



Fig(3): Internal schematic circuitry of the Synchro Phasor Control Unit (SPCU).

The ROM unit stores the rated bus parameter values from the database of the DPS. The RAM unit is a volatile temporary storage media for the instantaneous bus parameter values computed by the LPS unit. The standard and instantaneous bus parameter values are compared for fault detection in FDCC unit. According to the comparison results the FDCC unit will act accordingly to locate and isolate the line faults without interrupting the power distribution. The power levels on various bus lines are monitored and controlled by the SPCU unit with the help of its associated breakers.



Fig(4): Internal Circuit of the Breaker Circuit.

Each SPCU unit controls all its associated breakers with the help of three control signal lines such as BC (Breaker Control), BS (Breaker Status) and BTC (Breaker Trip Control). The schematic internal architecture of the breaker circuit

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is shown in fig(4), which consists of three relays and an associated logic circuitry to control three power distribution lines. All the breakers are identical in their structure and each can control three lines simultaneously with its associated logic circuitry.

IV. EXPERIMENTAL RESULTS

In this paper we proposed, developed, coded and implemented an interactive approach for enhancing the distributed power quality and fault Ride-through capability of a giant class power distribution systems using Synchro-Phasor Control Units (SPCUs) which determines the power quality deviation due to fault based on the analysis of voltage and current phasors of the individual transmission lines. To verify the operational effectiveness of the proposed approach the computer simulations are performed in the Matlab Environment and the simulation results are presented as follows.

DPS Rated Parameter Values			
Line NO	DPS_Current	DPS_Voltage	DPS_Phase
1	50	230	0
2	50	230	30
3	50	230	60
4	50	230	90
5	50	230	120
6	50	230	150
7	50	230	180
8	50	230	210
9	50	230	240
10	50	230	270
11	50	230	300
12	50	230	330

Table (1): Rated Parameter values of the DPS.

RENEWABLE POWER GENERATION UNIT1 Performance Statistics					
S NO	RPGU1_A	RPGU1_V	PDS_S1	RFC_PL1	TCULTU_RPL1
1	50	230	1	230	230
2	50	230	1	230	230
3	50	230	1	230	230
4	50	230	1	230	230
5	50	230	1	230	230
6	50	0	0	0	0
7	50	230	1	230	230
8	50	230	1	230	230
9	50	230	1	230	230
10	50	230	1	230	230
11	50	230	1	230	230
12	50	230	1	230	230

Table(2): Practical Performance statistics of RPGU1.

The standard values of the rated voltage, current and phase levels of the proposed DPS are given in table (1), whereas the rated parameter values of each RPGU unit are given in table(2).

SPCU1 OPERATIONAL SUMMARY		
SNO	Control Variable	Operational Status
1	SPCU Control	Enabled
2	SPCU Status	Active
3	SPCU Error Status	No Error
4	BR1 Control	Enabled
5	BR2 Control	Enabled
6	BR3 Control	Enabled
7	BR4 Control	Enabled
8	BR1 Status	Active
9	BR2 Status	Active
10	BR3 Status	Active
11	BR4 Status	Active
12	BTC1 Status	Untrip
13	BTC2 Status	Untrip
14	BTC3 Status	Untrip
15	BTC4 Status	Untrip

Table (3): Schematic operational summary of the SPCU1.

SPCU1 PERFORMANCE SUMMARY			
SNO	SPCU_BUS_LINE	LINE_STATUS	AMPLITUDE
1	LINE1	Closed	Rated
2	LINE2	Closed	Rated
3	LINE3	Closed	Rated
4	LINE4	Closed	Rated
5	LINE5	Closed	Rated
6	LINE6	Closed	Rated
7	LINE7	Closed	Rated
8	LINE8	Closed	Rated
9	LINE9	Closed	Rated
10	LINE10	Closed	Rated
11	LINE11	Closed	Rated
12	LINE12	Closed	Rated

Table (4): Schematic performance summary of SPCU1.

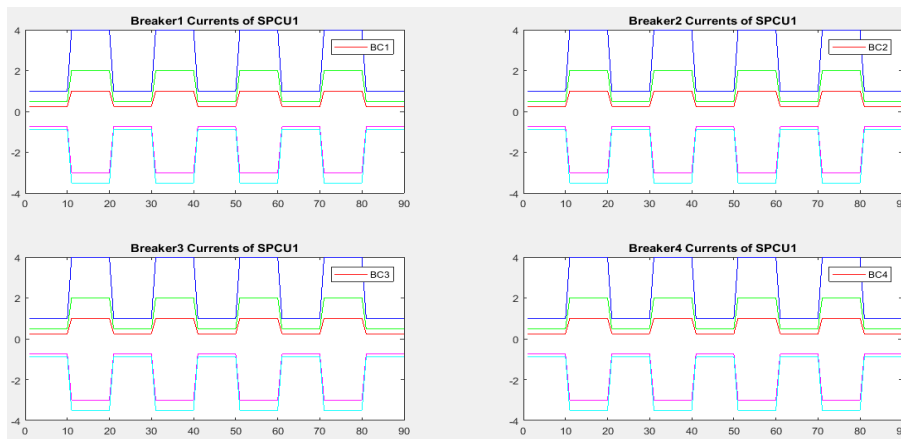
The operational parameters and their status information of each SPCU unit are given in table(3), whereas the performance summary of each SPCU unit is presented in table(4).

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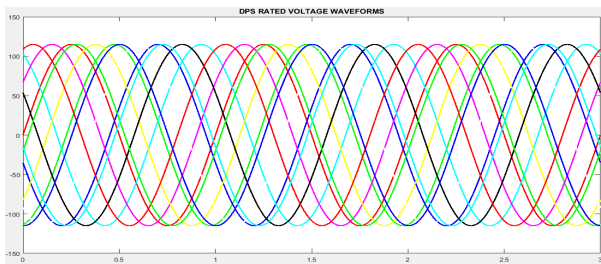
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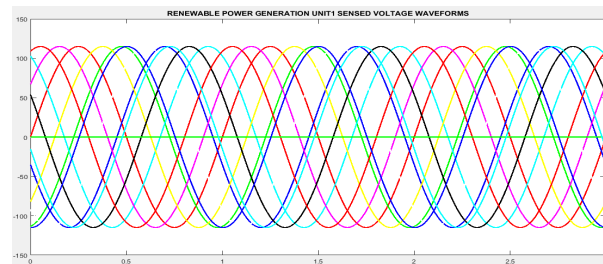


Fig(5): SPCU1 Breaker Current Waveforms.

Each SPCU unit has four breakers and each breaker can control three lines. The enable (CN), status(S) and error status signals of each SPCU and its associated breaker circuits are shown in fig(5).

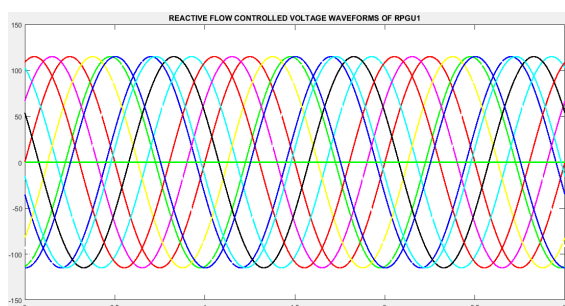


Fig(6): Rated Voltage Waveforms of the proposed DPS.

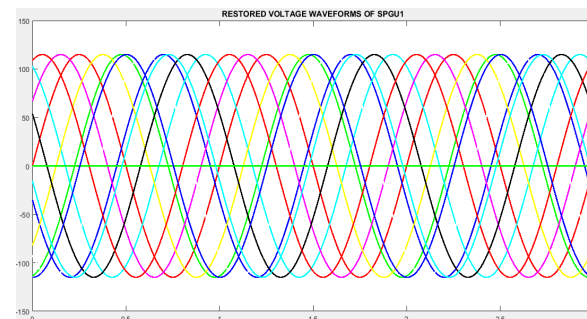


Fig(7): Instantaneous Voltage Waveforms of the RPGU1.

The rated voltage waveforms of the proposed DPS are illustrated in fig(6), where as the instantaneous sensed voltage waveforms of each RPGU Unit are shown in fig(7).



Fig(8): Reactive Flow Cancelled Power Levels.



Fig(9): RPGU1 restored line voltage levels.

The reactive power compensated voltage waveforms of each RPGU unit are shown in fig(8), whereas the restored voltage levels of each SPCU unit are shown in fig(9).

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V. CONCLUSION

In order to counteract to these hard striking reverse power flows and to establish a fault immunity and rated quality operation of the DPS. In this project we proposed an interactive approach for enhancing the distributed power quality and fault Ride-through capability of a giant class power distribution systems using Synchro-Phasor Control Units (SPCUs) which determines the power quality deviation due to fault based on the analysis of voltage and current phasors of the individual transmission lines. The fault protection of the proposed DPS is performed with an aid of another defensive module called an SPCU. Thus the proposed algorithm is designed to perform the fault isolated reactive power compensation in the DPS. Numerical tests on an industrial 12-bus DPS are proved that the proposed approach is best in all aspects and outperforms all the existing techniques.

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