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A Novel Algorithm to Improve the Power Quality for the Smart Grid and Integration with the Optimization Framework

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Abstract *- The objective of the smart grid is to afford the quality power or rated power to the user who can operate the devices /utilizations/apparatus at the adjacent mandate. But there are serene, convinced encounters that oppose the device's action to accomplish its dispensed task. The voltage is throw down/list or in supplementary words can be supposed that the no-rated power and brownout of power, the case when we have power but can't practice it then what meant for it. The brownout is equivalent to that water that can't thirst-quencher. The power quality subjects like fluctuations, voltage spikes, swell, sag, flickers are included in the system. In this paper, we are an effort to scrutinize the numerous challenges and trying to overwhelm such challenges. For Perfection, in power quality/ rating, the dataset is well-thought-out from IEEE. The Research paper has to try to perceive the proposed algorithm is fulfilling the devices/appliance's basic requirement or not. Moreover, it is an effort to enable the device to perform its basic functionality without any obstacles. The fallouts will be compared with the latest studies, which were available with Scopus/IEEE database recently. A comparative study will be shown that the algorithm is employed fit or not and trying to find the possibilities for amalgamation of the proposed algorithm with load/security optimization framework.*

Keywords *- Smart Grid, Power Quality, Integrated Technology, Quality Assurance, Optimization Framework*

I. Introduction

The term quality is an exhibition the aforesaid. It is earmarked by everybody's life expectancy with pride. When the quality appends with anything superiority of that entity is augmented automatically. The identical entity has materialized in the power engineering [1-2] when conversing power, and then everyone wishes the rated and quality power. The enthusiasts are equating the quality power [3] with quality nutriment/life etc. When food is respectable for health, it is called quality food, but if a food is deprived of nutrition and after taking it condition is 3-4 days bed rest, then the food is not a portion of quality food. Similar as quality power leads the device unstable/burnt / out of order/fail. The power industry also wishes quality power which is healthy for our smart/ devices/machines. Quality power is also important for the long life of our devices. The different organization has demarcated the term quality in their traditions. IEEE and IEChave also defined the power quality standards. IEEE standard 1100, IEC 61000, has already defined this term [4]. These organizations have already labeled some standards for execution processes surrounding electromagnetic waves satisfactorily. As per time and requirement, the definition and standards are changing communicatively. To expand the trustworthiness of the system, enhancement in power quality is the focal reason of the power engineers to gratify the consumer's demand. So due to these reasons, the study of the distribution system becomes more important. The distribution losses in 2014 are 19.5% as per the ministry of power [5], Government of India. Now professional's conversation about the voltage quality as well as current quality. The wide assortment of applications of power devices encourages the industry as well as researchers to think about it and improve the quality of power for better health and life of smart devices like mobile laptops, smart gadgets, etc.

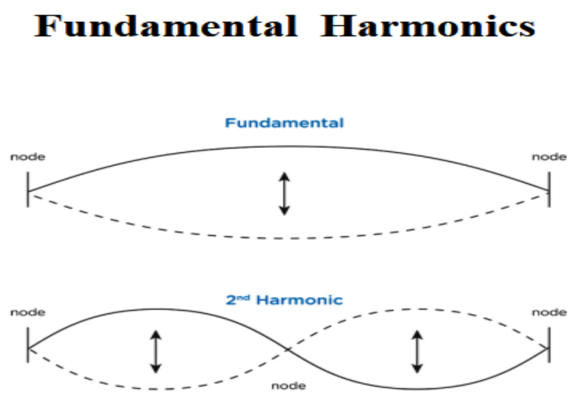

Figure 1: Harmonics [28]

All the Alternating Current (AC) equipment is talented to accept the sinusoidal waveform and rated voltage/current/frequency. In another hand, all the smart devices / World devices are premeditated for Direct Current (DC) voltage followed by a storage device called a battery and functioned with the help of a contraptioncipher. Throughout the script of this paper, it has minded the historical contextual of power quality and the current state of affairs in India as well as the world power scenario. The prime objective of power quality is to provender the quality contribution to the appliances/devices that have been stable and continuously deprived of interruption of assigned duties.

II. Historical Background and Related Work

After scrolling the publication history power quality, one paper is published in 1970 to keep in focus power quality and reliability, and then many different other papers provide analysis the power quality and the Soviet Union. The power quality was focusing from 1968. INSPEC stores the progress related to power quality. Approximately up-to-the-minute-correlated effort as follows:

Mallajoshula et al. (2019) [6] have presented numerous issues concerning power quality. The authors described that how mitigation devices reduce the harmonics in terms of cure the power and status of reduced harmonics in the system. The straightforward objective is to be allied to power for a quality life for devices as well as humans. The authors tried to solve quality-specific issues and perform the hybrid APF design for harmonics in the power system. Furthermore, authors make available the overview of harmonic problems related to power quality in admiration of voltage interruption, notching, fluctuation, transients, steady-state, voltage sag, swell, etc. The authors perform simulation using the FPGA technique. In order to implement the proposed solution, simulation is performed with MATLAB. The proposed synchronous detection algorithm with their work and perform the separate load RL, RC load.

Zhang, J. (2018) [7] have presented an outline of power quality in smart grid and generation systems. The author familiarizes the problematic areas associated with power quality in the generation unit. Furthermore, enlist the problem and their conceivable solution in respect of different parameters and frequencies. The author specifies the problematic zone, which differs from the frequency of the system. This paper also describes the current scenario and trends in power quality in China. They also recommend implementing the internet and big data for last-scale integration. Apart from this, also discuss the hormone generation impact and pollution, strategy for harmonic suppression, flicker, and measure for flicker.

Vita, V. (2017)[8] has proposed the decision-making algorithm for optimizing the size and placement of the Generation unit; the author's primary objective is to reduce losses and provide a better voltage profile. The author has used the IEEE-33 Bus system for the testing algorithm. The algorithm has independent work and is non-dockable. For the implementation of the proposed algorithm, MATLAB/Simulink and NEPLAN 360 were used and perform the comparative study in respect of the proposed algorithm.

Benjamin [9] has examined the reactive power and offer the solution of the reactive power compensation and relate the reactive power with the voltage by a relation. The authors fixated on reactive power support buses and branches. For assumption and testing proposed work, reactive power IEEE standard bus system was well-thought-out. The authors strained to minimize the losses and offer the solution for only technical losses.

Rabieeet al. [10] have apprised with the relationship between the reactive power with voltage, current, reactance, active power with the constraints of market values grit with the help of the CIGRE-32 bus test system network formation. All the settings were pre-assumed, and perform the load analysis was for detecting the loss lines. Moreover, performed a comprehensive study of Real-time price and real-time energy.

Prasad et al. [11] have proposed a simple and efficient structure for computation of the branch current in centrifugal distribution network by using Kirchhoff's voltage law and power equations. The proposed load flow algorithm enlightens the edifice assets of a centrifugal distribution system using the implementation of the LFA algorithm. In direction to implement the proposed algorithm, MATLAB is used and performed the simulation against several parameters.

III. Effect of Power Losses and Quality

The losses in any industry, as well as the power industry, is a negative sign of progress, and it will condense the wellbeing of devices/equipment and improve the cost of transmitting the power from Generation to Consumer. Advancement in current Setup and elevation of the prevailing technology for communicating with the latest devices and smart systems. Elimination or Minimization of losses is an oxygen level for the creation smart world. The smart world [32,33,35] is next-level integration of technology like Artificial Intelligence, Image Processing, Signal Processing, Robotics, and Control systems, etc. The smart world needs constant, unceasing, and quality Power for a healthy conversation of machines.

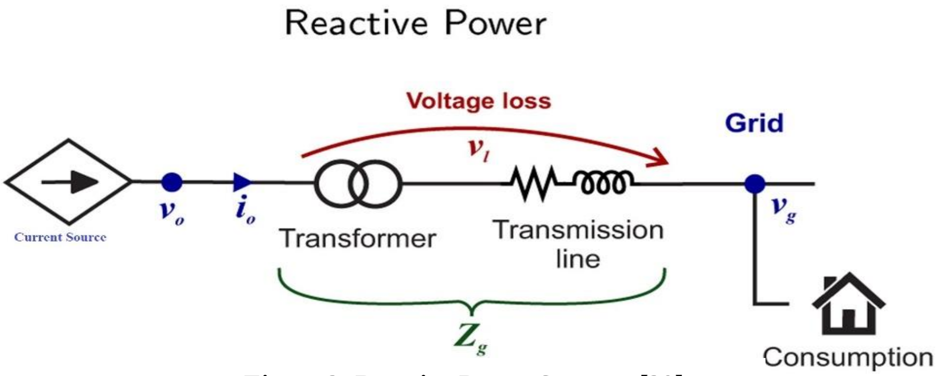

Figure 2: Reactive Power Support [29]

The losses are completely depending upon the requirement and operational condition of the system. Calculation of losses [12] is as follows:

$$\sum_{i=1}^{n}\sum_{j=1}^{n} A_{ij}\left(P_iP_j + Q_iQ_j\right) + B_{ij}(Q_iP_i - Q_jP_j)$$

$$A_{ij} = \frac{R_{ij}}{V_iV_j} Cos(\delta_i - \delta_j),$$

$$B_{ij} = \frac{R_{ij}}{V_iV_j} Sin\left(\delta_i - \delta_j\right)$$

The real and reactive power is denoted by P and Q.

R-Resistance,

V-Voltage,

δ- the angle at correspondence buses

IV. Propose of Power Quality Algorithm for Smart Grid

The Power Quality algorithm upholds the quality of power w. r. t. rated voltage and current. The algorithm controls the buses and their respective requirement from the cloud as well as local servers. Execution and plugin with the traditional grid are also possible. The algorithm is flexible to change, modify, integrate with the latest technology[37], and simple.

The proposed algorithm is as follows:

1. Start, Define bus system and their rating parameters
2. Determine voltage profile by performing load flow analysis in respect of undefined time
3. Calculate Reactive Power on each bus
   for voltage = 1
   Voltage = Voltage + 1
   forSource_Voltage = 1
   Source_Voltage = Source_Voltage + 1
   End for
   End for
4. Available Techniques →Select and Compensate Reactive Power Profile
5. Apply → Power Balance Equation → Store in Memory
6. Re-Perform load flow Analysis, Determine Bus Voltage Profile
7. Compare voltage profile with Stored data.
8. ***If***
   ± 5% Voltage ≥ Rated Voltage
   Then
   Stop

   Else
   Repeat 2 to 7
   End if
9. Synchronize with local/Cloud server with current log
10. Stop

V. Methodology

To implement the algorithm, the IEEE-33 standard bus system is considered. The IEEE-33 standard bus system is an amalgamation of buses and branches. The network model is operating under a common base value for all intents of this purpose. The peak of voltage magnitude is being considered at ± 5% of its rated power. All bus is indicating their index value along with the respective power factor. An internet-based plugin is connected to the local server and synchronizes data with the administrator database. It is allowing to make the centralized database to perform the centralized operation. To implement and perform the load analysis of the proposed algorithm is done by using the MATLAB 2017b. The algorithm is determining and optimizes the load and cost.

A. Problem Formulation

For a given system, the complex power supplying to any node can be written as :
Si=Vi (Ii)*=Pi+jQi
VS = sending end voltage
VR=receiving end voltage
Z=impedance of the line
R=resistance of the line
X=reactance of the line
P=active power
Q=reactive power
Z=R+jX

Using ohms law, the voltage drop in the line

$$V_{drop}=IZ$$

So receiving end voltage will be

VR=VS-IZ

and at each node, the reactive power sum is known, so by basic relation of the capacitor

$C=\frac{Q_i}{2\pi f V_2 R}$

Considering the India standard frequency is 50 Hz.

Now it will be calculated the reactive power [13] supplying by the capacitor bank [14], let it would be Q_{cap}

Net reactive power at that node will be

$Q_{act}=Q$

$_{node}-Q_{cap}$

By the relation

$$S = \sqrt{(P2 + Q2)}$$

Apparent power is calculated, and sending end currently is given by

$Is=\frac{S_{pu}}{Vs}$

By knowing voltage drop relation

VR=Vs-IZ

B. Testing

As per the above scientific modeling equivalences, an IEEE-33-balanced distribution system has been considered for the formation of a plugin for the smart grid by using the Internet of Things. The base value for the system is 12.66KV and 10MVA at a power factor of 0.8, lagging at the load side. The line and load data for the 33-bus system are further down in the table. To compute and compare in what manner voltage profile has achieved better quality at that particular bus, assuming the voltage is 1 p.u.

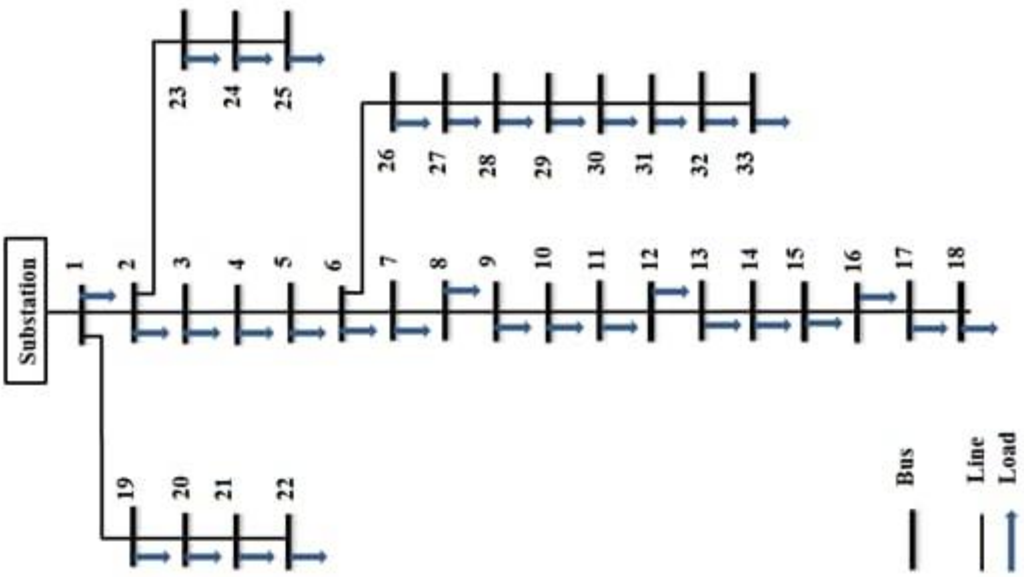

Figure 4: IEEE-33 Bus System[30]

The flow chart of Proposed Work is as follows:

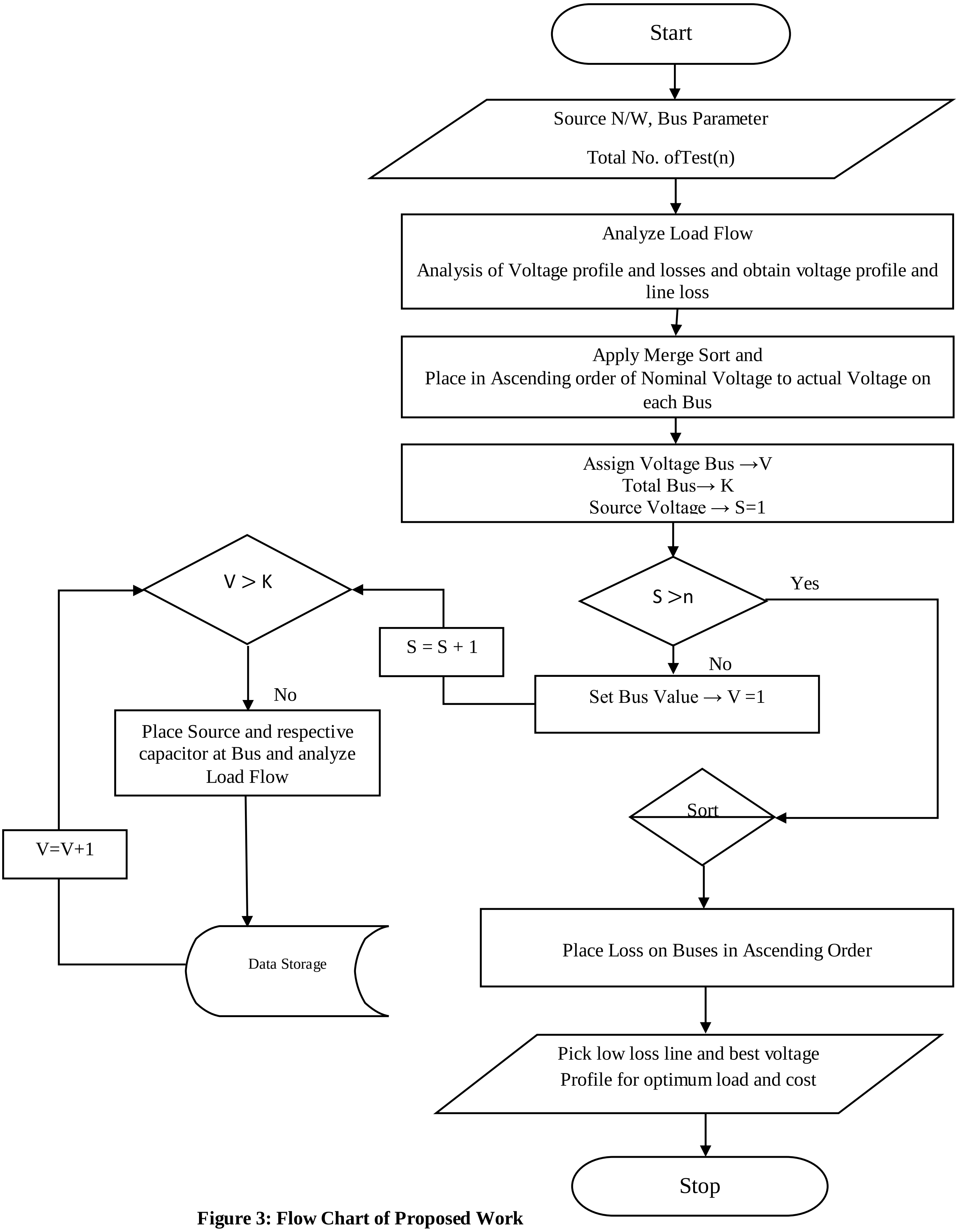

Figure 3: Flow Chart of Proposed Work

Table 1: Line and Load Data for IEEE-33 Bus Distribution System

S. No.	Sending Bus	Receiving Bus	Q_{actual}	Vs	IS	Length	Vr	VR
1	1	2	0.001305	1	0.37150	1 KM	0.997176	0.997599
2	2	3	0.006747	0.99769	0.32635		0.983863	0.986321
3	3	4	0.007673	0.98632	0.22673		0.976711	0.980504
4	4	5	0.009616	0.98051	0.21593		0.969603	0.974736
5	5	6	0.015317	0.97474	0.21141		0.951952	0.960449
6	6	7	0.005973	0.96045	0.13299		0.946127	0.955083
7	7	8	0.006395	0.95508	0.11276		0.930096	0.940219
8	8	9	0.005452	0.94022	0.09324		0.92219	0.932832
9	9	10	0.00554	0.93283	0.06620		0.916297	0.927541
10	10	11	0.005219	0.92754	0.06010		0.915426	0.926764
11	11	12	0.004735	0.92676	0.05527		0.913909	0.925403
12	12	13	0.004436	0.92540	0.04886		0.906694	0.918887
13	13	14	0.003799	0.91889	0.04264		0.90407	0.916502
14	14	15	0.002049	0.91650	0.02955		0.902514	0.915042
15	15	16	0.001853	0.91504	0.02304		0.901077	0.913712
16	16	17	0.001429	0.91371	0.01649		0.898669	0.911497
17	17	18	0.00096	0.91150	0.00993		0.898032	0.91092
18	2	19	0.000109	0.99760	0.03609		0.996617	0.997088
19	19	20	0.000173	0.99718	0.02708		0.992868	0.993663
20	20	21	0.000128	0.99363	0.01812		0.992088	0.99292
21	21	22	7E-05	0.99292	0.00906		0.991359	0.992255
22	3	23	0.001829	0.98632	0.09431		0.980279	0.983102
23	23	24	0.002208	0.98310	0.08547		0.973496	0.976993
24	24	25	0.001252	0.97700	0.04301		0.9701	0.973937
25	6	26	0.011671	0.96045	0.07594		0.94371	0.955451
26	26	27	0.011953	0.95545	0.09088		0.941044	0.953641
27	27	28	0.014112	0.95361	0.08518		0.92976	0.946129
28	28	29	0.015627	0.94613	0.07994		0.921522	0.940804
29	29	30	0.015204	0.94080	0.06785		0.917584	0.93839
30	30	31	0.004182	0.93839	0.04498		0.913205	0.934541
31	31	32	0.002824	0.93454	0.02905		0.912213	0.933676
32	32	33	0.00081	0.93368	0.00649		0.911902	0.933421

Table 2: Required Capacitor on Each Node

Node	C in μF	Node	C in μF	Node	C in μF	Node	C in μF
1	0.857962	9	0.185016	17	0.068021	25	0.007005
2	0.858027	10	0.178036	18	0.055893	26	0.007005
3	0.85822	11	0.173218	19	0.043703	27	0.003185
4	0.782009	12	0.130239	20	0.043749	28	0.020772
5	0.61495	13	0.081348	21	0.043541	29	0.014852
6	0.625967	14	0.080126	22	0.015216	30	0.008924
7	0.627969	15	0.078306	23	0.013996	31	0.008926
8	0.619435	16	0.078478	24	0.014007	32	0.00893

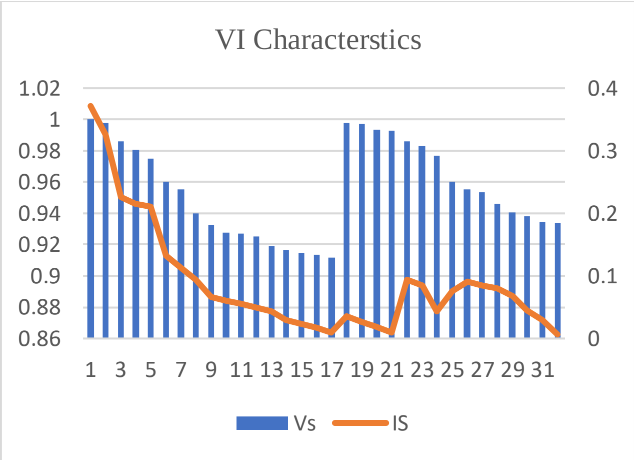

Figure 5: Voltage and Current on each bus

Simulation and Experimental Results

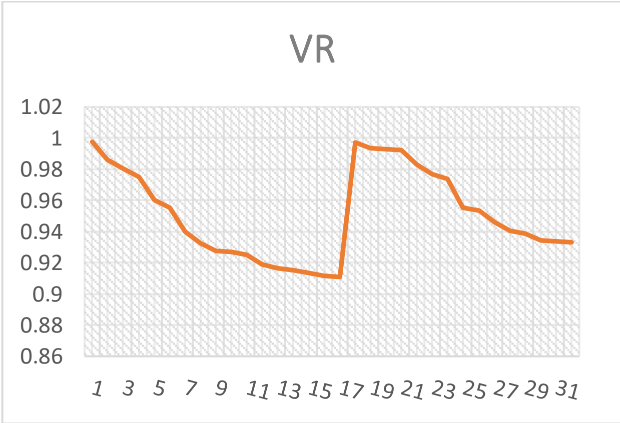

Figure 6: Results of Voltage profile

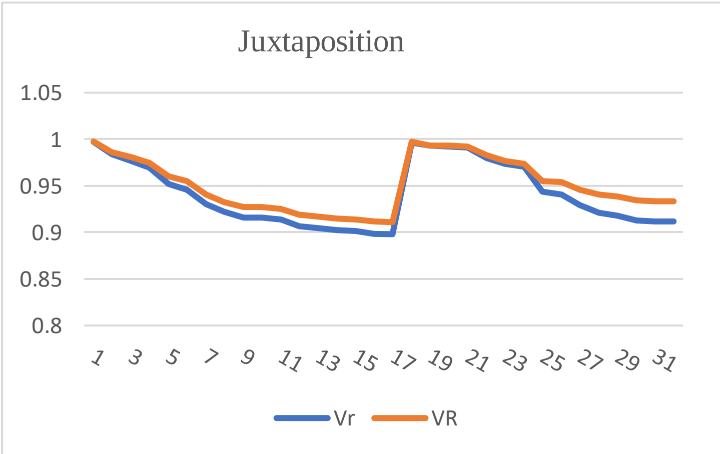

Figure 7: Comparison Between Existing and Proposed

VI. Juxtaposition

Comparison results are as follows:

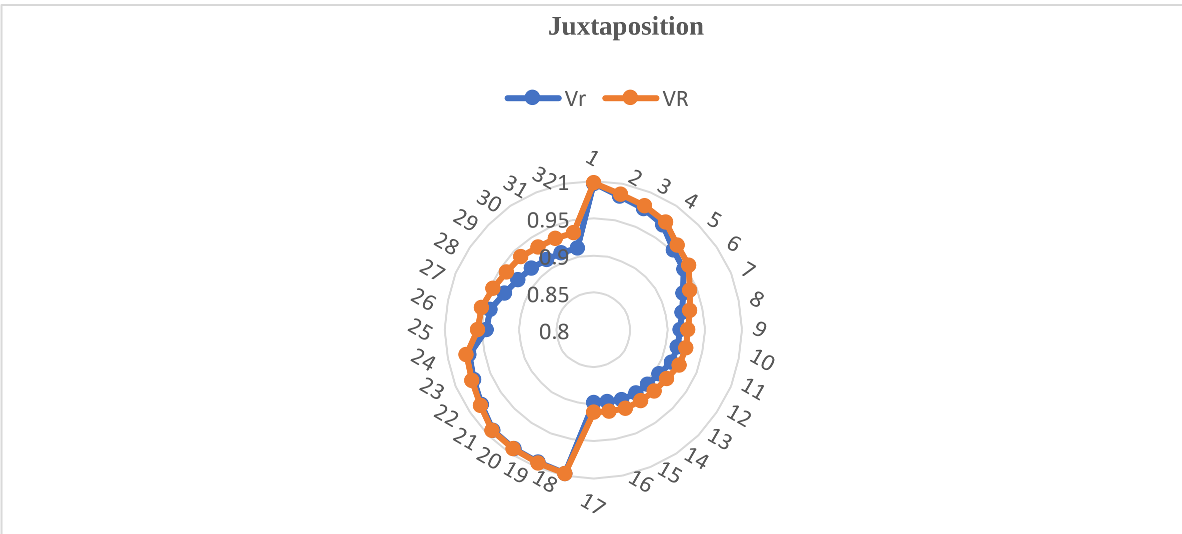

Figure 8: Comparison Between Existing and Proposed along Power Factor

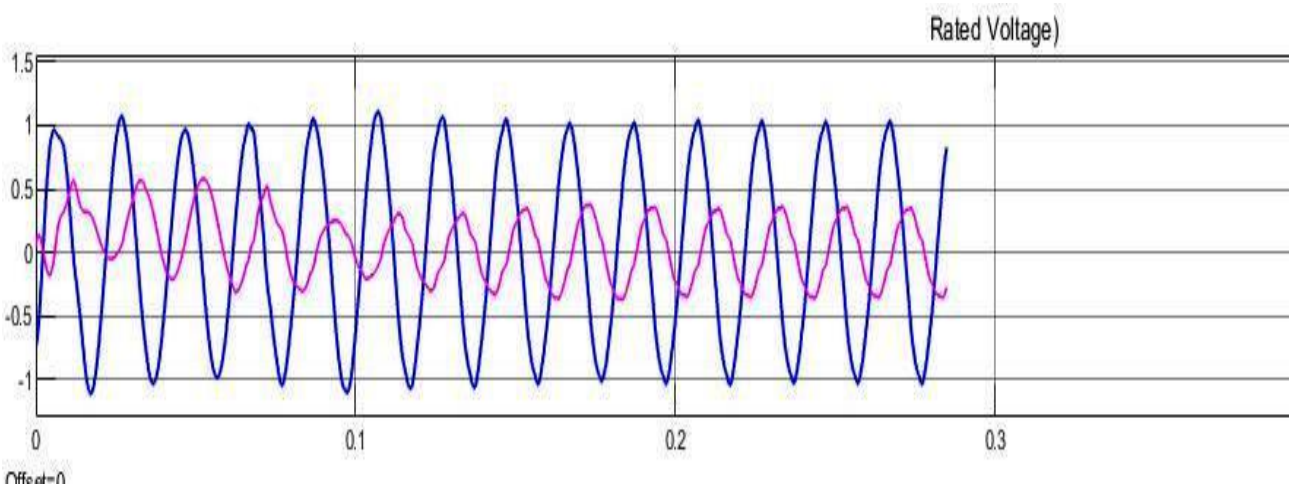

Figure 9: Compensated Power

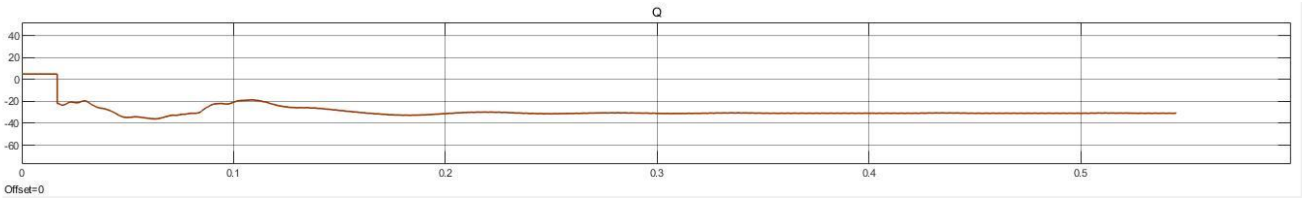

Figure 10: Reactive Power

VII. Discussion

IEEE-33 standard bus system has been designed/framed virtually by using MATLAB/Simulink. The substation is connected with the solar, wind, and third-party incoming line voltage for testing purposes. There is (n) no. of sources whether it is conventional or Non-Conventional.

All the parameters in respect of allied sources allotted the constant values and pragmatic the power balance equation. In respect of the accomplishment study of load flow, the Newton-Raphson method has been used. Similarly, acquire the voltage profile and bring it into line with the storage information to the cloud server. The buses and branches are sorted by using Merge Sort Algorithm. Low loss line and best voltage profile opted for achieving the optimum load and cost. Table 1 clearly shows the lower limit/bound and upper limit/bound of the voltage profile. However, table 2 indicating the required capacitor values to compensate for the brownout profile and share it with the cloud server.

VIII. Conclusion

The smart biosphere is an integration of smart technologies. The smart grid is the Foundation stone of the well-designed/cybernetic world which wishes a categorically profligate maneuver and ample the routine in a tiny duration of the stint. The research paper has projected an innovative algorithm for enlightening the power eminence for smart grids. The quality power offers a stable and smart edge for all natures of devices, whether it is smart or not. The proposed work is not the whole shebang but a foremost share for the great upshot. The proposed exertion is to analyze the harmonics in the system, produce the system stability, and settles to perform the intermittent assigned responsibilities of Applications/equipment. The comparison table shows the status of the proposed work. This will care for all smart environments and using the API plugin, and it will be dockable to plug with smart buildings, smart offices, smart cities. The proposed effort is one more footstep towards Digital India. This work is like a heavy breakfast for the smart city, which ensures the quality power for a quality life of devices as well as humans. In the future, we will be integrating this work with an optimization framework by using the Internet of Things environment.

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