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Novel Approach to Identify Weak Bus Using Synchro-phasor Unit and MVSI

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Abstract— **In this modern era of deregulated power generation monitoring mechanism of existing network become more complex and essential. Load management, uninterrupted power supply and power quality maintenance become important parameters for power engineers. Inclusion of Phasor measurement unit (PMU) makes monitoring much easier and more accurate. Depending on voltage current and phase angle obtain from PMU analysis of voltage stability become more effective. Stability Index like LSI, FVSI or NVSI are based on basic parameters. Considering load power as constant parameter of equivalent two bus network the total system analysis of Voltage Stability Index performed. In this proposed index phase angle effect was examined very effectively. PMU are mainly used to practical power systems, at various buses covering a large geographic area giving an accurate view of the entire system. Modified Voltage stability index include receiving end voltage, current, reactive power and phase angle of the system. Week bus detection in the system can be done basic of voltage stability index. MVSI is more effective than other conventional methods. It is also observed that with accurate PMU data the method become more authentic to predict the load in congested buses. Also, the proposed method to find out voltage stability is implemented & analyzed in MATLAB.**

Keywords— ***PMU, MVSI, Load Angle, Week Bus, Voltage Sensitivity index.***

I. INTRODUCTION

Around the world so many circumstances of voltage collapse and power blackouts happen in different location as a result of voltage instability. Diversity of modern loads in power system creates non uniformity of reactive power distribution for which voltage instability rises in the existing system. [1,2] Studies supposed that mainly load dynamics, OLTC which control potential difference of different devices and different parameter limiters like hitting, excitation limiters of the alternator produce voltage instability.[3,4] To ensure voltage stability after any type of fault system must have an intersection point in power voltage characteristic of load and existing network[5]. In recent year's Different power flow technique, Generic Algorithm used to develop various types of methodologies to detected unstable voltage profile. But many cases technique will not converge at unstable condition for singularity nature of the system.[6-9]. Phasor measurement units (PMUs) is an emerging field which offers time synchronized data of different parameters like voltage current and phase angle. Online monitoring of any type of power system become more reliable and accurate as PMUs used GPS and using PMUs wide area monitoring is also performed effortlessly [10-12]. Based on PMUs Backup monitoring systems are also being developed and tested across the globe. Particularly enhancement of reactive power demand forces the electrical system to operate near to its boundary limit of voltage stability [13]. As a result system becomes weak. If any existing load bus has great inclination towards voltage instability that bus is treated as weak bus. Meanwhile mathematical formulation like load power margin modal analysis has the ability to identify weak buses directly without any power flow methods. But the accuracy is not up to the mark and the techniques are time consuming and complex [14-16].Implementing recent technique like voltage stability index which Index is described the difference between two operating points i.e. current and the voltage collapse point keeping other system variable parameters (bus voltage and current magnitudes) constant. [17, 18] LSI, FVSI, MVSI some commonly used technique to identify weak bus based on index value [19-22]. All these available methods based on voltage current real and reactive power. In this paper a new method is developed to find out the voltage index of power system. Inclusion of Phase angle provides extra edge to Modified voltage stability index (MVSI). PMU implementation makes possible to incorporate the effect of load angle to simulate MVSI to identify instability and weak bus. The novelty of the paper is development of modified voltage stability index (MVSI) which incorporate real time data obtain from PMU and enactment of phase angle to find out voltage stability. A comparison study was performed to examine the effectiveness of MVSI over other methods. Effect of phase angle of stability factor was simulates on modified IEEE30 bus system using MATLAB Simulink model.

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II. VOLTAGE STABILITY INDEX AND MODIFIED IEEE 30 BUS SYSTEM

To track the performance of the system based on voltage is defined by voltage stability index which is as the ability of a power system to maintain acceptable voltages at all bus in the system under normal condition and after being subjected to disturbance. Voltage instability arises when demand response crossed the critical limit of transmission and generation capacity of the system. To identify and avoid adverse situation continuous monitoring is essential PMU and stability index serve these purpose. Using instant data from PMU index value can be calculated if the value crossed of come closer to the boundary limit primitive measures can be taken. Generally voltage stability index found from the load characteristic where difference is observed between two operating point. In general the critical value of VSI is considered as 1 for normal system. Single line diagram of standard IEEE 30 bus transmission system demonstrated in Figure.1and modified line data is also tabulated in table 1.

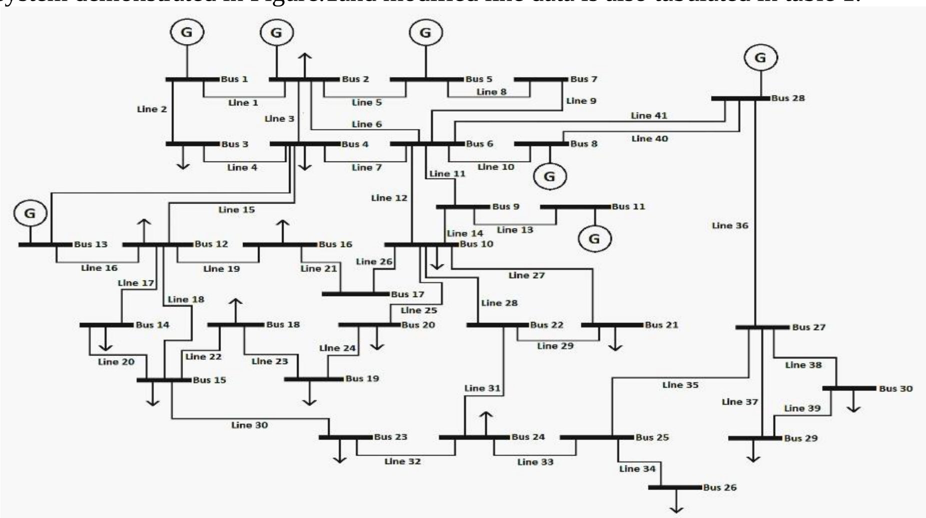

Figure. 1. SLD of modified IEEE 30 Bus System [10]

Based on Optimal placement technique PMUs are placed on bus no of 6, 9, 10, 12, 15, 18, 19, 20, 25 and 27. Real time data of different parameters like voltage current and angle data was captured for calculating voltage stability index values. Some minor modification was considered as no such practical data of PMU on IEEE30 bus system is not readily available with us. Mainly bus data (real power and reactive power) are parameters modified whereas line data kept unchanged.

TABLE I. MODIFIED LINE DATA FOR 30 BUS TRANSMISSION LINE

Line No.	From Bus	To Bus	Series Impedance (P.U.)		Source bus Voltage (V_{se}PU)	Receiving bus Voltage (V_{re})(PU)
			R	X		
1	1	2	0.02	0.06	1.06	1.043
2	1	3	0.05	0.19	1.06	1.00
3	2	4	0.06	0.17	1.043	1.06
4	3	4	0.01	0.04	1.00	1.06
5	2	5	0.05	0.20	1.043	1.01
6	2	6	0.06	0.18	1.043	1.00
7	4	6	0.01	0.04	1.06	1.00
8	5	7	0.15	0.20	1.01	1.00
9	6	7	0.03	0.08	1.00	1.00
10	6	8	1.01	0.04	1.00	1.01
11	6	9	0.00	0.21	1.00	1.00
12	6	10	0.03	0.56	1.00	1.00
13	9	11	0.40	0.21	1.00	1.082
14	9	10	0.42	0.11	1.00	1.00
15	4	12	0.11	0.26	1.06	1.00
16	12	13	0.07	0.40	1.00	1.071
17	12	14	0.12	0.26	1.00	1.00

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18	12	15	0.07	0.13	1.00	1.00
19	12	16	0.09	0.20	1.00	1.00
20	14	15	0.22	0.20	1.00	1.00
21	16	17	0.24	1.93	1.00	1.061
22	15	18	0.11	0.22	1.00	1.00
23	18	19	0.06	0.13	1.00	1.00
24	19	20	0.03	0.07	1.02	1.00
25	10	20	0.09	0.21	1.00	1.00
26	10	17	0.03	0.08	1.00	1.00
27	10	21	0.03	0.07	1.00	1.00
28	10	22	0.07	0.15	1.00	1.00
29	21	22	0.01	0.02	1.00	1.00
30	15	23	0.10	0.20	1.00	1.00
31	22	24	0.12	0.18	1.00	1.45
32	23	24	0.13	0.27	1.00	1.21
33	24	25	0.19	0.33	1.00	1.00
34	25	26	0.25	0.38	1.11	1.00
35	25	27	0.11	0.21	1.00	1.00
36	28	27	0.00	0.37	1.57	1.24
37	27	29	0.22	0.42	1.00	1.00
38	27	30	0.32	0.60	1.00	1.00
39	29	30	0.24	0.45	1.00	1.00
40	8	28	0.06	0.20	1.06	1.00
41	6	28	0.02	0.06	1.00	1.00

III. Block Diagram And Structural Outline

Under normal operating condition magnitude of bus voltage current and phase angle data measured and observed using PMU. GSM signal input merge with system data by means of PMU to produce time synchronized data which is used further for calculating voltage stability index. Some feedback has been taken to modify signal to achieve accurate decision.

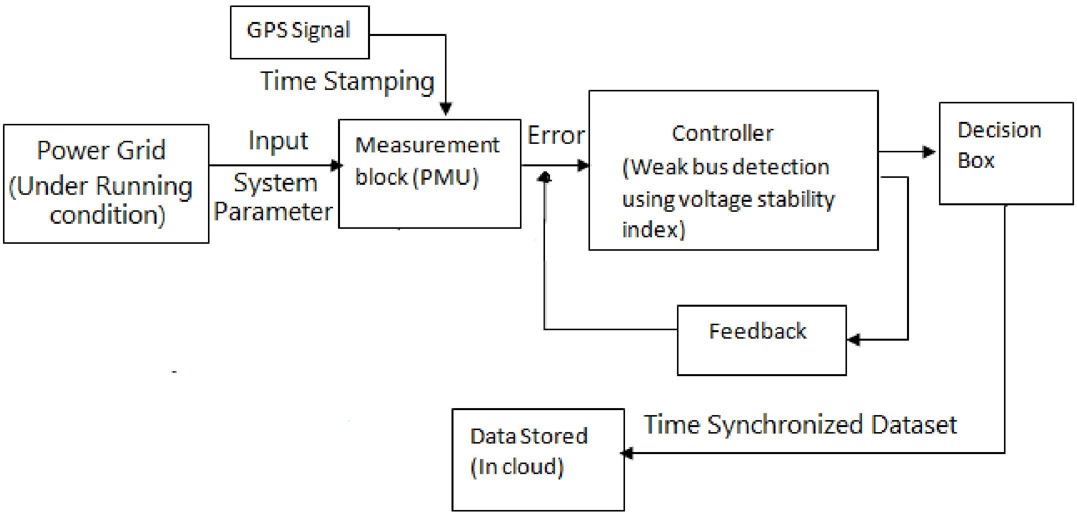

Figure. 2a . Block Diagram of proposed method

The proposed method explained using block diagram as illustrated in figure 2a. The outline of proposed method is described in Figure 2b and modified line data is tabulated in table 1. Initially live system is observed by PMUs from which on-time data of required parameter like voltage

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of sending end and receiving end, line current and phase angle values are taken for computation purpose. From the simulation model as shown in figure 3 real and reactive power was chosen for base value of the sensitivity index calculation. Using mathematical formula FVSI and new stability index MVSI was calculated. Depending on fixed MVSI, FVSI value identification of weak bus has been done. It is also communicate to the controller via GSM network to take some safety measure. The online data may store in cloud with the help of PMU. Line parameters like resistance reactance are used to simulate the proposed model in MATLAB Simulink environment, the observed output is considered as PMU data for 30 bus transmission line.

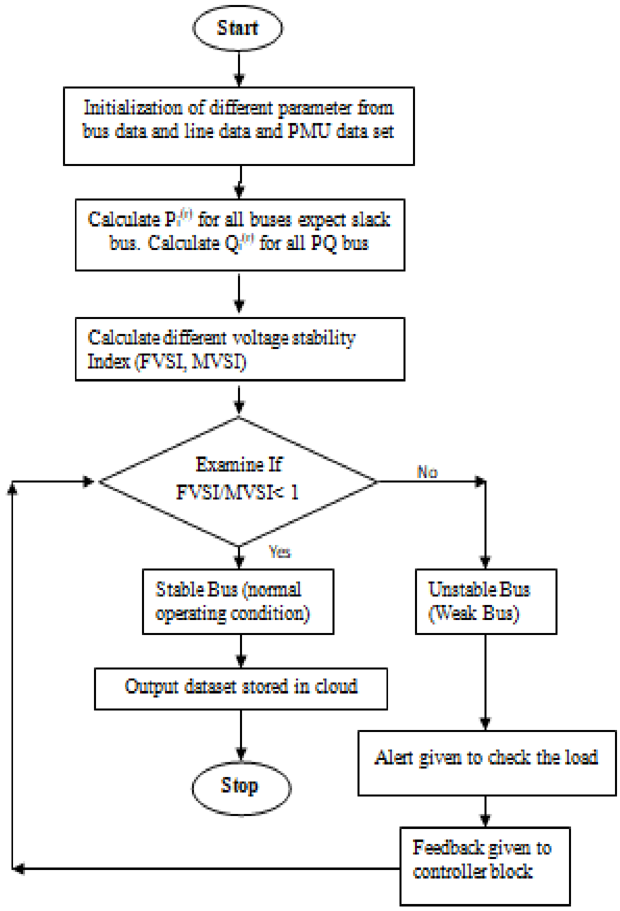

Figure. 2b . Flow chat of proposed methodology to identify weak bus

IV. Week Bus detection using Voltage stability Index

To deliver good power quality, uninterrupted service, system redundancy continuous monitoring is very much essential. By measuring voltage stability index time to time weak bus identification is possible. When load demand crossed the critical utilization limit of the system, system become unstable and the bus at which the load crossed the safety limit identifies as weak bus. Also the congestion level on the system can also be monitored. Implementation of PMU in the existing system can be done economically using optimum PMU placement algorithms.

The voltage collapse indicator, line stability index, fast voltage stability index etc. are utilized to find out the weak lines based on voltage, current and on-load demand of the live system. MVSI is newly included voltage stability index which include phase angle with existing parameters. The different Stability Index is used to determine the voltage stability for all lines linked between two buses in a transmission system. With the help of conventional mathematic for evaluating power flow in the lines of the simple bus system which consist of two buses, one considered as load bus and another is generator bus different index was formulated. The conventional power flows [18-22] at the source end (SE) and delivery end (RE) can be obtained as:

$$S_{SE} = \frac{|V_{SE}|^2}{Z}\angle\theta - \frac{|V_{SE}||V_{RE}|}{Z}\angle(\theta + \delta_{SE} - \delta_{RE}) \quad \ldots\ldots (1)$$

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$$\frac{|V_{SE}||V_{RE}|}{Z}\angle(\theta-\delta_{SE}+\delta_{RE})-\frac{|V_{SE}|^2}{Z}\angle\theta \quad \text{....... (2)}$$

From equation (1) and equation (2) active power (P_{RE}) and reactive power (Q_{RE}) of the system are formulate as:

$$cos(\theta-\delta_{SE}+\delta_{RE})-\frac{V^2{}_{RE}}{Z}cos\theta \quad \text{....... (3)}$$

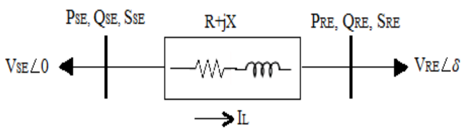
$$Q_{RE}=Sin(\theta-\delta_{SE}+\delta_{RE})-\frac{V^2{}_{RE}}{Z}sin\theta \quad \text{....... (4)}$$

As the value of load angle is very low at both end of the system, we can rewrite the difference as:

$$\delta_{SE}-\delta_{RE}=\delta$$

Using this V_{RE} can be obtained from (3) and (4) as:

$$\text{FVSI}=\frac{4Z^2Q_{RE}}{V^2{}_{SE}X} \quad \text{....... (5)}$$



In the above figure only two bus systems is taken for calculation power equations. Based on the above circuit we can write the expression of line current as flows

$$I_L=\frac{V_{RE}\angle 0-V_{SE}\angle\delta}{R+jX} \quad \text{....... (6)}$$

Using convolution concept equation (6) can be rewrite as:

$$I_L^*=\frac{\overline{V_{RE}}^*-\overline{V_{SE}}^*}{R-jX} \quad \text{....... (7)}$$

As we all know the value of resistance for conductor is very low so we can neglect and equation (7) become

$$I_L^*=\frac{\overline{V_{RE}}^*-\overline{V_{SE}}^*}{-jX} \quad \text{....... (8)}$$

The apparent power can be expressed as:

$$S=V_{SE}\ I_L^* \quad \text{....... (9)}$$

From equation (7) and equation (8) we will get active power and reactive power expression as:

$$P_{RE}=-\frac{V_{RE}V_{SE}}{X}sin\delta \quad \text{....... (10)}$$

$$Q_{RE}=-\frac{V_{SE}^2}{X}+\frac{V_{RE}V_{SE}}{X}cos\delta \quad \text{....... (11)}$$

Simplifying the equation (10) and (11) by eliminating δ we will get,

$$(V_{SE}^2)^2+(2Q_{RE}X-V_{RE}{}^2)V_{SE}{}^2+X^2(P_{RE}{}^2+Q_{RE}{}^2)=0 \quad \text{....... (12)}$$

From the above 2nd order equation two values of V_2 will be calculated. The condition for which we can get only one solution can be explained as:

$$(2Q_{RE}X-V_{RE}{}^2)^2-4X^2(P_{RE}{}^2+Q_{RE}{}^2)\geq 0 \quad \text{....... (13)}$$

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$$\frac{2X\sqrt{({P_{RE}}^2+{Q_{RE}}^2)}}{2Q_{RE}X-{V_{SE}}^2} \leq 1 \qquad \text{....... (14)}$$

Now the voltage stability index can be expressed as:

$$NVSI_L = \frac{2X\sqrt{({P_{RE}}^2+{Q_{RE}}^2)}}{2Q_{RE}X-V_{SE}^2} \qquad \text{....... (15)}$$

In this stability index δ value is neglected. Instead of neglecting if we consider angle value the expression will be:

$$MVSI = \frac{2X\sqrt{V^2I^2cos^2\theta+V^2I^2sin^2\theta}}{2VIsin\theta X-V_{SE}^2} \qquad \text{..... (16)}$$

Here active power and reactive power are replaced by voltage current relation. After simplifying equation (16) we will get,

$$MVSI = \frac{2XV_{RE}I\sqrt{cos^2\theta+sin^2\theta}}{2V_{RE}Isin\theta X-V_{SE}^2} \qquad \text{.... (17)}$$

$$sin^2\theta + cos^2\theta = 1 \qquad \text{....... (18)}$$

Using equation (17) equation (18) becomes,

$$MVSI = \frac{2XV_{RE}I}{2V_{RE}Isin\theta X-V_{SE}^2} \qquad \text{....... (19)}$$

V. SIMULINK MODELLING

Real time power system data using PMU is not easily available as because PMU are costly device. As a result modified 30 Bus transmission line is simulated in MATLAB-2017 Simulink territory. The Simulink model is formed as per IEEE standard only the reactive and active power has been changed as per requirement.

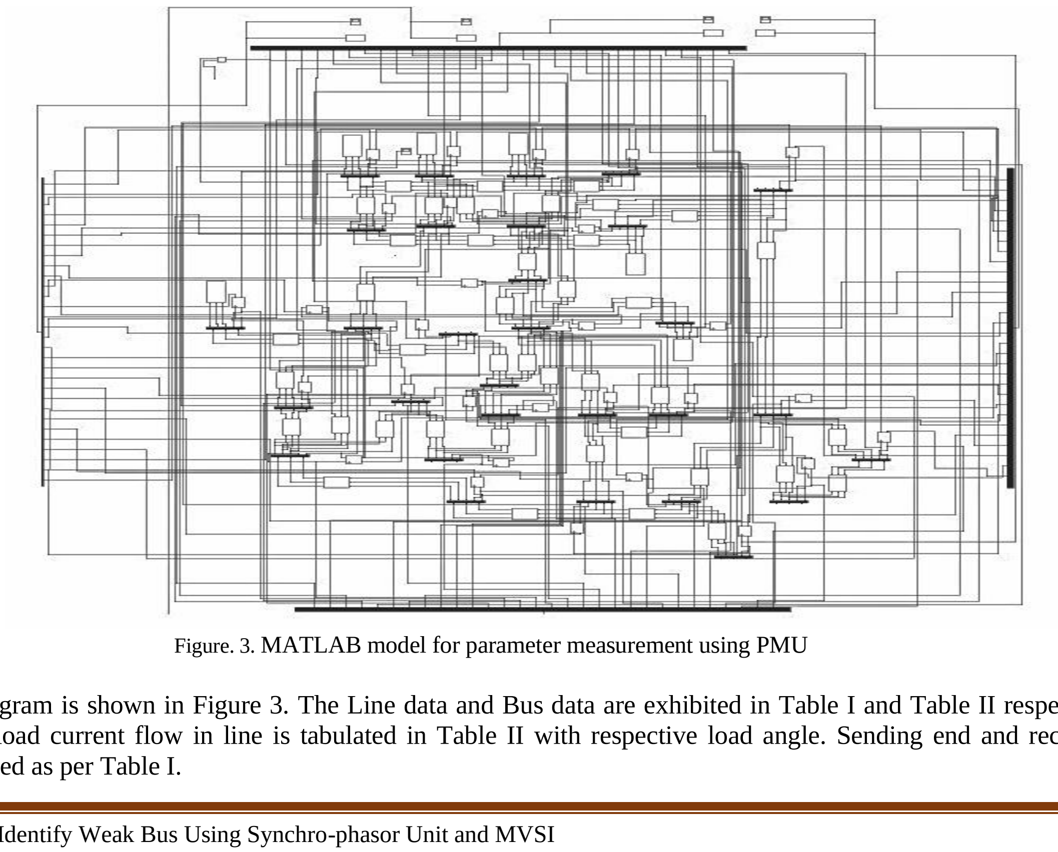

Figure. 3. MATLAB model for parameter measurement using PMU

The simulated diagram is shown in Figure 3. The Line data and Bus data are exhibited in Table I and Table II respectively. As per PMU output load current flow in line is tabulated in Table II with respective load angle. Sending end and receiving end voltage are observed as per Table I.

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TABLE II. REACTIVE POWER DISTRIBUTION FOR PROPOSED SYSTEM

Line no	Line Current (Amp)	Phase Angle	Real power	Reactive Power
1	11.7595	1.248	1.2	0.5
2	3.6591	1.303	1.25	0.53
3	7.1013	1.253	1.05	0.56
4	25.8088	1.253	1.06	0.61
5	8.448	1.252	1.32	0.52
6	2.8784	1.290	1.56	0.66
7	10.9749	1.93	1.48	0.54
8	13.666	1.256	1.65	0.58
9	9.8271	1.292	1.63	0.22
10	0.5122	1.570	1.45	0.12
11	0.2047	1.571	1.35	0.45
12	4.1198	1.337	1.23	0.35
13	1.6342	1.578	1.45	0.64
14	0.0945	1.570	1.36	0.25
15	3.0636	1.122	1.85	0.35
16	5.987	1.570	1.75	0.41
17	2.1329	1.101	1.46	0.36
18	0.0246	1.126	1.55	0.27
19	1.2414	0.734	1.23	0.86
20	1.3997	1.166	1.49	0.52
21	0.7306	1.114	1.76	0.26
22	1.6842	1.111	1.74	0.14
23	3.1022	1.107	1.64	0.45
24	2.2171	1.149	1.95	0.74
25	6.1891	1.204	1.37	0.65
26	1.8468	1.359	1.44	0.21
27	7.5147	1.119	1.37	0.66
28	0.7508	0.999	1.54	0.86
29	1.1517	1.111	1.52	0.93
30	0.1059	1.204	1.41	0.31
31	0.4454	1.113	1.67	0.45
32	0.4454	0.980	1.14	0.63
33	0.5295	1.088	1.28	0.33
34	1.7104	1.568	1.37	0.54
35	3.7116	1.084	1.62	0.14
36	1.5547	1.262	1.94	0.63
37	1.7717	1.616	1.88	0.55
38	0.1296	1.117	1.77	0.43
39	8.7956	1.114	1.64	0.14
40	1.7717	1.082	1.34	0.52
41	1.2414	1.269	1.33	0.62

VI. RESULT & DISCUSSION

Modified IEEE 30 bus system simulated in MATLAB environment and different base parameter like Voltage Current active and reactive power, power factor and different stability index has been observed. In Fig 3 voltage and current distribution has been represented.

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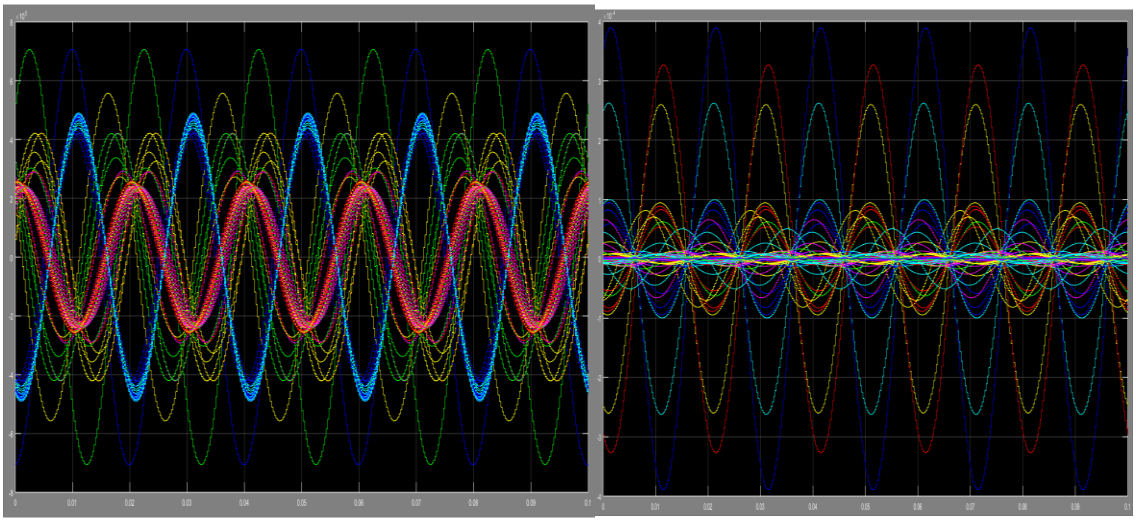

Figure. 3 .a. Voltage & Current waveform of IEEE-30 bus system

Mathematical expression for LSI, FVSI and MVSI is used to calculate the value of stability factors to identify the status of different buses. Obtained values of all 41 lines are shown in Table III where HL is signifies healthy condition and WL signifies weak or stressed condition of lines.

TABLE III. VALUE OF DIFFERENT VOLTAGE STABILITY INDEX

Line no.	LSI	FVSI	MVSI	Weak line as per LSI	Weak line as per FVSI	Weak line as per MVSI
1	0.5	0.11	0.22	HL	HL	HL
2	0.53	0.31	0.35	HL	HL	HL
3	0.56	0.35	0.64	HL	HL	HL
4	0.61	0.08	0.14	HL	HL	HL
5	0.52	0.39	0.75	HL	HL	HL
6	0.66	0.36	0.04	HL	HL	HL
7	0.54	0.07	0.16	HL	HL	HL
8	0.58	0.26	0.45	HL	HL	HL
9	0.22	0.18	0.32	HL	HL	HL
10	0.12	0.1	0.16	HL	HL	HL
11	0.45	0.42	0.77	HL	HL	HL
12	1.13	1.11	0.71	**WL**	**WL**	HL
13	0.64	0.41	0.09	HL	HL	HL
14	0.25	0.22	0.36	HL	HL	HL
15	0.35	0.46	0.96	HL	HL	HL
16	0.41	0.28	0.03	HL	HL	HL
17	0.36	0.63	0.28	HL	HL	HL
18	0.27	0.32	0.53	HL	HL	HL
19	0.86	0.49	0.62	HL	HL	HL
20	0.52	0.89	0.01	HL	HL	HL
21	0.26	0.45	0.67	HL	HL	HL
22	0.14	0.54	0.85	HL	HL	HL
23	0.45	0.32	0.24	HL	HL	HL
24	0.74	0.17	0.29	HL	HL	HL
25	0.65	0.51	0.28	HL	HL	HL
26	0.21	0.21	0.19	HL	HL	HL
27	0.66	0.18	0.31	HL	HL	HL

28	0.86	0.38	0.60	HL	HL	HL
29	0.93	0.06	0.1	HL	HL	HL
30	0.31	0.5	0.39	HL	HL	HL
31	0.45	0.51	0.57	HL	HL	HL
32	0.63	0.67	0.06	HL	HL	HL
33	0.33	0.87	0.35	HL	HL	HL
34	0.54	1.10	0.39	HL	**WL**	HL
35	0.14	0.53	0.27	HL	HL	HL
36	1.03	0.81	1.39	**WL**	HL	**WL**
37	0.55	1.06	1.09	HL	**WL**	**WL**
38	0.43	1.51	2.51	HL	**WL**	**WL**
39	0.14	1.16	1.92	HL	**WL**	**WL**
40	0.52	0.43	0.05	HL	HL	HL
41	0.62	0.13	0.23	HL	HL	HL

In the above Table III it is clearly visualized that maximum lime has stability index value under the boundary i.e. 1. As per LSI Bus number 12 and 36 has index value more than 1. According to FVSI 12, 34, 37, 38 and 39 has more than 1 value and as per MVSI bus number 36, 37, 38 and 39 have stability index value more than critical value. Aactive power value is set as 1.20 MW of the generators used in simulation to obtain for strong bus and weak bus detection.

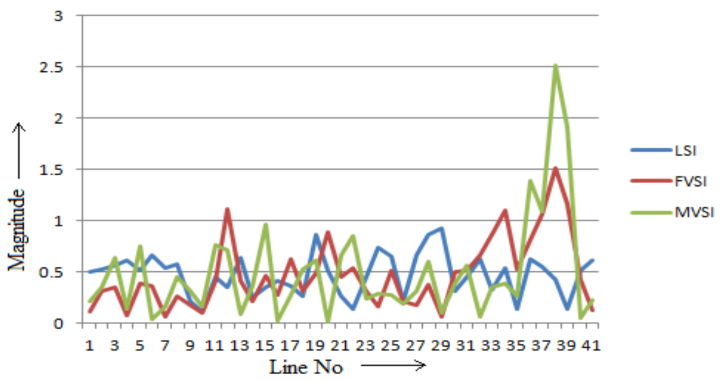

Figure. 4. Graphical representation of voltage sensitivity index for different lines.

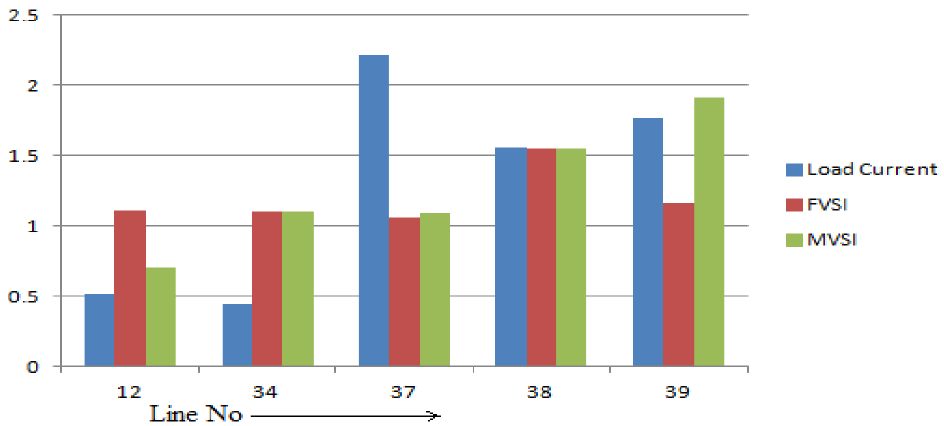

Figure. 5. Variation of Load current and line sensitivity index in identified weak lines.

Variation of Voltage sensitivity index for different lines is Graphical represented in figure 4 where blue line represent LSI red line represent FVSI and Green line represent MVSI values. In figure 5 the load current for specific lines have been shown with corresponding MVSI and FVSI values. From this graph it is clear that weak lines have high value of load current as well as voltage stability index.

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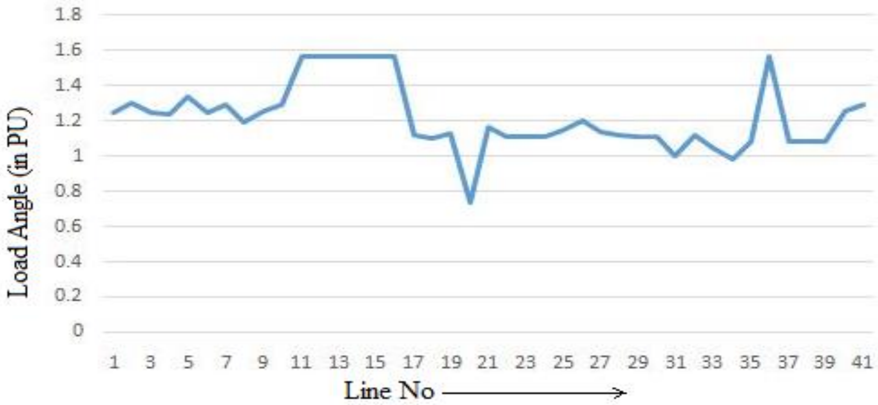

Figure. 6. Variation of load angle for all lines in proposed system

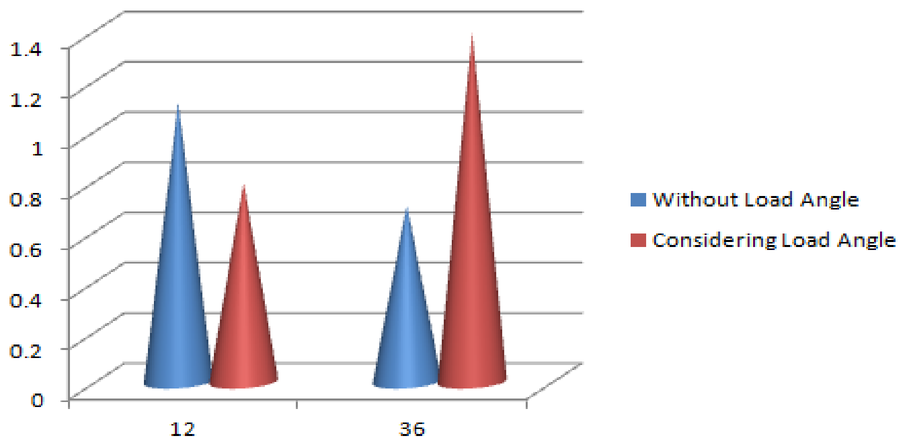

Figure.7. Effect of load angle variation Using MVSI method

Load angle is an important part depending on which the state of the line as well as bus has been changed. In figure 6 shows the distinction of load angle for all lines of proposed transmission system. From this graph it is visualized that the minimum value of the load angle is 0.71 and maximum is almost equal to 1.6. Rest value lies in an average 1.2. Utility of newly developed stability factor is demonstrated by figure 7. As per FVSI line no 12 are weak bus as its stability factor value is more than 1where load angle is not considered. After considering load angle in MVSI it is observed that line 12 is not under so much stress similarly it is observed that using MVSI which include load angle status of line no 36 has been changed. Lines no 36 become weak line whose stability factor value become 1.39 in spite of 0.81.

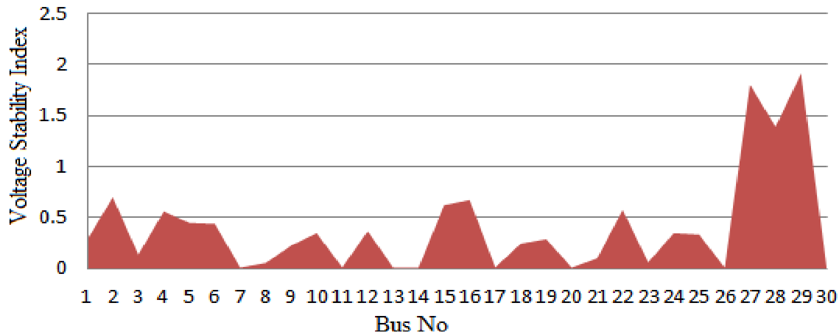

Figure.8. Identified weak bus based on Stability Index

The value which is below 1 depicts that they are healthy lines. As per figure.3 and table I it is clearly states the bus connections and relation with lines. Average stability factors value of connected line is calculated to identify all individual bus stability factors. From Figure 8 we can perceive the voltage stability factors of all buses. Bus 27, 28 and 29 has sensitivity factor more than 1 and these buses are considered as weak bus. 1.8067, 1.3948 and 1.919 are the respective values of MVSI which suggest that these buses are under stress. To keep the system running at its normal condition, immediate attention is required for this line.

CONCLUSION

The operational facets of power system give rise to some of the most challenging problems that are encountered while restructuring electric power industry. This report focused on one such problem that is weak bus detection in the deregulated power system. In this paper, an IEEE 30 Bus System is considered as the test case for simulation. The method that is used to find out the most sensitive and also the weakest line in the system is LSI and FVSI. The flow of power in each line in the system is examined and analyzed to recognize the weak lines in the system. Load variation, critical power, critical angle, stability factors are the main focus of this project. Thus, it can be concluded that weak bus identification is successfully implemented in the system. The nearby values of sensitivities indicate that the 30 Bus framework is basically a very small system in contrast to an authentic power network system. Every one of the generators demonstrates a solid impact on the congested line flow. This happens because a small framework is firmly associated electrically. It should be noted that significant simplifications can be visible only one large network such as 118 bus systems or any similar system.

FUTURE SCOPE

In this paper, we are using PMU and stability index to find out the voltage stability of an IEEE 30 bus system. The healthy and weak bus was identified based on the stability factor. Due to unavailability of real time PMU data, we are performing this project on simulation base in MATLAB environment. In future, we can include real time PMU data, to authenticate recent developed stability index which is capable of identifying the effect of power factor in terms of load angle variation. Economic placement of PMU restricts the position on some specific buses, for which parameters for all buses are not readily available. New mathematical formulation required for economical PMU placement. In modern power sector smart grid is an emerging field. We can also implement our process in smart grid as well as micro grid. Using real time load variation in distribution system, we can also treat the congestion management by this proposed methodology.

REFERENCE

[1] Ghosh, Sudipta, et al. "Optimal PMU Allocation Strategy for Completely Observable Networks With Enhanced Transient Stability Characteristics." IEEE Transactions on Power Delivery 37.5 (2022): 4086-4102.
[2] Kosen, Ian, et al. "UPS: Unified PMU-data storage system to enhance T+ D PMU data usability." IEEE Transactions on Smart Grid 11.1 (2019): 739-748.
[3] Meena, Manish Kumar, and Narendra Kumar. "On-line monitoring and simulation of transmission line network voltage stability using FVSI." 2018 2nd IEEE International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES). IEEE, 2018.
[4] Nazari-Heris, B. M.-I. M. (2015). Application of heuristic algorithms to optimal PMU placement in electric power systems: An updated review. Renewable and Sustainable Energy Reviews, 50, 214–228.
[5] Li, Dongdong, Mengxian Sun, and Yong Fu. "A General Steady-State Voltage Stability Analysis for Hybrid Multi-Infeed HVDC Systems." IEEE Transactions on Power Delivery 36.3 (2020): 1302-1312.
[6] Golpira, Hemin, Arturo Roman-Messina, and Hassan Bevrani. "Solar and Wind Integration Case Studies." (2021): 259-291.
[7] Dondariya, Chandrakant, and D. K. Sakravdia. "Voltage Stability Assessment and Improvement in Power Systems with Solar Photovoltaic Penetration." 2021 IEEE 2nd International Conference On Electrical Power and Energy Systems (ICEPES). IEEE, 2021.
[8] Mahaei, S. M., & Hagh, M. T. (2012). Minimizing the number of PMUs and their optimal placement in power systems. Electric Power Systems Research, 83(1), 66–72.
[9] Chakrabarti, S., Kyriakides, E., & Eliades, D. G. (2009). Placement of synchronized measurements for power system observability. IEEE Transactions on Power Delivery, 24(1), 12–19.
[10] Gopakumar, P., Mallikajuna, B., Jaya Bharata Reddy, M. and Mohanta, D.K., 2018. Remote monitoring system for real time detection and classification of transmission line faults in a power grid using PMU measurements. Protection and Control of Modern Power Systems, 3(1), pp.1-10.
[11] Mohammadniaei, M., Namdari, F. and Shakarami, M.R., 2019, December. Voltage Collapse Detection and Prevention Based on PMUs Measurement. In 2019 International Power System Conference (PSC) (pp. 497-503). IEEE

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[12] Chappa, H. and Thakur, T., 2020. Voltage instability detection using synchrophasor measurements: A review. International Transactions on Electrical Energy Systems, 30(6), p.e12343.

[13] Jirjees, M.A., Al-Nimma, D.A. and Al-Hafidh, M.S., 2018, May. Voltage stability enhancement based on voltage stability indices using FACTS controllers. In 2018 International Conference on Engineering Technology and their Applications (IICETA) (pp. 141-145). IEEE.

[14] Vournas, C.D., Lambrou, C. and Mandoulidis, P., 2016. Voltage stability monitoring from a transmission bus PMU. IEEE Transactions on Power Systems, 32(4), pp.3266-3274.

[15] Babu, R., Raj, S. and Bhattacharyya, B., 2020. Weak bus-constrained PMU placement for complete observability of a connected power network considering voltage stability indices. Protection and Control of Modern Power Systems, 5(1), pp.1-14.

[16] Sinha, A.A., Arya, M.K., Kumar, A., Mandal, R.K., Biswas, M., Ghosh, B.K. and Roy, S., 2018, May. Linear sensitivity based congestion management of IEEE 30 bus system using distributed generator. In 2018 2nd International Conference on Trends in Electronics and Informatics (ICOEI) (pp. 691-696). IEEE.

[17] Mandal, R.K., Ghosh, B.K. and Biswas, M., 2019. Sensitivity Factor Based Congestion Management of Modified 33-Bus Distribution System. Sustainable Communication Networks and Application: ICSCN 2019, 39, p.412.

[18] S.N. Singh, A.K. David, "Optimal Location Of FACTS Device For Congestion Management", ." Electric Power Systems Research, vol. 58, no. 2, pp. 71-79, 2001

[19] A.S. Nayak and M.A. Pai, "Congestion management in Restructured Power System using an optimal power flow framework," PSERC Publication 02-23, May 2002.

[20] Chakraborty, S., Koley, S., Mandal, S., Mandal, R.K., Ghosh, B.K., Biswas, M., Dutta, R., Ganguly, P. and Roy, S., 2019, July. Sensitivity Factor Based Congestion Management of Modified 33-Bus Distribution System. In International Conference on Sustainable Communication Networks and Application (pp. 412-423). Springer, Cham.

[21] Xu, Sudi, Hao Liu, and Tianshu Bi. "Field PMU Test and Calibration Method—Part I: General Framework and Algorithms for PMU Calibrator." Journal of Modern Power Systems and Clean Energy 10.6 (2022): 1507-1518.

[22] Hussian, Fidah, et al. "Contingency Ranking for Voltage Stability in Power System." 2021 IEEE International Conference on Electronics, Computing and Communication Technologies (CONECCT). IEEE, 2021.