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A Study on Impact of DG on Power System Voltage Stability

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ABSTRACT: In the recent times, modern power systems are operating under stressed conditions and this is making the system to operate closer to their operating limits. As the power system is normally an interconnected system, its operation and stability will be severely affected. Voltage instability phenomena is playing an important role in power system network and caused major blackout in the network. The enhancement of voltage stability through distributed generation has been widely adopted worldwide. This paper will help to study the variations in voltage stability of power system network when different types of distributed generation connected to system with the help of Fast Voltage Stability Index(FVSI) and Maximum Power Stability Index(MPSI) under different loading conditions. With help of MATLAB software a program is carried out on IEEE 5 bus system and IEEE 30 bus system and the state of voltage stability is observed from the results obtained.

KEYWORDS: Power system network, Voltage stability, Distributed Generation (DG), Fast Voltage Stability Index (FVSI) and Maximum Power Stability Index (MPSI).

I. INTRODUCTION

A power system can be defined as a system which explains about the generation of power, transmission of generated power to the substation and distribution of transmitted power to the consumers. In supplying the power to the consumers, quality must be maintained.[1] Modern power systems are operating under stressed conditions and this is making the system to operate closer to their operating limits. Operation of power system is becoming difficult due to increased competition in power sector, social and environmental burdens resulting to limited expansion of transmission network, lack of initiatives to replace the old voltage and power flow control mechanisms, imbalance in load-generation growth. All these factors are causing power system stability problems. A power system operating under stressed conditions shows a different behavior from that of a non-stressed system. As the system is operating close to the stability limit, a relatively small disturbance may causes the system to become unstable. As the power system is normally an interconnected system, its operation and stability will be severely affected.

In power system, voltage stability plays a very important role.[2] Voltage instability may cause blackouts and collapse of the power system. Voltage stability indices are used to know how close the system to voltage collapse. These indices may be use on-line or offline to help operators in real time operation of power system or in designing and planning operations.

II. DISTRIBUTED GENERATION

Distributed generation (DG), unlike traditional generation, aims to generate part of required electrical energy on small scale closer to the places of consumption and interchanges the electrical power with the network. It represents a change in the paradigm of electrical energy generation. [3] Distributed generation, also termed as embedded generation or dispersed generation or decentralized generation, is defined as small electric power source that can be connected to a distribution network by a distribution company at any node or by customer at the customer side of the meter.

Due to the fast growing of continuous load in the power system, it is possible to connect the small scale distributed generations (DG), which are affected by the environmental factors slightly. As a consequence, the connection of distributed generation to the grid may affect the power flows and voltage stability.[4] However the promotion of distributed generation (DG) resources in power systems offers benefits, such as reduction in power losses, improvement in voltage profile and reduction of on-peak operating costs. The trend in electricity charge promotes the location and time base pricing schemes. At peak periods, DGs can be used to supply some load demands thus reduce the cost of power taken from the network during high electricity charges



DG technologies are classified based on their capability of injecting real and/or reactive power in the system.[5]Accordingly, DG technologies are grouped as shown below:

Type1: This type DG is capable of delivering only active power such as photovoltaic, micro turbines, fuel cells, which are integrated to the main grid with the help of converters/inverters. However, according to current situation and grid codes the photovoltaic can and in sometimes are required to provide reactive power as well.

Type2: DG capable of delivering both active and reactive power. DG units based on synchronous machines (cogeneration, gas turbine, etc.) come under this type.

Type3: DG capable of delivering only reactive power. Synchronous compensators such as gas turbines are the example of this type and operate at zero power factors.

Type4: DG capable of delivering active power but consuming reactive power. Mainly induction generators, which are used in wind farms, come under this category. However, doubly fed induction generator (DFIG) systems may consume or produce reactive power i.e. operates similar to synchronous generator. Using these four types of DGs the variations in the stability is studied.

III. VOLTAGE STABILITY INDICIES

For determining the voltage stability of the system different types of Voltage stability indices are used. Some of the indices are:

1. Line Stability Index (LSI)
2. Voltage Collapse Prediction Index (VCPI)
3. Maximum Power Stability Index (MPSI)
4. Line Voltage Stability Index (LVSI)
5. L- Index (LI)
6. Fast Voltage Stability Index (FVSI)

In the above indices some are line stability indices and some are bus stability indices among them we considered FVSI index for line voltage stability and MPSI index for bus voltage stability. Both indices can be formulated as follows:

3.1 Fast Voltage Stability Index (FVSI): FVSI index is capable to identify critical areas in a large power system, capable to determine the point of voltage collapse, maximum permissible load and weak bus in the system and the most critical line in an interconnected system. [6]The line index that is evaluated close to 1 will indicate the limit of voltage instability.



Fig3.1 Two Bus Power System Model

FVSI is derived using a two bus power system model as shown in Fig3. 1.The symbols are explained as follows:

V_1, V_2 = Voltage on sending and receiving end buses.

P, Q = Active and Reactive power of the bus1 and bus2.

S =Apparent power of bus1 and bus2.

$\delta = \delta_2 - \delta_1$ (angle difference between sending and receiving end buses where $\delta_1 = 0$)

The line impedance is noted as $Z = R + jX$ with the current (I) that flows in the line given by;

$$I = \frac{V_1 \angle 0 - V_2 \angle \delta}{R + jX} \quad (3.1)$$

V_1 is taken as the reference and therefore the angle is shifted to 0. The apparent power at bus 2 can be written as

$$S_2 = V_2 I^* \quad (3.2)$$

Rearranging the Equation (3.2), we get

$$I_2 = \frac{(S_2 / V_2)^*}{V_2 \angle \delta} \quad (3.3)$$

$$= \frac{P_2 - jQ_2}{V_2 \angle \delta} \quad (3.4)$$

Equating equations (3.1) and (3.4)



$$\frac{V_1 \angle 0 - V_2 \angle \delta}{R + jX} = \frac{P_2 - jQ_2}{V_2 \angle \delta} \quad \text{---- (3.5)}$$

Separating the real and imaginary parts we get,

$$V_1 V_2 \cos \delta - V_2^2 = R P_2 + X Q_2 \quad \text{---- (3.6)}$$

And

$$-V_1 V_2 \sin \delta - V_2^2 = X P_2 - R Q_2 \quad \text{---- (3.7)}$$

Rearranging Equation (3.6) for P2 and substituting into Equation (3.5) yields a quadratic equation of V2 .

$$V_2^2 - \left(\frac{R}{X} \sin \delta + \cos \delta\right) V_1 V_2 + \left(X + \frac{R^2}{X}\right) Q_2 = 0 \quad \text{---- (3.8)}$$

The roots for V2 will be

$$V_2 = \frac{\left(\frac{R}{X} \sin \delta + \cos \delta\right) V_1 + \sqrt{\left[\left(\frac{R}{X} \sin \delta + \cos \delta\right) V_1\right]^2 - 4 \left(X + \frac{R^2}{X}\right) Q_2}}{2} \quad \text{---- (3.9)}$$

To obtain real roots for V2 , the discriminant is set greater than or equal to '0'; i.e.,

$$\left[\left(\frac{R}{X} \sin \delta + \cos \delta\right) V_1\right]^2 - 4 \left(X + \frac{R^2}{X}\right) Q_2 \geq 0$$

$$\frac{4 Z^2 Q_2 X}{V_1^2 (R \sin \delta + X \cos \delta)} \leq 1 \quad \text{---- (3.10)}$$

Since δ is normally very small then,

$$\delta \approx 0, R \sin \delta \approx 0 \text{ and } X \cos \delta \approx X$$

Taking the symbols 'i' as the sending bus and 'j' as the receiving bus, the Fast Voltage Stability Index (FVSI) can be written as follows:

$$FVSI_{ij} = \frac{4 Z^2 Q_j}{V_i^2 X_{ij}} \quad \text{---- (3.11)}$$

Where,

Z = line impedance

X_{ij} = line reactance

Q_j = reactive power at the receiving end

V_i = sending end voltage

The value of FVSI that is evaluated close to 1 indicates that the particular line is close to its instability point which may lead to voltage collapse in the entire system. To maintain a secure condition the value of FVSI should be maintained well less than 1.

3.2 Maximum Power Stability Index (MPSI): MPSI is calculated for the load buses in the system

Consider a simple 2 bus system shown in Fig 3.2. At receiving bus, as the load demand increased, the amount of active power delivered by the system to the bus also increases until it reaches a maximum value. The power transferred reaches the maximum value when the load impedance Z_L is equal to source impedance Z_S.

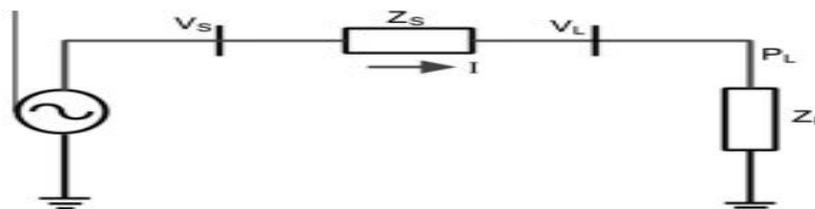


Fig 3.2 2-Bus system

The assessment of stability in large networks can be exceptionally demanding task. [7] Model reduction method is often employed to reduce the computational burden. The method transforms a multiple bus network into an equivalent 2-bus Thevenin model. The formulation of MPSI index begins with the transformation of network as shown in Figs.3.3 and 3.4. The power flow equation at node j in the local network can be written as:

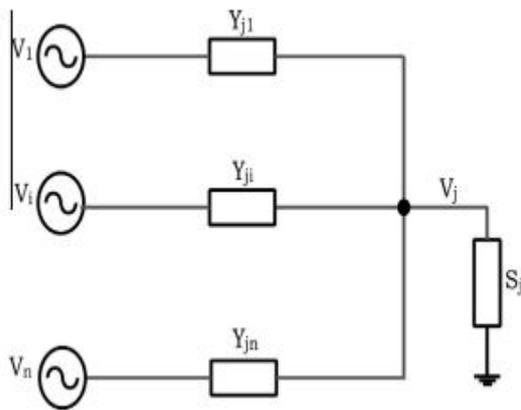


Fig 3.3 Typical local network

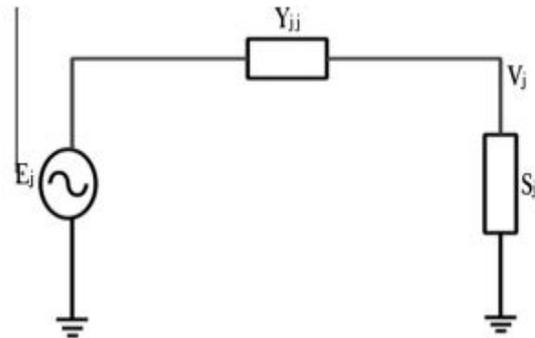


Fig 3.4 Reduced Circuit

The power flow equation at node j in the local network can be written as

$$V_j [Y_j] [V] = S_j \text{ ---- (3.12)}$$

Where S_j = apparent load power ; V_j = Voltage magnitude at load bus

$[V]$ = Nodal Voltages

In equation 12, $[Y_j]$ is row j-th admittance matrix and we can write:

$$[Y_j] = [-Y_{j1} - Y_{j2} - Y_{j3} - \dots + Y_{jj} \dots - Y_{jn}]$$

Where $[Y_j]$ is admittance between node j and node i, $[Y_{ji}] = G_{ji} + j B_{ji}$ and $i = 1 \dots n$ and $i \neq j$.

$$Y_{jj} = \sum_{i, i \neq j}^n Y_{ji}$$

The equivalent voltage of the network E_j obtained from node j can be written as

$$[E_j] = \frac{\sum_{i, i \neq j}^n Y_{ji} V_i}{Y_{jj}} \text{ ---- (3.13)}$$

Substituting eq. (3.13) for eq.(3.12) will give

$$V_j^* (E_j - V_j) Y_{jj} = S_j^* \text{ ---- (3.14)}$$

Eq. (3.14) is the load flow equation of the reduced network

Here maximum power transfer (MPT) theorem can be applied for ac and dc circuit analysis. The MPT theorem states the maximum power is transferred to a resistive load when the load resistance is equal to the internal resistance of the source in dc analysis. Similarly to ac circuit, the maximum power transfer condition can be achieved when the load impedance Z_L is equal to the source or Thevenin impedance Z_{TH} as shown in Fig 3.4. In ac circuit, the Thevenin impedance Z_{TH} can be written as:

$$Z_{TH} = R_{TH} + j X_{TH} \text{ ---- (3.15)}$$

Both resistance and reactance are considered in the equivalent Thevenin impedance calculation. Referring to MPT, the interest is to find the value of load resistance RL and reactance XL such that the power absorbed from the source is maximum.

The purpose of developing the power stability index is to be used with DG application. It has been claimed by, the inherent role of DG is to be used as a source of active power; such it is not necessary for DG to be able to produce reactive power. With respect to this definition, the derivation of the proposed voltage stability index focuses on the active power delivery in a network. The idea of maximum power transfer is to maximize the amount of active power that can be delivered to the load.

From Fig 3.1., the active power PL at the load can be written as

$$P_L = V_L I_L \cos \theta$$

$$= \text{Re} (V_L I_L^*) = \frac{V_L^2}{\text{Re} Z_L} \text{ ---- (3.16)}$$

Assuming that voltage and impedance of the source are known initially; therefore, the real power expression PL can be restated in terms of voltage and impedance of the source as:

$$P_L = \text{Re} (V_L I_L^*) \text{ where} \text{ ---- (3.17)}$$



$$V_L = \frac{Z_L}{Z_L + Z_{TH}} V_{TH} \quad \text{and} \quad \text{--- (3.18)}$$

$$I_L = \left(\frac{V_{TH}}{Z_L + Z_{TH}} \right)^* \quad \text{--- (3.19)}$$

The complex load power S_L can be written as:

$$S_L = V_L I_L^* = \frac{V_{TH}^2}{(Z_L + Z_{TH})^2} Z_L \quad \text{--- (3.20)}$$

Thus, the active power PL can also be expressed as:

$$P_L = \text{Re} (V_L I_L^*) = \text{Re} \left(\frac{V_{TH}^2}{|Z_L + Z_{TH}|^2} \text{Re}(Z_L) \right) = \frac{V_{TH}^2 R_L}{(R_L + R_{TH})^2 + (X_L + X_{TH})^2} \quad \text{--- (3.21)}$$

The delivered active power PL is maximized when $R_L = R_{Th}$ and $X_L = -X_{Th}$, the load impedance is equal to the complex conjugate from Thevenin impedance.

[8] Thus, the maximum real power absorbed by the load PL max is:

$$P_{Lmax} = \frac{V_S^2 R_L}{(R_L + R_{TH})^2 + (-X_L + X_{TH})^2} = \frac{V_{TH}^2}{4R_L} \quad \text{--- (3.22)}$$

According to theory of voltage stability, there is a maximum limit of power that can be transferred by the network. The maximum active power transfer is obtained when $Z_L/Z_{Th} = 1$. The condition represents critical loading point that must be avoided to preserve stability. At the point where $Z_L/Z_{Th} = 1$, the ratio of PL to PL max also shows unity value.

$$\frac{P_L}{P_{Lmax}} = 1 \quad \text{--- (3.23)}$$

By substitute PL from Eq. (3.16) and PL max from Eq. (3.22) into power ratio expression in Eq. (3.23) leads to the formulation of the proposed voltage stability index.

$$MPSI = \frac{4V_L^2}{\left(\frac{\sum_{i \neq j}^n Y_{ji} V_i}{Y_{jj}} \right)^2}$$

Eq. (3.23) defines the collapse criterion of the index. Any value close to 0 represents stable operating condition in contrary any value close to 1 implies critical operating condition.

IV. RESULTS

An algorithm is defined of how the programming is done in the MATLAB software. Various cases are considered such as IEEE 5 bus system and IEEE 30 bus system. For each case results are plotted using bar graphs. Finally how the objective is achieved is discussed in detail.

Algorithm: For the problem solving coding was done in MATLAB software, the steps that are followed in designing the program are discussed as follows:

- Step 1: For the IEEE system, load flow using Newton – Raphson Method has been carried
- Step 2: From the load flow solution updated Voltage, Active and Reactive power values are obtained.
- Step 3: In order to know the stability of system Fast Voltage Stability Index and Maximum Power Stability Index values are calculated.
- Step 4: Check whether the values of both indices are close to 0 or 1.
- Step 5: If values are near to '0' then the system is stable. Otherwise the system is unstable.
- Step 6: Now place different types of distributed generation to the given system at all load buses.
- Step 7: Check the change in the both voltage stability indices after placing dg.
- Step 8: Compare the Voltage stability indices values before and after placing distributed generation.



4.1 Case-1 IEEE 5 Bus System: The IEEE 5 bus system consists of 1 swing bus, 1 generator bus and 3 load buses and 7 transmission lines. The voltage profile of IEEE 5 bus system is represented as:

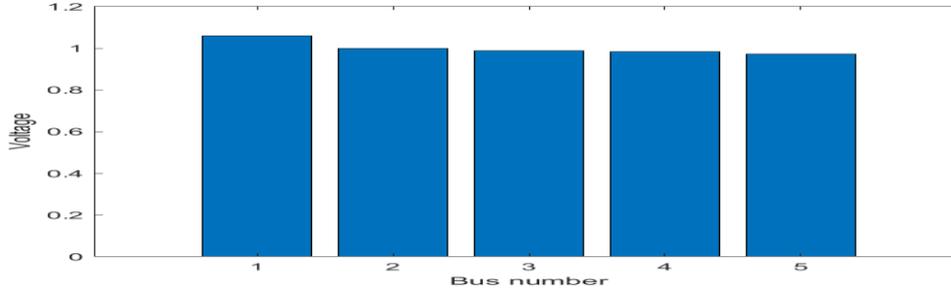


Fig 4.1. Voltage Profile of IEEE 5 bus system

The Fast Voltage Stability Index (FVSI) is calculated for lines connected in the system and the Maximum Power Stability Index (MPSI) is calculated for load buses connected in the system. The index values are calculated for the base case and also after connecting different types of distributed generation. Here we have taken two different DG values 10 MW and 30 MW and plotted the results.

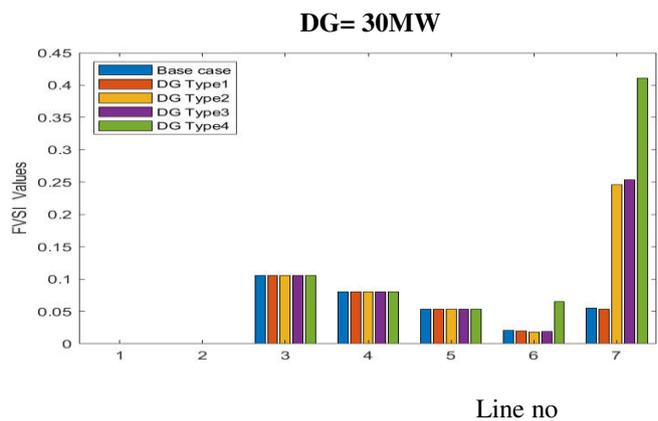
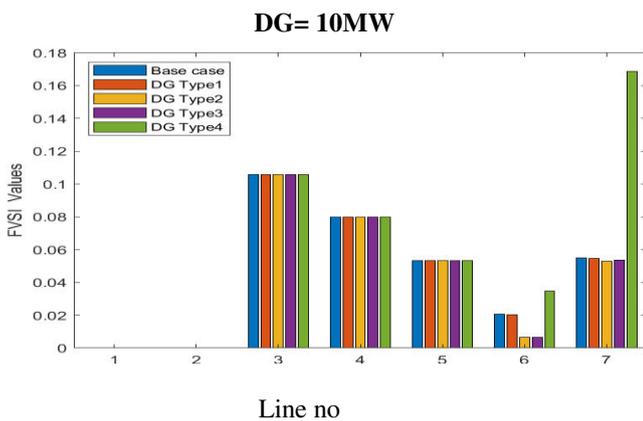


Fig 4.2 FVSI values of IEEE 5 Bus System with 10MW DG

Fig 4.3 FVSI values of IEEE 5 Bus System with 30MW DG

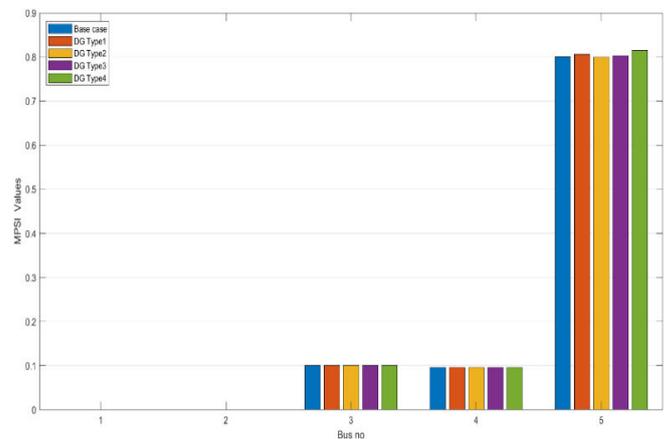
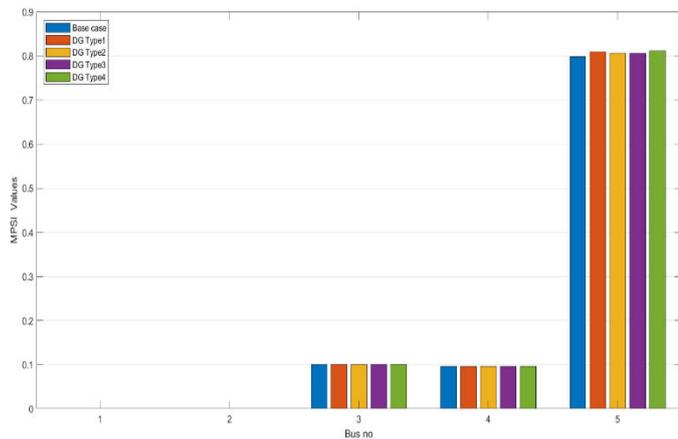


Fig 4.4 MPSI values of IEEE 5 Bus System with 10MW DG

Fig 4.5 MPSI values of IEEE 5 Bus System with 30MW DG



- From the Fig 4.2 and Fig 4.3, for both conditions the base case and when Type1 DG connected are similar (close to zero) .when Type 2 DG and Type 3 DG are connected the values are reduced from base case and almost near to zero. But for Type 4 DG connected the values are slightly increased compared to base values.
- From Fig 4.4 and Fig 4.5, due to the increase in the value of DG there is minute change in the values of index and the values are not close to '1' so the system is stable. There is no change in the values of bus 3 and 4, only the index values are varying at bus 5.

Now when load is reduced is reduced to half:The voltage profile is shown as below in Fig 4.6.The Voltage values are increased slightly.

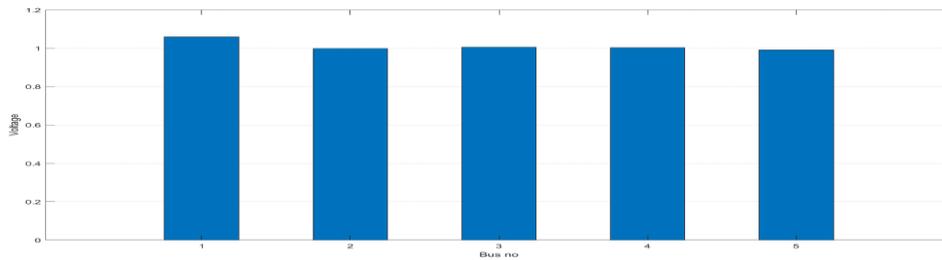


Fig 4.6 Voltage profile of IEEE 5 bus when load is reduced

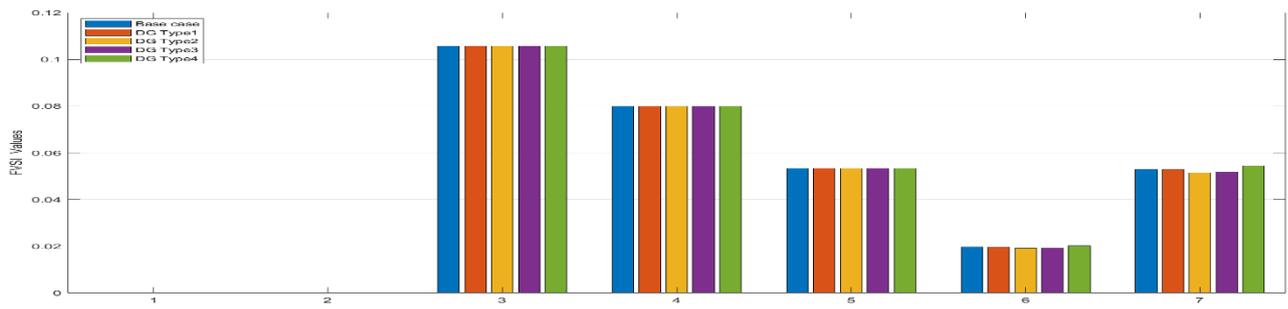


Fig 4.7 FVSI values when load is reduced for IEEE 5 bus system

The FVSI and MPSI values when the load is reduced. Considering DG value = 10 MW

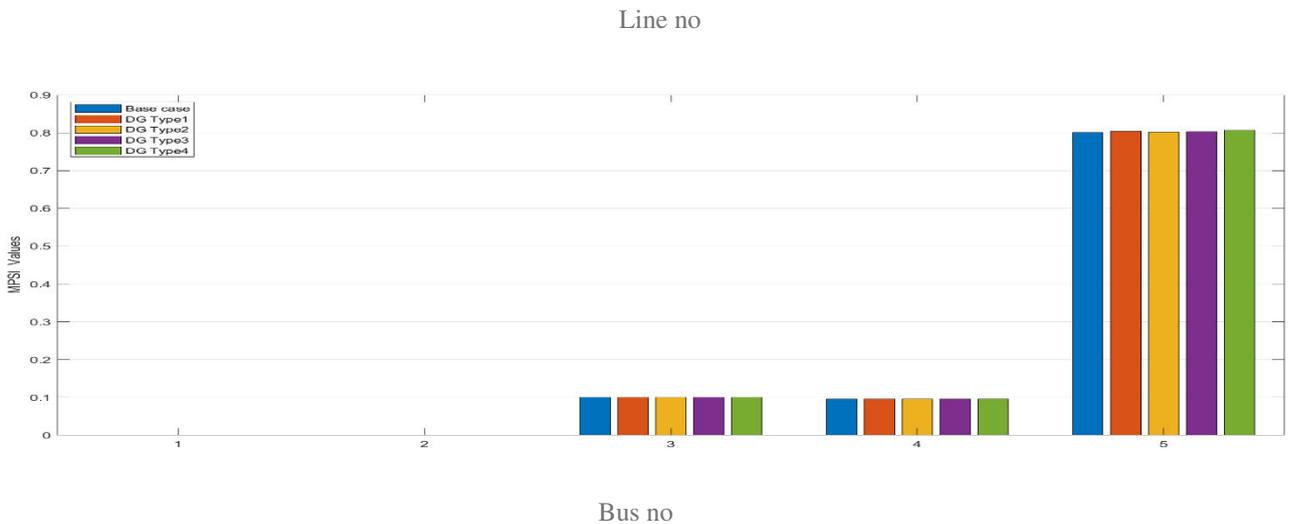


Fig 4.8 MPSI values when load is reduced for IEEE 5 bus system



- From Fig 4.7, it can be seen that there is a slight variation in the index values with reduction of load in all cases but for Type 4 DG connected system the index value is half of the index value of fully loaded condition.
- From Fig 4.8, we can observe that there is negligible change in the MPSI values even after the load is reduced. So we can conclude that even the load conditions are different the system is in stable condition.

4.2 Case -2 IEEE 30 Bus System:The IEEE 30 bus system consists of 1 swing bus, 5 generator bus and 24 load buses and 41 transmission lines. The voltage profile of 30 bus system is represented as:

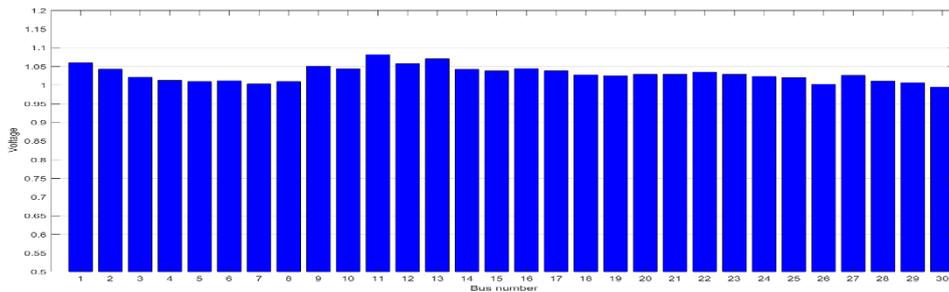


Fig 4.9. Voltage values of IEEE 30 bus system

The FVSI and MPSI values are calculated for the base case and also after connecting different types of distributed generation. Here we have taken two different DG values 5 MW and 10 MW and plotted the results.

FVSI values when DG=5MW

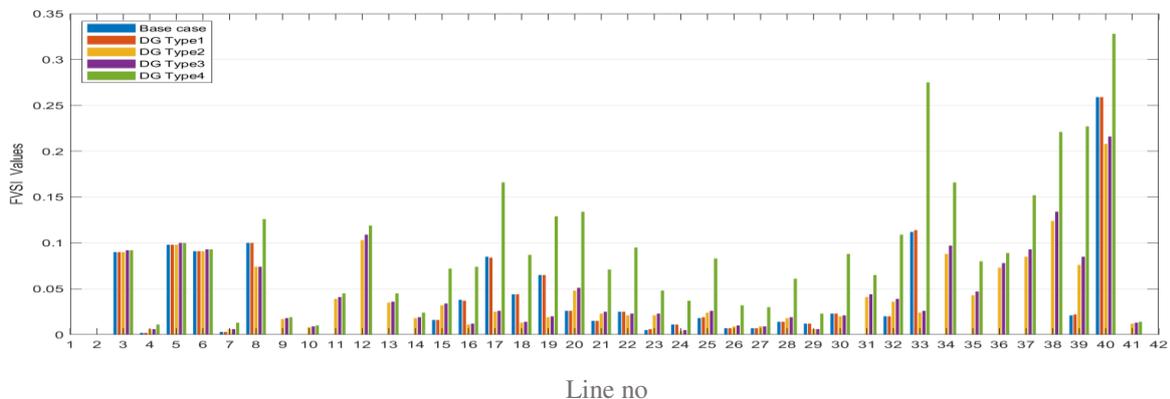


Fig 4.10 FVSI values of IEEE 30 bus system with different types of DGs with 5 MW DG

FVSI values when DG=10MW

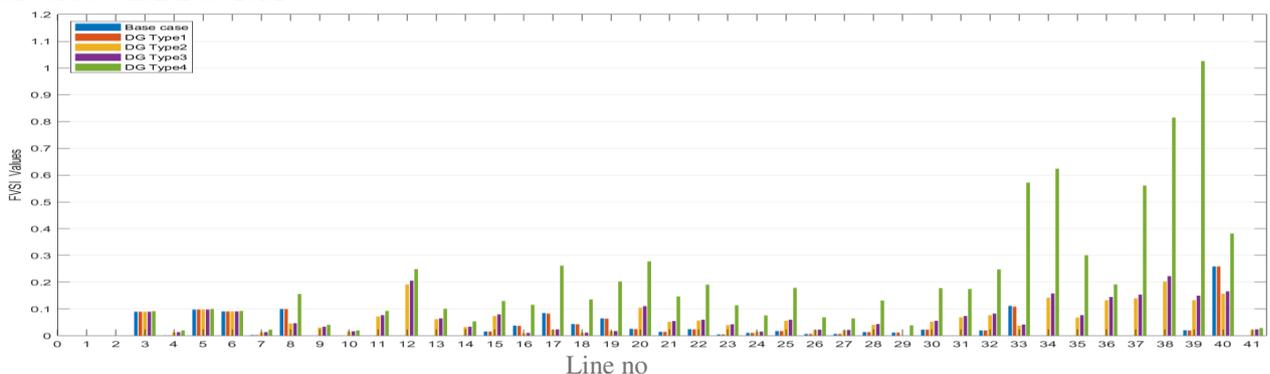


Fig 4.11 FVSI values of IEEE 30 bus system with different types of DGs with 10MW DG



From both Figs 4.10 and 4.11, for both DG values at all cases the values are not close to ‘1’ except for type 4 DG with 10 MW DG value the stability index value at one line is ‘1’ showing the proximity to voltage collapse. So it is not considerable DG value for type 4 DG connected system.

MPSI values when DG=5MW

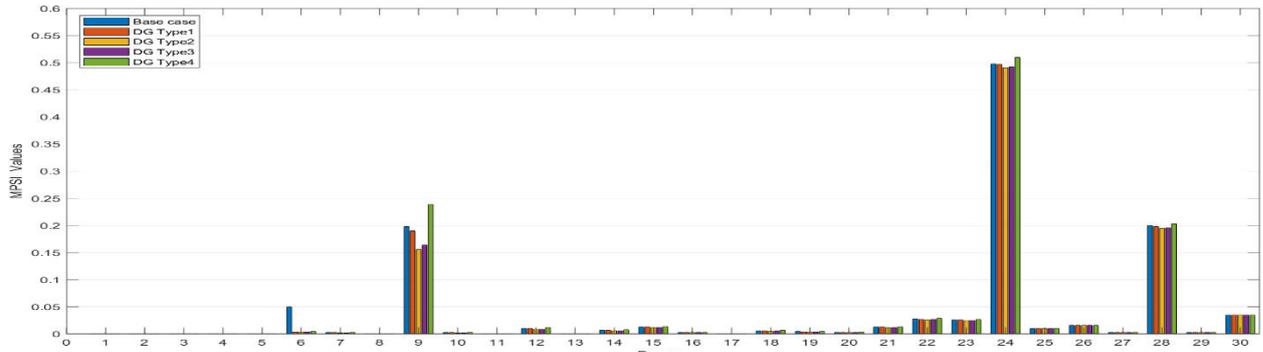


Fig 4.12 MPSI values of IEEE 30 bus system with different types of DG with 5MW DG

MPSI values when DG=10MW

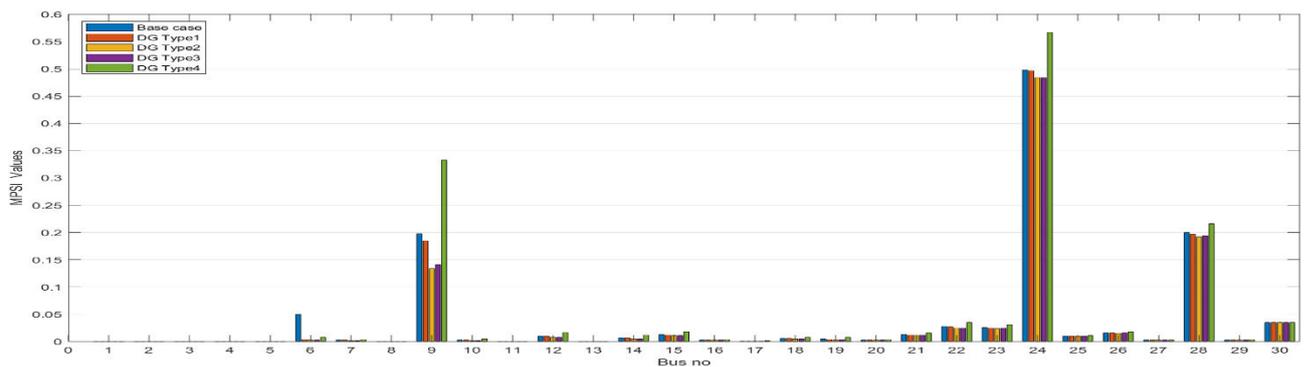


Fig 4.13 MPSI values of IEEE 30bus system with different types of DGs with 10 MW DG

From both Figs 4.12 and 4.13, we can observe that the index values when different types of DGs connected are similar to that of base case even the DG has increased. In this case too only at bus 24 the index values are in between ‘0’ and ‘1’ but the system is stable as all the values are not close to ‘1’.

Now when load is reduced to half: The voltage profile is shown as below in Fig 4.14. The Voltage values are increased slightly.

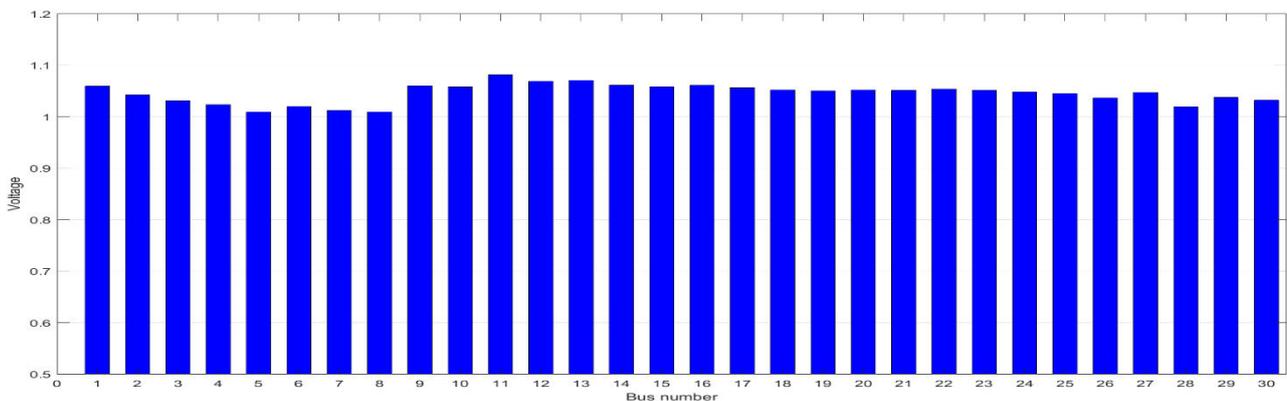


Fig 4.14 Voltage Profile of IEEE 30 bus system when load is reduced

The FVSI and MPSI values when the load is reduced. Considering DG value = 10 MW

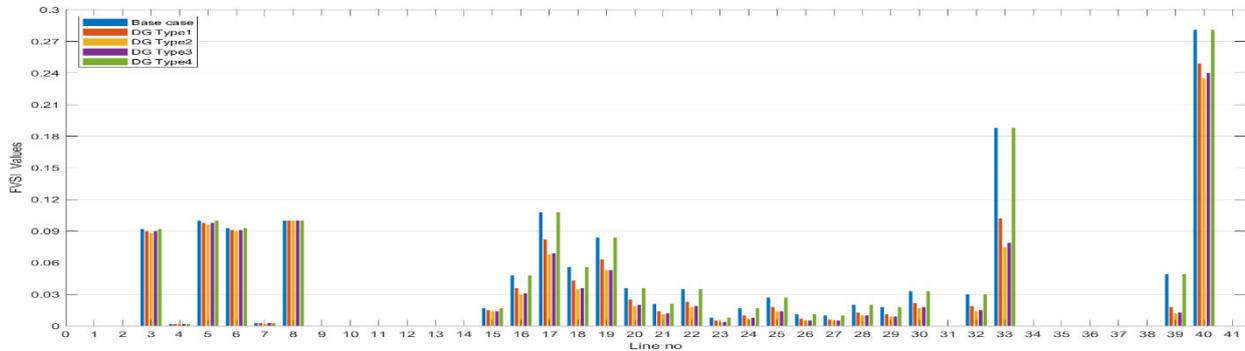


Fig 4.15 FVSI values of IEEE 30 bus system when load is reduced to half

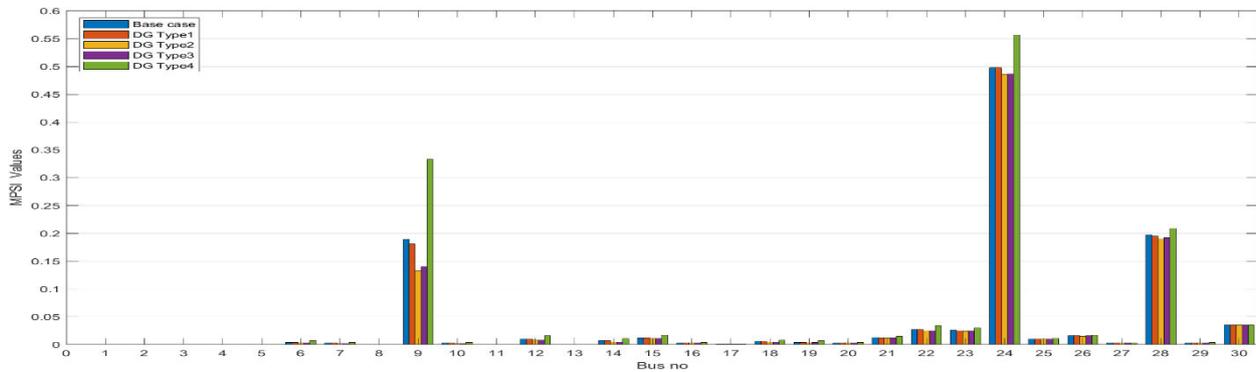


Fig 4.16 MPSI values of IEEE 30 bus system when load is reduced

- From the Fig 4.15, the index values in all cases are reduced when load is reduced. When load is full, one value exceeded '1' when Type 4 DG is connected to system, but as load reduces the index has reduced. So, the entire system is stable as all values are close to '0'.
- From the above Fig 4.16, we can observe that with the reduction load the change in the stability index values is very small and the only bus 24 have the index value between '0' and '1' but the entire system is stable because all the values are within the permissible limits.

V. CONCLUSION

- ❖ From the results we can state that for both conditions i.e., when the load is full and reduced to 50%, the Maximum power stability index (MPSI) values with all types of DGs connected to system gives a stable condition to both systems.
- ❖ The Fast voltage stability index (FVSI) values when the load is full and reduced with all types of DGs connected, for IEEE 5 bus system stable condition is achieved but for IEEE 30 bus system with Type 4 DG connected at one line the index value is equal to '1' when fully loaded but got reduced when load is reduced to 50%. But the other types of DGs have given a stable condition to system at all lines.
- ❖ So from the results we have studied the variation of voltage stability of power system for the taken conditions and achieved the objective.

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Appendix A

IEEE 5 BUS SYSTEM

BUS DATA:

Bus no	Bus type	Voltage	Angle	PG	QG	PL	QL
1	1	1.06	0	0	0	0	0
2	2	1	0	40	30	20	10
3	3	1	0	0	0	45	15
4	3	1	0	0	0	40	5
5	3	1	0	0	0	60	10

LINE DATA:

From Bus	To Bus	R(pu)	X(pu)	B(pu)
1	2	0.02	0.06	0.03
1	3	0.08	0.24	0.025
2	3	0.06	0.25	0.02
2	4	0.06	0.18	0.02
2	5	0.04	0.12	0.015
3	4	0.01	0.03	0.01
4	5	0.08	0.24	0.025

APPENDIX B

IEEE 30 BUS SYSTEM

BUS DATA:

Bus	type	V _m	δ	P _g	Q _g	P _l	Q _l	Q _{min}	Q _{max}	Q _{inj}
1	1	1.06	0	0	0	0	0	0	0	0
2	2	1.043	0	40	50.0	21.7	12.7	-40	50	0
3	3	1.0	0	0	0	2.4	1.2	0	0	0
4	3	1.06	0	0	0	7.6	1.6	0	0	0
5	2	1.01	0	0	37.0	94.2	19.0	-40	40	0



6	3	1.0	0	0	0	0.0	0.0	0	0	0
7	3	1.0	0	0	0	22.8	10.9	0	0	0
8	2	1.01	0	0	37.3	30.0	30.0	-10	40	0
9	3	1.0	0	0	0	0.0	0.0	0	0	0
10	3	1.0	0	0	0	5.8	2.0	0	0	19
11	2	1.082	0	0	16.2	0.0	0.0	-6	24	0
12	3	1.0	0	0	0	11.2	7.5	0	0	0
13	2	1.071	0	0	10.6	0.0	0.0	-6	24	0
14	3	1.0	0	0	0	6.2	1.6	0	0	0
15	3	1.0	0	0	0	8.2	2.5	0	0	0
16	3	1.0	0	0	0	3.5	1.8	0	0	0
17	3	1.0	0	0	0	9.0	5.8	0	0	0
18	3	1.0	0	0	0	3.2	0.9	0	0	0
19	3	1.0	0	0	0	9.5	3.4	0	0	0
20	3	1.0	0	0	0	2.2	0.7	0	0	0
21	3	1.0	0	0	0	17.5	11.2	0	0	0
22	3	1.0	0	0	0	0.0	0.0	0	0	0
23	3	1.0	0	0	0	3.2	1.6	0	0	0
24	3	1.0	0	0	0	8.7	6.7	0	0	4.3
25	3	1.0	0	0	0	0.0	0.0	0	0	0
26	3	1.0	0	0	0	3.5	2.3	0	0	0
27	3	1.0	0	0	0	0.0	0.0	0	0	0
28	3	1.0	0	0	0	0.0	0.0	0	0	0
29	3	1.0	0	0	0	2.4	0.9	0	0	0
30	3	1.0	0	0	0	10.6	1.9	0	0	0



LINE DATA:

From Bus	To Bus	R(pu)	X(pu)	B(pu)	Tap Ratio
1	2	0.0192	0.0575	0.0264	1
1	3	0.0452	0.1652	0.0204	1
2	4	0.0570	0.1737	0.0184	1
3	4	0.0132	0.0379	0.0042	1
2	5	0.0472	0.1983	0.0209	1
2	6	0.0581	0.1763	0.0187	1
4	6	0.0119	0.0414	0.0045	1
5	7	0.0460	0.1160	0.0102	1
6	7	0.0267	0.0820	0.0085	1
6	8	0.0120	0.0420	0.0045	1
6	9	0.0	0.2080	0.0	0.978
6	10	0.0	0.5560	0.0	0.969
9	11	0.0	0.2080	0.0	1
9	10	0.0	0.1100	0.0	1
4	12	0.0	0.2560	0.0	0.932
12	13	0.0	0.1400	0.0	1
12	14	0.1231	0.2559	0.0	1
12	15	0.0662	0.1304	0.0	1
12	16	0.0945	0.1987	0.0	1
14	15	0.2210	0.1997	0.0	1
16	17	0.0824	0.1923	0.0	1
15	18	0.1073	0.2185	0.0	1
18	19	0.0639	0.1292	0.0	1
19	20	0.0340	0.0680	0.0	1
10	20	0.0936	0.2090	0.0	1
10	17	0.0324	0.0845	0.0	1
10	21	0.0348	0.0749	0.0	1
10	22	0.0727	0.1499	0.0	1
21	23	0.0116	0.0236	0.0	1
15	23	0.1000	0.2020	0.0	1
22	24	0.1150	0.1790	0.0	1
23	24	0.1320	0.2700	0.0	1
24	25	0.1885	0.3292	0.0	1
25	26	0.2544	0.3800	0.0	1
25	27	0.1093	0.2087	0.0	1
28	27	0.0000	0.3960	0.0	0.968
27	29	0.2198	0.4153	0.0	1
27	30	0.3202	0.6027	0.0	1
29	30	0.2399	0.4533	0.0	1
8	28	0.0636	0.2000	0.0214	1
6	28	0.0169	0.0599	0.0650	1



**Impact Factor:
7.569**



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