Dynamic Performance Enhancement for Wind Turbine with SEIG Feeds Local Distribution Network Using ANN

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This paper presents:

- An artificial neural network (ANN) scheme to keep the terminal voltage and the frequency constant for SEIG connected to fixed speed wind turbine feeds a local distribution network during different loading conditions.

- studies the dynamic disturbances such as wind speed variation or/and load changing either the equivalent load ratio or its power factor by adapting on-line the shunt capacitor bank equivalent capacitance to match the new operating conditions.

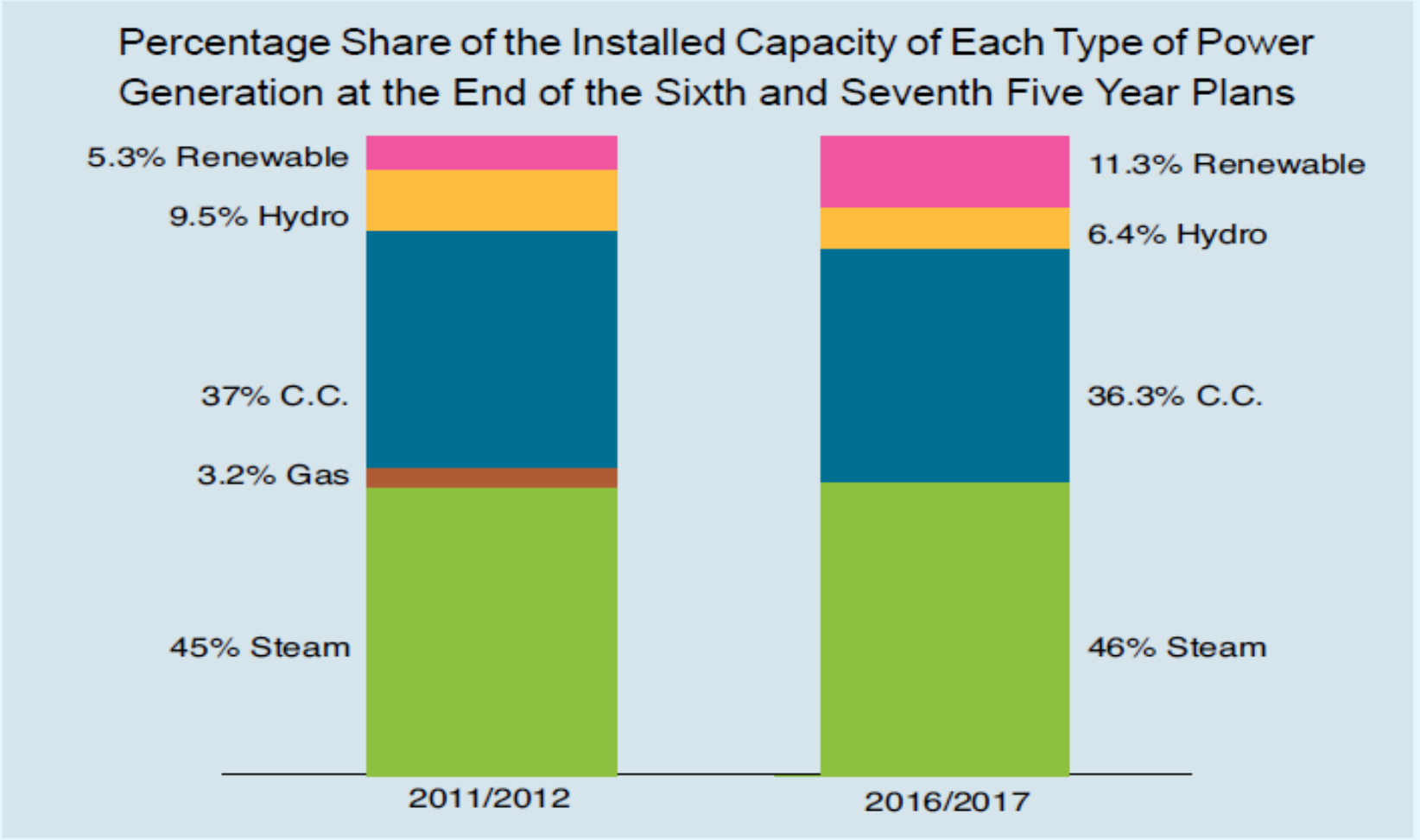
- The results show that proposed ANN scheme is capable to enhance the wind SEIGs terminal voltage and frequency during such dynamic disturbances.

- SIMULINK and ANN tool boxes under MATLAB program is used to achieve this study.

Outlines :

- Introduction
- Proposed System Modeling
  - ANN Controller Scheme
- SEIG Capacitance Requirements
- Problem Formulation
- Simulation Results and Discussions
  - Case 1, increasing the load
  - Case 2, decreasing the load
- Conclusions

Egyptian UPG Generation

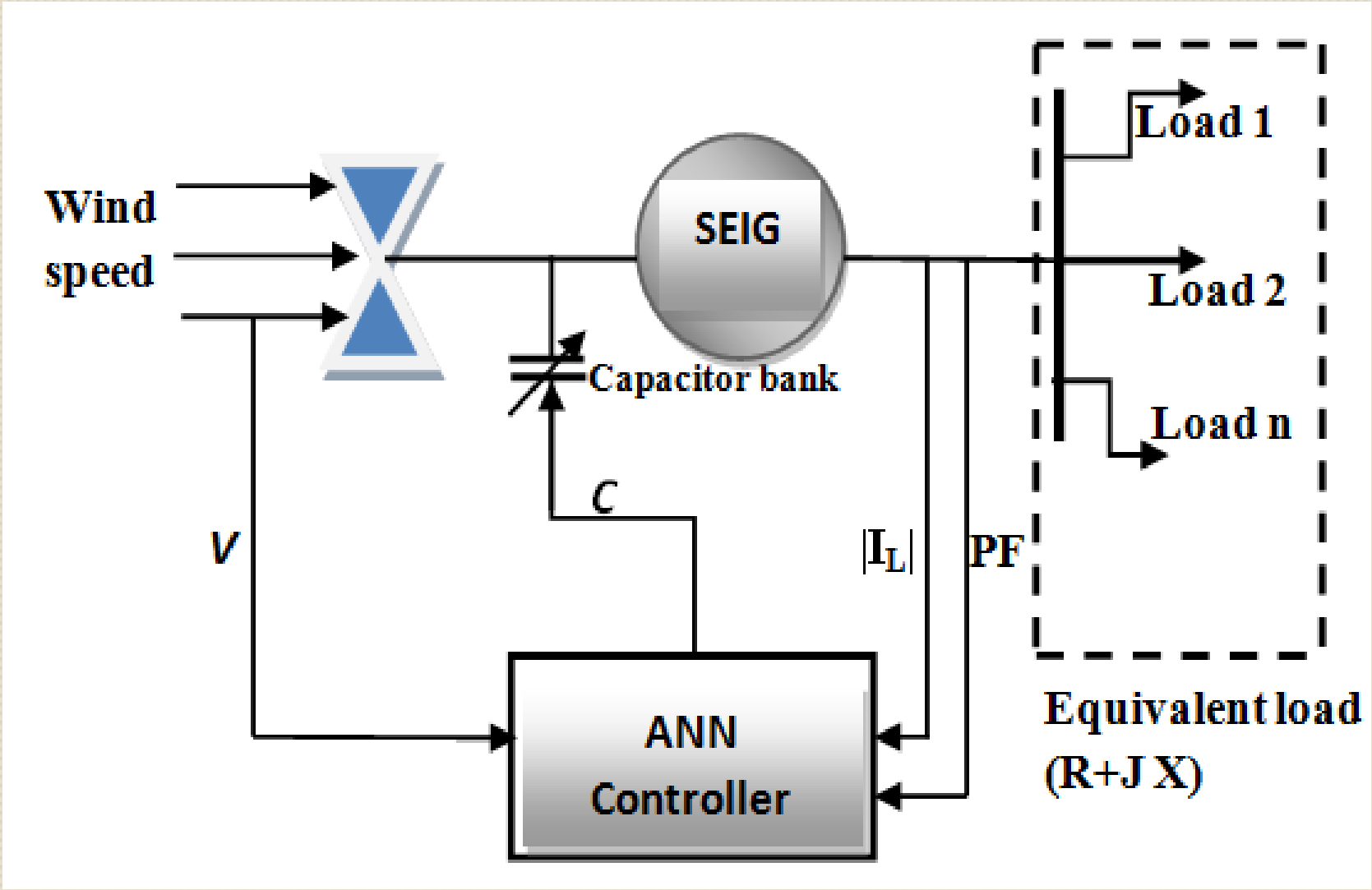


- That leads to high needs of:

1-Enhance the Local distribution Networks with Renewable resources

2-Integration of these local distribution networks to Egyptian grid

Proposed local distribution network with ANN



Proposed local distribution network with ANN

The proposed on-line algorithm to have constant voltage and frequency operation for SEIG

1.Measuring the wind speed (V).

2.Measuring the total generator voltage, current (I_L) and angle (φ).

3.Calculate the equivalent load (R+ jX) and PF.

4.Feeding the ANN inputs ($|I_L|$, PF, V) to have the corresponding minimum capacitance.

5.Adapting on line the shunt capacitor value to have to match the load situation.

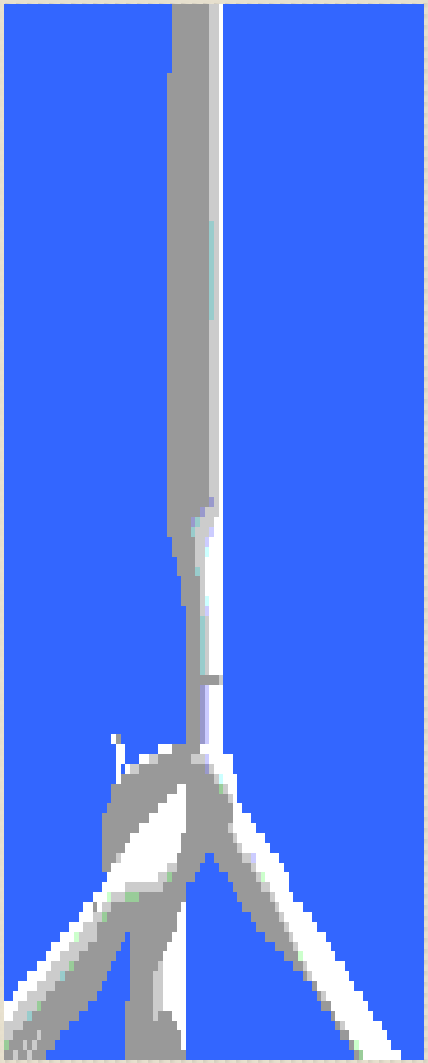
Mathematical model of Proposed System

Wind turbine modeling

Horizontal axis wind turbine which power characteristics of the turbine.

$$P_m = .5\rho A C_p V^3$$

- **A :the area swept by the rotor blades (m^2)**
- **v : the wind velocity (m /s)**
- **ρ: air density (kg/v^3)**
- **Cp: power coefficient is function of tip ratio and pitch angle (ϒ , ß).**



$$C_p = 0.22\left(\frac{116}{\lambda_i} - .4\,\beta - 5\right)e^{\frac{-12.5}{\lambda_i}}$$

Where λi calculates from

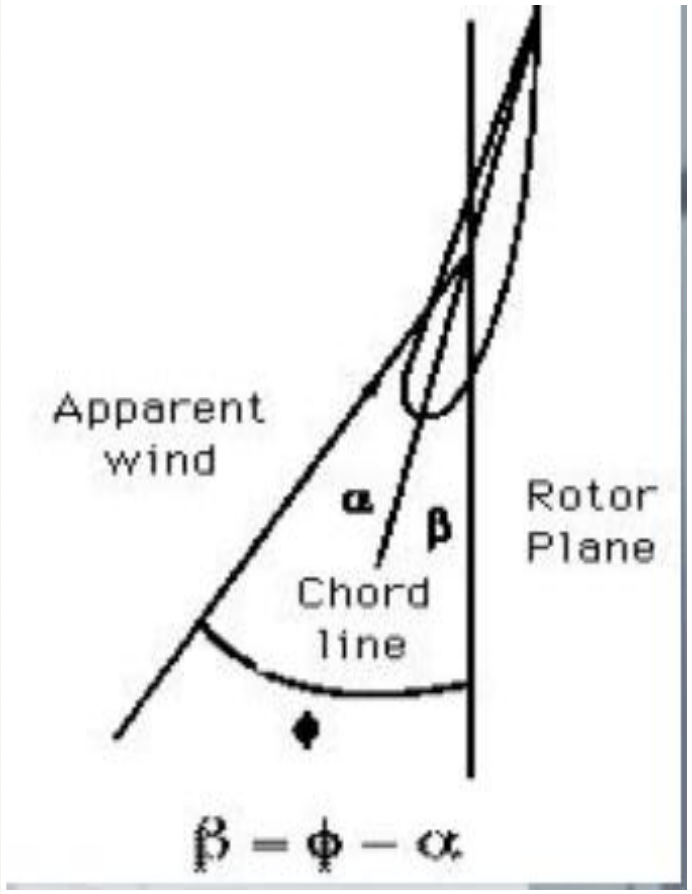
$$\frac{1}{\lambda_i} = \frac{1}{\lambda + 0.08\beta} - \frac{0.035}{1+\beta^3}$$

where λ is tip speed ratio=(R.ωm/v)

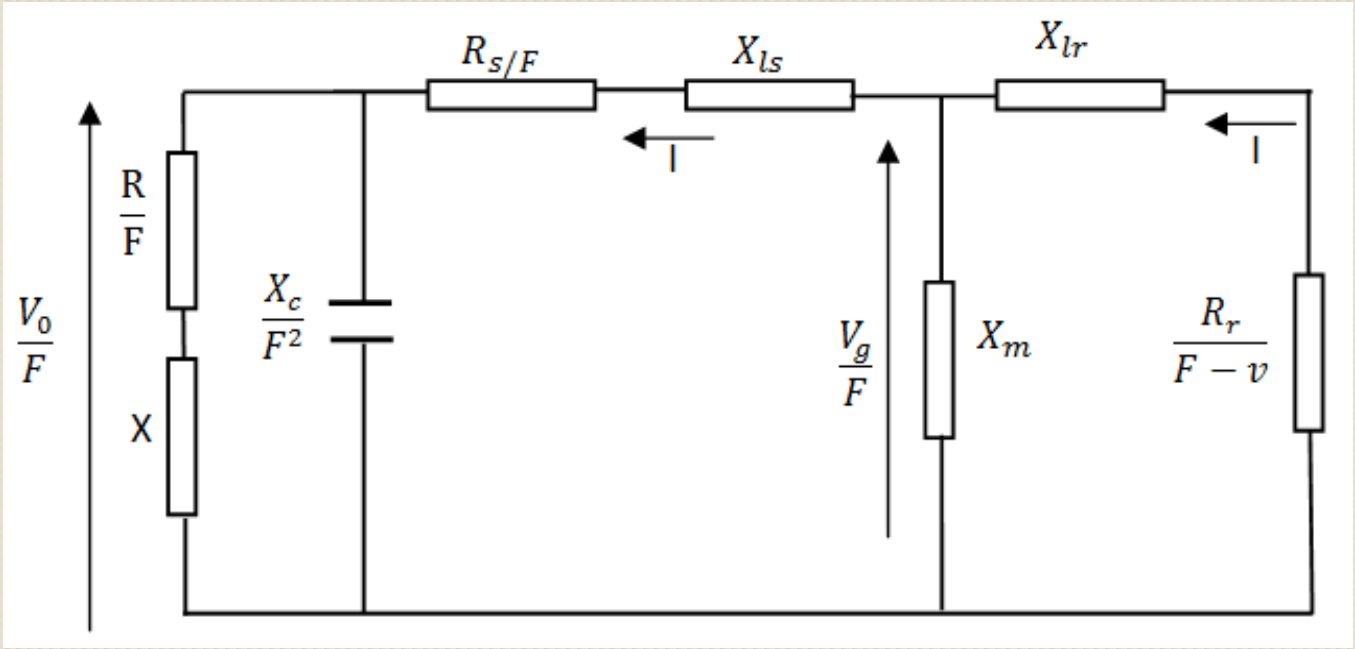
R: radius of the blades, v is wind speed

ß is pitch angle between the chord line and rotor plane

- Φ~ Apparent wind angle (degree)
- α~ Angle of attack (degree)



SEIG Capacitance Requirements



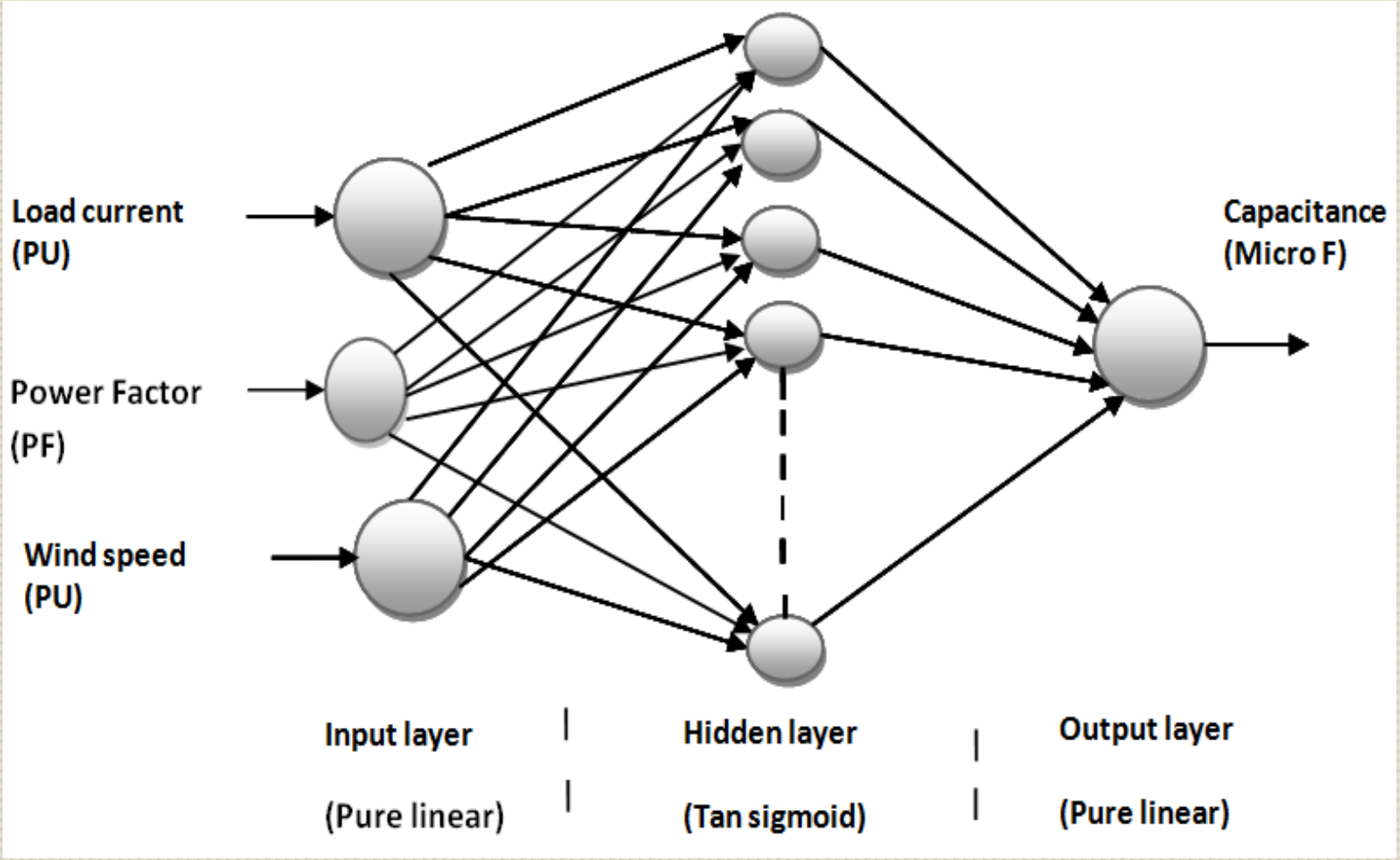
SEIG steady state Model

$$IZ = 0.0$$

$$Z = \left(\left(\frac{R_r}{F-v}\right) + jX_{lr} \parallel jX_m\right) + \frac{R_s}{F} + jX_{ls} + \left(\frac{-jX_c}{F^2} \parallel \left(\frac{R}{F} + jX\right)\right)$$

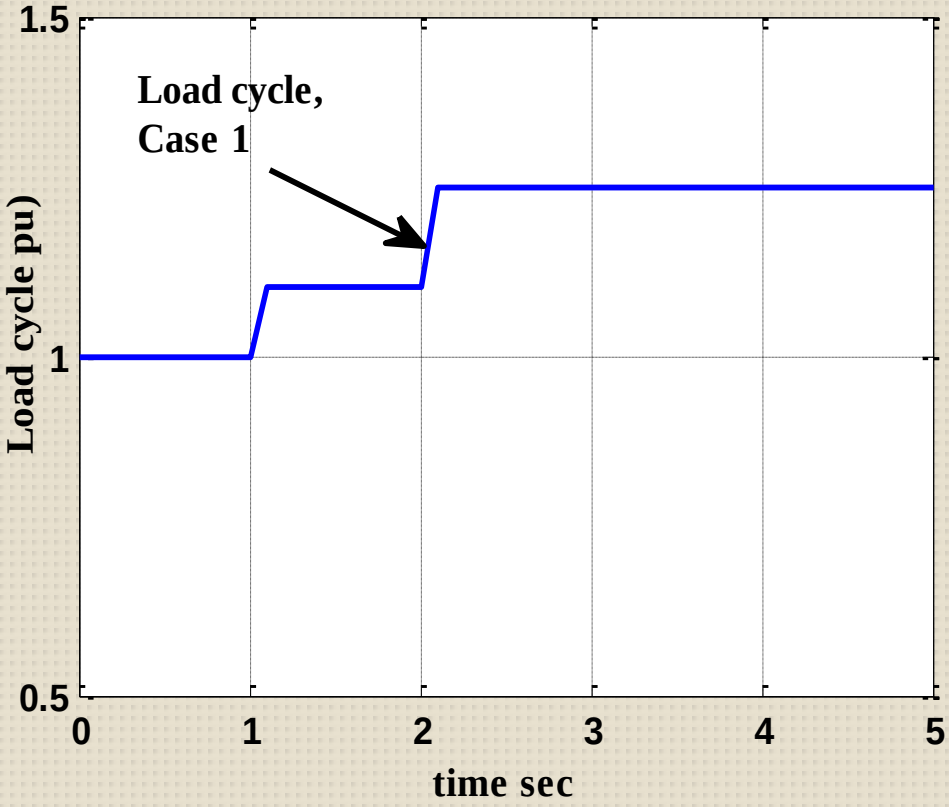
$$C_i = \frac{1}{2\,pi\,F\,X_{ci}}$$

ANN Controller Scheme

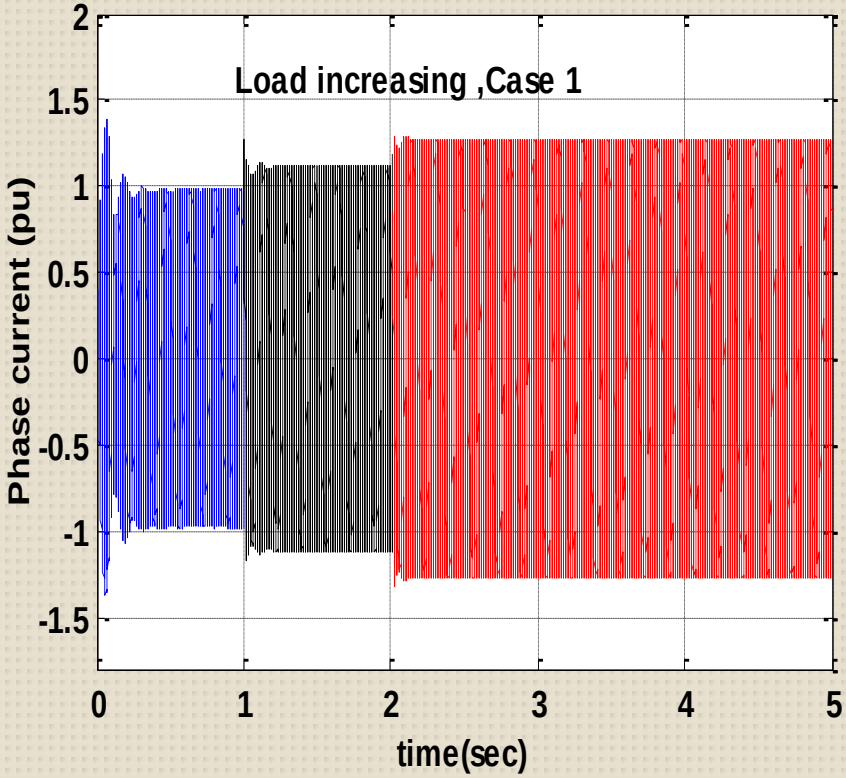


Simulation Results

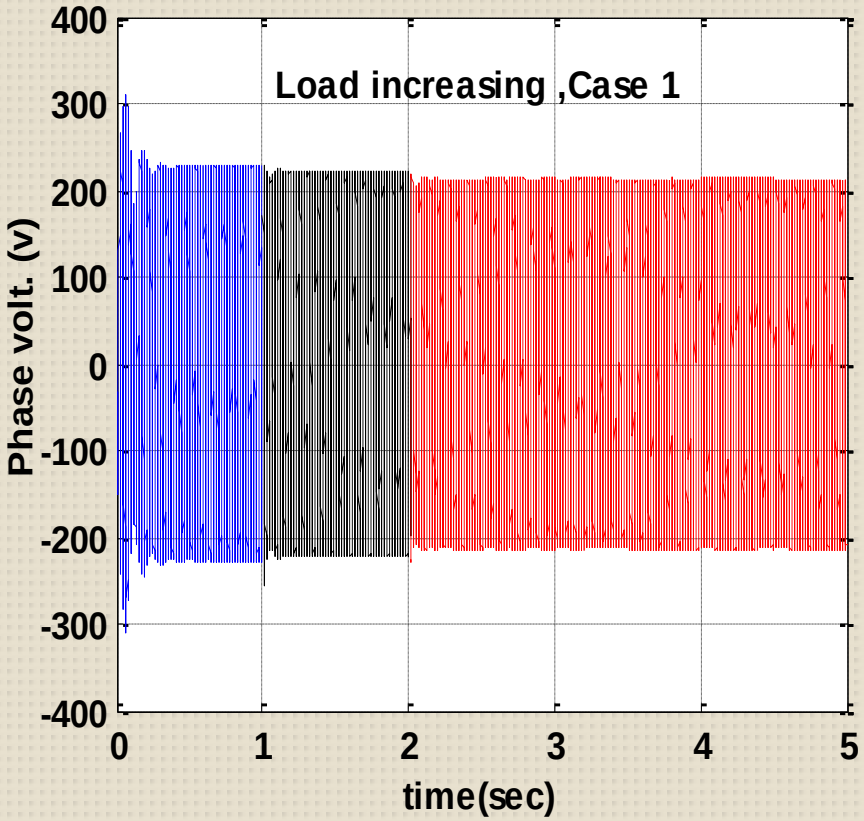
Case(1) Load Increasing



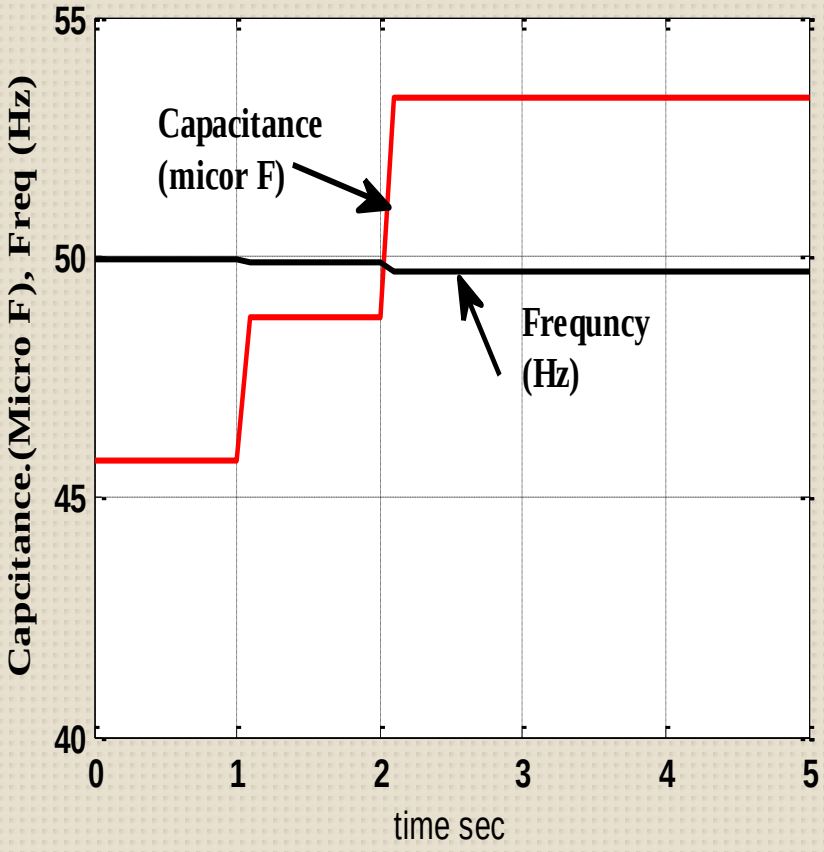
Load increasing



SEIG Phase current

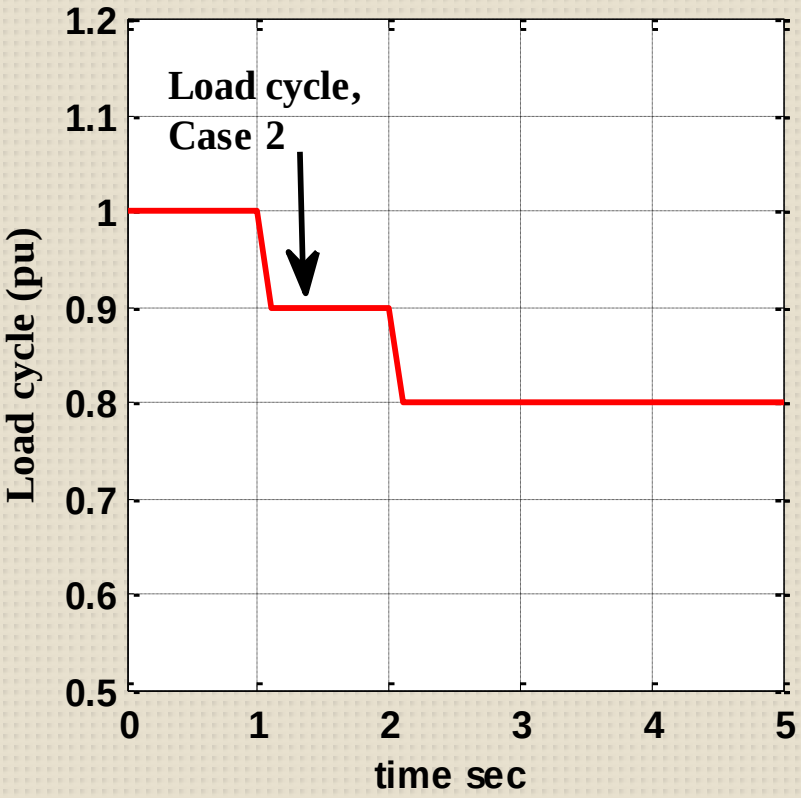


Phase voltage

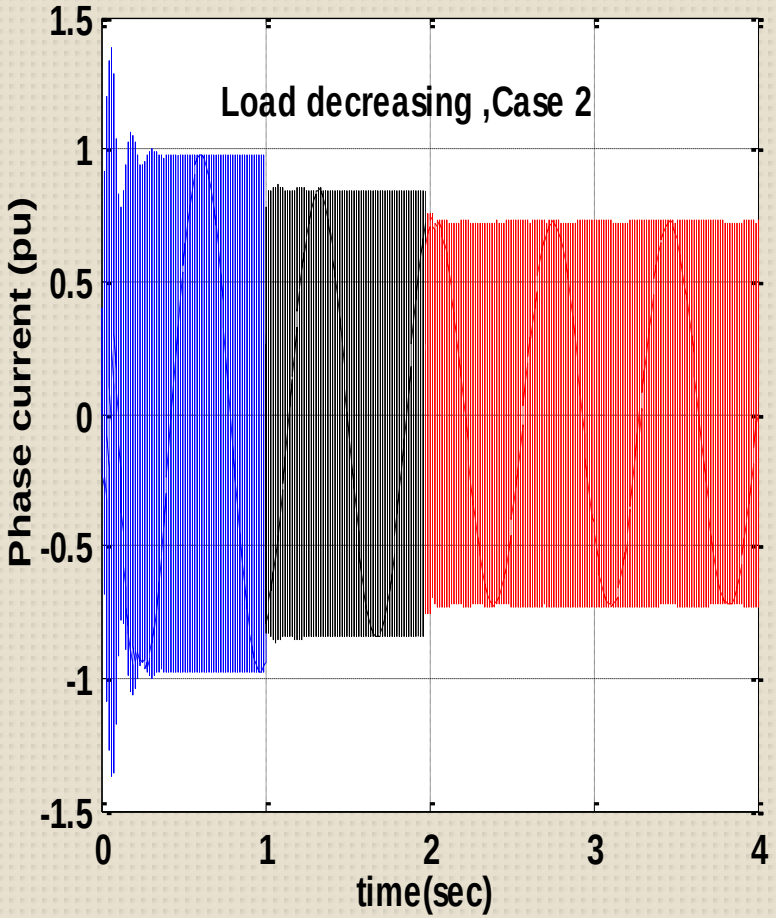


Frequency and capacitance

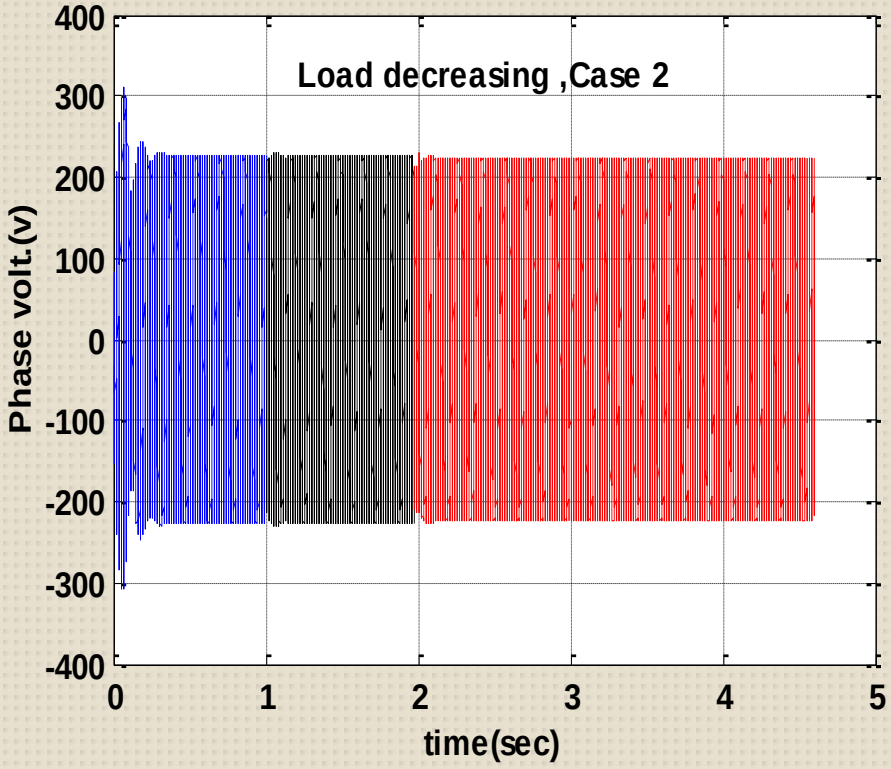
Case(2) Load Decreasing



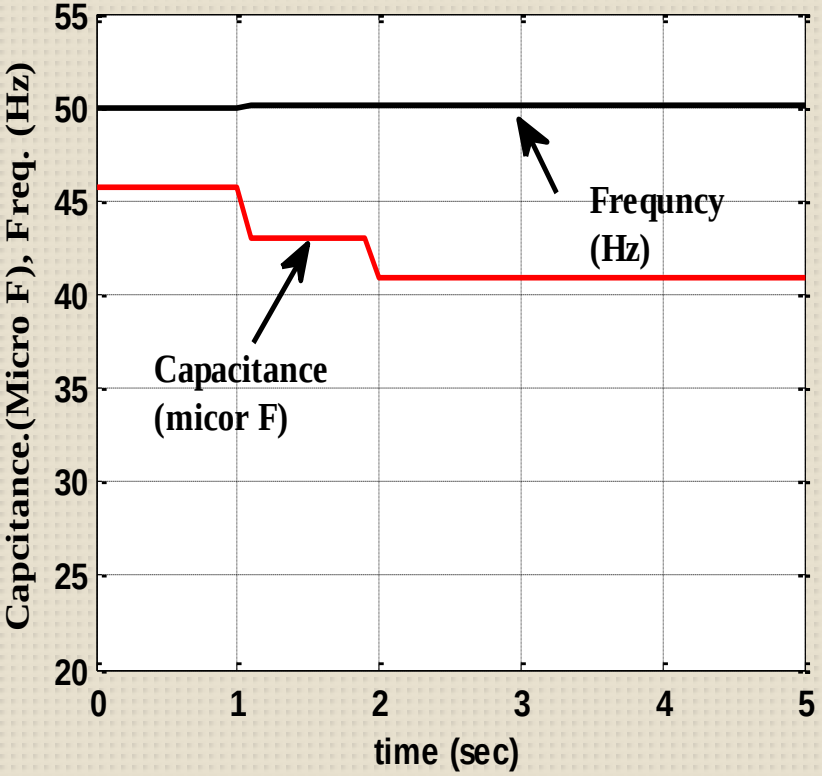
Load decreasing duty cycle



SEIG Phase current



Phase voltage



Frequency and capacitance

Conclusion

In this paper,

- **Minimum capacitor values required for SEIG at different loading and wind speeds for steady state model are determined**
- **These values are used to learn ANN.**
- **An on line scheme to enhance to the dynamic behavior of SEIG is presented using ANN intelligent controller is proposed.**
- **The results show that the suggested ANN controller is sensitive and reliable to enhance the SEIG voltage and frequency during dynamic disturbances.**
- **This proposed technique can be implemented for isolated load wind generators and can be extended to local area network at distribution network.**

Thank you

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