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Power System Stabilizer Based on Artificial Bee Colony Algorithms.

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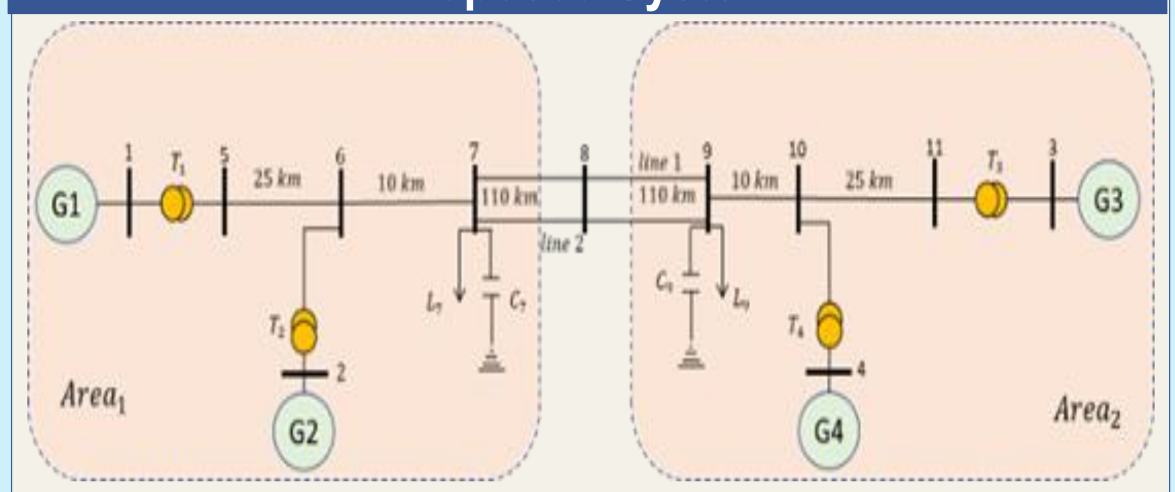
Abstract

Transient stability of power systems is increasingly enhanced through the use of fuzzy logic systems compared with classical controllers. Fuzzy Logic Power System Stabilizers (FLPSS) are optimized in this paper using an Artificial Bee Colony Optimization Algorithm (ABC). ABC-FLPSS has been evaluated using two-area 4-machine and eleven-bus multimachine power systems. For optimizing fuzzy logic power system stabilizer scaling factors, an objective function is formulated as the Integral Squared Error of rotor speed deviation. Changes in parameter values as well as removal of transmission lines are evaluated. Compared to FLPSS and CPSS, ABC-FLPSS controller is superior in performance. ABC-FLPSS controllers are capable of maintaining system stability with fewer parameters. Additionally, it can reduce power loss and dampen oscillations. Furthermore, it can be easily integrated into existing power systems. The ABC-FLPSS controller showed improved transient stability compared to FLPSS and CPSS, even with the removal of one transmission line. This demonstrates its robustness and ability to maintain system stability under changing conditions. Adjusting the mechanical power input of Generator 3 resulted in enhanced stability when controlled by the ABC-FLPSS. This highlights its effectiveness in optimizing power system performance.

Objectives

- Design Logic Power System Stabilizer (FLPSS) to significantly increase power systems' robustness and ultimately improve the quality of power supply to end-users.
- Design a FLPSS to damp local and inter-area oscillations following disturbances through the use of an Artificial Bee Colony Optimization Algorithm (ABC).
- Suggest two areas with four machines and eleven buses to evaluate the ABC-FLPSS performance under a variety of disturbances and loads.
- Optimize the scaling factors of FLPSSs using the Integral Squared Error (ISE) of rotor speed deviation as an objective function.
- Evaluate the proposed controller involves simulating the test system under different conditions.

Proposed System

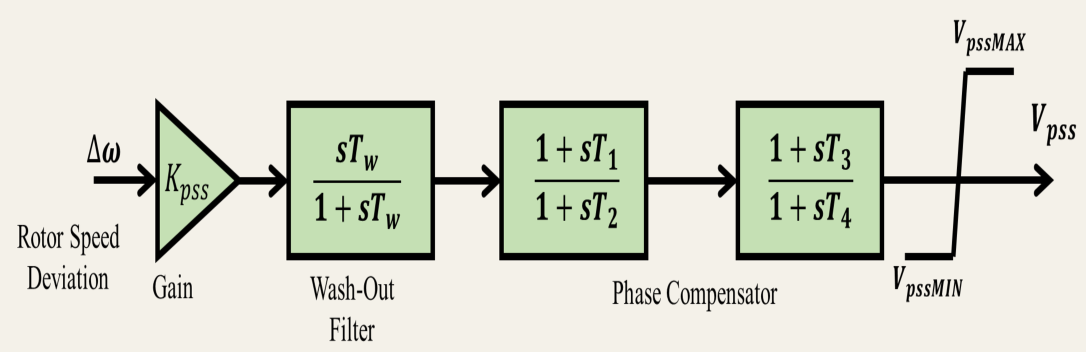


Two-area, four-machine, eleven-bus test power system

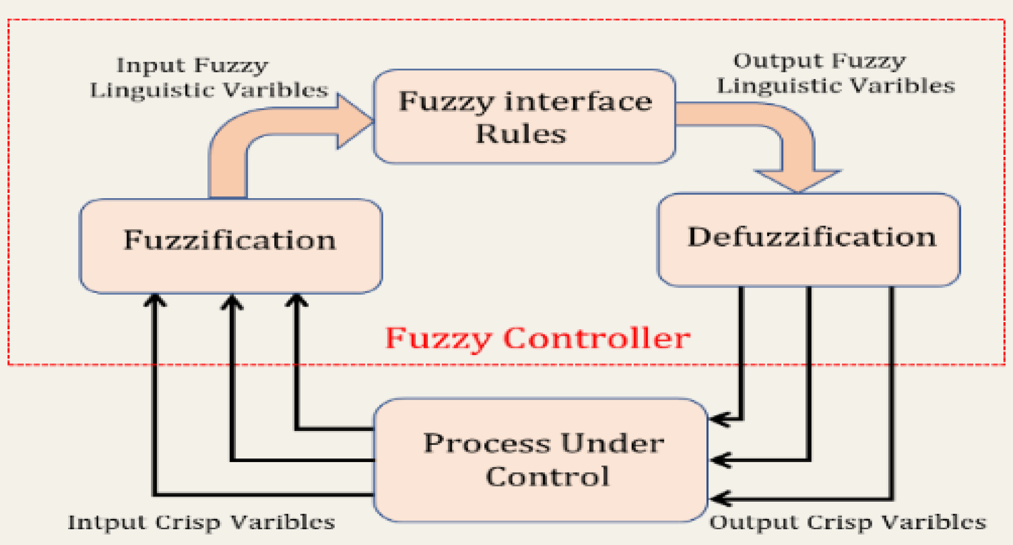
System Methodology

1. Conventional Power System Stabilizer Structure

$$V_{pss}(s) = K_{pss} \times \frac{sT_w}{1+sT_w} \times \frac{1+sT_1}{1+sT_2} \times \frac{1+sT_3}{1+sT_4}$$



2. Fuzzy Logic based Power System Stabilizer



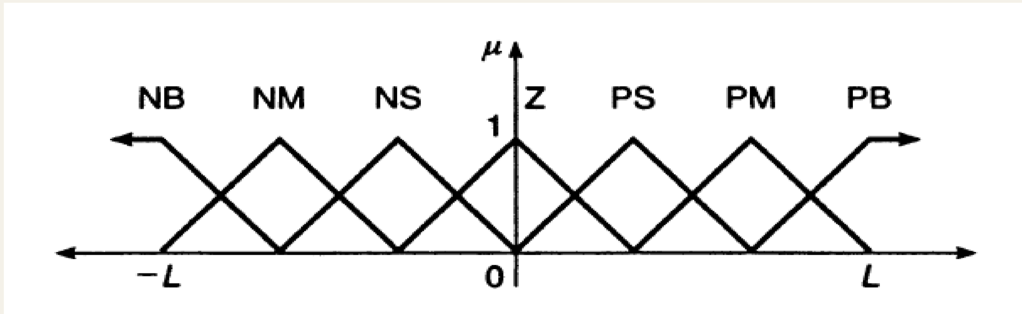
System Methodology

The control action of the fuzzy logic control is performing in three main steps:

A. Fuzzification,

Two steps are involved in the fuzzing process.

- The first step is to measure and scale the input variables (speed, power and acceleration).
- The second step is to transform the measured crisp values into the corresponding fuzzy variables (linguistic variables) using membership functions.



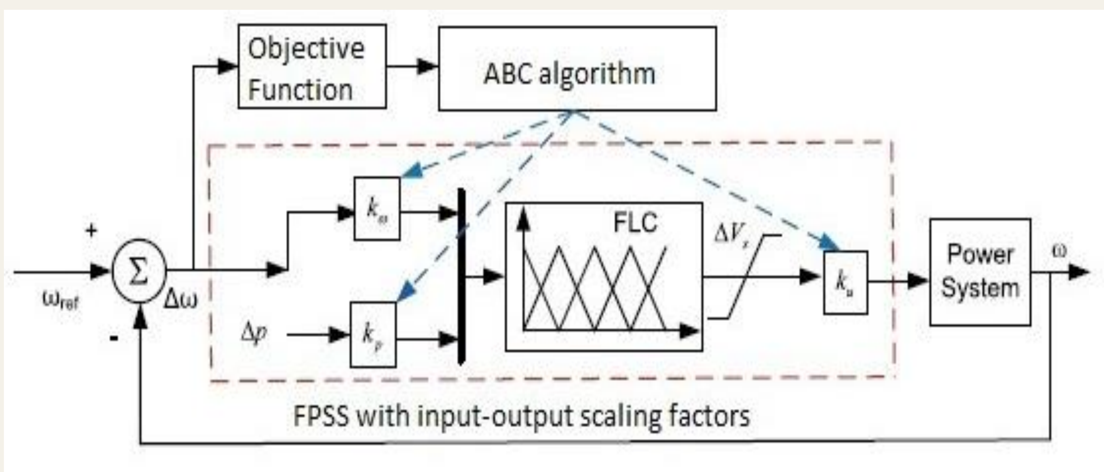
Triangular Membership Function

B. Fuzzy Inference Rules

Δω / Δp	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	Z
NM	NB	NB	NM	NM	NS	Z	PS
NS	NB	NM	NM	NS	Z	PS	PM
Z	NM	NM	NS	Z	PS	PM	PM
PS	NM	NS	Z	PS	PM	PM	PB
PM	NS	Z	PS	PM	PM	PB	PB
PB	Z	PS	PM	PB	PB	PB	PB

C. Defuzzification: it is necessary to get the actual values back again from their fuzzy. In the proposed controller, the centroid defuzzification method is used for this purpose.

3. Artificial Bee Colony Optimization Algorithm



ABC algorithm for tuning FLPSS input-output scaling factors

Simulation Results and Discussion

The simulation is done under various disturbance imposed to the system including:

- Three-phase symmetrical fault at the terminal of generator 1.
- Three-phase symmetrical fault at the middle of transmission Line1.

Parameter \ Generator	G1	G2	G3	G3
$K_{\omega i}$	1.00	1.02	1.05	2.46
K_{pi}	1.67	1.37	3.00	1.31
K_{ui}	1.15	1.02	1.74	1.49

1. Removing one of the two parallel Transmission lines connected the two areas.

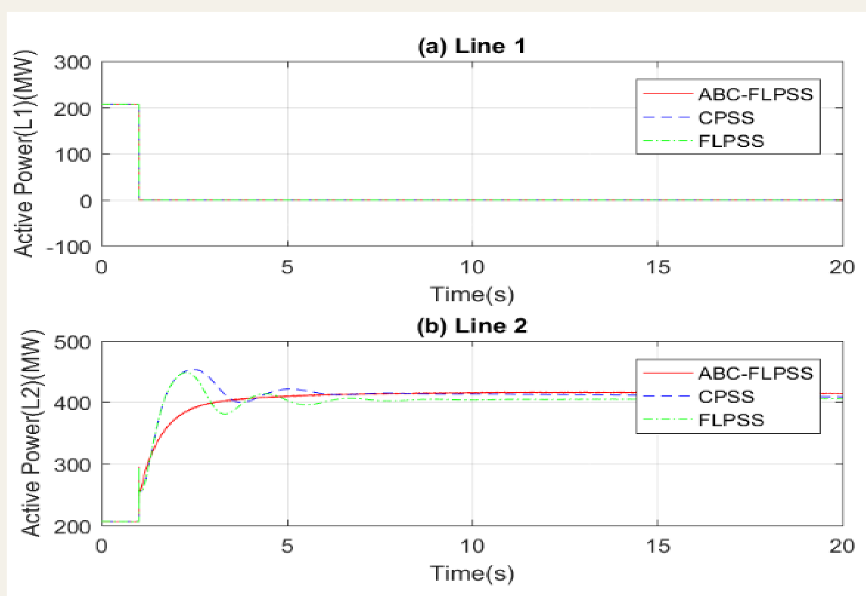


Fig. Active Power Flow with removing Line 1 between bus 7 and bus 8

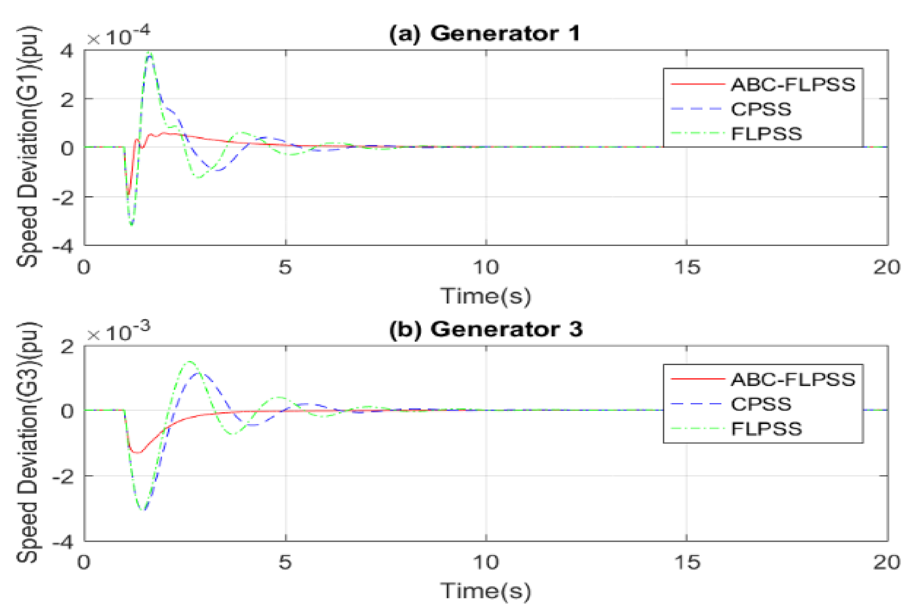


Fig. Speed Deviations with removing Line 1 between bus 7 and bus 8

Simulation Results and Discussion

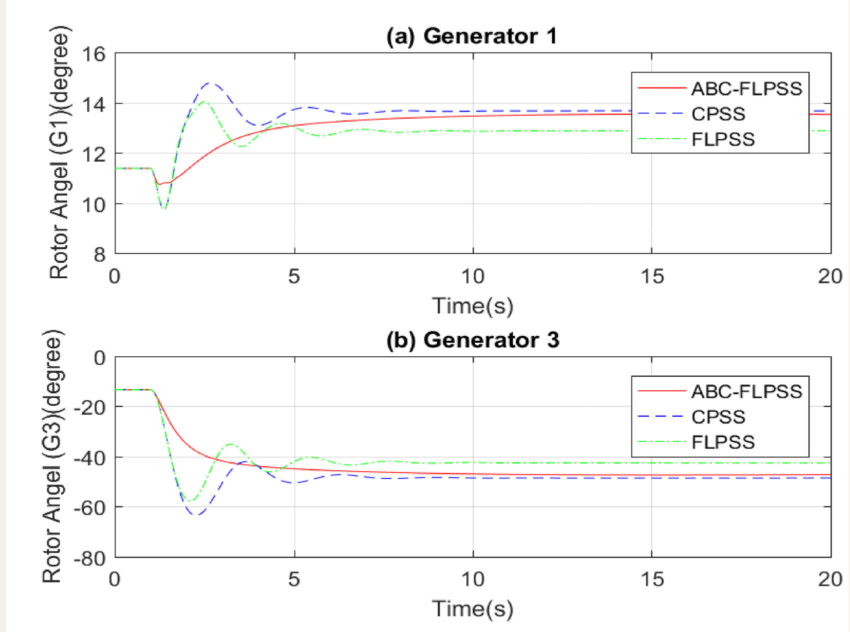


Fig. Rotor Angles with removing Line 1 between bus 7 and bus 8

2. Adjusting the mechanical power input of Generator 3.

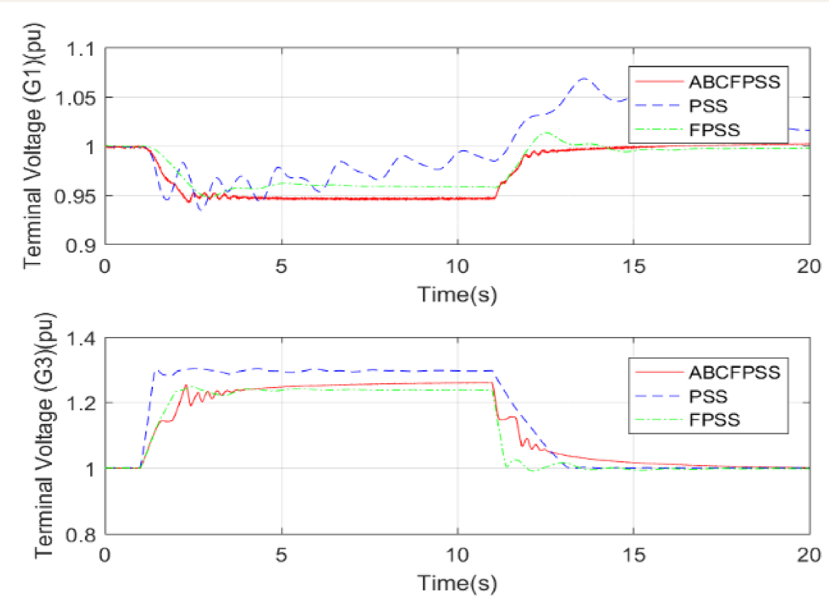


Fig. Terminal Voltages with Changing the Input Mechanical Power of G3

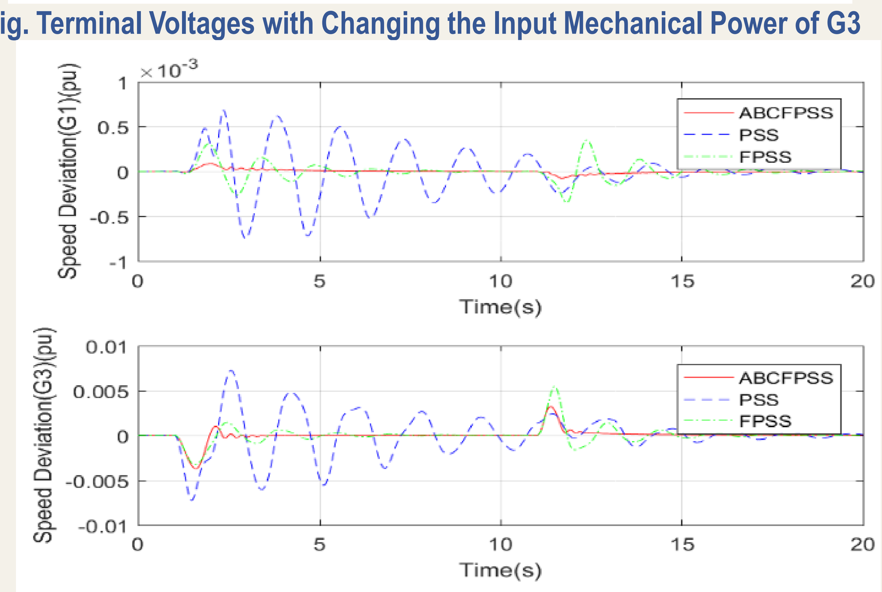


Fig. Rotor Speed Response with Changing the Input Mechanical Power of G3

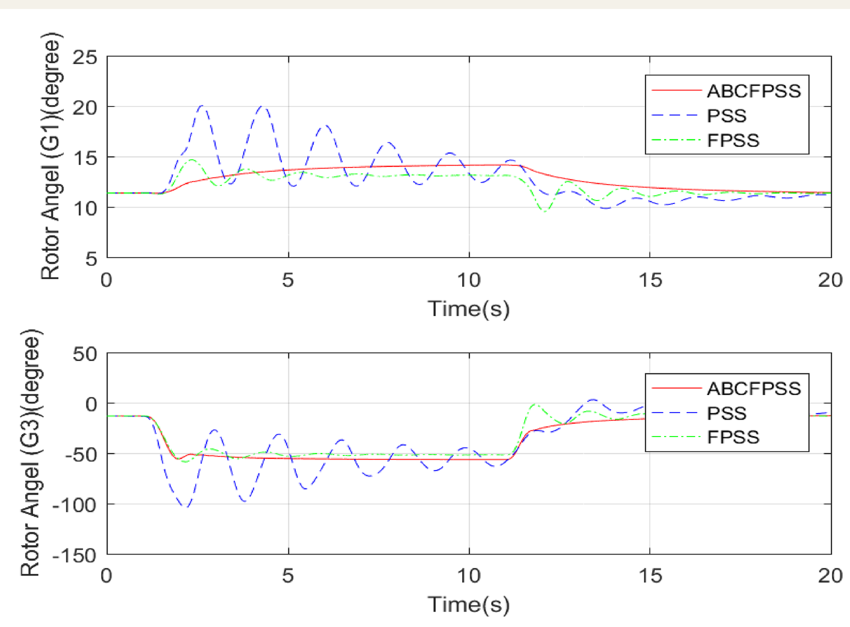


Fig. Rotor Angle Response with Changing Input Mechanical Power of G3

Conclusion

- The paper suggests that fuzzy logic controllers, due to their capacity to handle system uncertainties, are efficient for nonlinear dynamical systems, unlike classical controllers, which require precise mathematical models and measurements. It introduces the ABC optimization technique to enhance transient stability in multimachine power systems by optimizing fuzzy logic PSS input-output scaling factors. Simulations comparing the proposed controller with conventional power system stabilizers indicate that ABC-FLPSS effectively dampens power system oscillations, enhancing transient stability and robustness. The controller shows promise for real-world applications in power grids, renewable energy systems, and electric vehicle networks, contributing to reliable and efficient operation and preventing blackouts. Overall, the paper concludes that the ABC optimization technique effectively improves the transient stability and robustness of multimachine power systems, outperforming conventional stabilizers in damping power system oscillations, even under varying operating conditions.

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