eq. (31) can also be written as follows

$$L_i = \frac{P_i}{P_T} L \tag{32}$$

which means that losses allocated in this manner are proportional to partial branch flows. But this is precisely the way losses are assigned in references [C, 1], the only difference being, therefore, in the philosophy adopted to previously split total power flows among transactions.

We agree with Dr. Bialek's comments on the aggregation invariance property (actually, we included on purpose Tables II and III to illustrate this fact). The regulator may opt for considering every load bus as a default transaction (Table III) or it may permit that all buses of a utility be considered at once (Table II). Considering how many other factors influence the economic decisions of market agents, it is very unlikely that a coalition be formed for the sole purpose of benefiting from loss allocation. Anyway, it remains to be studied whether or not the proposed loss allocation schemes induce efficient use of the grid by participants.

Finally, in the lower part of 11) a pair of brackets is clearly missing, as the branch resistance should multiply both terms.

Once again, we would like to thank Dr. Bialek for his interesting comments.

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Discussion of "Application of Unified Power Flow Controller in Interconnected Power Systems—Modeling, Interface, Control Strategy, and Case Study"

Edvina Uzunovic and Claudio A. Cañizares

This interesting paper[1] presents a fundamental frequency model of the UPFC that includes the dc link dynamics and, therefore, is suitable for steady state and some dynamic studies. Similar models have been previously proposed for VSI-based FACTS controllers, such as the STATCOM, the SSSC and the UPFC in [1]–[4]. In [3], in particular, the authors demonstrate that these types of models can be used to correctly represent the behavior of the STATCOM in transient stability studies; this is accomplished by comparing the results obtained for typical stability studies of a test system against results obtained with a detailed EMTP model of the controller (other papers soon to be published by the discussers present similar results for the SSSC and UPFC). One advantage of these types of models, as demonstrated in [3], is that it is possible to represent the detailed control blocks, almost in full detail, of VSI-based FACTS controllers.

Based on the results presented in [3], [4] and the experience of the discussers with these models, however, it is of particular importance to adequately represent the inverter losses in the model, especially when PWM control techniques are used as in the current paper. These losses should be represented as a resistance connected in shunt with the dc link capacitor (see the UPFC model proposed in [4]). If this resistance is not included, the model becomes unreliable, generating inaccurate results when using it to study the stability of power systems that include VSI-based FACTS controllers.

The comments from the authors regarding this particular issue would be appreciated.

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Closure to Discussion of "Application of Unified Power Flow Controller in Interconnected Power Systems—Modeling, Interface, Control Strategy and Case Study"

Zhengyu Huang, Yixin Ni, C. M. Shen, Felix F. Wu, Shousun Chen, and Baolin Zhang

The authors thank the discussers for their interest, comments and valuable contribution to the topic.

The discussers' comments mainly addressed the two aspects:

1) The power frequency model suggested in the paper[1] is similar to some previously proposed models.
2) A resistance should be added in parallel to the dc link capacitor to represent the inverter losses for VSI-based FACTS devices.

The responses to the two aspects are as follows:

1) The authors' objective in deriving the power frequency model for the UPFC is not only for the UPFC study but also for a versatile interface of various shunt and series FACTS devices to ac network in the stability study [1]. The interface should also be suitable to any kinds of control strategies including AI-technology

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[1]Z. Huang *et al.*, *IEEE Trans. Power Systems*, vol. 15, no. 2, pp. 817–824, May 2000.

based control [2] and to multiple FACTS devices that is significant to the coordination of various FACTS controllers and classical controllers in enhancing large scale power system transfer limits. The authors agree that the discusser-mentioned previous work has made important contributions to the topic.

2) In order to reduce the efforts in computer programming, the authors neglected the VSI losses of the UPFC in the paper. There is no serious difficulty to include it in the current model. The discussers recently revealed that it is important to include the VSI losses in the stability study through time simulation using detailed EMT model. The authors think the conclusion is reasonable. Usually the simplified math models are widely used in engineering study from synchronous machines to HVDC transmissions. As we all know the model simplification will cause some limitation in applications. The authors have that experiences in the past research work especially in the direct methods applications in transient stability study when incorporating the excitation system model [3] and the HVDC transmission model [4] into the direct methods. We think the discussers' work in this aspect is valuable.

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Discussion of "The Application of Power System Stabilizers to a Multigenerator Plant"

M. J. Gibbard and D. J. Vowles

The author is to be congratulated on an interesting paper[1] in which some important issues are raised that are often overlooked in the tuning of Power System Stabilizers (PSSs).

Being interested in the problems posed in the paper,[1] we attempted to apply a somewhat different design procedure [1], [2] to the author's four-machine infinite-bus system. The procedure attempts to compensate for magnitude and phase of the transfer function (PVr) between the voltage reference input (Vr) and the electrical torque (P) on the generator rotor, the shaft dynamics of all generators being disabled. (A theoretical basis for this approach is established in [3].)

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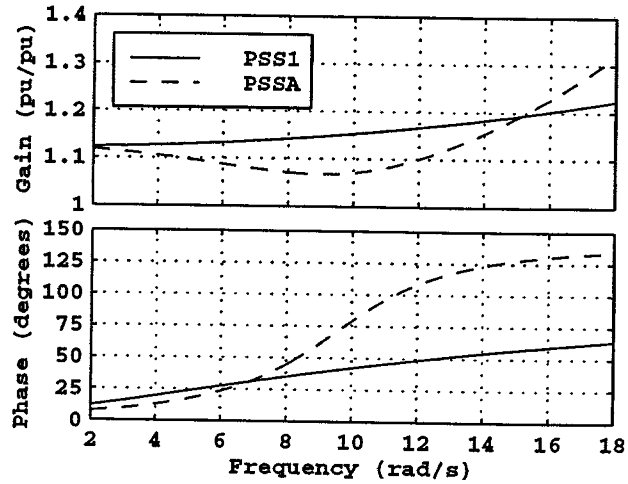

Fig. A. Comparison of the frequency responses of PSS1 and PSSA over the frequency range of interest.

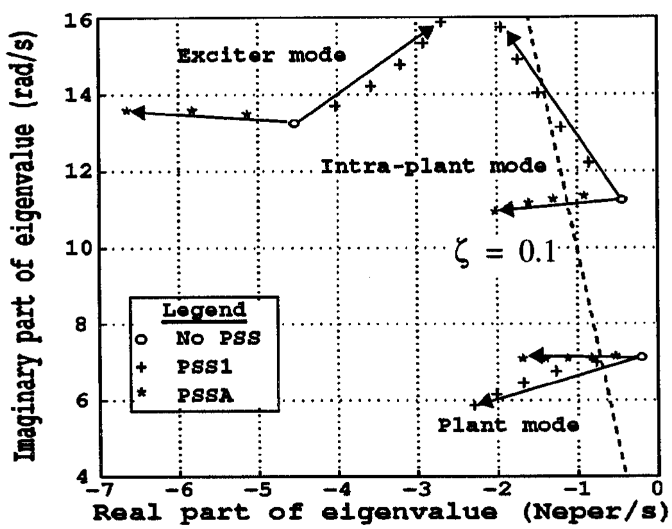

Fig. B. Root-loci of the plant, intra-plant and exciter modes for PSS1 and PSSA. The gains of both PSSs are incremented from zero to 10 in steps of 2.0 pu/pu.

An analysis of the PVr transfer function for the generators reveals that considerably more phase lead is required at the intra-plant modal frequency than that provided by the author's PSS1. The speed-input PSS design based on the PVr transfer function, PSSA, produces additional phase lead as shown in Fig. A. The root-loci plots of the plant, intra-plant and excites modes are shown in Fig. B for comparison with those of PSS1 given in Figs. 4 and 5. The transfer function of PSSA is the same as that for PSS1 except the compensator zeros are replaced by the complex pair $1 + 0.06s + 0.01s^2$.

Some slight modifications to PSSA further improve its performance. While the form of the root-loci for the plant and intra-plant modes in Fig. B can be explained, an explanation for those of the excites mode requires further work.

This four-machine infinite-bus system appears to have a number of anomalous features.

- In performing an analysis of interactions between stabilizers for this system, it was found that significant interactions occur. When positive, such interactions enhance the damping of the particular rotor mode, when negative the effect is deleterious to damping