Discussion

Anjan Bose (Arizona State University, Tempe, AZ): The authors must be congratulated on developing a voltage contingency selector that is satisfactory for the AEP system. This is a difficult problem because most attempts to speed up the solution results in unsatisfactory levels of accuracy. In this paper, the speed is achieved by developing an algorithm, a portion of which can be done off-line. This is similar in concept to the distribution factors method for a line flow contingency selector.

The method is dependent on many approximating assumptions. Although the paper shows satisfactory accuracy for the AEP system, it would be difficult to generalize to other systems without actual testing. Even for the AEP system, it is not clear whether the testing conducted was extensive enough to detect conditions under which the assumptions would fail. In particular, the K_0 and K_1 values, that characterizes the linearity assumptions, would appear to have a profound effect on the accuracy of the selector. The paper assumes that a simple norm threshold can be experimentally defined to determine if these values should be updated. Experience with the distribution factors method for real power shows that for many systems the linearity assumption is so weak that the updating has to be done too frequently for the method to be worthwhile. In any case, topology changes force immediate updating.

The timing comparison for the 1P-1Q and the VSEL shows VSEL to be better by a magnitude. From the description of the new method it is not clear that the number of computational steps were actually 15 times less than the first iteration of FDLF. It is also difficult to see why the 1P-1Q took so much longer unless it was rebuilding the B', B'' matrices for each outage instead of just using the matrix investion lemma. It should also be pointed out that the comparison is a little misleading since the 1P-1Q method accomplishes both real power and voltage selections whereas the VSEL only does the voltage selection.

Finally, the most difficult problem with voltage contingency calculations is posed by the local voltage controls. It is not clear whether the AC solutions used in the paper included the voltage controls. The 1P-1Q method can incorporate some voltage controls but must other approximate methods cannot. In practical terms, this question is rather important because a contingency that appears to cause severe voltage problems may really be within easy local control, but the calculation of the control effects always imposes a severe time penalty.

The authors have developed a new method which should be of great interest to others. Their comments on some of the points raised above would be very useful.

Manuscript received August 5, 1985.

M. G. Lauby (MAPP CC, Minneapolis, MN): The authors have presented a technique for selection of possible voltage violations. I have the following comments and remarks.

The authors state that there are two ways currently being employed for contingency simulation. I feel this is quite an erroneous statement, as there are a number of techniques now in use, both performance index and screening tools, for on-line and off-line applications ([1,2] to name a few). In fact, we use one of these in a planning tool we employ [1].

Ranking by performance indices and/or screening tools in local areas or "pockets" has its strengths in CPU efficiency and the selection of localized problems. In fact this was realized and implemented in [3]. However, one has to be concerned about outages that cause voltage violations in other pockets. Indeed, for this reason, we decided to implement the "concentric relaxation" method [4] for local problems and a universal performance index for system-wide problems [3,4]. Have the authors investigated this possibility?

Finally, I noted that you only compared the AC-loadflow, 1P-1Q, and ACS rankings based on the resultant performance indice. However, since identification of violations is what these screening and performance indexes are used for, why wasn't the size of the voltage violations pointed out and for which contingencies did they occur? As an example, perhaps the branch contingency 10 to 15 which was ranked '9' by the AC ranking and 22 by the ACS ranking is a voltage violation! That would identify how well the ACS performed (or didn't). Would you please indicate which contingencies caused violations?

REFERENCES

[1] T. A. Mikolinnas and B. F. Wollenberg, "An Advanced Contingency Selection Algorithm", *IEEE Trans. on PAS,* Vol. PAS-100. Feb. 1981, pp. 608-617.

[2] *EPRI EL-2526,* Project 1530-1, "Transmission System Reliability Methods", July 1982.

[3] M. G. Lauby, T. A. Mikolinnas, N. D. Reppen, "Contingency Selection of Branch Outages Causing Voltage Problems", *IEEE Trans. on PAS,* Vol. PAS-102, Feb. 1983.

[4] J. Zaborsky, K. W. Whang, and K. Prasad, "Fast Contingency Evaluation Using Concentric Relation", *IEEE Trans. on PAS,* Vol. PAS-99, Jan/Feb. 1980, pp. 28-36.

Manuscript received July 31, 1985.

Iraj Dabbaghchi and Guillermo Irisarri: The authors wish to thank the discussers for their interest in our paper. Their comments and questions will be addressed individually.

Prof. Base

a) The AEP EHV system is a well-behaved one and for most part virtually free of "weak points", that is, areas where the active/reactive decoupling assumption fails, as evidenced by a variety of real-time tests performed on a number of security monitoring and analysis functions. Our test results indicate that the reactive power mismatch representation using K_0 and K_1 (i.e., Eq. (A1.8) of Appendix I of the paper) provides an adequate model for this application. This model is not quadratic in angles, but more accurate than its linear counterpart. It is somewhere between linear and quadratic. Hence, it can not be classified as pure linear as Prof. Bose has assumed.

b) The angle norm test performed to evaluate the "goodness" of the reference case is for analog values only. It basically determines how far the real-time state has drifted from the state for which K_0 and K_1 and the related off-line scalar quantities were computed. This has nothing to do with the speculated linearity. Besides, we do not recommend that other organizations adopt our method blindly. We agree with the discusser that each power system has its own physical characteristics and a method that is suitable for one system may not necessarily perform as well elsewhere.

c) The 1P-1Q algorithm reported in the paper undates B' and B'' using the Matrix Inversion Lemma. No rebuilding takes place, as the discusser has speculated. The coefficient matrices (namely, B', B", and YBUS) were not treated as sparse arrays, however. Also notice that the VSEL algorithm updates the angles too, but uses a faster procedure than 1P-1Q (see Eq. (5). of the paper). Since the ultimate objective is the computation of J(V), there is little incentive to make the intermediate results (such as the post-outage angles) accessible, as in 1P-1Q. The post-outage angles are used implicitly by both PSEL algorithm of reference [2] of the paper and the VSEL algorithm. So, the fact that 1P-1Q yields the post-outage angles is practically useless. Besides, real power flow contingency selection (PSEL algorithm) and voltage contingency selection (VSEL algorithm) are two distinct functions. They might not even be executed in a PSEL-VSEL sequence. In fact, at AEP the number of functions in the Automatic Contingency Selection (ACS) area has now grown to seven. Exchange of intermediate results among these functions is virtually out of question due to the non-simultaneity of execution and software engineering considerations.

d) The VSEL algorithm as implemented has no provision for local voltage controls. Voltages at generator buses are excluded from the analysis. Only load buses (i.e., PQ bus type) are processed and this fact is clearly reflected in the title of the paper. However, the AC load flow solutions took into account the reactive power injection limits. This apparent discrepancy results in a conservative estimate for ACS. That is, the ACS method actually performs better than it appears. In particular, the real-time results for ACS in the paper correspond to an extreme case where the reference case was retained for an extended period to time. With more frequent updating, the ACS output is much closer to the AC load flow results.

Mr. Lauby

e) The statement made in the Introduction section of the paper clearly refers to the "traditional" procedure for security assessment and this section is intended to review the justification for the automatic contingency selectors. The authors are very pleased that Mr. Lauby's organization actually uses some form of the ACS function. Contingency screening (as we perceive it) is basically the 1P-1Q algorithm of the paper without calculating the performance index and as such, it does not constitute a separate approach from ACS.

f) We have not considered the concentric relaxation method.

g) The objective of ACS is to "detect" the violation of the steady-state security limits. The "identification" of actual violated limits is performed by the subsequent AC load flow runs for the selected contingency cases. As we define it, detection and identification are two distinct steps. This is somewhat similar to the original approach to the bad data processing in the context of state estimation.

Manuscript received September 9, 1985.