MASTER

**SECURITY ASSESSMENT OF POWER SYSTEMS INCLUDING ENERGY STORAGE
AND WITH THE INTEGRATION OF WIND ENERGY**

**Progress Report
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CONTRACT ACTIVITY

As of August 1979, Dr. D.M. Triezenberg was replaced by Dr. P.C. Krause as co-principal investigator. During this quarter G.E. Gareis (25%) P.C. Krause (30%), C.M. Ong (20%), J.P. Sullivan (5%) and O. Wasynczuk (50%) have been involved in this contract.

ABSTRACT

The progress of the first three tasks of the wind energy part of the contract is discussed. Emphasis is on the modeling of the wind and the detailed computer representations of three candidate wind systems; namely, MOD-1, MOD-2 and the Shackle machine. Once the detailed computer representations of these wind systems have been developed the next step is to begin work on the reduced order models to be used in transient stability programs.

WIND MODELING

The objective of the wind modeling task is to establish a computer model that includes the effect of the turbulent structure of the wind on the aerodynamic performance of the wind machine. Ultimately the model will supply the unsteady shaft torque given the stochastic properties of the turbulent boundary layer while allowing feedback to the blade pitch change mechanism.

As a first step all the possible influences on the unsteady shaft torque are considered. These are outlined below:

Wind Model

1. Temporal Variation
2. Spatial Variation
 - a. Horizontal
 - b. Vertical
3. Wake Effect

Multiple Machines

4. Tower Influence

5. Unsteady Aerodynamics

a. Time Response of Lift and Drag

b. Aero Elastic Effects

6. Effect of Yaw and Yaw Rate

The formulation of a model including the temporal and spatial variations of the wind on a quasi-steady, rigid wind machine rotor has been initiated. That is initially, effects 3, 4, 5 and 6 will not be included. Work on this simplified model will continue during the next quarter.

MODELING OF SINGLE-UNIT, WIND POWERED GENERATORS

The objective of this task is to develop detailed computer simulations of wind powered generators representative of wind systems which will be integrated into power systems in the near future. The wind generators which are presently being simulated are MOD-1, MOD-2 and the Shackle machine.

A preliminary simulation of the MOD-2 was done for NASA/Lewis Center under a grant which is terminating in November 1979. This simulation is now being modified and refined under this contract.

The simulation of MOD-1 is beginning. This system is similar in many ways to the MOD-0 which was simulated at Purdue Prior to this contract. Field tests on the MOD-1 are available from NASA and will be used to verify the computer simulation.

Work on the Shackle machine has not started as yet. During the next quarter our consultant Dr. P.M. Anderson will contact Southern

California Edison for the purpose of obtaining data for the Shackle machine so that this simulation can begin.

STABILITY INVESTIGATION OF SINGLE-UNIT, WIND POWERED GENERATORS

One of the objectives of this task is to investigate the validity of an eigenvalue or linearized analysis of wind powered generators. Since in some modes of operation the input torque is varying due to wind gusts. The validity of an eigenvalue analysis is suspect. An eigenvalue analysis of the MOD-0 performed prior to this contract was found to be of little use in the design of the associated control systems. An eigenvalue analysis will be performed on the MOD-2 and its accuracy will be determined by comparison with the detailed computer representation. It is planned for this work to start in the next quarter.

Large excursion (transient) stability has been investigated for the MOD-0 and the MOD-2 (MOD-2 under a NASA grant). Transient stability studies for the MOD-2 are now being continued under this contract. Results of the present stability studies will be reported in the next quarterly report.