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An Optimal Control Law By Eigenvalue Assignment For Improved Dynamic Stability In Power Systems

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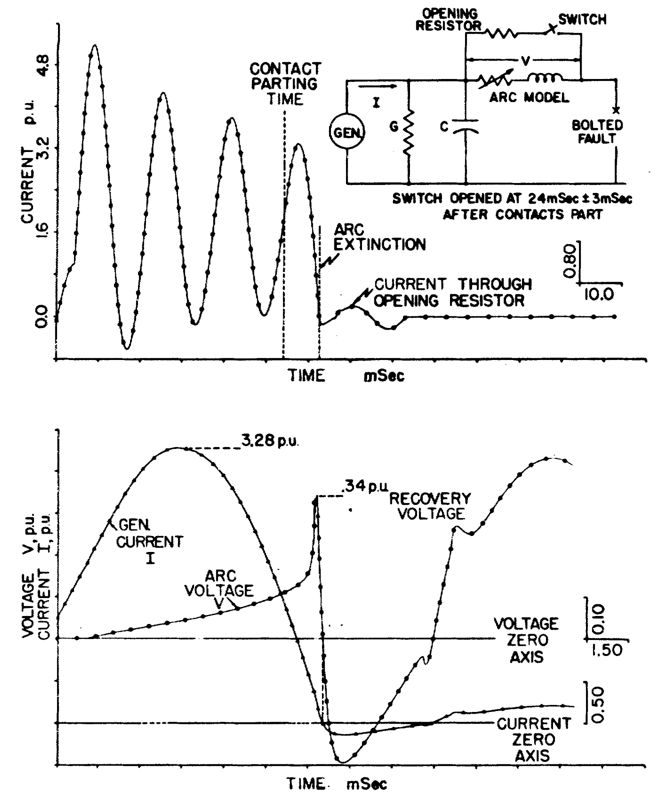

Fig. 3. Current and voltage waveforms from a simulation of the performance of a 26-kV generator circuit breaker.

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To realize a pre-assigned set of eigenvalues for a closed loop system the present algorithms available, for the computation of feedback control laws when multivariable and multi-input systems are considered, require the computation of the rational canonical form (normal form) or the Jordon canonical form for the open loop system. An algorithm which does not require such computations is presented in this paper for the improvement of the dynamic stability in power systems. The algorithm is very convenient for use with other algorithms which seek to optimize, in some sense, the feedback control law while achieving arbitrarily assigned eigenvalues for the closed loop system.

For a power system described by a state matrix equation

$$\dot{x} = Ax + Bu$$

and a desirable linear feedback control law of the form

$$U = Fx$$

a solution for the F matrix is presented in this paper which minimizes the Lagrangian

$$\Omega = tr(\tfrac{1}{2}F'RF + L')[(A + BF)P - PD)$$

where R is a diagonal weighting matrix, D is a diagonal matrix of eigenvalues, P is the matrix of eigenvectors of the closed loop system and L is a matrix of Lagrangion multipliers.

The procedure suggested for the solution of the F matrix is as follows:

–Assume any values for F
–Modify the first row of F so as to realize eigenvalues given by D and determine P
–Using value of P and new F find the diagonal matrix Q such that the mean square error of $F = -R^{-1}B'P^{-1}QP'$ between right and left hand sides is minimized
–From this computed value of Q determine a new F
–The new value of F is then computed to improve convergence

$$F = F + \alpha[F_1 - F]$$

–The second step above is then repeated until convergence is achieved

A model power system example is considered and a control law developed from which the system dynamic response is calculated. A complete development of the control law procedure is described and numerical examples are given to describe the iteration procedure.

The objective of the paper is to describe an optimal constant linear control law which arbitrarily achieves a preassigned set of system eigenvalues. The computation requirements are much smaller than those of conventional linear optimal procedures. Therefore the procedure presented gives a fast calculation of a desirable control law.

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Experimental and Theoretical Study of a D.C. Arc in a Constant Diameter Nozzle Flow

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Abstract—The cold air flow field for a 1.27 cm constant diameter nozzle was determined for subsonic and transonic flow velocities. The dc arc voltage and current measurements were made for an arc gap of 5.52 cm and a current of 100A. With a channel flow model with constant arc temperature and the energy integral for the convective cooling, analytical expressions were derived for the arc radius, electric field strength, and arc voltage as functions of the cold flow properties, current, and axial distance. Calculated arc properties agree well with measured values.

Experimental Apparatus

A constant diameter nozzle with a diameter of 1.27 cm and a length of 3.81 cm was constructed out of Lexan. Hemispherical upstream and hollow downstream electrodes were made from 1.27 cm diameter copper-tungsten rod. The distance between the electrodes is 5.52 cm. Detailed static and impact pressure measurements were made to define the cold flow field [1]. A 2000 volt rectified system supplies dc current to the arc.

Cold Flow Properties

The cold flow velocity through the constant diameter nozzle is varied by adjusting the reservoir pressure. From the measured static pressures the local flow Mach numbers and densities were cal-