Desired Optimization Problem


References:

Benefits:
(i) It allows us to embed different kinds of steady-state convex optimization problems;
(ii) If the desired optimization problem has a certain distributed structure, the resulting controller is distributed and can be implemented in a closed-loop manner;
(iii) the trajectories of the closed-loop system asymptotically converge to an equilibrium point at which the desired optimization problem is solved.

Today’s Grid

Supply = Demand
Unresponsive
Predictable

Tomorrow’s Grid

Supply = Demand
Responsive
Less controllable
Highly uncertain
Distributed
Large scale

Challenge: The control and optimization for power networks need to operate at faster time-scales for reliability and economic efficiency.

Bridging the Gap: Distributed Frequency Control and Economic Efficiency

Conventional Frequency control

Dynamic model e.g. swing equations
Power flow model e.g. DC/AC power flow

Economically Optimal Frequency control

Load-side participation
Real-time economic dispatch

Goal: the closed-loop dynamical system can automatically track the optimal solution of an economic optimization problem (e.g. economic dispatch, optimal power flow) and the control scheme can be implemented in a distributed (i.e. communicating with neighbours) and closed-loop (i.e. no information of exogenous disturbances) manner.

Main Results

I. Primary Load Frequency Control

System Dynamics

Generator bus:

Load bus:

Real branch power flow:

Optimization Objective

Load Control

Swing dynamics plus the load control scheme serve as a distributed partial primal-dual gradient algorithm that solves the objective optimization problem. The load control scheme is completely decentralized.

II. Economic Automatic Generation Control (AGC)

System Dynamics

Optimization Objective

Economic AGC

Swing dynamics plus the ACE-based AGC serve as a partial primal-dual gradient algorithm to solve a convex optimization problem. This problem is then re-engineered to derive the economic AGC, which is distributed and easy to implement.

III. Distributed Control and Economic Optimality (general formulation)

System Dynamics

Economically Optimal Control

“Economically Optimal” Control

System dynamics plus the built-in controller serve as a primal-dual gradient algorithm to solve a quadratic saddle point problem. This problem is then re-engineered to modify the controller, which converges to the optimal point of the desired optimization problem.

References:


