Optimal Power Flow Pursuit

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Real-time distribution system optimization

A new method develops distributed feedback controllers that continuously drive the power set points of inverter-interfaced devices to solutions of AC optimal power flow (OPF) problems. Leveraging online optimization techniques for the synthesis of the controllers thus achieves network-level performance metrics in real time while voltages are regulated within given limits. The controllers rely on instantaneous voltage measurements and do not require knowledge about the loads present in all feeder locations. These controllers can be implemented in microcontrollers that accompany interfaces of gateways and inverters. As a result, a controller that can pursue fast-changing OPF targets is beneficial and advantageous to those deploying traditional OPF and autonomous schemes because it is extremely adaptable and can result in better reliability and increased power quality. As an application, the developed controllers enable an integration of photovoltaic systems well beyond current limits.

Solves optimal power flow problems

The desire to improve grid resiliency and enable a sustainable capacity expansion has led to the growth of distributed energy resources (DERs) and utilization of renewable energy sources. DER allows for smaller amounts of aggregate energy to meet the regular demand of the commercial, industrial and domestic consumers. When combined with renewable energy sources, the distribution network supplying power is transformed into a smarter and more sustainable grid. One major challenge in a distribution network is to optimally integrate DERs and renewable energy sources in large scale while congruently regulating voltages and ensuring that power-quality requirements are met. Feeders with high integration of photovoltaic systems give a prime example, given the increased likelihood of overvoltage conditions during solar peak hours. In this context, autonomous techniques currently tested for the distribution networks include Volts/VAR and Volts/Watt and may result in suboptimal system operation, with the former requiring the inverters to be oversized. On the other hand, centralized optimization approaches may not offer sufficiently fast decision-making capabilities because in the time required to collect data from all of the nodes in the network the underlying load, ambient and network conditions may have changed. This new algorithm solves optimal power flow problems and is backed with theoretical guarantees while enabling low-complexity implementation.

Phase of Development

- Prototype developed

Benefits

- Solves optimal power flow problems
- Resilient to communication latency
- Real-time optimization

Features

- Implementable onto micro-controllers and existing devices
- High integration of DERs with reliability guarantees
- Seek system-level performance objectives in real time
- Enable inverter-based voltage regulation
- Increased operational efficiency

Applications

- Photovoltaic systems
- Grid efficiency
- Utility industry
- Micro-grid optimization
- Manufacturers of inverters (photovoltaic systems and other distributed energy resources)
- Distribution networks featuring inverter-interfaced distributed energy resources

Researchers
Sairaj Vijaykumar Dhople, PhD
Assistant Professor, Electrical and Computer Engineering
External Link (ece.umn.edu)

Publications
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