Optimization in modern power systems

Lecture 1: Introduction

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Outline

- Welcome!
- Let's introduce ourselves!
- My chance to get to know you better: Pre-course questionnaire
- What is optimization?
- Learning Objectives
- General info about the course
- Short introduction to linear optimization
- DC-OPF: linearized optimal power flow

What is optimization?

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Learning Objectives

- Recognize and formulate problems for operation and investments in power systems
- Basic principles of
  - Linear programming
  - Quadratic programming
  - Nonlinear programming, and
  - Semidefinite programming
- Formulate the dual of an optimization problem and the optimality conditions (KKT)
- Explain what locational marginal price is in electricity markets
- Design and solve:
  - DC-OPF
  - AC-OPF
- Understand and apply convex relaxations (e.g. semidefinite programming)
- Describe three advantages and disadvantages of each formulation
- Organize, plan, and carry out work in a group project
- Analyze and present the results in front of an audience

General Info About the Course

- Lectures
  - Location: Building 325, Room 113
  - Time: 9:00-11:00, every day
- Working on assignments
  - Location: Building 325, Room 153
  - Time: 11:00-13:00, every day
- According to DTU rules, 5 ECTS credits correspond to about 8-9 hours of work per day over the 3-week period for this course. This means you are expected to continue working on the assignments during the afternoon.

General Info About the Course

- Necessary for the class
  - Please bring your laptop with Matlab installed. And please make sure you also have the Matlab Optimization toolbox installed.
- Course Material
  - R.D. Christie, B.F. Wollenberg, I. Wangesteen, Transmission Management in the Deregulated Environment. Proceedings of the IEEE, vol. 88, no. 2, pp. 170-195, Feb. 2000.
  - S. Boyd, L. Vandenberghe, Convex Optimization. Cambridge University Press (Chapters 4 and 5).
  - H. Glavitsch, R. Bacher, Optimal Power Flow Algorithms. ETH Zurich, (around 1999).

Assignments

1. DC-OPF
2. AC-OPF
3. Solution methods of optimization problems
   - Study in groups the principles of different solution methods (one method per group)
   - prepare a presentation to present at end of the class
   - peer-reviewing: review the presentation with another group before presenting in front of class

Evaluation

- 50% Presentation and Assignments
- 50% Oral Exam
- Exam on the last day of the course, Jan 20, 2017

Linear Programming

- Example of a linear program: Suppose a production manager is responsible for scheduling the monthly production levels x_j of a certain product for a planning horizon of twelve months.

Production cost c_j per month	$\min \sum c_j x_j$
subject to:	
total annual demand D	$x_1 + \ldots + x_{12} = D$
maximum production capacity per month m_j	$0 \leq x_j \leq m_j$

Linear Program

Linear Programming

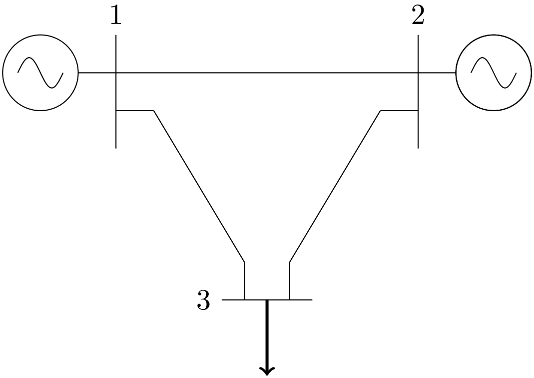
$$\min c \cdot x$$

subject to:

$$a_i \cdot x = b_i, \quad i = 1, \ldots, m$$
$$x \geq 0, \quad x \in R^n$$

- LP: Optimization variables in the form of a vector x.

Economic Dispatch and Optimal Power Flow: Short Introduction on the Board



Economic Dispatch

$$\min \sum_i c_i P_{G_i} \tag{1}$$

subject to:

$$P_{G_i}^{min} \leq P_{G_i} \leq P_{G_i}^{max} \tag{2}$$

and

$$\sum_i P_{G_i} = P_D \tag{3}$$

Economic Dispatch

$$\min \sum_i c_i P_{G_i} \tag{4}$$

subject to:

$$P_{G_i}^{min} \leq P_{G_i} \leq P_{G_i}^{max} \tag{5}$$

and

$$\sum_i P_{G_i} = P_D \tag{6}$$

How do you interpret these constraints for a 2-generator system on the cartesian plane?

DC-OPF

$$\min \sum_i c_i P_{G_i} \tag{7}$$

subject to:

$$P_{G_i}^{min} \leq P_{G_i} \leq P_{G_i}^{max} \tag{8}$$

and

$$\mathbf{B} \cdot \theta = \mathbf{P_G} - \mathbf{P_D} \tag{9}$$

and

$$\frac{1}{x_{ij}}(\theta_i - \theta_j) \leq P_{ij,max} \tag{10}$$