Project 3:

Feasible space of the Shor relaxation for AC-OPF

Stage 1

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Description

This a two-stage project. There are multiple approaches to complete the project. In the first stage, you are expected to outline a possible approach to carry out the assignment. In the second stage, we will provide you with an outline for a possible approach along with some questions to answer. You are free to use this approach or any other approach you may develop. Comparison of two or more approaches will receive bonus points.

This project has two main goals. The first is to apply techniques in order to determine the feasible space of the Shor relaxation for the AC-OPF problem. The second is to gain a better understanding of the possible conditions that drive local solution algorithms (such as those in Matpower) for the non-convex OPF to a non-global optimum, and the conditions that drive the Shor-relaxed OPF to a non-physically meaningful solution.

Consider the AC-OPF problem "WB5" from [Bukhsh, Grothey, McKinnon, & Trodden '13] with the one-line diagram shown below. (See the file `WB5.m`)

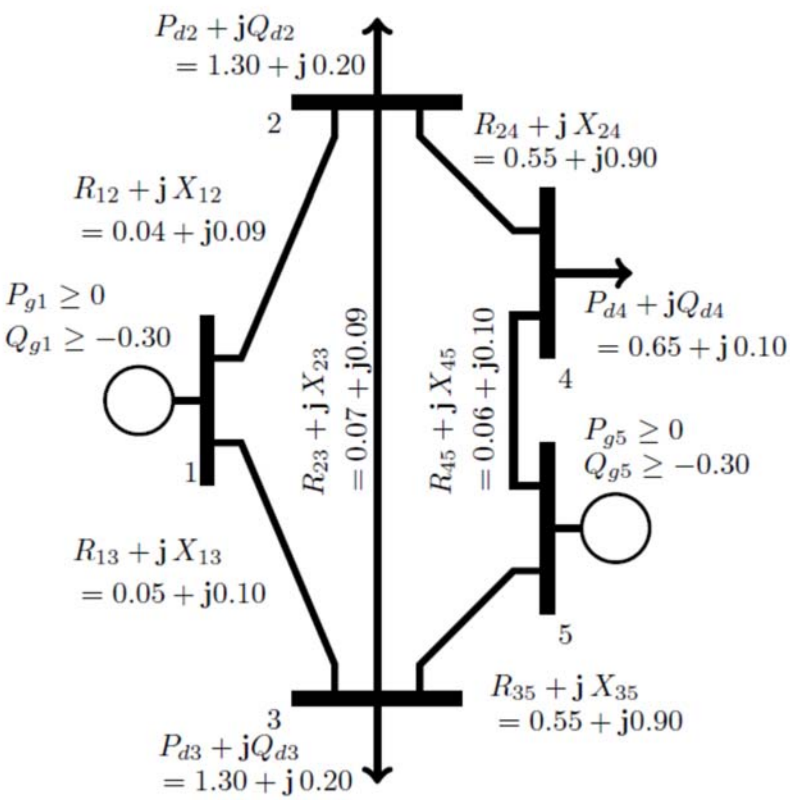

Figure: 5-bus system [Bukhsh, Grothey, McKinnon, & Trodden '13]

1. Based on the data you were provided (`feasible_space_WB5.mat`), plot the feasible region of the AC-OPF in a 2-D graph, where the x-axis represents the *active power* generation setpoints of G1 and the y-axis represents the *active power* generation setpoints of G5.

2. Solve the AC-OPF problem in Matpower. What is the optimal solution? Does this solution coincide with the global optimum of the original AC-OPF problem?

The aim of the next question is to create the feasible region of the Shor relaxation for this problem. In order to do that, you need to create a set of possible operating points for the given load profile, and then compute the projection of these points to the feasible region.

3. Determine the feasible region of the Shor relaxation of AC-OPF.

4. Graphically compare the feasible space of the Shor relaxation from Question 3 with the feasible space of the original problem from Question 1. Identify on the figure the optimal solution to the Shor relaxation of the original AC-OPF problem. Does the solution to the Shor relaxation coincide with the global solution to the original AC-OPF problem?

5. Is the optimal solution of the Shor relaxation a physically meaningful solution? Using both graphical and numerical arguments, what indicates that it is or it is not?

6. With the guidance of the graphical comparison from Question 4, propose at least one other AC-OPF problem such that a solution from Matpower and the solution to the Shor relaxation both find the global optimum. For this question, you are only allowed to change the coefficients of the objective function and the constraint limits. The power demand and the network must remain unchanged.

Hints:
The feasible region of the Shor relaxation must be a convex set, since the problem is convex. A convex hull calculation could help you visualize this convex set.

For plotting purposes, you may want to consider using the function `convhull.m`